Net Zero Energy Roadmap Implications

In 2018, the City of Burlington announced its goal of becoming a Net Zero Energy ("NZE") city by 2030. BED subsequently adopted this goal as its strategic direction, and in September 2019 published a *Net Zero Energy Roadmap for the City of Burlington* ("Roadmap") that outlines specific pathways and recommendations for Burlington to accomplish its goal.

> Net Zero Energy is defined as reducing and eventually eliminating fossil fuel consumption in the building and ground transportation sectors by substantially increasing energy efficiency and then switching the remaining fuel to renewably sourced electricity.

The Roadmap provides a comprehensive assessment of the total annual energy consumption in Burlington under business as usual ("BAU") conditions,[1] and describes two alternative scenarios and timelines for achieving a fossil fuel free community: one by 2030 ("NZE30"); the other by 2040 ("NZE40").

BED's involvement with the City's NZE efforts actually began several years ago with securing renewable energy resources. These efforts continue to this day, as BED focuses on meeting its Tier 3 obligations under the RES with electrification programs (rather than lower cost RECs) to the greatest extent possible. Fully decarbonizing the heating and ground transportation sectors will require significant future investments by BED (and other stakeholders) in programs, measures, distribution upgrades, load control capability, and technical assistance. The level of annual investment is expected to be orders of magnitude greater than the current funding directed at BED's energy efficiency utility (approximately $2.2 million annually) and beneficial electrification programs (approximately $0.996 million in 2021 and growing).

Although BED is a leading participant in the City's NZE efforts, the goal cannot be achieved by BED's actions alone. Additional efforts to support NZE will include potential City policies aimed at requiring additional weatherization in existing buildings, and strategic electrification work in new buildings. Partnerships with other City Departments as well as key external partners such as Champlain Valley Weatherization Services, VGS, Green Mountain Transit, and others will play an important role. In some cases, federal or state policy changes may be required. A state policy example is S. 337, which is currently under review. If enacted, S. 337 would provide BED (and other authorized efficiency utilities) with additional flexibility to

[1] A copy of the full Roadmap report is attached and can also be found at: buringtonelectric.com/nze

redirect existing electric efficiency funds toward greenhouse gas reduction initiatives. Still other potential policies identified in the NZE Roadmap that are not directly in BED's control include pricing carbon, developing a transit plan, and changing land use patterns. BED is actively engaged with local, state, and federal officials regarding activities and potential funding to advance Net Zero Energy, but we have not scoped additional funding sources or amounts needed beyond those identified in other chapters of this IRP. Therefore, for the purposes of this IRP, BED assumes that adoption of beneficial electrification technologies, such as electric vehicles and heat pumps, will not occur at a significantly different pace than our BAU scenario until specific policies are enacted. Instead of planning for a NZE30 or a NZE40 future, BED assumes that adoption of beneficial electrification measures will mirror national treads to ensure resource adequacy and reliability are maintained, pursuant to 30 V.S.A. §218c. The BAU modeling outputs do serve, however, as the starting point for evaluating the potential impacts associated of a Net Zero Energy future, which we further describe below.

This chapter provides a high-level assessment of the potential implications of achieving the initial stages of the Roadmap. Specifically, this chapter discusses:

- Roadmap assumptions and outputs;
- Expected distribution system impacts at 102.8 MW;
- Expected power supply requirements at 102.8 MW;
- Preliminary revenue impacts at 102.8 MW; and,
- Whether the sum of the above would tend to increase or decrease BED's average cost per KWH of providing electric service ("Rate Pressure")

Net Zero Energy Roadmap Overview

Reaching the NZE goal by 2030 will require a paradigm shift in how Vermont designs clean energy programs (either with aggressive incentives, state mandates, or both, etc.). Achieving the goal also will require some modification of Burlingtonians' current energy consumption habits. At a minimum, successfully attaining NZE depends on:

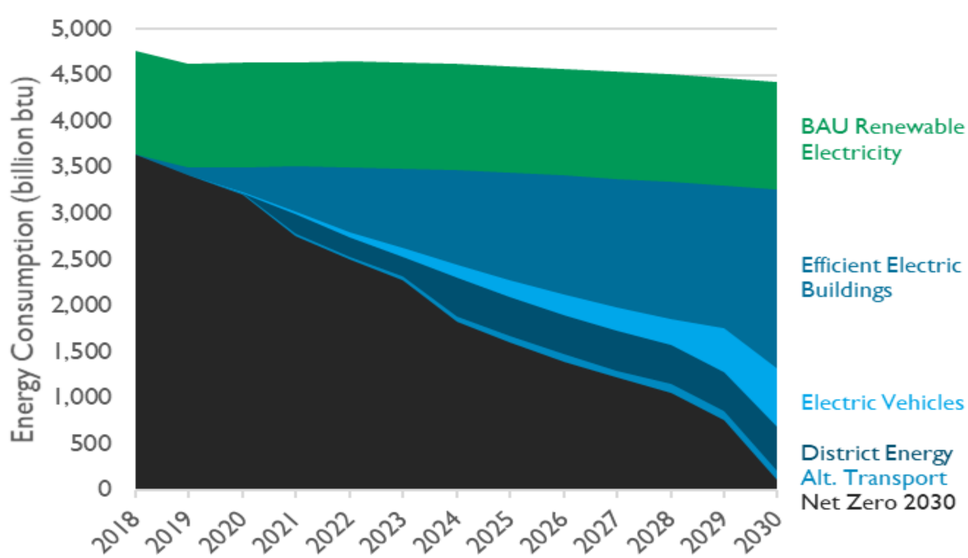
- Substantial reductions in energy use through accelerated and integrated energy efficiency, particularly in the thermal sector;
- Widespread active and passive demand response to limit system impacts to the greatest extent possible;
- Expansion of the distribution system's capability to serve new loads reliably, prior to those loads coming online;
- Comprehensive citywide planning for all new construction projects and major renovations, including renovations of historic buildings to avoid retrofit needs at later dates;

- Widespread adoption of beneficial electrification technologies, such as heat pumps and electric vehicles;
- Maintaining our 100 percent renewably sourced electricity generation portfolio; and,
- Stakeholder support and engagement among all of BED's partners.

In short, the NZE goal requires an "all-hands-on-deck" effort to fully transform two large market sectors that are fundamentally important to the state and local economy: building thermal energy needs and transportation. The main tools that BED can currently leverage to work toward accomplishing the NZE goal are the Renewable Energy Standard, especially our Tier 3 obligations, as well as our EEU programs.

To provide guidance to the community and other decision-makers on how Burlington can attain NZE, BED commissioned the aforementioned report to establish a citywide total energy consumption baseline. This baseline consumption, which amounts to over 4,500 billion BTUs, including renewably generated electricity, serves as the starting point toward the NZE goal. The Roadmap identifies the energy uses that need to be de-carbonized and the implementation "trajectories" required to accomplish the goal by different dates.

Figure 1 Total Energy Consumption



By determining the amount of decarbonization that is needed by generic end use, the Roadmap provides insight into how Burlington can begin the process of reducing fossil fuel consumption by switching to renewably sourced electricity or reducing energy consumption. As Figure 1 demonstrates, fossil fuel consumption (black shaded area) is replaced over time with clean electricity (green and blue shaded areas). To successfully "bend down" the fossil fuel consumption curve, the Roadmap directs Burlingtonians onto four pathways to NZE: efficient electrically heated buildings; electric vehicles; district energy; and, alternative transport. Each pathway includes a set of goals, which are explained further below. The magnitude of the potential fossil fuels savings by pathway is shown in varying shades of blue in the graph above. It should be noted that for transportation sector purposes, only trips by Burlington residents are counted in the Roadmap, although there will be a secondary focus on reducing fossil fuel use by visitors and commuters to the City. As loads are converted from fossil fuel in each sector, that energy will need to be powered by increasing the current amount of renewably sourced electricity (depicted in green in Figure 1).

Pathway 1: Efficient Electric Buildings

Customers will need to dramatically shift from traditional heating systems (i.e. hydronic boilers and hot air furnaces fired by fossil fuels) to new advanced heat pump technologies for space conditioning and domestic hot water.

Air-source heat pumps ("ASHPs"), also referred to as cold climate heat pumps ("CCHPs"), are currently the main technology in Vermont capable of providing sufficient heating capacity, except during extreme cold temperature events (below 0°F). With current technology, Vermonters typically maintain their existing conventional heat source to ensure their building is safe and comfortable during such extreme cold weather. A significant number of CCHPs have been installed throughout Vermont in the past several years and are currently providing customers with more than adequate heat as well as new cooling capabilities. It is expected that the number of CCHP installations will continue increasing, even under our BAU scenario. But in this scenario, their adoption is more rapid, as further discussed below.

While residential heat pump adoption rates have steadily increased in Vermont, the customer's economics for installing a CCHP in Burlington are challenging. Within BED's territory, more than 95% of customers have natural gas heat systems. Because natural gas prices are at all-time low levels, it costs less to heat with natural gas than with a CCHP at present retail electric rates. Therefore, most BED customers will not achieve energy cost savings by switching from natural gas heat to a CCHP system (though for customers wishing to decarbonize their heating load, CCHP technology does compete favorably with the cost of heating with renewable natural gas). It should be noted, however, that many customers may be interested in CCHPs not only for heating, but also their efficient cooling capability.

Although making the economic case for CCHP adoption in Burlington has challenges, the NZE30 modeling outputs would require installation of heat pump technology in all new buildings by the mid-2020s.[2] To facilitate extensive heat pump adoption among existing

[2] In addition to the most widely adopted CCHP technologies, other heat pump technologies include ground source heat pumps ("GSHPs"), water-to-water heat pumps, air-to-water heat pumps, and variable refrigerant flow ("VRFs") heat pumps for commercial applications.

building owners without an increase in the price of natural gas (either intrinsically or due to an explicit carbon adder), BED would need to do one or more of the following:

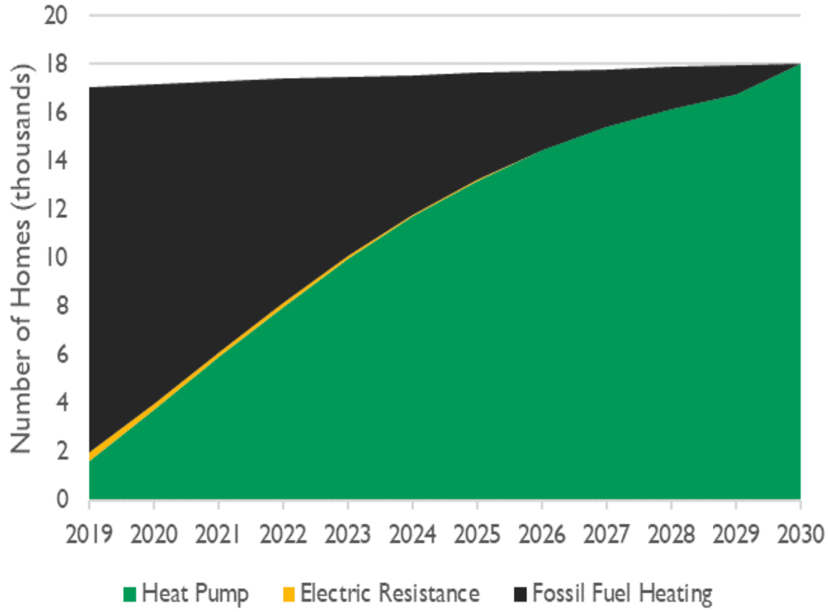
1. Substantially increase incentives above those currently permitted under the Vermont RES (which BED is piloting through its Green Stimulus program)
2. Take action to encourage such conversions at the City government level
3. Offer reduced electric rates for CCHPs, particularly those that are load controlled. [3]

Over the next 2 – 4 years, BED will need to closely monitor changes in the pattern of electric use over time and the City's progress toward heating all buildings and domestic hot water with heat pumps. BED will have to keep tabs on the number of annual and cumulative heat pump installations and simultaneously encourage building owners to increase the thermal efficiency of their buildings by weatherizing the building shells, air sealing, and, in some cases, replacing windows and/or doors. Research into end-use metering and load control options may support special CCHP rate options. Having the capability to control heating and cooling loads from CCHPs – especially to the extent that buildings are probably weatherized – will minimize the impacts of heat pumps on our distribution system and resource requirements.

As Figure 2 below indicates, the NZE30 model anticipates that nearly 10,000 residential heat pumps would need to be installed by 2024, and 18,000 by 2030. Today, there are only 225 advanced heat pumps installed in Burlington, well short of the NZE targets. BED believes NZE progress may come in a non-linear fashion, and depending on technology and policy, the pace of growth may change substantially during the next ten years. This happened with solar adoption, for example. The NZE goals indicate that nearly all households in the City, including those residing in apartments, condominiums, and single-family structures, would need to install CCHPs.

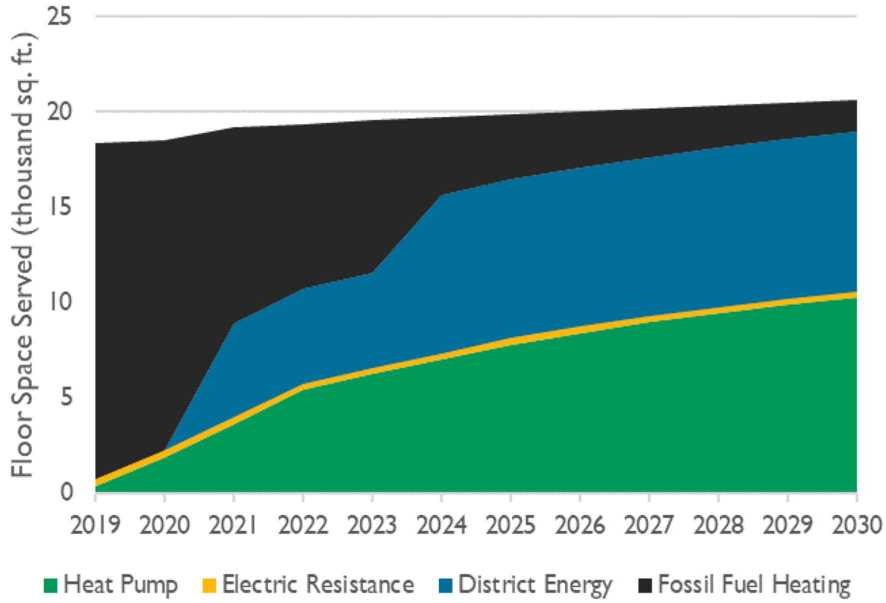
[3] However providing CCHP rate credits would have the effect of reducing the benefits of widespread beneficial electrification on rate pressures. For more information, see Chapter 6.

Figure 2 Residential Households with heat pumps



In the commercial building sector (Figure 3), the NZE30 scenario assumes that an increasing amount of floor space will convert to heat pump technology (mostly VRFs, although GSHPs could also be a viable option) even if their existing boiler systems remain in place. In this scenario, heat pumps will serve as the primary heating system and existing heating equipment will back up heat pumps only during extreme cold weather. Also, the NZE30 scenario assumes that a district energy system will be in place and eventually expand to provide heating to substantial portions of the City's large buildings (e.g., UVM Medical Center).

Figure 3 Commercial Floor Space heated with heat pumps

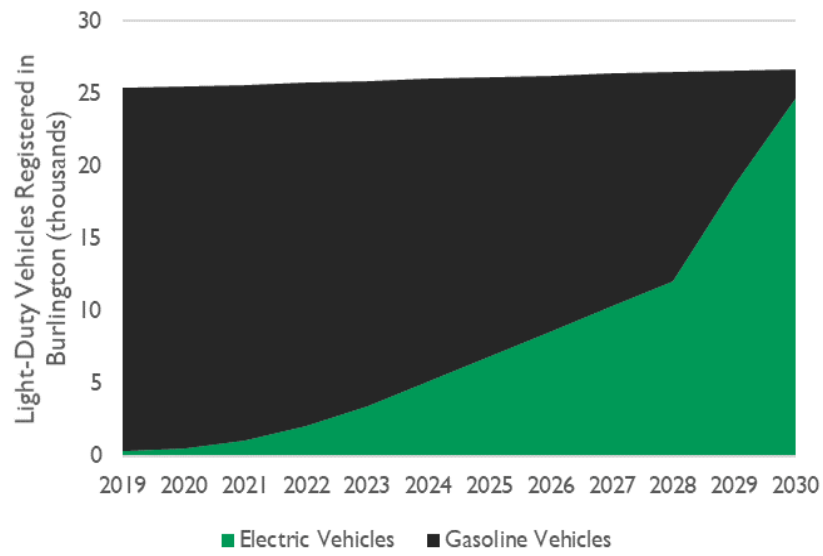


Pathway 2: Electric Vehicles

The electric vehicle ("EV") pathway also aims to achieve aggressive goals for the City. Today, there are approximately 24,000 light-duty vehicles registered in Burlington. Under a BAU case, by 2030 we expect this number to increase modestly as the City's population grows. To achieve the NZE30 goal, the Roadmap assumes that almost all of the light-duty vehicles in Burlington are converted to electric vehicles by 2030.[4] As shown in Figure 4, the rate of EV adoption needs to be brisk to achieve this goal, particularly after 2022, and would require Burlingtonians to convert from existing internal combustion engines ("ICEs") in significant numbers before the end of their expected useful life (12 to 14 years). Under NZE30, the model assumes that nearly 5,000 vehicles registered in Burlington will be electric by 2024, an increase from approximately 500 today. By 2029 and 2030, nearly 10,000 additional ICE vehicles will need to be replaced with EVs. In a typical year, about 1,500 new vehicles are registered in Burlington. BED existing Tier 3 incentives are unlikely to result in this level of accelerated adoption alone, but improving EV technology, increased access to used EVs, and improved charging infrastructure are expected to be of material assistance.

Figure 4 Electric Vehicle Adoption curve

[4] While other vehicles in the City may also be converted to electrically powered motors such as e Buses, transit buses, and others, this section focuses on light-duty passenger vehicles as they are expected to have the greatest impact on BED's load requirements.



Pathway 3: District Energy

The district energy system ("DES") pathway details how large customers[5] can reduce natural gas consumption by partially converting their buildings to steam based on the thermal energy produced from sustainably harvested biomass. In the Roadmap, this pathway consists of diverted steam-based energy and recaptured waste heat from the McNeil Generation Station being distributed via new pipelines to the University of Vermont ("UVM") Medical Center campus and ultimately expanding to serve other buildings. Ultimately, the Roadmap modeling outputs assumes that the DES could potentially reduce natural gas consumption by 475 billion BTUs annually, or about 15 percent of total fossil fuels consumed for building heating. The diverted steam would be used for space heating, domestic hot water, and potentially other thermal processes. The initial buildout of a DES would need to begin no later than 2021 in order to meet the NZE30 goals, and one or more large customer(s) would need to agree to become an anchor tenant to justify the significant upfront capital investment needed to build the system.

Once the capital investment is made, the DES could eventually be expanded to connect with other customers in the vicinity of the steam pipeline system or to integrate additional renewable thermal sources of energy. As is the case with CCHP, the economics of a DES are challenged by the very low price of natural gas today. On the positive side, a biomass-based DES appears to be a cost-competitive method of decarbonizing compared with other options, particularly for large customers. BED has received (and intends to seek additional) grant funding to offset DES engineering study and capital costs. Such studies are necessary to provide potential DES customers with the cost certainty necessary to gain their financial commitment

[5] In the early years of development, it is assumed that only large institutional customers would connect to a DES.

and move the project forward. It is also important to note that VGS has been fully engaged in the DES project as a key partner.

DES would potentially have significant impacts on BED not in terms of new or additional electric load, but in terms of impacts on the McNeil Generating Station (e.g., improved efficiency, changed operational cycles, and potential revenue diversification).

Pathway 4: Alternative Transportation

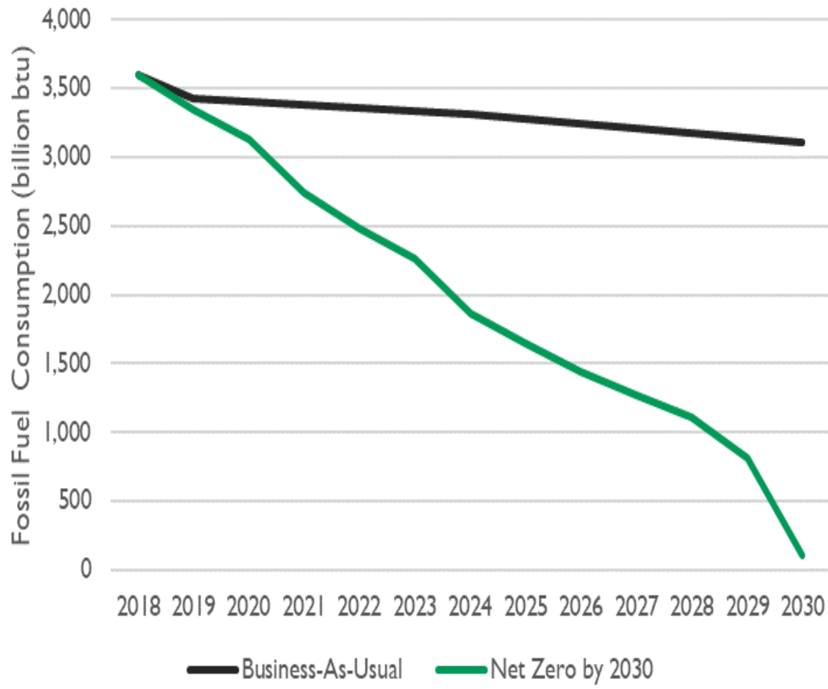
The last major pathway BED and the City will need to pursue involves alternative transportation modes and related behavioral changes. If achieved, this pathway is expected to result in a 5 percent reduction in fossil fuel consumption. The alternative transport pathway assumes that, given increased multi-modal transportation options for commuting to work and other destinations, Burlingtonians will drive a personal vehicle less often. Such options include biking, taking public transit, carpooling, and/or walking.

This pathway is not expected to have dramatic impacts on BED, unlike the DES, EV, and CCHP pathways.

Load and Emission Impacts

Net zero energy does not mean zero energy consumption. Instead, NZE means that as our customers' fossil fuel consumption trends downward over time, their energy needs that are not met by increased efficiencies and/or are replaced with renewably sourced electricity as the City's preferred energy source. Thus, the region below the black line in Figure 5, which represents BAU consumption of fossil fuels, is replaced with renewably sourced electricity. The model also anticipates that the total amount of energy consumed will decrease to a little more than 3,000 billion BTUs because of increased efficiency in the building and transportation sectors.

Figure 5 Fossil Fuel only consumption



Under the NZE30 scenario, the increase in electricity consumption will notably impact BED's existing operations and require upgrades to and modification of certain aspects of its operations to ensure continued reliability. Should the City successfully reach NZE using the Roadmap pathways, the net impact on BED's load requirements would be an increase to roughly 550 GWh from 340 GWh, and peak demand may go from the current 65 MW to 140 MW, as shown in Figures 6 and 7. However, the timing of these load impacts is uncertain, largely because many aspects of achieving NZE by 2030 (or 2040), such as implementing complementary policy actions, are beyond BED's control. Perhaps more uncertain is the progress, if any, that the rest of New England might make toward NZE, and the impacts on the wholesale electric market and transmission systems that total decarbonization would cause.

Therefore, BED selected a load threshold of 102.8 MW and the load shape and timing associated with decarbonization activities to achieve that threshold to understand the early effects of progress toward the Roadmap. 102.8 MW was selected as a load level that would stress the distribution system past its current capability of serving roughly 80 MW load, along with a shift to a winter peak. Additional engineering analysis is in process to understand the upgrades needed to serve the full load outlined in the Roadmap, but these analyses are sufficiently complicated to require additional time to perform.

Again, the graphs below do not represent actual forecasts of specific load occurring by a specific date. The analysis in this chapter does, however, conclude that the rate impacts of distribution upgrades required by load increasing to 102.8 MW during the early stages of the Roadmap are not adverse, although distribution system investment will be needed. Additionally, increases in load may actually work to reduce average costs and rates, as discussed below.

Figure 6 Renewable Electricity sales

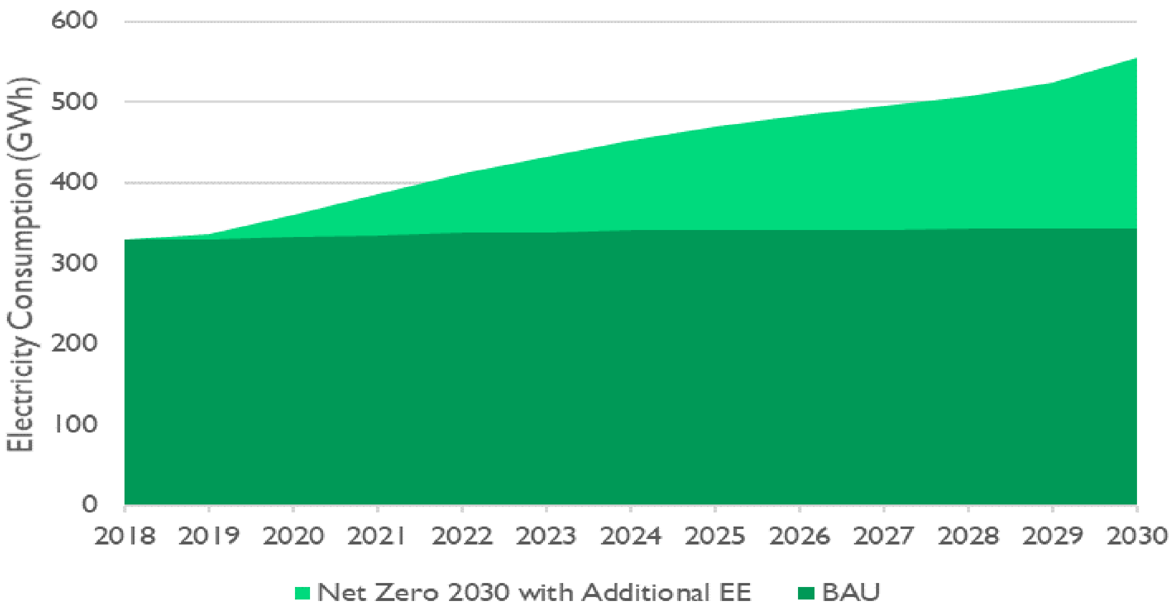
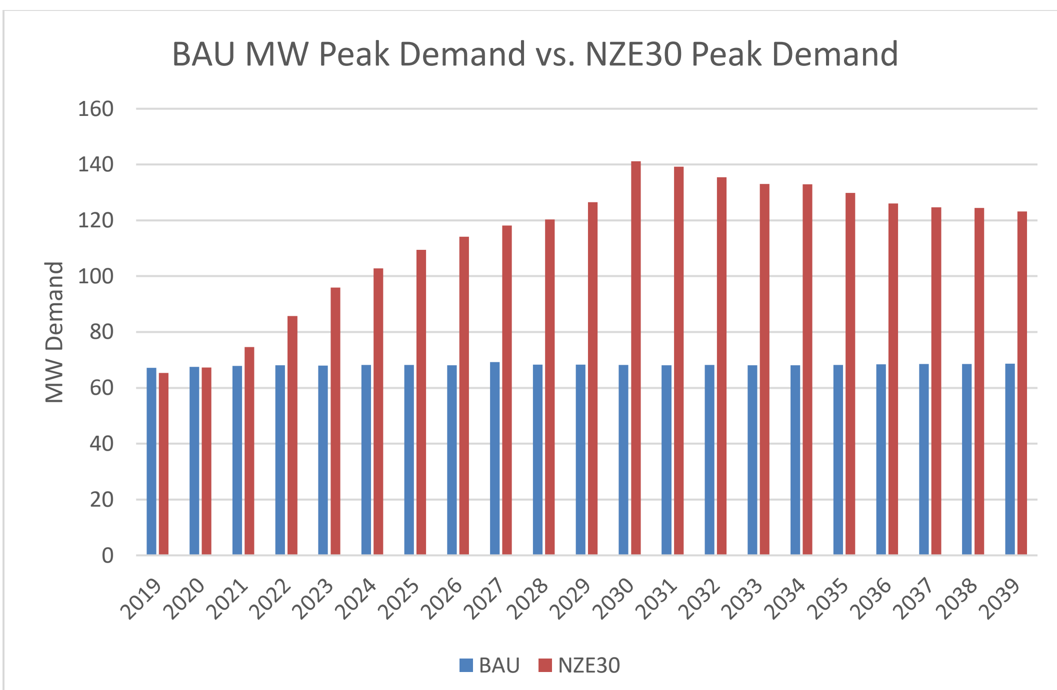
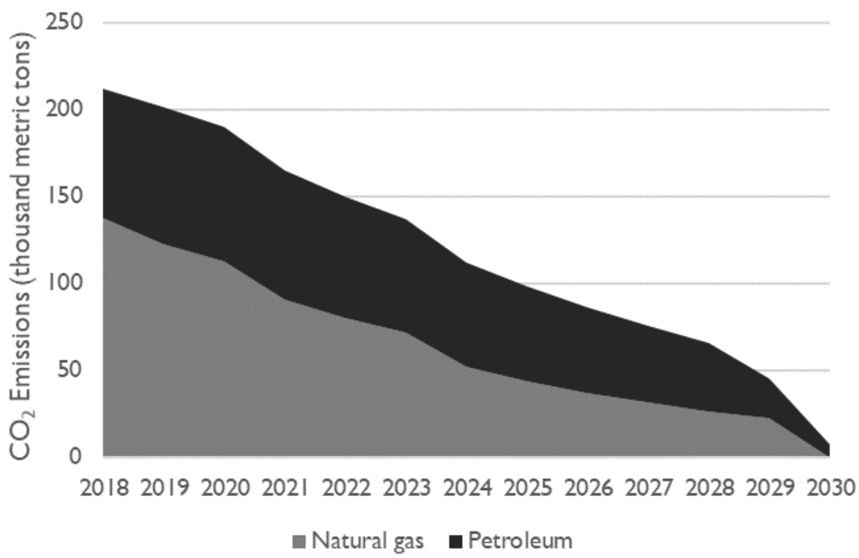


Figure 7 Peak Demand



The NZE30 projections of reduced fossil fuel consumption and lower GHG emissions will provide significant societal and economic benefits to customers and those benefits have not been quantified in this preliminary analysis. As shown in Figure 8, NZE30 may reduce GHG emissions by approximately 200,000 tons. Reductions of this magnitude will undoubtedly contribute to improvements in regional air quality and public health.

Figure 8 GHG Emissions reductions



Potential Distribution System Impacts

BED's NZE30 Roadmap highlights that as load grows with adoption of beneficial electrification measures, so does the potential for system-wide distribution impacts. This cause and effect relationship is illustrated in Figure 7 above, which shows an estimated peak of 102.8 MW in January 2024 and an estimated peak of 140 MW by January 2030. As peak demand grows, BED will need to make additional investments in its distribution system (ahead of loads actually occurring) to ensure continued reliability. However, absent policy directives to achieve NZE goals, BED does not anticipate that an increased demand for power will materialize suddenly. Furthermore, BED is currently not on the trajectory shown in Figure 7.

BED will be able to verify the actual pace of increased demand in electricity by monitoring the rate at which its customers adopt beneficial electrification technologies and the corresponding changes in BED loads, to determine at what point upgrades will need to commence. Selecting 102.8 MW as an initial load level for analysis provides BED insight into the subset of investments needed to fully prepare for NZE30 achievement (by setting an analysis level that cannot be served reliably by BED's existing distribution system – see T&D Chapter). Setting an initial evaluation load level also sheds light on the general economics of achieving

NZE from an electric utility perspective in terms of incremental power costs, retail revenues, and whether the combination of these impacts appears to result in upward or downward rate pressures.

To determine whether distribution system upgrades would be necessary to reliably serve a peak demand load of 102.8 MW, BED analyzed its existing distribution system as it is constructed today and explored four contingency scenarios. In each scenario, one of four main distribution substations serving the City was taken offline at a time: the McNeil substation, East Ave #3, East Ave #4, and the Queen City Substation. If one of these distribution substations were to be disabled unexpectedly, circuit loading and voltage levels would exceed engineering limits. The effect of such conditions, were they to occur, could cause large areas of unserved load in the event of an outage, as well as poor power quality across much of the distribution system.

By modeling the effects of one substation outage at a time, BED's engineering staff is seeking to determine what system upgrades are required to mitigate issues and provide reliable service to BED customers at increased load levels.

The following upgrades were identified to address the circuit overload and voltage issues. It is anticipated these projects will take four to seven years to complete depending on labor staffing levels and the availability of capital funds for this purpose in the context of the complete scope of BED's capital budget (i.e., NZE projects plus other projects not related to NZE).

Project Description	**Project Type**
Upgrade 2L5 Cable from 350 CU to 1000 CU	Upgrade to Existing
Buell St - Convert to 3-Phase	Upgrade to Existing
Heineberg Rd upgrade to 556AL	Upgrade to Existing
Starr Farm Beach – Convert to 2-Phase	Upgrade to Existing
Ethan Allen Pkwy convert to 2-Phase	Upgrade to Existing
Convert Ethan Allen Pkwy northern area to 3-phase and balance the loads	Upgrade to Existing
Upgrade Secondaries/Services and Transformers	Upgrade to Existing
Extend 1L2 to North Avenue & transfer load from 1L4 to 1L2	New Installation
Install 4-Way Padmount or Submersible Switch at Starr Farm Rd & North Ave	New Installation
1L2 extended to Starr Farm Rd 4-way switch and then to Barley Rd	New Installation
Extend 2L1 Circuit to pick up load off 1L1 Circuit	New Installation

Transfer load between 1L1 to 1L4 - Install 556 AL from Staniford Road to North Ave - Install 556 AL from Woodbury Road to North Ave - Install 556 AL from Woodlawn Road to North Ave - Install SCADA controlled switch connecting 1L1 and 1L4.	New Installation
Create a new 2L8 Circuit	New Installation

Modeling results with these upgrades indicate that voltage limitations and thermal loading conditions across the distribution network would remain within appropriate engineering parameters at the 102.8 MW of peak demand, and that consistent, reliable service could be maintained.

Based on the best available information at the time of writing, the total estimated cost of the above infrastructure upgrades ranges between $19 million and $24 million (estimates were prepared using 2019 figures for labor, material, and overhead costs). This estimate is based on using existing personnel to complete the work over the seven-year span and not hiring external contractors.

While this analysis presents a solution at the 102.8 MW level, BED will continue evaluating the potential implications of the NZE load forecast of 140 MW in 2030. It is anticipated that the conclusion of the 140 MW analysis may require upgrades at the substation and/or sub-transmission level.

It is important to note that under the fully realized NZE30 scenario, BED anticipates that there will be several newly identified system upgrades required to support loads beyond the 2024 threshold that are not included above. However, these new potential upgrades will be considered starting from the solutions found in this interim analysis. Once an engineering solution has been developed that adequately supports the forecasted NZE30 load, any additional system upgrades will need to be reviewed in consideration of the projects required at the 102.8 MW load level so that the upgrades previously built would not need to be upgraded again in the latter half of the current decade. Through this iterative process, BED will be in a position to better plan what the distribution system of 2030 will need to look like to support a NZE city and what upgrades it will require along the way without undertaking upgrades that will be superseded in too short a period of time.

Power Supply Requirements

Maintaining a 100 percent renewably sourced electric generation portfolio remains the centerpiece of BED's clean energy strategy and is necessary to decarbonize Burlington's energy needs. The strategy will require BED to procure more renewable energy to serve the energy needs associated with the 102.8 MW load levels (an additional 119 GWh or a 35% increase over current needs). While such an increase in energy requirements may be significant for BED, it isn't significant relative to the amount of renewable electric energy generated and wheeled throughout the New England system.[6] And, because BED's new energy procurements are so small relative to the total renewable wholesale energy market, we do not expect energy prices to materially increase relative to current prices because of Burlington's NZE efforts. Indeed, BED has already conducted informal discussions with an existing hydroelectric supplier about potentially procuring additional power supplies. That supplier has indicated a willingness to provide such additional renewable power supplies to BED at competitive wholesale prices. Accordingly, for purposes of this NZE analysis, BED assumes that up to 120 GWhs of additional power (inclusive of line losses and reliability reserves) will be available at an average wholesale cost of $41 per MWh.

With respect to capacity, transmission, ancillary, and REC costs, BED similarly assumes that the need for these additional resources is *de minimus* relative to the amount of resource availability throughout the region. As a result, the wholesale cost of such services is expected to be similar to current costs, or to follow similar trends in the case of transmission costs for the analysis in this chapter. Combining all expected wholesale energy costs (i.e. energy, capacity, transmission, ancillary, and RECs) will naturally increase BED's cost of service in the aggregate by a material amount. BED's conclusions regarding the ability to implement the early stages of the Roadmap contained in this chapter are predicated on these assumptions.

Preliminary Rate Impact Conclusions

The NZE30 pathway results in both significant forecasted costs and net revenue improvement for BED. This is illustrated below by showing first the forecasted incremental costs associated with the NZE30 pathway, then the translation of those incremental costs to $/kWh, and finally the impact on the projected rate path of the NZE30 pathway.

Incremental Costs ($)

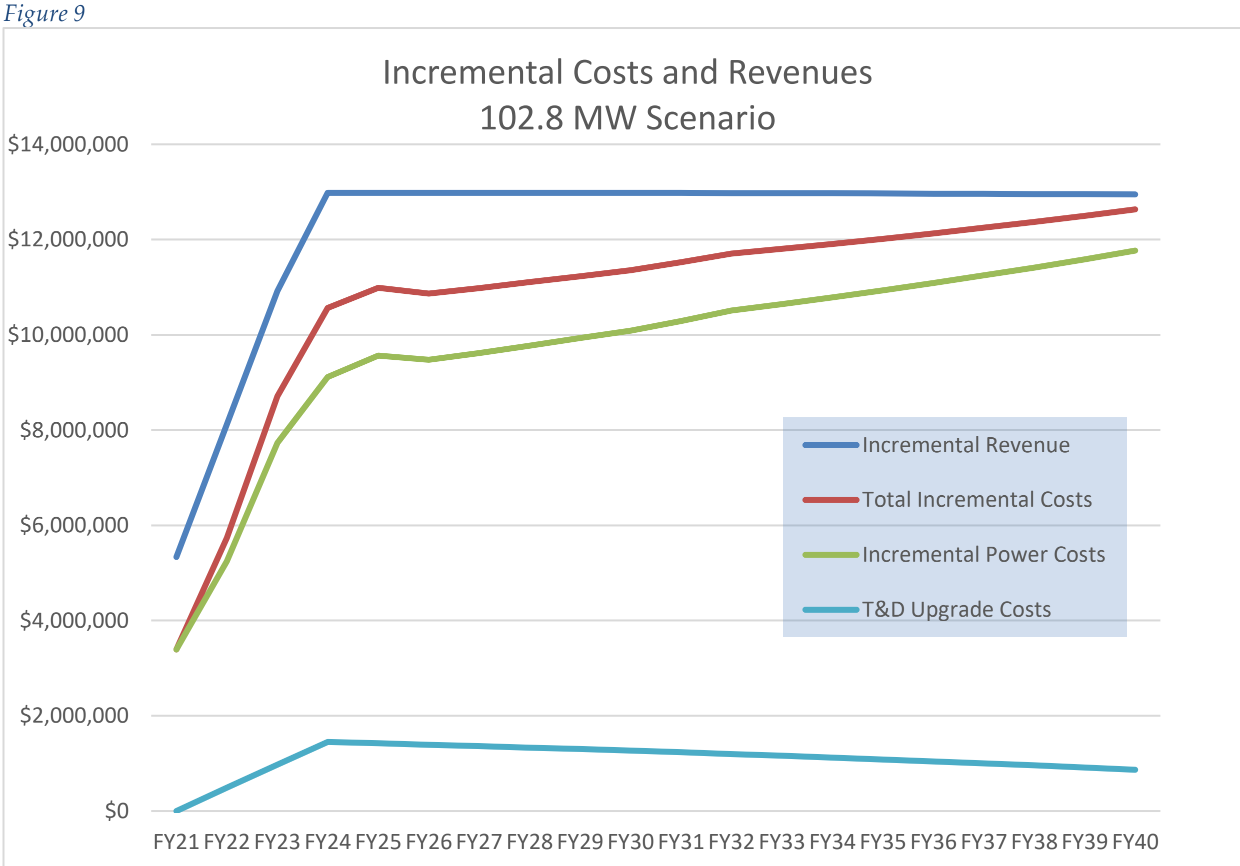
Figure 9 illustrates the expected annual costs associated with serving the Roadmap loads at 102.8 MW. In order to generate relevant IRP model outputs, the timing of the loads was aligned with the NZE30 pathway for costing purposes through 2024 (i.e., to the 102.8 MW level) and the BAU growth rates were used for the remainder of the IRP horizon. This methodology yields a load slightly higher than 102.8 MW in the outer years of the evaluation, but not by a magnitude large enough to change the conclusions in this section.

[6] According ISO-NE, 11,149 GWh of renewable and 8,788 GWh of hydro was generated in 2019. *See;* https://www.iso-ne.com/about/key-stats/resource-mix/

T&D capital costs were converted to annual costs through a 25- to 33-year depreciation schedule and a 20-year bond issuance that is consistent with the expected life of the proposed upgrades and BED's current borrowing practices.

Figure 9 indicates that the combined cost to serve the incremental load associated with the 102.8 MW Scenario (the carrying cost of the expected distribution upgrades and incremental power and transmission costs) is lower than the projected revenues under existing rates (assuming no discount to CCHP rates but including BED's off-peak EV charging rate) for the full 20-year period. This would be true at BED's base case projections of wholesale power costs, even if BED had no increases in rates in the next 20 years. It is also informative to note that at the 102.8 MW level, the costs of upgrading the distribution system are far less significant than the wholesale power costs. The review of required T&D upgrades to support loads greater than 102.8 MW will indicate if this relationship changes materially as load levels increase. Excess revenues over the incremental costs to serve provide a contribution to BED's existing fixed costs, which can help to reduce rate pressure, provide some discount to CCHP rates without adding to rate pressure, or a combination of the two.

Figure 9

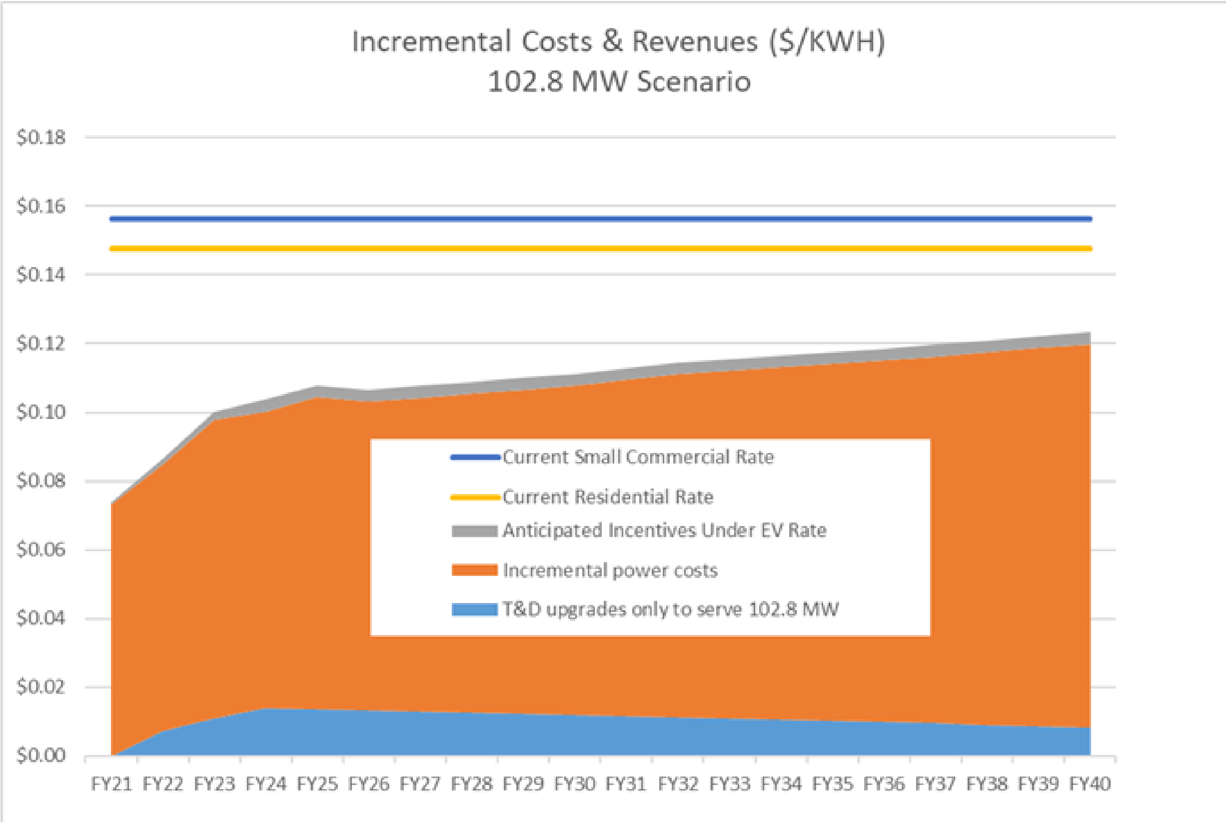


Incremental Costs ($/kWh)

Figure 10 restates the information shown in Figure 9 in terms of cost per kWh to reflect the incremental impacts of both total costs and load. This shows a similar relative magnitude of costs, with the wholesale costs being the majority, rate incentives being significant, and the costs of upgrades being much less significant. For comparison purposes BED has added two lines showing BED's current energy rates for Residential (RS) and Commercial (SG) customers. (Because industrial rates include a demand charge, they are excluded here for simplicity.)

The "T&D Upgrade Costs" area of the graph shows the impact of the distribution upgrades required to serve approximately 102.8 MW of load, depreciated and bonded appropriately. The "Incremental Power Costs" area again shows that the incremental wholesale power and transmission costs are the largest component. Finally, the "Anticipated Incentives Under EV Rate" area shows the impact of offering rate incentives for much of the forecasted load increase related to the number of EVs in the City at the 102.8 MW load level. (Note: this is shown in Figure 10 as an incremental cost for comparison to the existing retail rates on a per KWH basis but is shown in Figure 9 as a reduction in expected revenues). The combined incremental cost to serve the 102.8 MW load is below existing retail electricity charges for the residential and commercial classes over the IRP horizon, provided that new CCHP load is served under the existing rates.

Figure 10

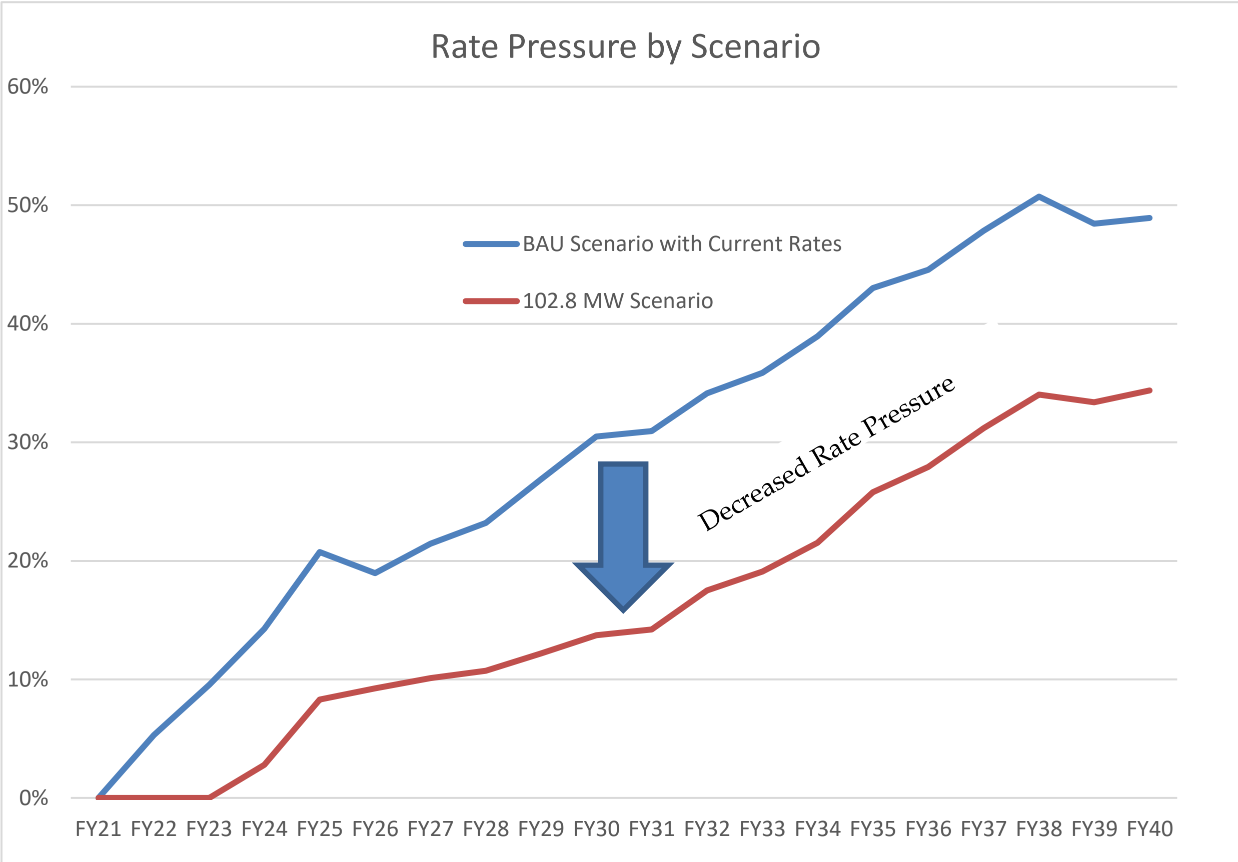


Rate Pressure

Figure 11 compares the change in average cost of service per kWh of retail load ("rate pressure") under the BAU case versus the same change under the 102.8 MW Scenario (using current rates for residential, commercial, and the EV incentive, but without discounting the rate for CCHP sales). The BAU path assumes rate incentives for EV charging as well, but for less electrification of vehicles.

Figure 11 shows decreased rate pressure due to additional electric loads associated with the 102.8 MW scenario after allowing for the incremental costs to serve those loads as described above.

Figure 11



Conclusions

Given the assumptions discussed in this chapter, the 102.8 MW Scenario model outputs indicate that the early stages of electrification toward NZE30 would result in significant increases in electric loads that BED would be required to serve. The model further indicates that BED would change from a summer-peaking utility to a winter-peaking one as more heat pumps are installed (however, BED does not assume NE would change to a winter peaking region in this analysis). Due to these increases and shifts in our energy delivery requirements, BED would expect to incur additional distribution infrastructure costs to reliably serve these loads and that these capital costs would be material as the load exceeds the current capacity of BED's systems.

Future increases in costs are mostly driven by the costs associated with meeting the energy, capacity, and transmission costs related to the increased load under the 102.8 MW Scenario. The need to reinforce sections of the distribution system, and associated costs, to reliably serve increased demand are far less significant. As an offset to these increased costs, new heating, cooling, and transportation loads would also result in additional retail revenues generated from adoption of these beneficial electrification technologies. The cost to serve the expected increases in our load requirements from the Roadmap does not include costs of expanded beneficial electrification programs to meet NZE goals. The annual MWHe requirements of Tier 3 do not come close to the load "trajectory" identified in the Roadmap for decarbonization by 2030 or even 2040. It is expected that non-utility actions may be the largest component in resolving that gap and achieving NZE

In order to implement NZE, at whatever its final deployment rate ends up being, material investments related to beneficial electrification programs will be needed and electric consumption will increase dramatically. BED will need to act to limit peak load impacts wherever possible, while also working with customers to increase the overall energy efficiency of their buildings and ground transportation needs. BED will also need to anticipate when increases in demand for power will occur and have in place a distribution network capable of reliably supporting that demand when it occurs. Power and transmission resources will also need to be secured in time, although the existing wholesale market structure makes the timing of additional resources less critical than that of the needed distribution system upgrades.

BED believes that the primary impacts of the early stages of the Roadmap are:

1. Changes in load level and load shape
2. Increased distribution investments to serve a load level of 102.8 MW
3. Increased costs related to wholesale power costs and transmission
4. Increased retail revenues associated with the new load

BED has not assumed:

1. Material increases in capital costs associated with load control. Any incremental BED costs associated with load control will need to be considered when rates for load-controlled service are established.
2. Material increases in O&M costs (distribution maintenance, customer service, etc.). To the extent that some of the distribution upgrades represent early replacement of existing infrastructure, some O&M costs may be reduced slightly.
3. Incentive costs associated with BED's existing Tier 3 plans (not considered incremental costs of the 102.8 MW scenario in this analysis).

BED has performed this preliminary economic impact of the 102.8 MW loads using the original T&D project cost estimates (converted to annual carrying costs) and using the base case IRP assumptions for wholesale power costs and transmission. For the purposes of this evaluation, BED assumes that the 102.8 MW load level would occur in 2024 and load will grow only slowly thereafter. The analysis is informative and allows for a comparison of the base case rate path to the rate path of the 102.8 MW Scenario with the load shapes assumed in the Roadmap.

BED's analysis shows that the loads associated with the 102.8 MW load level, the costs of associated distribution infrastructure, and the power and transmission costs related to those loads can be served not only without creating rate pressure, but in fact reduce rate pressure by providing additional contributions to existing fixed costs, provided that:

- The assumptions are reasonable
- Electric rates are not materially discounted for CCHP loads without generating additional savings in the costs assumed.

This analysis serves as BED's current basis for modeling the effects of Net Zero Energy actions. It is not definitive without further analysis (currently underway) to verify that the above conclusion would hold true through the full magnitude of load changes envisioned in the Roadmap, although the relatively small proportion of costs associated with the T&D upgrades needed for the 102.8 MW scenario provides for some optimism.