Chapter 5 – Comprehensive Energy Services

Introduction

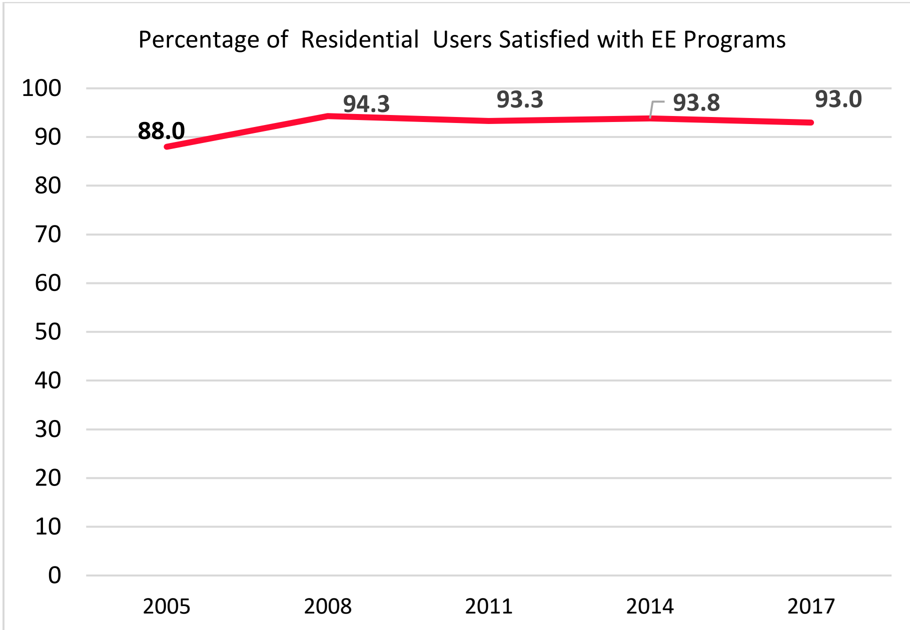
In this chapter, we provide an overview of the importance of BED's energy efficiency programs. We begin with a historical look at the benefits of electric energy efficiency investments, and then discuss how future investments in comprehensive energy services, (traditional electric efficiency and beneficial electrification programs), will help to ensure that BED is prepared to meet increasing customer demand for electricity, while simultaneously meeting the State required reductions in greenhouse gas emissions.

BED's energy efficiency programs are designed to meet the requirements of its Order of Appointment, Vermont's renewable energy standard (Act 56) and the City's NZE initiative as described in preceding chapters. To effectively meet these directives, BED will need to design and implement new customer rates to incentivize customer adoption of beneficial electrification technologies such as EVs and heat pumps, while also lowering the societal cost and impact of increased energy consumption. Simultaneously, BED will need to invest in distribution system upgrades to ensure continued system reliability with increasing customer demand for electricity. BED is well equipped to rise to the challenge of accomplishing these tasks.

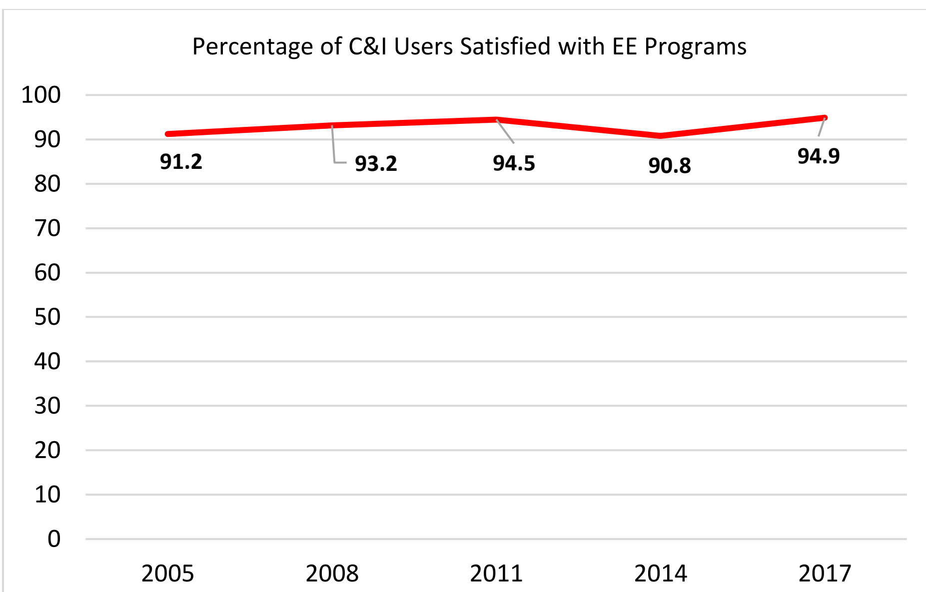
Comprehensive energy efficiency as a valued customer service

To provide the energy services our customers have come to expect, BED will need to continue investing in electric energy efficiency even under a base case scenario. BED also contends that offering only traditional electric efficiency services in the future will be ineffective and inconsistent with the State's Comprehensive Energy Plan. BED must instead provide comprehensive energy services aimed at reducing GHG emissions, source energy reductions and total energy cost savings. By offering comprehensive energy services to customers that include traditional electric efficiency and beneficial electrification services such as incentives for highly efficient heat pumps, EVs, discounted residential EV rates and load controls, BED will be in a much stronger position to meet customer interest in such programs as well as maximizing existing grid capacity to the benefit of all customers.

Continuing BED's tradition of providing electric energy efficiency services is warranted not only because these services generate positive net energy benefits, consistent with 30 V.S.A. §209, but also because customers are extremely satisfied with the services. A recent customer survey poll indicates that 93% of participating residential customers were satisfied with BED's energy efficiency programs.[1]



The same poll concludes that 95% of participating commercial customers were also satisfied with BED's energy efficiency offerings.[2]



[1] 2017 Burlington Electric Residential Customer Survey, by Spruce Lane Consulting, Dec. 2017.
[2] *Id.*

BED is aware that additional effort is needed to increase awareness and participation in its electric energy efficiency programs. We also acknowledge that barriers still exist to participating in our electric efficiency programs. In past regulatory filings, BED has outlined many of these long-standing barriers which include but are not limited to the following:

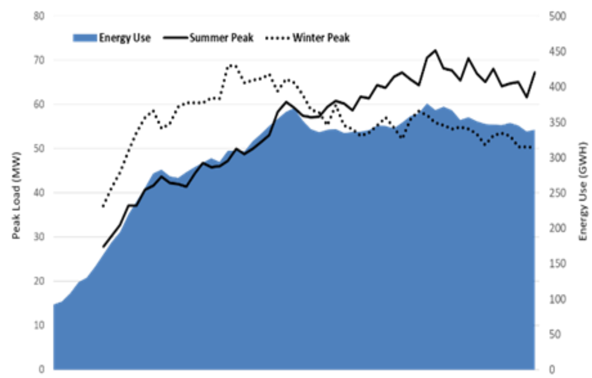
- Most residential and commercial customers rent their building spaces (60% residential, 70% commercial customers);
- 85% of residential rental units are individually metered for natural gas and electric service so tenants pay their utility costs directly creating a split-incentive paradigm;
- A high percentage of customers are connected to natural gas (95% residential, 99% C&I) which costs less to use for heating than electricity;
- 35% of residential accounts are turned over annually so these customers will not benefit from long-term savings from BED's efficiency programs; and,
- Average electricity consumption across BED's residential customer class is already among the lowest in the U.S. at 390 kWh per month.

The aforementioned survey of 439 residential customers confirms that many of the above barriers are still in place today. The same survey indicates that the cost of new efficiency measures (net of incentives) is also a barrier to participation. Some customers view efficiency program participation, particularly our TEPF weatherization program, as being overly complicated despite our efforts to simplify the process to the greatest extent possible. Nevertheless, we are encouraged that many of our customers take advantage of the energy services that BED provides. These include programs that reduce gasoline and natural gas consumption such as electric-lawn mowers, electric bikes, heat pumps, integrated controls, EVs and home-based EV charging.

These added innovative energy services (i.e. Tier III programs) and incentives undoubtedly help to reduce our customers' total energy consumption and bills. Indeed, 63% of residential customers indicated that offering new and innovative services, such as those mentioned above, would be important to them in the future. As BED continues to ramp up its Tier III programs, its energy services staff will need to continue providing customers our original efficiency programs to help customers reduce their electric consumption through efficient appliances, weatherization and lighting controls. However, by combining these efficiency services with demand response services and potentially new rate designs, BED will maximize its ability to influence the times at which customers consume electricity in order to improve BED's system load factor. Improving BED's load factor could produce co-benefits such as decreasing electric rates to the benefit of all customers, including non-participants. More importantly, combining Tier III and electric energy efficiency services under one umbrella service offering allows BED to further advance the value proposition of transitioning away from fossil fuels.

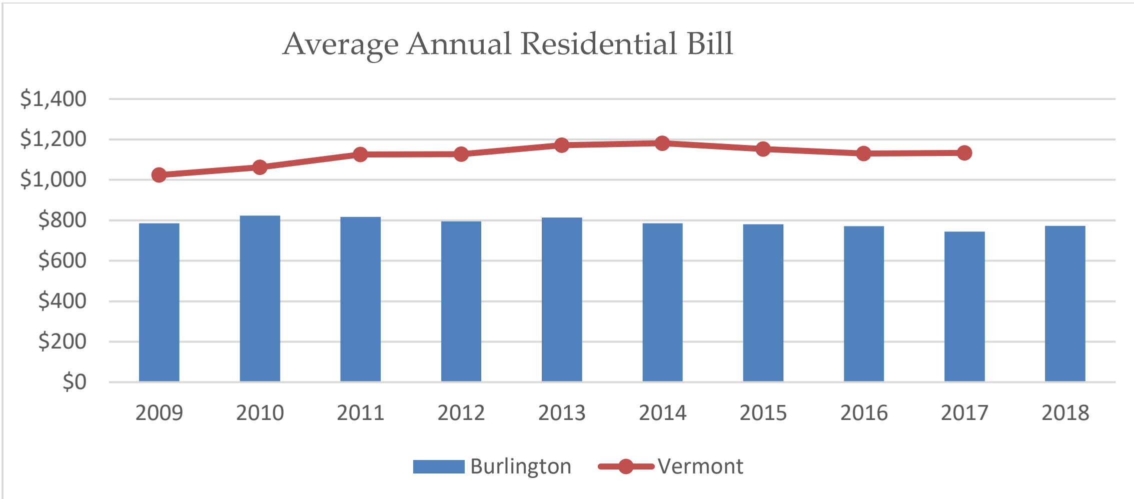
Continuing to invest in electric energy efficiency is also warranted because such investments are a least cost resource that BED can tap into to help improve reliability. Electric energy efficiency investments help to offset anticipated future growth in electric loads and system peak demand as the transformation of the transportation and building sectors unfolds. Thus, continued investment in cost effective energy efficiency, including thermal efficiency and weatherization, should help customers to right-size their heat pump equipment, which reduces electric loads to a greater extent than without added weatherization. Also, increased electric efficiency investments could lower the potential impact of EV's charging in homes and businesses throughout Burlington, including those EV's owned by non-Burlingtonians charging at BED's publicly available chargers.

Historical Results of Electric Energy Efficiency



As noted at the outset of this IRP, BED has been providing energy services for nearly 30 years. Investments in these services have proven effective in many ways. Electric efficiency has helped to flatten load over the past 10 years, allowing BED to defer costly growth-related upgrades to the transmission and distribution T&D system. Efficiency has helped to reduce the need to acquire additional wholesale energy on the spot market or to arrange for the purchase of new power through contracts with renewable energy generators located some distance from Burlington. Thus, continued energy efficiency investments allow for increasing levels of consumers' dollars to be re-invested in Vermont's local economy. Energy efficiency expenditures are made almost entirely locally, typically in the form of professional services, skilled trades employment, and equipment purchases. Not only is the value of the City's building and energy-using equipment improved, but locally retained dollars are "multiplied" many times over by subsequent consumer spending.

Most importantly, BED's energy efficiency investments have significantly contributed to lowering BED customers' electric bills. Currently, BED residential customers have some of the lowest electric bills in the State as shown in the graph below.



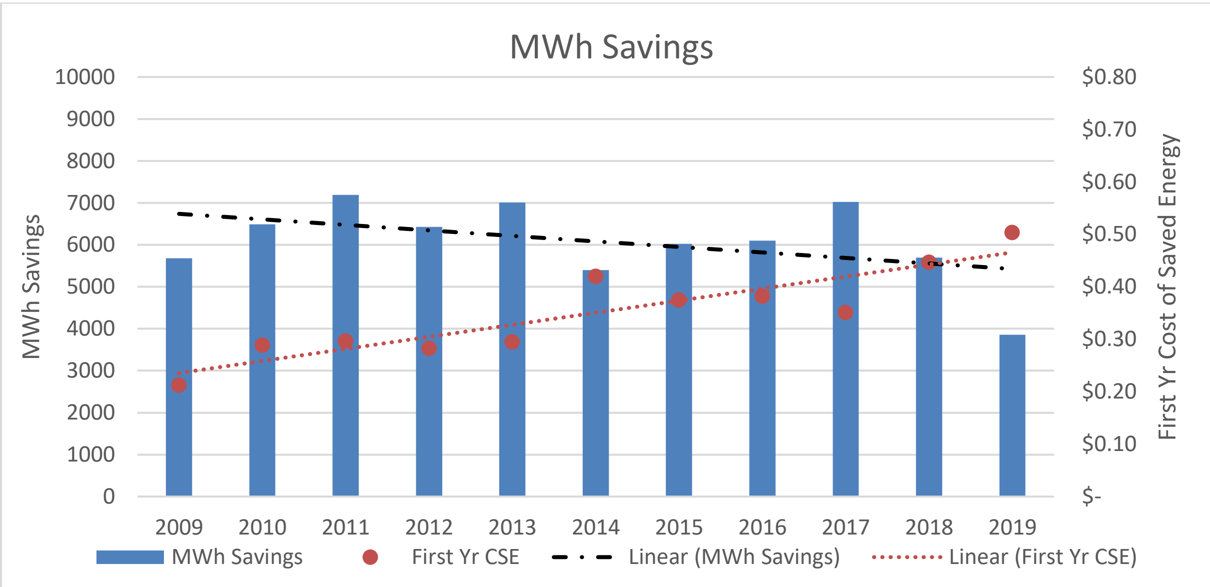
In short, electric efficiency is an effective investment that has been producing reasonable returns for BED and the City for years. And, we expect that these investments will continue generating such returns well into the future through existing and proposed efficiency and Tier 3 programs.

Electric Efficiency Programs

BED provides energy efficiency services and incentives through five main programs: Business Existing Facilities, Business New Construction, Efficient Products, Residential Existing Buildings and Residential New Construction. Ten-year average investments and savings by program are as follows:

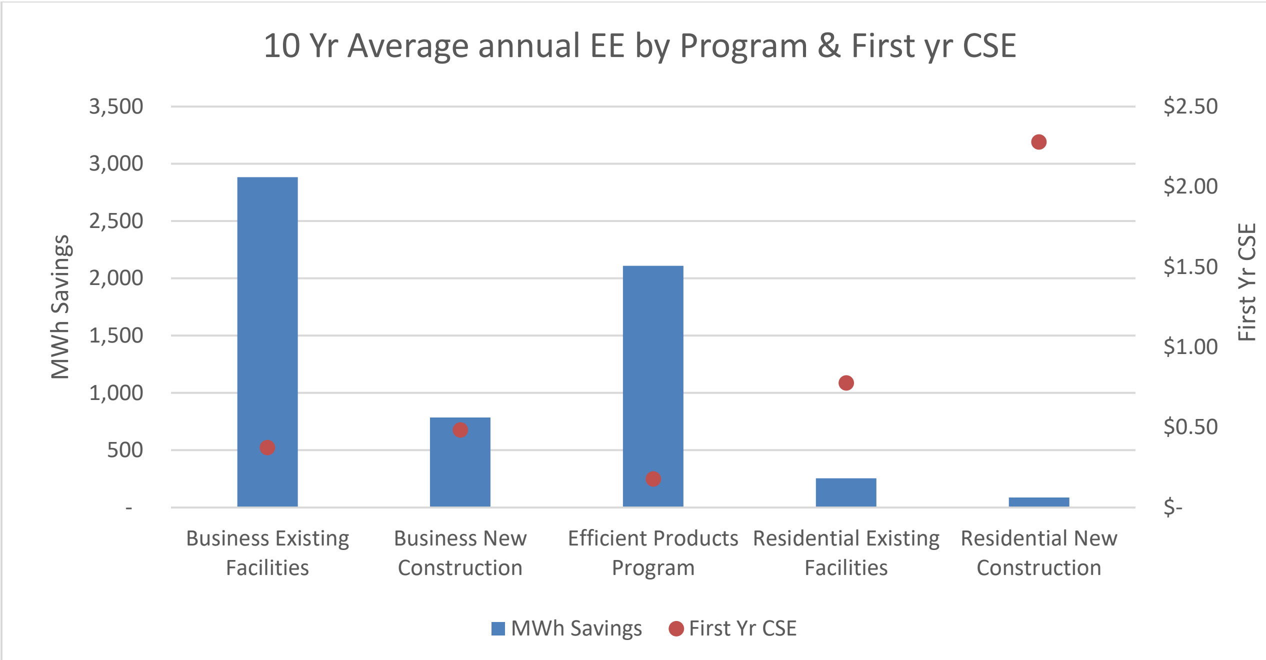
Program		Total Program Costs	Net MWh Savings	BED First Yr CSE (kWh)	BED Levelized CSE (kWh)
Business Existing Facilities	$	1,088,194	2,884	$0.37	$0.03
Business New Construction	$	377,690	786	$0.48	$0.04
Efficient Products Program	$	367,658	2,109	$0.18	$0.02
Residential Existing Facilities	$	219,064	254	$0.78	$0.06
Residential New Construction	$	118,529	88	$2.28	$0.07
GRAND TOTAL	**$**	**2,171,135**	**6,122**	**$0.35**	**$0.03**

In aggregate, BED's energy efficiency programs have reduced electric consumption by 5,000 to 7,000 MWhs annually. Such savings amount to roughly 1 – 2% of annual retail sales. First year cost of saved energy has ranged from $0.30 to $0.40 per kWh saved. Overtime, however, MWh savings accumulate as efficiency measures remain in place for up to 10-12 years, on average, and even longer for new construction projects. These savings have cost BED roughly $0.03 per kWh ($0.33 First yr CSE divided 12yrs). When compared to the levelized cost of wholesale energy ($0.04 to $0.08/kWh), energy efficiency has proven to be an attractive investment that has contributed to BED's efforts to comply with 30 V.S.A. §218c.



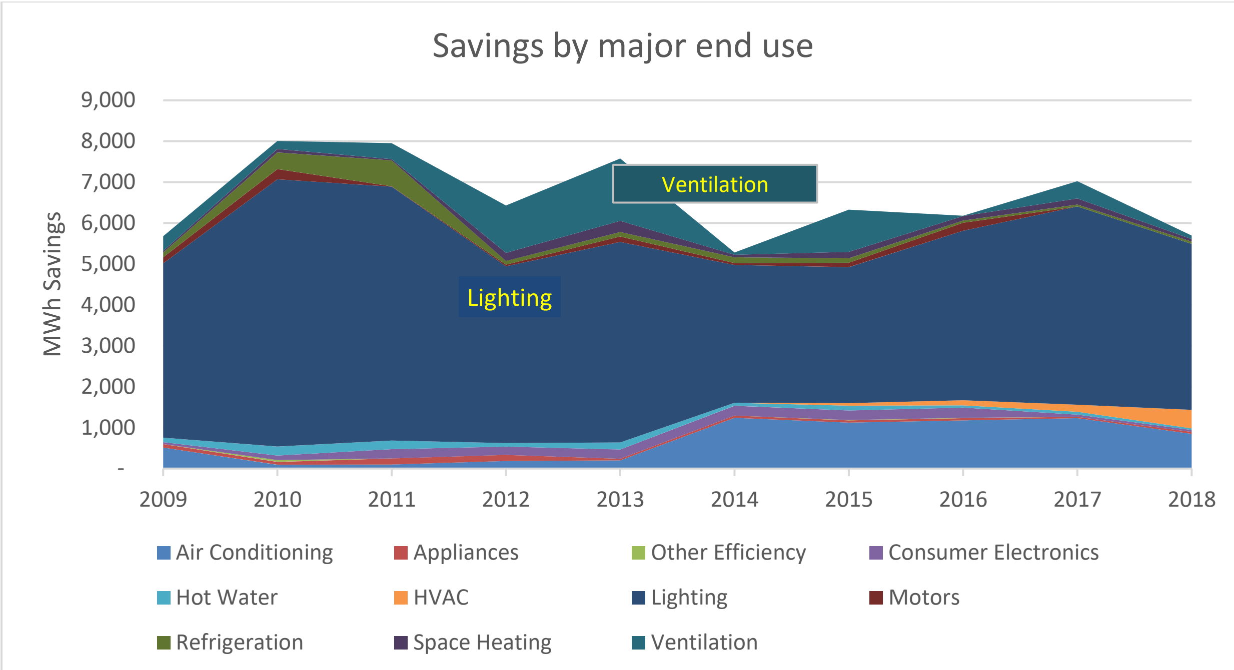
As shown in the above graph, annual incremental energy savings have been decreasing year over year. Meanwhile, the first-year cost of savings has been increasing. These trends are consistent with statewide trends and reflect BED's long history of providing energy efficiency services which has the effect of depleting the reservoir of additional cost-effective electric savings within City limits. Electric energy efficiency resource depletion is a function of cumulative measure adoption over time and market maturity, more stringent building codes and appliance standards and lower energy costs.

By taking a look at individual program results, it becomes clear that the vast majority of historical savings are primarily driven by the commercial sector.



As shown in the graph above, most of the savings have been associated with custom projects for lighting, refrigeration and heating, ventilation and air conditioning (HVAC) equipment within the facilities of our existing business customers. The efficient products program, which is primarily available to residential customers but also small businesses, has also successfully generated low cost electric savings over the past 10 years. Most of these program savings are attributable to retail store price buy-downs on efficient screw-based lamps and through the Smartlight program which provides incentives to lighting installers/contractors (who, in turn, primarily serve small to medium sized businesses) through midstream dealers. On a 10-year average basis, the business programs and the efficient products program have yielded cost effective savings that are less than the cost of avoided wholesale energy.

On the whole, lighting related savings, including controls, have generated most of BEDs savings over the last 10 years.

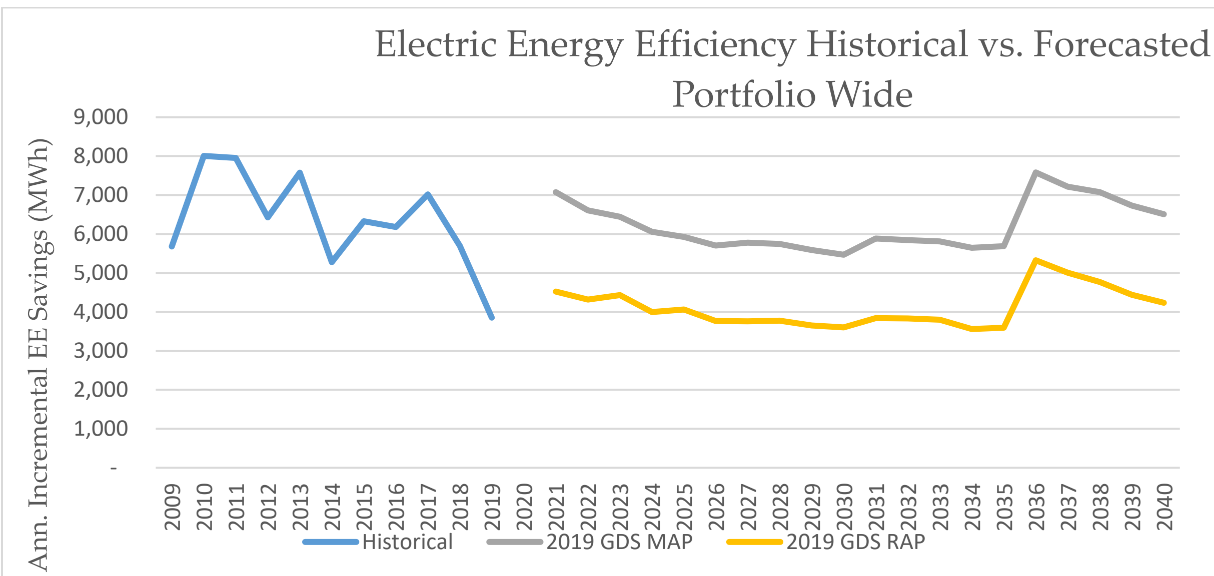


Energy Efficiency as a future resource

Because BED has accomplished the bulk of the available traditional electric efficiency work, it has become increasingly clear over the past two years that the remaining reservoir of cost-effective electric energy efficiency projects is decreasing. BED's long history of providing electric energy efficiency services has encouraged customers to adopt new and more efficient electrification technologies, particularly lighting technologies such as LEDs and, more recently, renewable heating technologies such as air-source heat pumps. So, it has been expected that higher rates of efficiency adoption would inevitably reduce the pool of cost-effective electric savings. Looking forward, some traditional electric savings will undoubtedly persist as new technologies are commercialized, new buildings are developed, and existing buildings are renovated. But questions about the relative size and cost of overall future MWh savings potential remain unanswered at this time.

Such uncertainty should not however dissuade stakeholders from continuing to invest in electric efficiency programs, especially if future investments are combined with beneficial electrification measures. With respect to existing electric efficiency potential, the results of a recent potential study conducted by the Department of Public Service's contractor – GDS Associates – ("GDS Study") indicate that future traditional electric efficiency savings continue to trend lower. Based on GDS' study, future traditional electric realistic potential savings could range between 3,700 MWhs and 4,700 MWhs annually over the next 10 years. Commercial sector savings are still expected to dominate future incremental savings well into the future with savings of approximating 3,300 MWhs to 3,900 MWhs annually – roughly 80-85%of total efficiency portfolio savings. Meanwhile, residential savings are estimated to amount to 600-725 MWhs annually. Because LEDs are becoming commonplace in so many locations, savings generated from BED's efficient products program ("EPP") are anticipated to decrease significantly. However, lighting fixtures, lighting controls and advanced appliances will continue to generate some future savings but not nearly at the level that screw-based LEDs and CFLs have in the recent past. As a result of the community's transition to LEDs, efficient product program savings are expected to be considerably lower in the future.

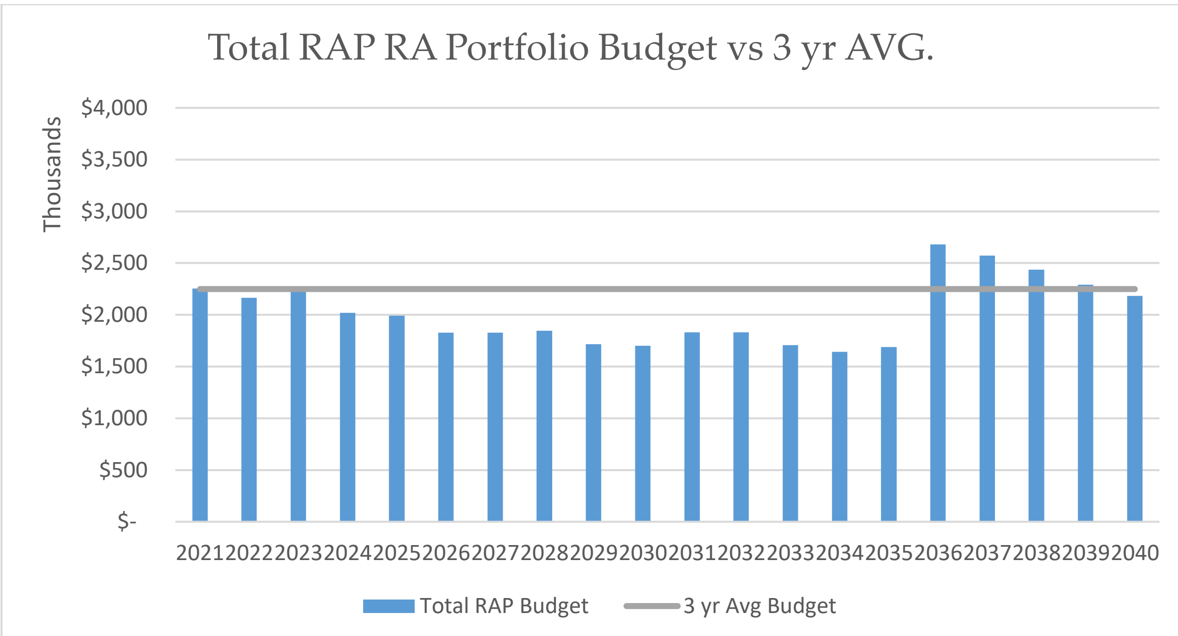
After taking into account the impact of a successful transition to LEDs , future traditional electric energy efficiency savings are expected to be 20 to 40%lower, on average, than a previous 2016 GDS electric efficiency potential study and 30 to 40%lower than average historical savings.



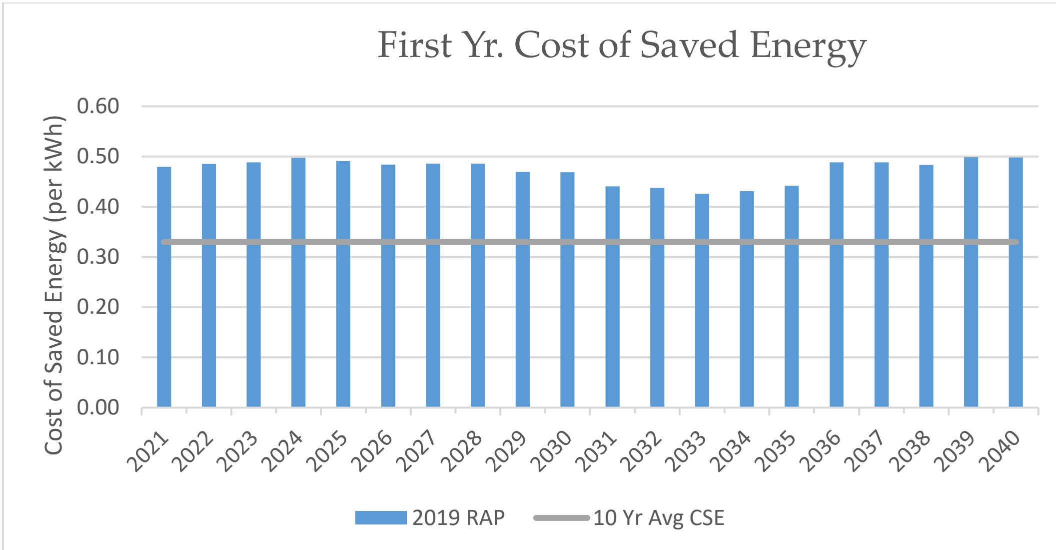
While lighting is expected to contribute less to future traditional energy savings, other types of electrification technologies will become more important. These include the following:

- Heat pumps, including air-to-water heat pumps;
- Thermal shell upgrades coupled with heat pump installations;
- Refrigeration;
- Ventilation and Circulation.
- Motors;
- Heat pump water heaters; and,
- Lighting controls.

Based on the 2019 GDS Study, BED also anticipates that future ratepayer investments in traditional electric efficiency programs will amount to approximately $2.4 million annually (including Development and Support Service (DSS) but not including TEPF) over the next three years, before trending downward in 2024 as new building codes and appliance standards take effect. Such future investments will essentially mirror BED's $2.4 million three-year annual average investment in electric energy efficiency, including DSS, as shown in the Realistic Achievable Potential (RAP) Resource Acquisition (RA) graph below.



With future electric savings decreasing over time and the budgets remaining flat, the cost of those savings is expected to increase. As noted, the 10-year weighted average first-year cost of saved energy is approximately $0.33 per kWh saved, or about $0.033 on a levelized basis. As discussed above, first-year cost of saved energy has been slowly increasing. The reasons for these steady cost increases are many. The primary reason however relates to the fact that acquiring electric savings beyond relatively easy lighting savings typically means that BED needs to motivate customers to buy more expensive equipment or replace existing equipment earlier than the end of its working lifetime. Doing so requires BED to provide greater incentives and additional technical assistance than in the past. BED anticipates that its customers will continue to seek out such additional technical assistance and higher incentives. As the graph below indicates, the GDS Study results confirm our expectations relative to the rise in the cost of first year electric energy savings.



Beneficial Electrification

As noted above, BED is actively assisting customers to achieve the community's aggressive NZE goals. An integral part of this effort includes BED's beneficial electrification programs ("Tier III"), which are designed to encourage customers, in accordance with Vermont's Renewable Energy Standard ("RES"), to replace fossil fueled technologies with new electrified technologies that result in lower greenhouse gas emissions. Both the RES and NZE goals have had a measurable impact on BED's decision-making and planning processes. Since 2017 – the first year of the RES – BED has been implementing a series of programs designed to beneficially electrify two key market sectors: Transportation and building space heating. Our objective for implementing these programs is to transform the local energy market away from fossil fuel consumption and toward efficient technologies powered from renewable resources.

To effectively serve these markets, BED provides customers with technical assistance and financial incentives for the following technologies:

- Electric buses;
- AEVs(new and preowned);
- PHEVs (new and preowned);
- Electric bicycles;
- Advanced residential heat pumps;
- Heat pump water heaters;
- Electric lawnmowers;
- Induction cook stoves;
- Commercial leaf blowers;
- Electric forklifts;

- Commercial variable refrigerant flow heat pumps; and,
- Ground source heat pumps.

Of the measures noted above, electric buses, AEVs and PHEVs and advanced heat pumps are expected to contribute the most to future increases in BED's load requirements and peak demand under the NZE scenario, as noted earlier.[3] However, it is important to reiterate that under a business as usual scenario, BED does not anticipate that adoption of the above-noted Tier III measures by customers will have a material impact – on balance – on BED's future generation and supply resources.

In order to fully assess the range of plausible outcomes that these major transformational technologies may impose upon our generation and supply resources, as well as our ability to effectively serve customers over the planning horizon, BED developed a "mini-model" evaluation tool. The main purposes for conducting the mini-model analyses were to:

- Re-confirm the fundamental economics of the major technology options, which inform our forecasts of customer adoption; and,
- Re-test the economic value of these technologies to BED and society at large.

Mini-Model Methodology

While each technology described below is unique, the outputs of mini-model share a common structure and methodology. Each section begins with a brief description of the technology and the key assumptions that were used in the model to perform two economic tests. The report then summarizes the utility cost test ("UCT") and societal cost test ("SCT") results for each technology. After the UCT and SCT sections, the report provides an assessment of the potential impacts of the technology on BEDs resource requirements and their Tier III implications, i.e. overall costs to BED, GHG emissions reductions and Tier III credits, where applicable. The results of the economic tests and potential Tier III impacts are then used to develop a recommended course of action.

Utility Cost Test

The utility economic cost test is intended to demonstrate whether a particular technology produces a net benefit to BED; either through reduced wholesale costs or increased revenues that exceed marginal costs. Reduced utility costs result from reduced power supply costs, inclusive of energy, capacity, transmission, and ancillary service expenses. Increased

[3] It is worth noting that VRF and gSHP technologies are currently offered on a custom basis. As such, BED will assess the potential impacts of these technologies as individual projects are presented to BED. While large scale VRFs and GSHP technologies may consume significant amounts of electricity, BED does not anticipate that more than two large VRF projects and one large gSHP project will be completed in the next three – five years. Accordingly, we expect that the impacts of these projects on reliability and the cost to serve customers will be *de minimus*.

utility revenues are generated from additional retail sales, additional wholesale energy sales, or increased renewable energy certificate ("REC") revenue.

Whether a measure produces net benefits for BED depends largely on four key variables that are expected to impose the greatest degree of risk on BED's net present value ("NPV") cost of service. The key variables are the wholesale cost of energy, capacity, and transmission and the forecasted values for renewable energy credits ("RECs").[4] The values for each applicable variable were then grouped together to create a base case scenario, which reflects the mostly likely outcome given our assessment of future wholesale energy, capacity, transmission, ancillary costs, as well as REC values.[5]

Societal cost tests

The societal cost test includes utility costs, as well as the costs that society bears such as illnesses caused by pollution, reduced productivity, and climate related damages. These costs are generally referred to as "externality" costs; or costs that have been attributed to the provision of a service or product that is borne by society at large but is not included in the price of the service or product provided. BED's application of the societal cost test measures the avoidance of such externality costs that are broadly shared by society, such as emissions and other environmental impacts. Externality costs can be avoided by reducing fossil fuel consumption or reducing electricity use generated from a non-renewable source. Reduced societal costs can be attributed to actions by either the customer or the utility. For the purposes of this test, BED adopted a $100/ton of carbon as an avoided externality cost, which has the effect of increasing the value of beneficial electrification and electric efficiency.

As mentioned, none of the beneficial electrification measures noted above are expected to have a material impact under the business as usual scenario on BED's generation and supply resources or on its overall cost of service. Some of the measures, E -bikes, e mowers and e-leaf blowers, for example, consume so little electricity that re-conducting the above noted economic tests for the purposes of this IRP would not have yielded materially different outputs from prior analyses and, as a result, those technologies have been omitted from this analysis as they would not have significantly changed BED's resource requirements. With respect to e- forklifts, induction stoves, variable refrigerant flow heat pumps (VRF) and ground source heat pumps (gSHPs), BED does not currently expect customers will adopt these technologies in significant

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[4] For additional discussion relative to these four variables, please refer to Chapter 6.

[5] In the 2016 IRP, BED grouped the four key variables together into four cases: base, low, high and weighted average cases. These cases assumed low, high and most likely (or base) wholesale costs. These costs were then weighed in order to develop a weighted average cost profile. In BED's assessment, wholesale costs are not currently expected to be materially different in the future than the costs that BED developed in the 2016 IRP. Therefore, this IRP includes only the base case costs used in the last IRP.

numbers any time soon. So even if each of these technologies consume relatively large amounts of electricity ,BED does not believe that the cumulative effect of their adoption will materially impact BED's resource plans. Therefore, this IRP also does not include the economic test results of these technologies since system and resource impacts, if any, will be negligible.

Historical results

When BED initially launched its Tier III programs in 2017, there were a limited set of technology offerings to manage. That changed over time as the State's technical advisory group ("TAG") approved new technologies and customer awareness about incentives for electrification technologies grew. As the table below demonstrates, the number of measures adopted by BED's customers has increased from 39 to 305 (omitting BED owned Electric Vehicle Service Equipment "EVSE") as the number of offerings increased.

Count	2017	2018	2019
AEV	33	12	30
PHEV	5	14	19
PreOwned AEV			1
PreOwned PHEV			4
Home EVSE charger			13
Custom			1
E Bike		61	64
Resi Elec Mower			142
HPWH			4
Public EVSE	7	7	8
Workplace EVSE			1
MultiZone ccHP			4
SingleZone ccHP	1	1	22
Totals	**46**	**95**	**313**

It is also worth noting that of the 305 technologies incentivized in 2019, 279 measures were adopted by unique customers. Along with these increases in adoption, BED's program investments have also grown substantially from $44,000 to $128,000, excluding administrative expenses.

Incentives	2017	2018	2019
Production			
AEV	$ 40,200	$ 14,400	$ 38,400
PHEV	$ 3,000	$ 8,400	$ 21,000
PreOwned AEV			$ 800
PreOwned PHEV			$ 3,900
Home EVSE charger			$ 5,200
Custom			$ 1,000
E Bike		$ 15,250	$ 16,000
Resi Elec Mower			$ 17,600
HPWH			$ 2,400
Public EVSE			$ -
Workplace EVSE			$ 1,000
MultiZone ccHP			$ 3,450
SingleZone ccHP	$ 600	$ 375	$ 16,250
SingleZone ccHP Add'l Rebate			$ 1,200
Totals	**$ 43,800**	**$ 38,425**	**$ 128,200**

To date, the total impact of these new technologies on total load requirements and system reliability has been minimal. So, too, has been the rate impact from providing incentives and technical assistance after net marginal revenues are taken into account, especially since EV customers are strongly encouraged to use electricity during off peak demand periods when wholesale energy, capacity and transmission costs are lower than usual.

Although the load impacts thus far have been minimal, adoption of these measures is helping the City and the State make progress toward their respective clean energy goals. So, it is important to continue supporting these Tier III programs for the foreseeable future. As shown in the table below, estimated lifetime GHG emissions reductions amounted to 1,965 tons in 2017. By 2019, cumulative lifetime emissions reductions have grown to 5,732 tons as new measures were adopted and the older vintage Tier III measures continued to operate in the City and elsewhere.

Cumulative GHG emission reductions	2017	2018	2019
AEV	1,190.4	1,623.3	2,741.6
PHEV	101.0	383.8	848.5
Public EVSE	634.4	634.4	725.0
WorkPlace EVSE			41.1
Ebikes		234.8	246.3
HPWH			23.4
ccHP	39.5	79.0	1,105.7
Cum. Totals	**1,965**	**2,955**	**5,732**

With respect to resource requirements, BED estimates that past technology adoption has increased MWh sales from 145 MWhs to 430 MWhs on a cumulative basis. After considering line losses and reliability, these new electricity sales increased BED's load requirement from approximately 175 MWhs to 516 MWhs over the same time period. Meanwhile, electric efficiency investments have been reducing electric consumption by 7,022 MWhs, 5,696 MWhs and 3,854 MWhs in 2017, 2018 and 2019, respectively.

MWh sales	2017	2018	2019
AEV/PHEV	85.5	143.9	265.4
Public EVSE	56.0	56.0	64.0
Workplace EVSE	-	-	3.6
ccHP	3.3	6.5	91.4
HPWH	-	-	5.3
Total	**144.7**	**206.5**	**429.7**

On top of the energy efficiency impacts, 141 new net metered and group net metered systems, representing approximately 1,995 MWs_{AC} of capacity, were added to BED's system over the past several years. Therefore, electric efficiency investments and net metering have substantially offset the growth in electricity sales attributable to BED's past beneficial electrification programs. Thus, BED anticipates that if electric efficiency and net metering continue to be supported at the same level that they are today, the potential impacts of future beneficial electrification programs on BED's resource requirements are likely to remain static under the business as usual scenario.

The future of beneficial electrification programs

Successfully transforming the transportation and building space heating markets will likely take another 10 to 20 years to accomplish. Accomplishing this goal will, however, require significant additional State and City support to increase public awareness about how existing and future Tier III technologies can supplant fossil fuel driven technologies without inconveniencing customers. BED cannot achieve this extraordinary feat alone. It will need to work collaboratively with many other stakeholders, including State government, City officials, Vermont's distribution utilities and technology providers. Of course, BED will do its part in this statewide effort. Indeed, BED is committed to continue investing in beneficial electrification programs up to the allowable amounts under existing statutes. BED also intends to continue offering comprehensive electric efficiency services to offset the increased loads caused by beneficial electrification adoption so long as the Commission continues to approve efficiency budgets that enable us to acquire all cost-effective electric savings.

In line with our commitment to transform markets, BED fully expects to continue offering beneficial electrification incentives and technical assistance to customers who adopt the following technologies:

	Tier III Projects	No. of Units	Total Budget	2020 Est. yearly MWh Sales	Est. lifetime GHG emissions reductions
Transportation	Electric Buses	2	$150,650	106	1,873
	AEVs & PHEVs (new&preOwned)	200	$290,000	450	3,752
	BED owned EV Chargers	8	$0	64	725
	Workplace EV Chargers	5	$5,800	18	206
	E Bikes	100	$32,000	-	-
Bldgs	ccHP	83	$84,000	271	3,277
	HPWH	50	$34,500	66	293
Other	Electric Forklifts	1	$6,600	-	-
	Electric Commercial Lawnmowers	1	$4,000	-	-
	Electric Residential Lawnmowers	100	$11,500	-	-
	Commercial Leafblowers	5	$1,150	-	-
	Induction Cookstoves	100	$17,250	-	-
Semi Custom	Commercial VRFs	2	$230,000	6	-
	GSHP	1	$115,000	-	-
Totals		**658**	**$982,450**	**981**	**10,125**

As the table above indicates, if BED can successfully implement all of the Tier III measures above in 2020 (and beyond), expenses will increase by about $983,000, inclusive of administrative expenses. Also, electric sales associated with these measures will likely increase by 981 MWhs annually and lifetime GHG emissions will be lowered by over 10,000 tons. In the sections that follow, we provide an overview of the major technologies that are most likely to be adopted by customers in the greatest numbers over the next several years and will therefore have the greatest impact on future resource decisions.[6]

Electric Buses

In terms of their size, length and seating capacity, electric buses are similar in nearly all respects to their diesel-powered counterparts. They, too, are required to pass the so-called Altoona test before the federal government will award a grant to a public transit authority that seeks to purchase one. This rigorous and multifaceted test evaluates the same metrics for both an electric bus and a diesel-powered transit bus. In general, the federal Altoona test assesses the reliability, safety, maintainability, structure integrity, noise, performance (i.e. acceleration, top speed and braking), and fuel economy of all buses. The results of the test conclude that electric buses are much cleaner and quieter to operate. Moreover, fuel and maintenance costs are reported to be substantially less than their diesel-powered counterparts. Indeed, the fuel economy of a 40-foot Proterra electric bus ranges between 17 MPGe to 27 MPGe, whereas a typical diesel bus ranges between 4.00 MPG and 5.00 MPG.[7]

Because electric buses are a new technology, their initial cost can be nearly twice that of diesel buses. Hence, the purpose of BED's electric bus program is to provide as much financial assistance as possible to reduce the high incremental cost of electric buses. BED has designed its semi-custom e-bus program to achieve two fundamental goals: (1) reduce fossil fuel consumption in the City and the GHG emissions associated with such consumption; and, (2) provide Green Mountain Transit ("GMT") the support necessary to acquire additional electric buses.[8] This support comes in the form of a performance-based incentive structure, as further described in BED's 2020 Tier III plan. Importantly, BED's financial incentive is considered by the Federal Transit Authority to be equivalent to local matching funds that are necessary to secure federal grants. Without BED's incentive, GMT would have to seek out additional local funding sources from either the State, the City or other towns in Chittenden County.

As noted in BED's previous IRP, as well as in our Tier III plans, cities and transit operators in recent years have been motivated to procure electric buses to reduce emissions and other smog-inducing particulates. For many communities, transitioning from diesel to electric buses is oftentimes a part of a city's overall sustainability efforts. City residents and commuters

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[6] For more information about the remaining Tier III measures, please refer to the BED's Tier III plan filed with the PUC on 11/1/2019.

[7] See Altoona test report No. LTI-BT-R1406, Penn State Transportation Institute, pg. 134

[8] In February 2020, two battery-electric Proterra buses were delivered to GMT. The buses went into daily operation during the first week of March 2020. Pursuant to its Tier III plan, BED provided GMT a $131,000 performance-based incentive. BED funds, along with a VLITE grant, were combined with other State and Federal grants to purchase the buses.

across the country have also expressed a preference to reduce fossil fuel dependency, as evidenced in increased use of public transportation, carpooling, car-sharing and multi-model transportation. In 2015, approximately 17% of all transit buses were hybrid-electric (i.e. compressed natural gas CNG fueled with electric auxiliary systems) or all-electric or biodiesel worldwide. By 2026, the market share of all electric and hybrid public transit buses is expected to continue increasing at a faster pace to approximately 5-6%compound annual growth rate (CAGR) – about 291,000 units, as battery technology improves, and costs decrease.[9]

Several cities have been operating electric buses for a few years now. They include Dallas, Texas (seven electric buses scheduled for service in early 2017), Indianapolis, Indiana (21 electric buses currently in operation), Seattle, Washington, and Worcester, Massachusetts. Since first reporting about electric buses in our 2016 IRP, several more cities have acquired electric buses and incorporated them into their fleet. Additional cities and regions that have purchased Proterra buses include Pioneer Valley Transit Authority in Holyoke, Massachusetts, Breckenridge, Colorado., University of Montana, Chicago Transit Authority and many others.[10]

Key assumptions

To model the cost-effectiveness of electric buses, BED made several assumptions about their operating characteristics. The variables that have a disproportionate impact on modelling results include the incremental cost of the electric bus, long-term diesel prices (which affect fuel savings), and maintenance savings.

Major Assumptions - Electric Bus (lifetime)			
Customer	Est. Incremental Costs	$	450,000
	Maintenance Savings		$55,081
	Fuel Savings		$106,064
	Measure Life (yrs)		12
BED	Increased MWh sales		52.8
	Net Revenue		$59,000
	Tier III Costs	$	75,325
	Credits		1258
	Net Tier III MWH e Cost	$	35.54
BTV	GHG Emissions reductions		936

As indicated above, the incremental cost of the electric bus was approximately $450,000 greater than a conventional diesel-powered bus. The cost is considerably higher than reported

[9] Fortune Business Insight, *Electric Bus Market Size, Share & Industry analysis, 2019 – 2026. Jan.2020. See:* https://www.fortunebusinessinsights.com/electric-bus-market-102021

[10] For additional information, see; https://www.proterra.com/company/our-customers/

by BED in its 2016 IRP. The reason for this cost increase is related to GMT's decision to purchase a full 12-year battery warranty, rather than risk having to replace the battery in six to eight years. In previous years, BED assumed that the incremental cost of an electric bus without an extended battery warranty approximated $450,000. Despite the higher costs, the accumulated lifetime operating savings (i.e. fuel and maintenance savings) of an electric bus will likely provide for increased cash flow to GMT over time, especially after factoring for grants and incentives. Maintenance expenses are also expected to be $0.19 per mile driven which is lower than maintaining a diesel bus, thus saving GMT $55,081 over the 12-year lifetime of the electric bus.[11] Also, lifetime fuel savings of $106,064 represent the difference between BED's electric time-of-use rate ($0.10/kWh) and the lifetime costs of diesel fuel for a bus that achieves no less than 4.25 MPGs.[12]

For BED, each electric bus travelling 30,000 miles annually will consume about 52.8 MWhs. Presently, GMT has programmed each bus to charge under BED's existing TOU tariff. Such TOU rates will cost GMT $0.10/kWh. However, GMT's contribution toward BED's fixed costs are not anticipated to be much greater than $0.06/kWh, since wholesale energy costs approximate between $0.03 and $0.04/kWh for off-peak power. As such, GMT's cumulative contributions to our net fixed costs are likely to range from $30,000 to $40,000 on a net present value basis over 12 years. Concerning Tier III costs, BED will continue offering generous incentives and support toward the cost of new electric buses, although it is quite possible that future incentives could be less than the current incentive of $65,500 per electric bus driven 30,000 miles annually. For purposes of this analysis, however, it is assumed that the current incentive structure will remain in place for the next several years. Accordingly, BED is assuming a total cost per bus of $75,000, including administrative expenses. After considering net revenues, the cost of Tier III credits is not expected to amount to more than $35 per MWhe.

Utility Cost Test

Under the utility cost test, promoting electric buses is anticipated to result in positive net benefits to all ratepayers in the amount of nearly $40,000 per electric bus over each bus' 12-year lifespan. Benefits flow from increase electric sales of $50,000 to $59,000. Costs increases include energy ($17,000), RECs ($1,000) and ancillary ($1,300). As noted above, GMT has programmed its e buses to charge at nighttime when capacity costs are negligible. Accordingly, the model excludes additional capacity and Regional Network Service Transmission ("RNS") costs associated with electric buses.

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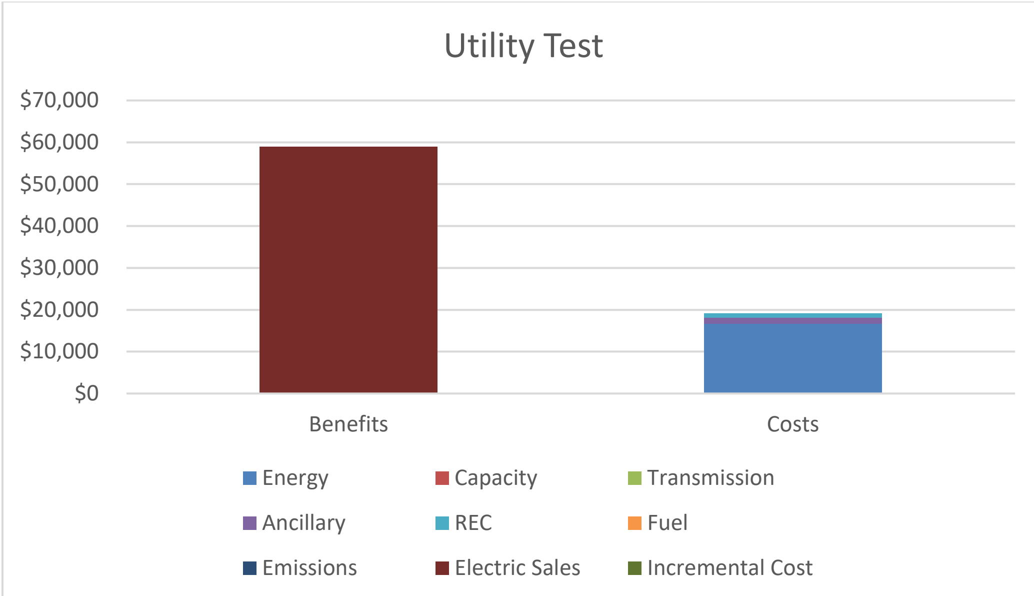
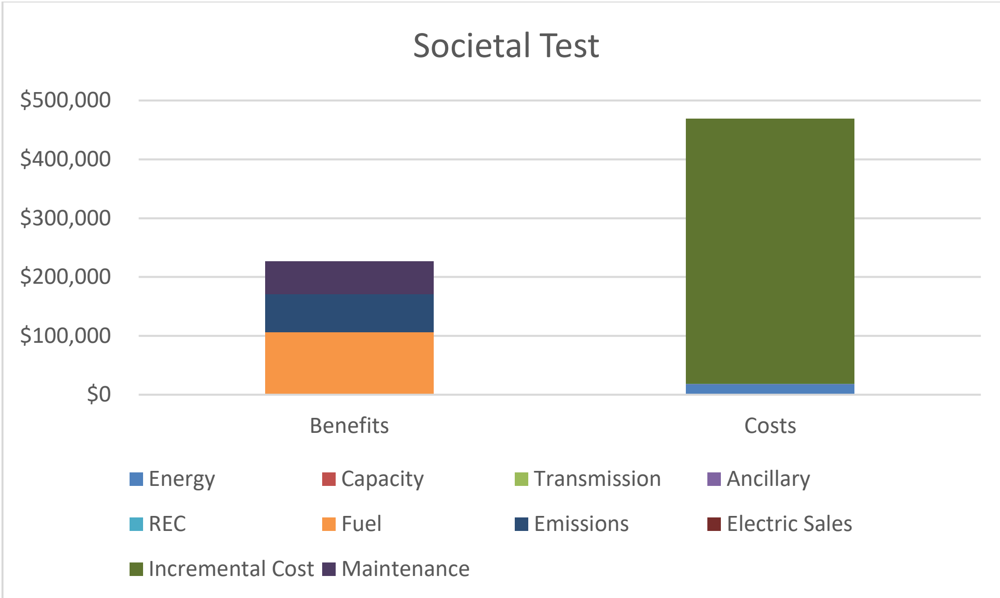
[11] Net present value discounted at 3.5%

[12] Diesel cost were assumed to cost $2.20/gallon and increase by the rate of inflation annually (2.0%).



Societal Cost Test

From a societal cost perspective, an electric bus generates a net present value loss of $242,000 over 12 years. The loss is due to the higher than expected incremental cost ($450,000) of the bus relative to a diesel bus. As noted above, GMT's purchase of e-electric buses is largely funded through federal grants. These grants cover 80% of the capital cost of each electric bus. Were this analysis to include only the costs paid by Vermont's organizations, then Vermont-specific net societal benefits could amount to as much as $117,000 over the 12-year lifespan of an electric bus (these Vermont specific benefits are not shown in the graph below). Additionally, while net societal costs appear to exceed societal benefits based on the specifics of GMT's most recent transaction, BED does not believe this transaction will be indicative of future transactions. In the future we anticipate other factors will help to improve societal benefits over time. First, battery prices, which is the largest component cost of the electric buses, have been trending lower as electric bus manufacturing increases and the technology improves. Second, alternative financing options are just now being explored by regional transit agencies and other stakeholders. Third parties, for example, are beginning to enter the market and offer transit agencies financing terms, such as battery leases, in order to increase the cost competitiveness of e-buses relative to diesel buses. BED is confident that as this financing niche market develops over time, societal benefits will only improve.



Net benefit variables that have been included in the above graphic are diesel fuel savings ($106,000), maintenance expense reductions ($55,000) and emissions reductions ($65,000). In addition to the incremental cost of the electric bus, other net benefit costs include: Energy ($17,000), RECs ($1,000), and ancillary costs ($1,300).

Recommended course of action.

Given GMT's recent success in accessing federal grant funds to purchase electric buses, as well as the level of State and local enthusiasm around electrifying the public transit fleet, BED recommends that it continue to support GMT and its purchase of additional electric buses in the future. Accordingly, BED will continue to offer incentives and technical support. Going forward, BED will also continue to explore options to reduce the upfront capital cost of electric buses. As part of this effort, BED may consider partnering with additional parties to lease the battery – which is the primary cost driver – or to even help GMT through an on-bill financing program.

EVs

Since BED's 2016 IRP, EV technology has rapidly evolved along with BED's customer interest in its AEV and PHEVs programs. Just a few years ago, the number of AEVs and PHEVs offered for sale were limited, their range of travel was relatively short and EVs were cost prohibitive for most Vermonters relative to traditional vehicles. Today, Drive Electric Vermont lists 16 AEVs and 19 PHEVs, prices vary from $30,000 to $85,000 and, the range of travel has increased from less than 100 miles per charge to over 230 miles. These improvements, along with competitive pricing and federal, State and utility incentives are gradually accelerating customer adoption of EV technology in place of traditional fossil fuel powered internal combustion engine ("ICE") vehicles .

While new AEV and PHEV sales are still a fraction of statewide auto sales annually, the future of electrifying Vermonter's vehicles remains bright. Many automotive and electric utility analysts anticipate that as manufacturers continue to incrementally improve battery technology and electric utilities work to make EV charging more ubiquitous, AEV and PHEV sales should increase over time. Such increases in sales will be slow at first but may eventually climb at a faster rate of growth in the latter half of the decade. In VTRANs opinion, new AEV and PHEV sales are expected to reach 15%of annual new vehicle sales by 2025.[13] BED is hopeful that these predictions will come to fruition.

Under its BAU scenario, BED anticipates that the transformation of Vermont's vehicle market will follow national and international trends as more products are introduced. Auto market trends indicate that over the next several years, an increasing number of manufacturers plan to expand their product offerings and increase investments in electrification technologies. According to Electric Power Research Institute (EPRI), Ford plans to spend $11 billion on new EV technology and introduce 40 new (or refurbished) EVs (16 AEVs and 24 PHEVs). General Motors announced 20 new or re-designed AEVs and fuel cell powered vehicles globally by 2023. With a $40,000 manufacturer's suggested retail price ("MSRP"), GMs Chevy Bolt is already a best seller in the U.S. and in Vermont. Hyundai plans to bring 38 new models to the U.S. market by 2025. And, finally, VW announced, in 2018, a $50 billion investment worldwide in AEVs, self-driving cars and other types of electric transportation technologies by 2023. VW expects to build up its AEV manufacturing capacity to almost 15 million vehicles annually by 2025. This increased capacity allows for VW to expand its product line internationally, which is already extensive, to include up to 50 AEV models and 30 PHEV models within the decade.[14]

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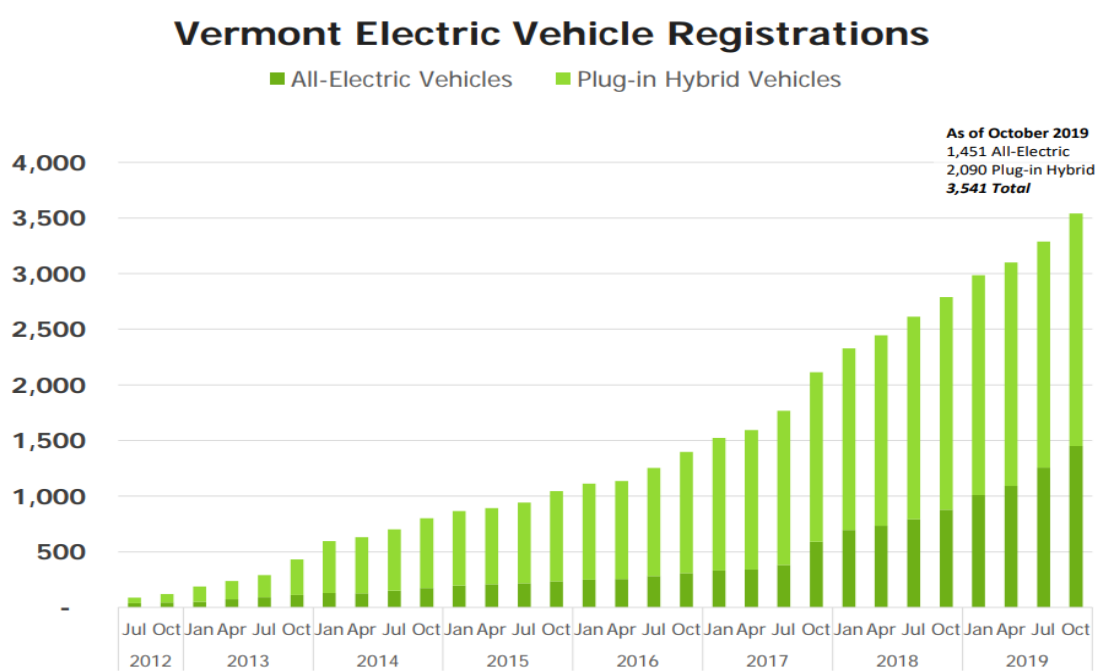
[13] *See:* Vermont Agency of Transportation, *Section 15. 2016 Plug-in hybrid and electric vehicle registration fees*, Legislative report, December 2016.

[14] EPRI, *Consumer Guide to Electric Vehicles,* March 2019.

In Vermont, AEV and PHEV sales have been rising at a steady pace each year since 2012. But in 2017, when the RES took effect, sales growth started to increase at a faster rate.[15] Some of the acceleration in EV adoption was associated with Nissan's temporary $10,000 rebate for older Leaf models in 2017. Other reasons include:

- Increased public education and outreach;
- New products flowing into the State;
- Technology upgrades (i.e. greater range);
- Incentives (federal, state and utility); and,
- Expansion of public and private charging infrastructure.

As the graphic below indicates, the number of registered EVs in Vermont has steadily increased from less than 500 in late 2013 to over 3,500 in late 2019.

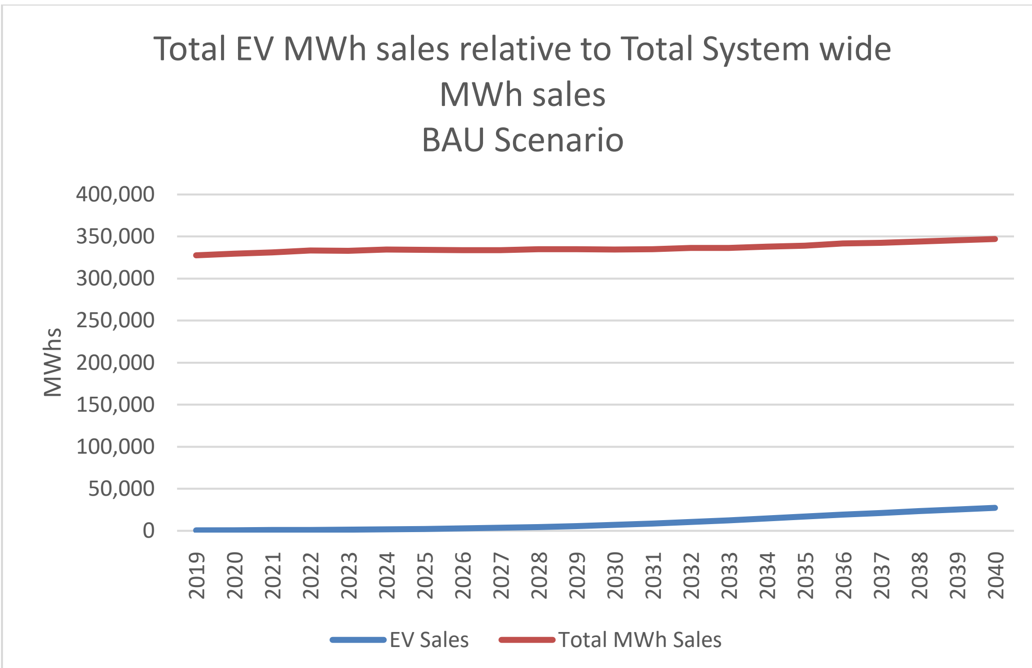


BED intends to continue supporting City- and statewide efforts to shift the automotive market away from traditional, fossil fuel powered vehicles to electrically powered vehicles. Although BED's ability to transform the market is limited, it will continue to work with other stakeholders to encourage adoption of EVs at a faster rate than today. For the next several years, BED will continue to offer incentives for new EVs ($1200+/vehicle) and preowned EVs ($800). BED will also continue to offer financial and technical assistance to customers – both residential and commercial – seeking to install level 2 or 3 electric charging systems. And, BED will

[15] *Courtesy of Drive Electric Vermont, Feb. 2020.*

continue to help raise public awareness about the benefits of going electric through social media, Drive Electric events, and dealership education and outreach.

As noted above, the initial rate of EV adoption under the business as usual scenario is likely to be relatively slow. As the graph below indicates, EV-related MWh sales are expected to increase from approximately 0.21%in 2020 to 2.07%in 2030. Cumulatively, the number of EVs will likely amount to about 2900 vehicles by 2030 across the City, representing approximately 11%of registered vehicles in Burlington. The total load caused by this many EVs is expected to reach about 7,981 MWhs in 2030, and 31,000 by YE2040.[16]



Although some circuits may be affected by increased Burlingtonian EV adoption when several homeowners in the same neighborhood charge their vehicles at the same time, BED does not expect that a BAU transformation of the automotive market will materially impact our resource plans over the next 20-year time horizon. Under the NZE scenario, however, EV market penetration, along with rapid adoption of heat pump technologies, may have a more consequential system impact. For more information about this scenario, please refer to the NZE chapter.

Key assumptions

[16] EV MWh Sales of 6,940 in 2030 times 1.15 reliability and line loss factor; EV MWh sales of 27,317 times 1.15 reliability and line loss factor.

As with other beneficial technologies, the potential impact of EV adoption in Burlington is measured, in part, by our assessment of the benefits and costs of EV ownership for customers, BED and societally. The more cost-effective EVs become over time, the more EVs that will be purchased by Burlingtonians. However, the rate of adoption will be tempered by slow vehicle turnover since most vehicles remain in service for 10-15 years. Thus, replacing traditional ICE vehicles with EVs will be a slow process.

To model the cost effectiveness of AEVs, BED incorporated the following major inputs into its testing procedures.

Major Assumptions - All Electric Vehicle, new & preowned (lifetime)		
Customer	Est. Incremental Costs	$7,000
	Maintenance Savings	$2,122
	Fuel Savings	$7,988
	Measure Life (yrs)	12
BED	Increased MWh sales/year	3.01
	Net Revenue	$584
	Ann. Miles Driven	9,500
	Tier III Costs	$1,380
	Credits	37.69
	Net Tier III MWH e Cost	$21.12
BTV	GHG Emissions reductions	36

For BED, each AEV travelling between 8,000 and 10,000 miles annually will consume about 3.01 MWhs. BED assumes that nearly all AEV owners will elect to subscribe to BED's EV rate credit program, providing such customers with a significant retail electric discount of $0.06 per kWh. Pursuant to BED's approved EV rate tariff, customers enrolled in this program agree to charge their vehicles after 10:00 pm and before 12:00 pm . In return for adhering to this tariff condition, BED customers will be able to charge their vehicles for $0.08/kWh. Under this scenario, BED expects to generate net income of just $0.02/kWh, which will provide a modest contribution to fixed costs. At this lower contribution rate, BED therefore anticipates generating between $60 and $70 annually from each AEV, or about $584 on a net present value basis over the 12-year life of a vehicle (assuming the rate credit program remains effective during this period).

For PHEV's many of the same assumptions are applied to determine their cost effectiveness, as shown in the table below.

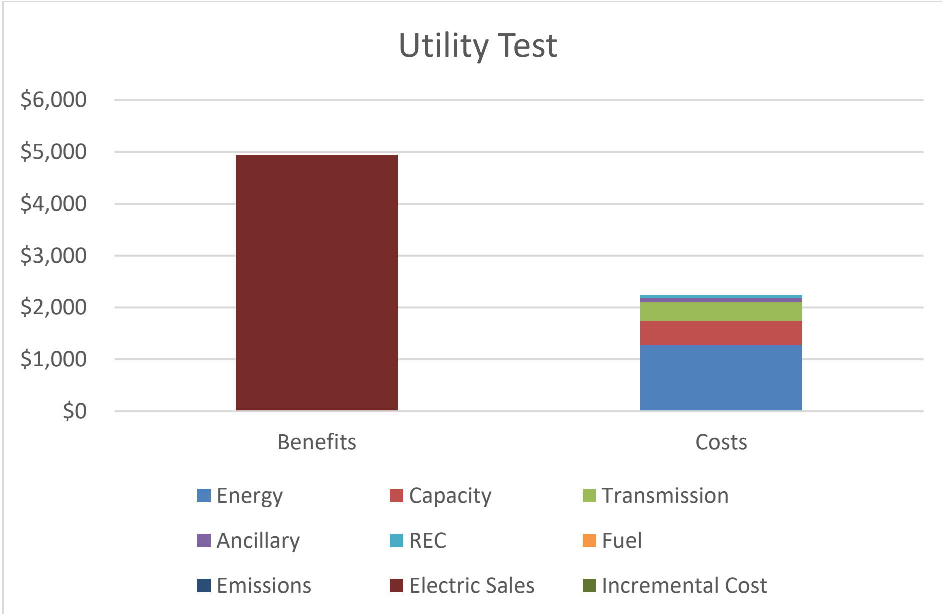
Major Assumptions - Plug In Elec Vehicle (lifetime)		
Customer	Est. Incremental Costs	$4,200
	Maintenance Savings	$1,034
	Fuel Savings	$3,928
	Measure Life (yrs)	12
BED	Increased MWh sales/year	1.596
	Net Revenue	$308
	Ann. Miles Driven	9,500
	Tier III Costs	$1,380
	Credits	28.20
	Net Tier III MWH e Cost	$38
BTV	GHG Emissions reductions	19

Customer Impacts:

As the tables above indicate, new EV owners could easily lower their transportation costs by switching to electrically powered vehicles. AEV owners would experience a simple payback on their incremental investment ($7,000, net of federal income tax credits and utilities rebates) of less than a year in fuel savings alone, especially if they charged in accordance with BED's residential credit tariff. Assuming each AEV owner drives 9,500 miles annually, their gasoline costs of nearly $10,000 (in 2020 dollars) would be completely avoided but their electric costs would increase by approximately $2,300. And, since AEVs require far less maintenance, owners should also experience significant maintenance related savings over time. PHEV owners will also benefit from these savings at a smaller scale.

Utility Cost Test

Increases in the number of EVs charging in Burlington has the potential to generate modest net utility benefits for all customers, even those who do not own an EV. This is so because EVs are load builders and generate incremental MWh sales in excess of the cost to serve them. For customers that take service under BED's existing EV rate, the net benefits are even greater. Under a BAU scenario in which an EV is uncontrolled, utility net benefits are anticipated to amount to approximately $2,700 per AEV (slightly less for PHEVs). If 80%of AEV owners take service under BEDs EV rate, net benefits could increase to approximately $3,500 per vehicle. Utility benefits amount to roughly $4,900 in retail revenues (in 2020 dollars), while costs include energy ($1,300), capacity ($475), transmission ($361), ancillary ($76) and RECs ($60).



Societal Cost test

Under the net societal cost test, overall costs could amount to more than $1,600 per AEV, resulting in negative net societal benefits. Societal costs exceed benefits due to the high incremental costs of AEVs ($15,700) relative to traditional ICE vehicles.[17] Unlike the customer and utility cost tests, incentives such as the federal income tax credit and utility rebates are considered transfer payments from one group of customers to another. Thus, incentive payments are not factored into the analysis and the full incremental cost of an AEV must be included in the analysis since someone is paying for the higher cost of an AEV (i.e. society at large is through higher taxes and/or utility rates). However, the incremental cost of an AEV is highly speculative and subjective. It depends on the baseline vehicle (i.e. ICE vehicle) that is used for comparison, the trade-in value of an existing vehicle and the type of AEV that the owner is considering for purchase. For purposes of this analysis, the $15,700 incremental value assumes an MSRP of $40,000 for an AEV and a MSRP of $24,300 for a traditional ICE vehicle. In BED's view, prospective? AEV owners would likely be comparing the cost of an AEV to a $30,000 to $35,000 ICE vehicle. If this were the case, then societal benefits would be slightly positive per AEV.

Additionally, the full cost of AEVs is widely expected to decrease over the next few years as the above-mentioned manufacturers introduce new products to the market and battery costs fall.[18] Other societal benefits include gasoline savings ($10,500), avoided CO2 emissions

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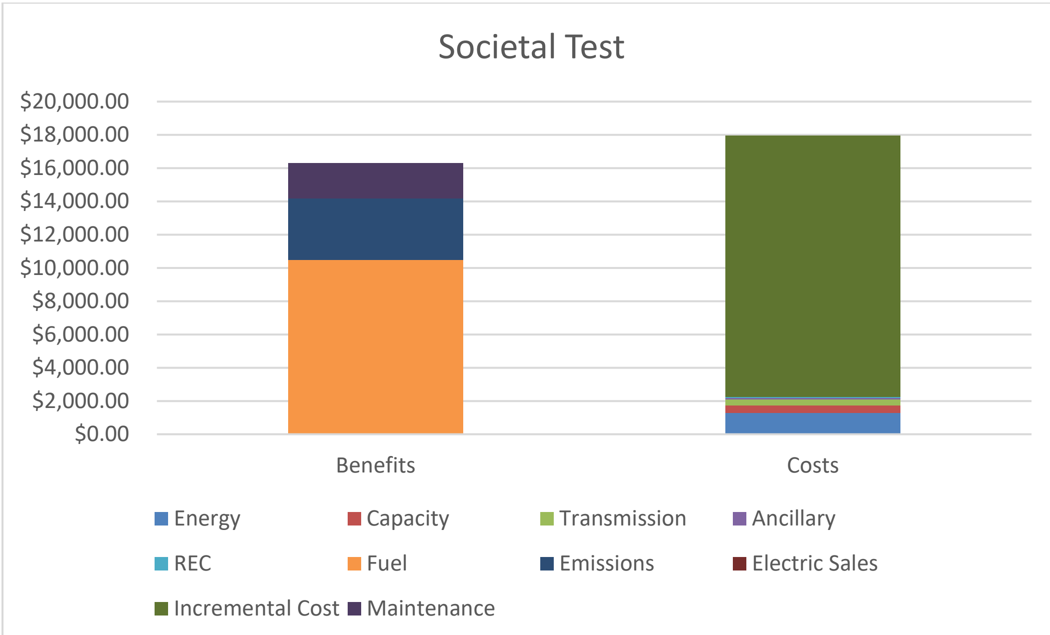
[17] *See;* 2019 Tier III TAG annual report.
[18] For additional information, *See:* https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf

($3,686) and vehicle maintenance savings ($2,100). Other incremental costs include energy purchases to serve the AEV load ($1,300), capacity ($475), transmission ($361), ancillary ($76) and RECs ($60).



Recommended course of action

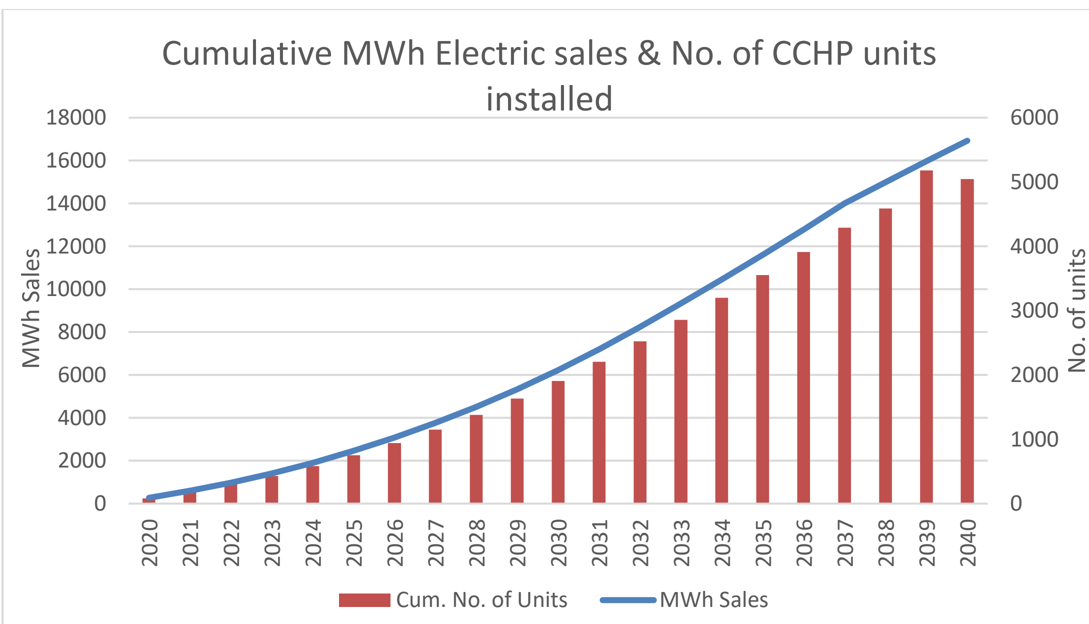
As noted above, BED shall continue to vigorously support local and State efforts to expand the light duty EV market. Primarily, these activities include providing financial incentives to customers, raising customer awareness, engaging auto dealers and public outreach.

Heat Pumps

As noted in its 2020 Tier III plan, BED will continue to support the installation of heat pump technologies in homes and businesses. Such technologies include but are not limited to cold climate heat pumps ("CCHPs") and heat pump water heaters ("HPWH") for residential customers, and variable refrigerant flow pumps, efficient air-to-water heat pumps and even, potentially ground source heat pumps for commercial and residential customers. For purposes of the IRP, BED has modelled the impacts of ccHPs and HPWHs, as these technologies are likely to be adopted by customers in greater numbers and may impose a larger impact on BED's resources than the other beneficial electrification technologies.

BEDs existing CCHP and HPWH programs will primarily target new construction and major rehabilitation projects, as well as "green" customers seeking to dramatically reduce their carbon footprint and disconnect from the natural gas pipeline. Targeting these segments of Burlington's building space conditioning market provides for greater opportunities to offer meaningful financial assistance to customers, as CCHP and HPWHs can be a lower first cost solution compared to installing a traditional fossil fuel boiler and hydronic distribution system. For example, the cost of installing a CCHP is approximately $4,500 compared to $5,500 to $7,000 for a natural gas fired boiler. BED is not aggressively seeking to persuade natural gas customers to augment their existing heat system by installing a CCHP because natural gas customers who install a CCHP will most likely experience higher home heating bills as natural gas heating costs are lower than electric heating costs. BED will instead provide potential retrofit customers, if asked, information about whether a CCHP is the right solution for them given their circumstances and carbon goals. BED will also suggest that customers weatherize their building before installing a CCHP.

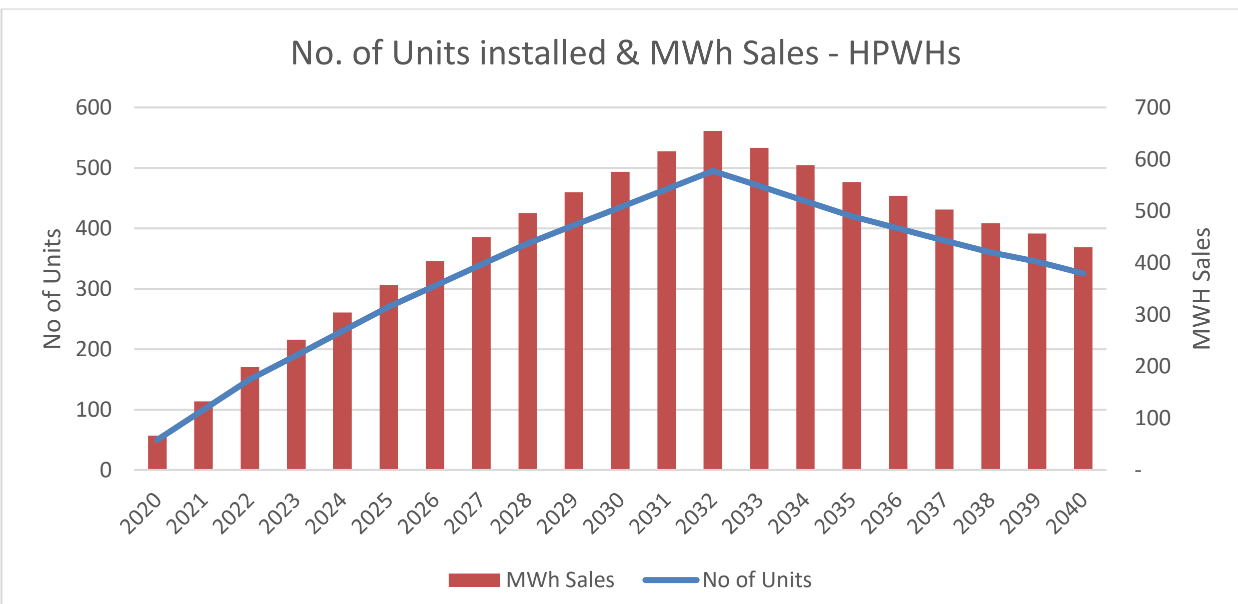
Due to the cost challenges that CCHP and HPWH face related to the low price of natural gas relative to electricity, BED believes that the number of forecasted CCHPs and HPWHs that could be installed in the City will be substantially less than the forecasts of other distribution utilities in Vermont. As shown in the graph below, BED expects as many as 80 to 90 CCHPs to be installed throughout the City in each of the next several years before tapering off in later years. Cumulatively, the number of installed CCHPs throughout the City may exceed 5,000 units by the end of 2040. As CCHPs are installed, MWh sales will of course increase; reaching roughly 17,000 MWhs by the end of2040.



When customers install CCHPs, BED is committed to actively promoting the installation of active controls so that customers are able to effectively monitor the British thermal unit (BTU) output of their heat pump based on internal building conditions and outdoor air temperatures. Such controls, in theory, allow for alternative heating systems (such as electric resistance for newly constructed buildings, or existing natural gas fired boilers in homes) to be used as the primary heat source heat during exceptional cold periods when the newly installed heat pump's output and efficiency are severely compromised. Such controls may also provide BED with the capacity to shift demand from exceptionally high cost periods to lower cost periods to reduce capacity and RNS costs. It is important to note that BED's active control of heat pumps will almost always occur during the summer months to shift cooling related electric loads, as opposed to shifting loads during winter periods when heating needs are critical. Moreover, when customers call BED energy services staff for technical advice, customers will be encouraged to also increase the weatherization of their building as a means to improve comfort and heat pump performance.

It bears noting that customers can also access CCHP incentives through the statewide upstream program administered by Efficiency Vermont and BED. When they do, third party contractors typically install the CCHP equipment and pass along the incentives to the customer. Such incentives are paid to CCHP distributors out of BED's electric energy efficiency budget and passed along to customers.

As for HPWH, BED similarly does not expect that increases in the number of installations will have a material impact on resource planning efforts.



As highlighted in the graph above, total MWh sales may top out at 430 MWh, assuming a cumulative total of 325 units are installed by 2040.[19]

[19] The number of units installed tapers off after 13 years as units are retired from service and not replaced with a new HPWH.

Key assumptions

For purposes of evaluating the impact on BED's resource planning activities, the following major assumptions were made for CCHPs.

Major Assumptions - CCHP		
	Single head	**Multi head**
Installation cost	$4,500	$8,000
Ann. MWh Sales (avg.)	3.27	
Ann. Net Rev. (at $0.10/kWh)	$327	
Net Electric Rev.(Lifetime, NPV)	$4,309	
Measure Life	18	18
Avg. COP	2.4	2.4
Avg. FF displacement (%)	40%	50%
Avg. Incentive, incl. Admin	$875	
Avg. net lifetime credits	15	29
MWh e Cost (net)	$ 37	$19

With respect to HPWH, the following assumptions applied to our models:

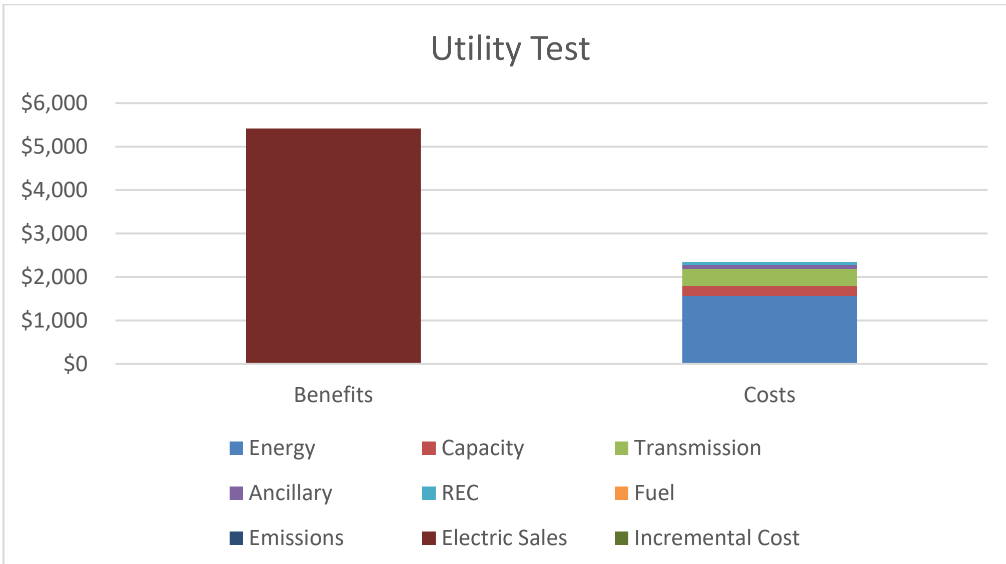
Major Assumptions - HPWH	
Installation Cost	$2,100
Avg. MWh usage (ann.)	1.32
Ann. Net Rev. (at $0.10/kWh)	$132
Net Electric Rev. (Lifetime, NPV)	$1,364
Measure Life	13
Avg. COP	2.05
Fuel Displacement	100%
Avg. Incentive, including Admin	$690
Avg. net lifetime credits	18.96
MWh e cost (net)	($36)

Utility Cost Test

As is the case with increasing EV adoption, an increase in heat pump installations will increase electric loads in Burlington. [20]Thus, they have the potential to generate net utility

[20] It bears noting that the customer, utility and societal cost tests herein reflect the results of our CCHP results. But, BED has also conducted similar tests of HPWH. In the interest of brevity, the HPWH test results have been omitted. Although the amount of the net benefits or costs differ slightly between the

benefits for all customers, even for those who do not install one in their building through downward rate pressure resulting from increasing electricity sales. Based on the above major assumptions, each CCHP installed could generate net benefits of approximately $3,000 (in 2020 dollars) over its 18-year lifespan. Benefits are driven by incremental lifetime electric sales of $5,400 per unit. Utility benefits are offset by increased costs associated with energy ($1,567), capacity ($224), transmission ($395), ancillary ($85) and RECs ($66).



It is important to note however that the economics of the CCHP are very sensitive to a host of important variables including each unit's coefficient of performance COP, room layout, building weatherization, outside air temperatures and fuel prices. Any deviation from the assumptions highlighted above could materially affect the currently anticipated net benefits of heat pumps in Burlington. The same is applicable to the customer's economics, as well as the societal costs test, which is further described below.

Societal Cost Test

Under the net societal cost test, overall lifetime costs exceed benefits by roughly $2,300 per CCHP installed. Total benefits are generated by natural gas fuel savings ($3,000) and avoided emission costs ($1,500). Lifetime costs are primarily driven by the incremental cost of installing a heat pump ($4,500) but also because of the low cost of natural gas in Burlington. Incremental costs can vary considerably and depend on the circumstances related to each building's characteristics and its existing electric systems. For example, if the building's

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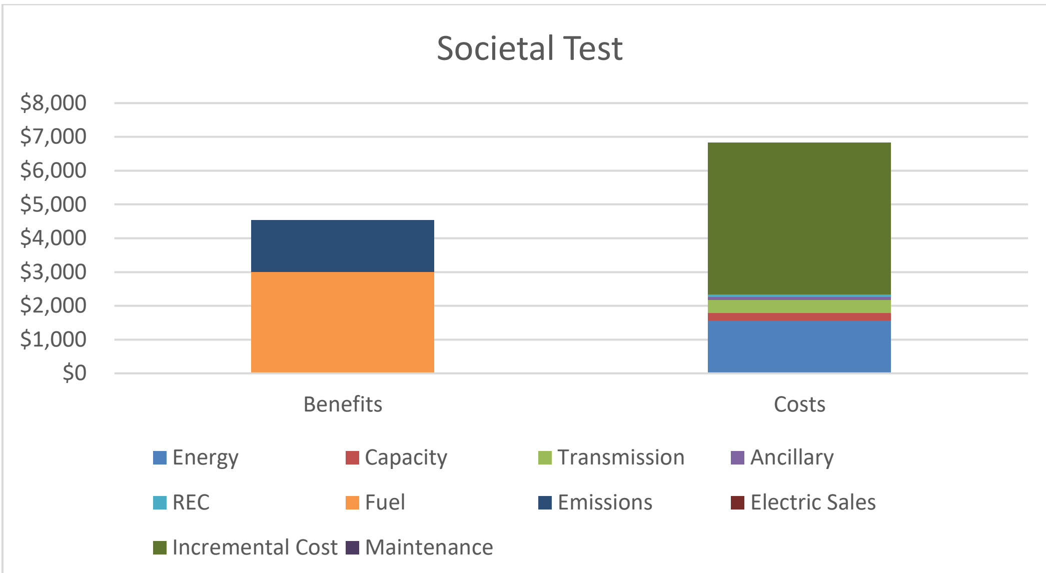
two technologies, the HPWH results are highly similar directional to that of the ccHP results; meaning that HPWH are expected to generate net losses under the customer and societal cost tests, and marginal net benefits under the utility cost test.

electrical junction box needs upgrading, installation costs could easily exceed the average cost of $4,500 per CCHP. Otherwise, installation costs for small single family homes could be significantly less as a single head unit would likely serve the majority of the heating needs of the home. In such instances, the customer would not need to substantially augment the building's electrical system. Plus, the energy savings of a smaller home could be greater than the amounts assumed for modelling purposes.



Other societal costs include energy ($1,566), capacity ($224), transmission ($394), ancillary ($85) and RECs ($66).

Recommended course of action.

Consistent with its NZE, Tier III and EEU initiatives, BED is committed to supporting the aforementioned heat pump programs to the greatest extent possible. Such support includes but is not limited to financial incentives, technical assistance and increasing public awareness about our clean energy programs, in general, and heat pump technologies in particular. All of BED's efforts are designed to address barriers to program participation, as well as to provide meaningful assistance to the State's effort to reach its own clean energy goals.

Conclusion

Although the reservoir of traditional electric energy efficiency project savings may be diminishing due to extraordinary advancements in lighting technologies (and the increase in energy codes and appliance standards), and other electric savings are expected to cost more, investing in traditional electric efficiency in Burlington will provide valuable cost savings for some time to come. The primary reason to continue investing in traditional electric efficiency is to offset the anticipated increase in electric load and peak demand that will likely be triggered by BED's beneficial electrification programs and NZE initiatives. To effectively address these anticipated increases, BED will continue to combine its traditional electric efficiency investments and programs with its beneficial electrification (or Tier III) programs. Combining these services together into a comprehensive, customer-centric energy service offering has multiple co-benefits including but not limited to the following:

- Combining energy services helps to reduce the first-year cost of saved traditional electric savings by spreading overhead costs over more service offerings;
- Customers have expressed an interest in BED combining energy services together as a means to fully address their total energy needs; and,
- Combining energy services helps to alleviate the potential grid impacts of increased adoption of EVs and advanced heat pumps in the City.

Recommended course of action

Based on the above, BED will continue to combine traditional electric energy efficiency investments and program services with beneficial electrification services into comprehensive energy services to better serve customers. By combining services together, BED will be able reduce the acquisition cost of traditional electric energy efficiency as well as offset the expected grid impacts that may be triggered by increased adoption of EVs and advanced heat pumps. Pursuing the maximum achievable electric efficiency goals will also help to improve BED's overall resource adequacy needs relative to pursuing a lower electric savings goal based on a budget-constrained potential savings model.