Chapter 3 - Generation & Supply Alternatives

Consistent with 30 V.S.A. §218c, BED evaluated its future energy and capacity needs and compared them to its current resources and planned resource additions. Future energy and capacity needs are rooted in the 20-year load forecast, which reflects various scenarios including the potential impacts of strategic electrification initiatives, distributed generation resources and electric energy efficiency. However, this IRP rests on a final forecast that reflects our assessment of the most likely scenario for our future energy requirements and annual capacity obligations (i.e. demand at ISO-NE peak hour plus reserves).

In this chapter, BED provides an overview of its existing energy and capacity resources, as well as a description of the renewable energy credits generated from such resources. This chapter then provides a summary of BED's processes for evaluating future supply options. Lastly, this chapter includes an analysis of the potential resources available to BED to meet its future obligations.

Current Resources

Over the 2020-2040 IRP planning period, BED's existing resource mix is comprised of owned and contracted resources. Table 3.1, below, provides an overview of the basic characteristics of BED's existing resources and describes the growth and expiration of BED's contracted resources during the IRP period.

Table 3.1: 2020-2040 Power Supply Resources

Resource	Description	Fuel	Location	Expiration
BED Owned Resources				
McNeil	Dispatchable unit	Wood	VT Node 474	Owned
BED GT	Peaking unit	Oil	VT Node 363	Owned
Winooski One	Run of river hydro	Hydro	VT Node 622	Owned
Airport Solar	Fixed array rooftop solar	Solar	Internal to BED system	Owned

Resource	Description	Fuel	Location	Expiration
BED (585 Pine St) Solar	Fixed array rooftop solar	Solar	Internal to BED system	Owned
BED Contracted Resources				
NYPA	Preference power	Hydro	Roseton Interface 4011	Niagara: 2025 St. Lawrence: 2032
Hydro Quebec	7x16 Firm energy only	HQ system mix	Highgate Interface 4013 (via market bilateral)	2035 and 2038
VEPPI	PURPA Units	Hydro	Various VT Nodes	2020
VT Wind	Intermittent	Wind	VT Node 12530	2026
Georgia Mountain Community Wind	Intermittent	Wind	VT Node 35555	2037
Great River Hydro	Small hydro portfolio (7x16)	Hydro	Vermont Node 335	2024
Hancock Wind	Intermittent	Wind	Contract delivers to Vermont Zone 4003	2027.
Market	ISO-NE or bilateral energy	System mix	Various NE Nodes	No market energy contracts currently

Resource	Description	Fuel	Location	Expiration
Solar	Long-term contract - Intermittent	Solar	Internal to BED system	2032 and 2043
Solar	Net metering - Intermittent	Solar	Internal to BED system	N/A

- **McNeil Station:** BED is a 50% owner of the McNeil Station, which entitles BED to 25 MW of nameplate capacity (though peak capability is higher). The plant is projected to operate approximately 60-70% of the total available annual hours for the entire IRP period. The selective catalytic reduction unit installed in 2008 has allowed for the reduction of NO_x emissions as well as the ability to improve the economics of plant operations through the sale of Connecticut Class I RECs. BED bids the unit partially based on variable costs but recognizes that REC revenues will be received in addition to energy revenues.
- **Burlington Gas Turbine**: BED is the sole owner of this oil-fired peaking unit with a 25.5 MW nameplate rating. BED's Gas Turbine ("GT") is assumed to be available to provide peaking energy, capacity, and reserves.
- **Winooski One:** BED took ownership of the Winooski One facility effective September 1, 2014. This is a Low Impact Hydropower Institute ("LIHI") certified hydro facility electrically connected to BED's distribution system. LIHI's voluntary certification program recognizes hydropower dams that are minimizing their environmental impacts and enables such low impact projects to access certain REC markets. Winooski One currently produces MA Class II (non-waste) RECs in addition to the energy and capacity normally associated with such a unit. The unit is qualified in the Forward Capacity Market (as an intermittent resource) and operates at an approximate 50% annual capacity factor.
- **Airport Solar:** on January 26, 2015, BED commissioned its 576.5 kW DC (499 kW AC) rooftop solar facility on the Burlington International Airport Parking Garage. BED has a 20-year lease for this rooftop space. With this project, the airport has reduced the need to import energy from outside sources.

- **BED Rooftop Solar:** In October 2015, BED commissioned a 124 kW DC (107 kW AC) solar array on the rooftop of BED's Pine Street headquarters. This new solar array is a BED-owned asset and reduces the need to buy energy from outside sources.

- **NYPA**: BED receives approximately 2.616 MW of New York Power Authority ("NYPA") power through two separate contracts. The contracts, Niagara and St. Lawrence, expire in 2025 and 2032, respectively. Energy under these contracts is favorably priced but NY Independent System Operator ("NYISO") ancillary charges are incurred to deliver the energy to New England.
- **Hydro Quebec**: Along with many of the other Vermont utilities, in 2010 BED executed a contract for firm energy deliveries from Hydro Quebec. For BED, this contract started in November 2015 at 5 MW and will increase to 9 MW beginning November 2020. The current contract expires in 2038. Energy deliveries are by market transfer and are delivered during the "7x16" market period (i.e. hour ending 8 to hour ending 23, all days including holidays). This contract does not provide any corresponding market capacity.
- **VEPP Inc.**: BED currently receives a share (approximately 0.3 MW of nameplate rating) of the output from generators under a contract with VEPP Inc. BED modeled the VEPP Inc. units assuming normal weather conditions with individual unit contracts (and respective output) retiring according to their contract terms. Effective 6/1/2010, VEPP Inc. generators are considered intermittent resources and have a much lower capacity rating than in previous years. In accordance with 30 V.S.A. § 8009(g), as of November 2012, BED only must take an assignment of Ryegate energy if BED fails to meet its statutory baseload biomass requirement by generating at least 1/3 of its annual energy needs with McNeil biomass generation.[1,2,3] BED has met this requirement every year with McNeil generation and plans to continue to do so. During the first year of the IRP period, all the remaining VEPP Inc. contracts for hydro power will expire, but the impact on total energy supply will be quite small.

---

[1] 30 V.S.A. § 8009(a)(2) "Baseload renewable power portfolio requirement" means an annual average of 175,000 MWh of baseload renewable power from an in-state woody biomass plant that was commissioned prior to September 30, 2009, has a nominal capacity of 20.5 MW, and was in service as of January 1, 2011.

[2] 30 V.S.A. § 8009(b) Notwithstanding subsection 8004(a) and subdivision 8005(d)(1) of this title, commencing November 1, 2012, the electricity supplied by each Vermont retail electricity provider to its customers shall include the provider's pro rata share of the baseload renewable power portfolio requirement, which shall be based on the total Vermont retail kWh sales of all such providers for the previous calendar year. The obligation created by this subsection shall cease on November 1, 2022.

[3] 30 V.S.A § 8009(g) A retail electricity provider shall be exempt from the requirements of this section if, and for so long as, one-third of the electricity supplied by the provider to its customers is from a plant that produces electricity from woody biomass.

- **Vermont Wind:** BED receives 16 MW of the 40 MW nameplate capacity of Sheffield Wind Farm in Sheffield, VT. This contract includes the energy, capacity, RECs and ancillary products from the facility throughout the lifetime of the ten-year contract and five-year extension, which will expire in 2026.
- **Georgia Mountain Community Wind**: In 2012, BED entered into a 25-year contract for 100% of the output from the 10 MW Georgia Mountain Community Wind facility. The contract includes energy, capacity, and other credits.
- **Great River Hydro:** BED has two and five-year agreements (covering the period 2018-2024) with Great River Hydro for 7.5 MW of output from a portfolio of hydro resources located on the Connecticut River. The contract is unit-contingent based on the combined output of the three facilities specified and includes the renewable attributes associated with the actual output delivered to BED.
- **Bilateral Market Contracts:** For any energy that BED needs beyond what is supplied by its owned and contracted resources, BED has a long-standing strategy of hedging its exposure to spot market price variability. Based on its energy needs, BED may purchase 1/3 of its remaining energy requirements for the future 7-15 month period at the end of each calendar quarter, if necessary. Such purchases effectively hedge most BED's energy requirements for the following 12-month period. This strategy has been approved by BED's Board of Electric Commissioners and the City of Burlington Transportation and Energy Committee. Additionally, BED's strategy allows for additional purchases if spot energy market prices are at a level that allows some measure of rate stability. Currently, BED does not have significant annual market exposure and is not expecting to rely on the structured purchasing policy in the near future.
- **Solar (Contracted):** BED has obtained the rights to the output of relatively small PV arrays located on several of the City's schools as well as on some non-profit housing properties. These projects are under long-term purchase power agreements that expire in 2032. BED also has the rights to the output of the 2.5MW South Forty Solar array, which expires in 2043.
- **Solar (Net Metered):** Burlington customers can install net metered projects (with solar being the predominant technology in BED's territory). Net metered projects reduce Burlington's load, and lower BED's capacity obligation. At the end of 2019, Burlington had net metered customers in all rate classes:

  Behind the Retail Meter Solar Accounts

  - Residential Service = 216
  - Small General Service = 7
  - Large General Service = 11
  - Primary Service = 1

- Total = 235

Grid Connected Solar Accounts[4]

- Residential Service = 68
- Small General Service = 52
- Large General Service = 28
- Total = 148

- **Vermont Standard Offer Contracts:** Since January 1, 2017, pursuant to PUC Order of January 13, 2017 in case 8863, BED has been exempted from purchasing Standard Offer energy. BED has continued to meet the requirements for this exemption and expects to continue to do so for the IRP period.

Renewable Energy Credits

As shown in the table below, BED obtains RECs from a variety of generation resources. BED generally sells its high value RECs to generate additional revenue. RECs generated from BED's resources could also be retired against load in the future if such retirements help BED to achieve renewable energy requirements at a lower cost than is possible by purchasing replacement RECs.

Table 3.2: BED REC Resources

Resource	Description	Fuel	REC Classification	Status
BED Owned Resources				
McNeil	Dispatchable Biomass	Wood	Connecticut Class 1	Active Sales
Winooski One	Run of River hydro	Hydro	Massachusetts Class 2 (non-waste)	Active Sales
Airport Solar	Fixed array rooftop solar	Solar	Massachusetts Class 1	Active Sales
BED (585 Pine St) Solar	Fixed array rooftop solar	Solar	Vermont Tier 2, Massachusetts Class 1	Active Sales

[4] 38 solar arrays were interconnected directly to the grid, with one or more customers taking a share of generation from these arrays.

Resource	Description	Fuel	REC Classification	Status
BED Contracted Resources				
VT Wind	Intermittent wind	Wind	Tri-Qualified (Connecticut, Massachusetts, and Rhode Island Class 1)	Active Sales
Georgia Mountain Community Wind	Intermittent wind	Wind	Tri-Qualified (Connecticut, Massachusetts, and Rhode Island Class 1)	Active Sales
In-City Solar (8 sites)	Long-term contract (PPA)	Solar	Massachusetts Class 1 (4 of 8 are currently registered); two are also registered as Vermont Tier 2	Active Sales
Hancock Wind	Intermittent Wind	Wind	Tri-Qualified (Connecticut, Massachusetts, and Rhode Island Class 1)	Active Sales

Gap Analysis

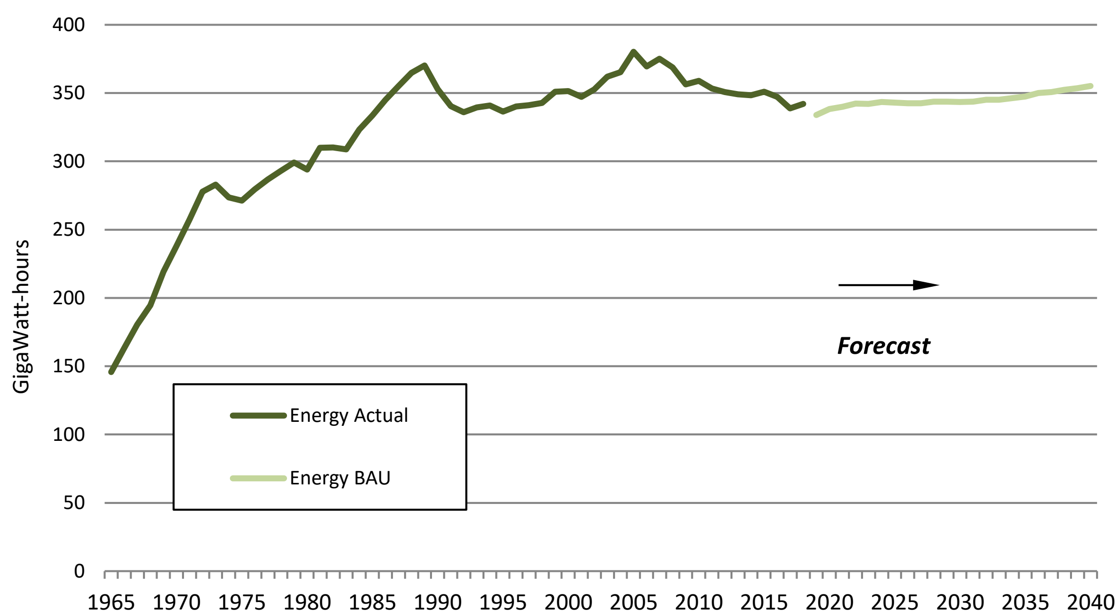
Under the BAU scenario, energy load in the City is expected to increase from 331 GWh to 342 GWh between 2020 and 2023. Thereafter, energy loads, in the aggregate, are forecasted to increase around 0.2% annually. Flat load growth during the outer years is generally perceived to be a function of aggressive energy efficiency programs, rising building codes/standards and appliance efficiency standards, and flat population growth.

There is, however, the potential for energy loads to increase at a faster pace than the BAU scenario. Factors that could drive electric energy loads up include but are not limited to a population growth rate that is higher than originally anticipated, a more robust economy that results in job and business creation and greater acceptance of energy transformation projects than projected or other activities taken by local or State governments that accelerates the pace of strategic electrification.

Energy loads could also decrease relative to the BAU scenario at least in the short term. Lower than expected energy demand would likely be due to increased levels of net metered PV installations, economic recession and/or population migration out of the City and/or Vermont.

Figure 3.1 reflects our BAU load forecast as shown in the Demand for Electricity chapter.

Figure 3.1 System Energy Forecast: 2020-2040



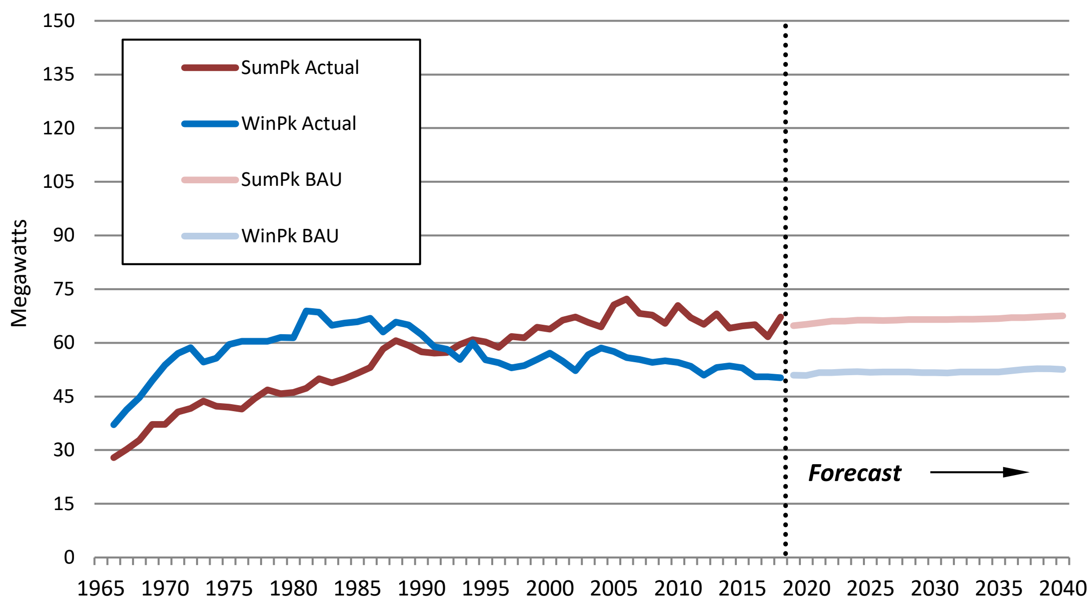
Similar to forecasted energy sales, system peak demand is also expected to remain flat over the short term planning period. Flat growth is contigent primarily on “normal” weather patterns continuing into the future; meaning, summer tempertures do not vary dramatically from historical trends. Under this base case scenario, BED also assumes that the duration of summer hot spells is not materially different than past experiences.

Higher than expected peak demand growth may, however, be driven by a variety of causes. The most likely reason would be hotter than expected summer tempertures. Demand could also rise due to increased population growth, higher employment and/or business formation levels than anticipated, as well as additional cooling demand in building areas that were not previously air conditioned. Such additional cooling load increases, if they occur, could be a consquence of increased adoption in cold climate heat pumps, which also serve as efficient cooling systems during the summer.

Additionally, winter peak demand could increase relative to BAU expectations due to higher than expected market penetration of cold climate heat pumps used for space heating. Since current peak winter demand is considerably lower than summer peak demand, increased use of cold climate heat pumps is not viewed as a potential reliability problem during the winter in the BAU scenario, however, as noted in the Net Zero Energy ("NZE") chapter, Burlington's peak may shift to the winter under the NZE scenarios.

Summer peak demand may also decrease in comparison with BAU in the short term at least. Reasons that may lead to lower peak demand include higher penetration of net metered PV and/or increases in demand resources. Decreases in population growth and economic malaise could also diminish both summer and winter peak demand.

Figure 3.2 System Peak Demand Forecast: 2020 - 2040



As noted above, customer adoption of energy transformation technologies may impact BED's energy and capacity needs in the future. A faster than anticipated rate of adoption of cold climate heat pumps, electric buses, and electric vehicles, for example, could increase BED's need for new energy resources. Also, if more net metered solar arrays are installed, BED's energy requirements could be lower than anticipated. Demand response, solar, and battery storage could reduce peak demand relative to expectations. Whether such technologies can offset one another as they are deployed is unknown at this time. At the current anticipated rates of deployment, BED does not envision a scenario in which such beneficial electrification technologies could have a material negative impact on system reliability. Nevertheless, BED will be monitoring when energy transformation projects are being deployed and the location of such projects to evaluate their impacts, if any, on BED's future energy and capacity needs.

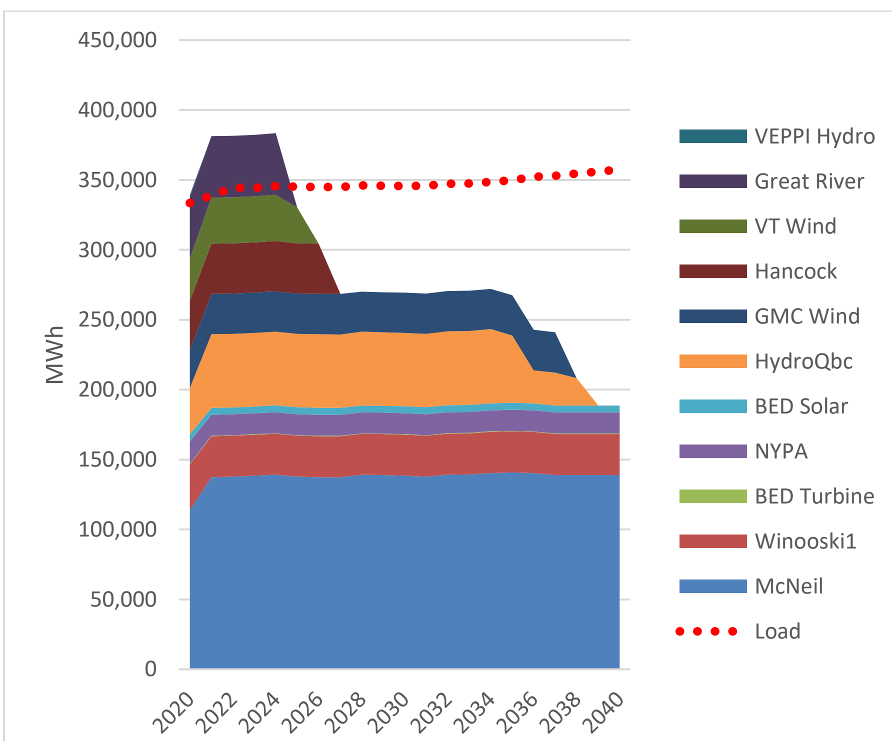
Energy Needs & Resources

BED anticipates that its energy needs will exceed its energy resources from owned and contracted sources by 2025 though this is subject to some risk of lower than anticipated output from intermittent resources. Thus, BED will need to acquire additional resources under contract or purchase spot market energy to close the gap that begins in 2025, as illustrated in

Figure 3.3 below. The energy supply gap beginning in 2025 results from the expiration of the Great River Hydro contract at the end of 2024 followed by the expiration of the extended VT Wind contract and the Hancock Wind contract. BED would require replacement contracts to be from renewable resources; preferably from resources located in Vermont–though an extension of an expiring contract for some time cannot be ruled out.

As in previous IRPs, approximately 40% of BED's energy supply is generated by the McNeil power plant. BED does not expect this situation to materially change during the IRP planning period. However, a long-term loss of McNeil's electrical output, which is highly unlikely, would significantly alter BED's energy position. Also, the economics of the McNeil facility depend on five key inputs: plant costs, capacity factor, the price of energy, the price of capacity, and the price of RECs (currently Connecticut Class 1). Due to historically low wholesale energy prices, the economics of operating the McNeil plant have been challenging over the past few years. For additional information concerning the economics of the McNeil plant, please refer to McNeil study in the appendix. While the McNeil plant operated at a loss in 2019, the study determined that its continued operations generate substantial societal benefits.

Figure 3.3: Forecasted Load v. Projected Supply Resources as of July 2020

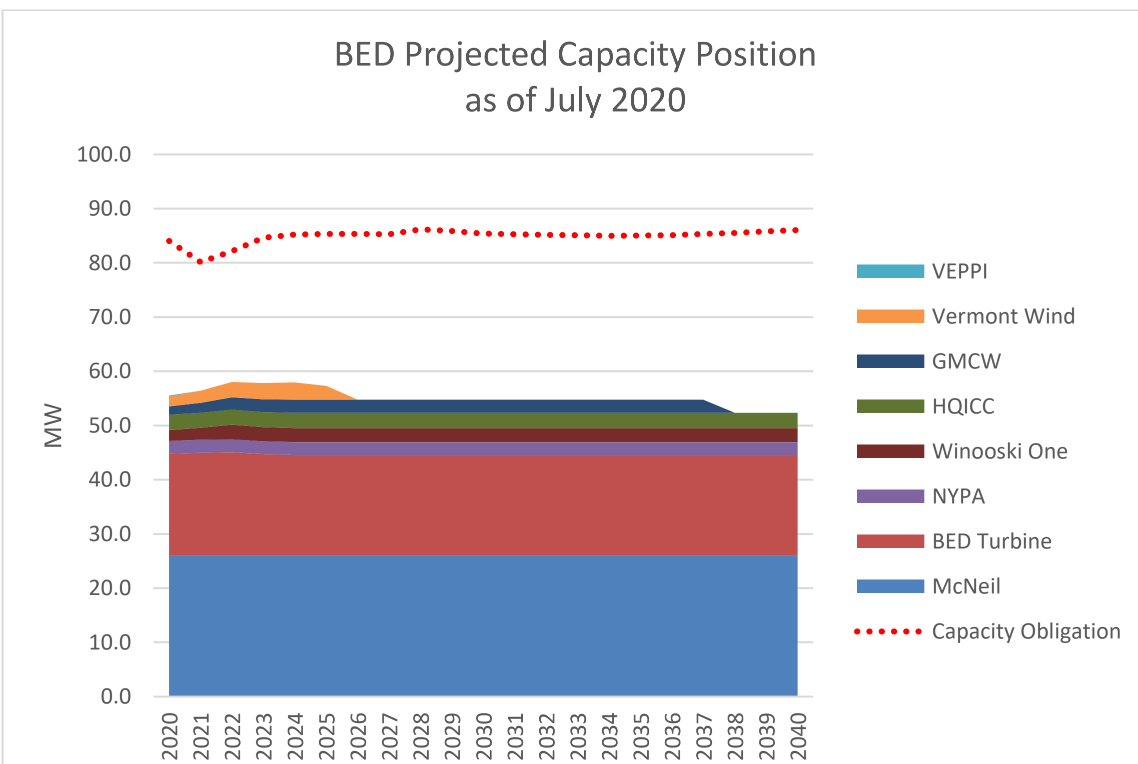


Resource Capacity

BED owns and contracts for generation resources sufficient to satisfy roughly two-thirds of its capacity obligation, inclusive of the 15% reliability margin imposed on all distribution utilities by ISO-NE (see Figure 4.4 below). Of the resources that BED controls, two facilities provide most of the capacity available to comply with regional requirements. These resources are the 50 MW McNeil biomass facility and the 25 MW gas turbine.[5]

To make up the capacity shortfall, BED is required to purchase additional capacity. Such payments are necessary to ensure generators in New England are able earn revenues during all times of the year even though they may only be needed during the hottest days of the year. This potential for a capacity shortfall is not unique to BED and many distribution utilities in New England are also required to pay generators for their capacity should it be needed. BED anticipates, as do many other Vermont distribution utilities, that this capacity shortfall situation will persist into the future. Accordingly, BED has undertaken additional evaluations of alternative resources to identify a cost-effective path forward. As discussed in more detail below, these additional evaluations might include building additional capacity resources, contracting with another generator, or pursuing demand response initiatives, including energy storage.

Figure 3.4



[5] BED owns a 50% share of the McNeil Plant.

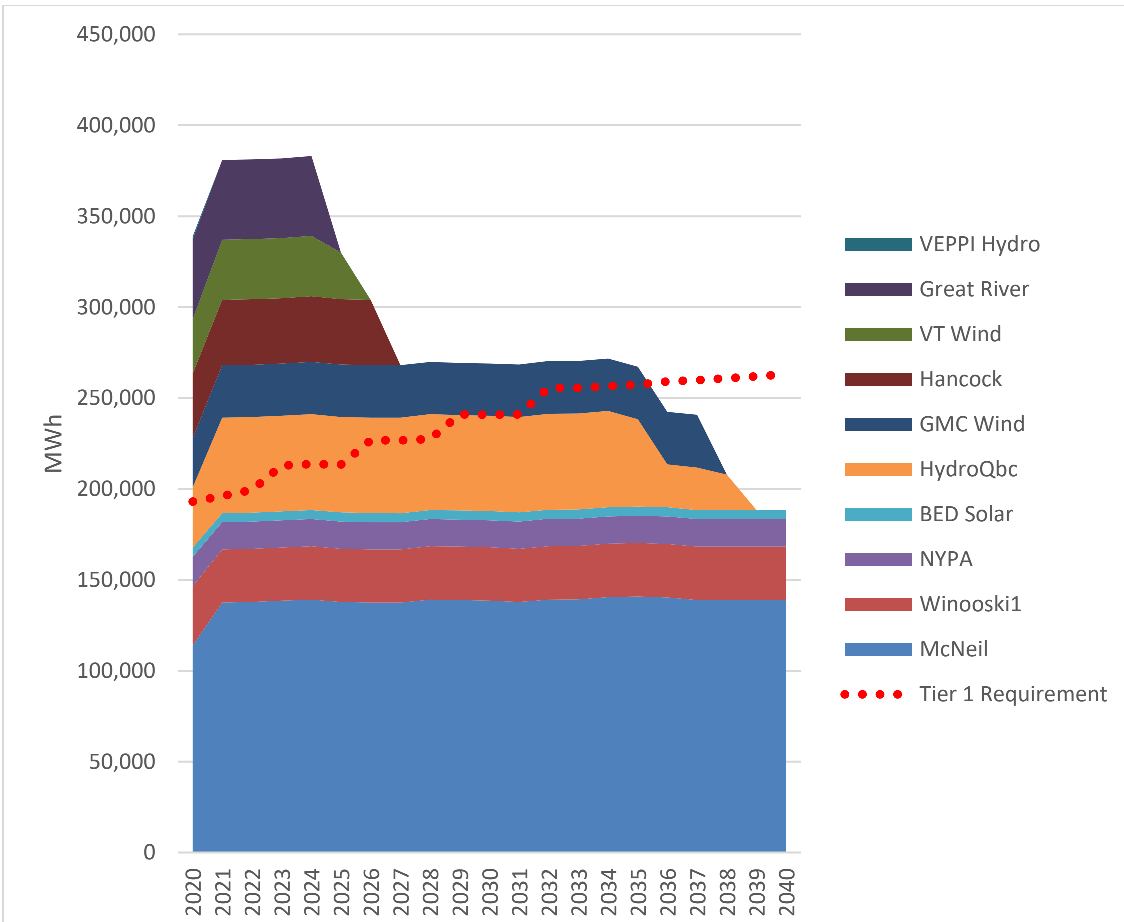
Renewability Needs & Resources

In addition to BED's own commitment to meeting 100% of its energy needs with renewable resources, BED is also subject to Vermont's Renewable Energy Standard (RES). The RES will impact BED's need for specific types of energy resources over the IRP time horizon.

RES Tier 1

With its current resources, BED is in a strong position to satisfy its Tier 1 obligation, which required 55% of retail sales in 2017 (increasing annually to 75% by 2032) to be met with renewable resources. As shown in Figure 5.4, BED expects to be greater than 75% renewable just with its current resources through 2034.

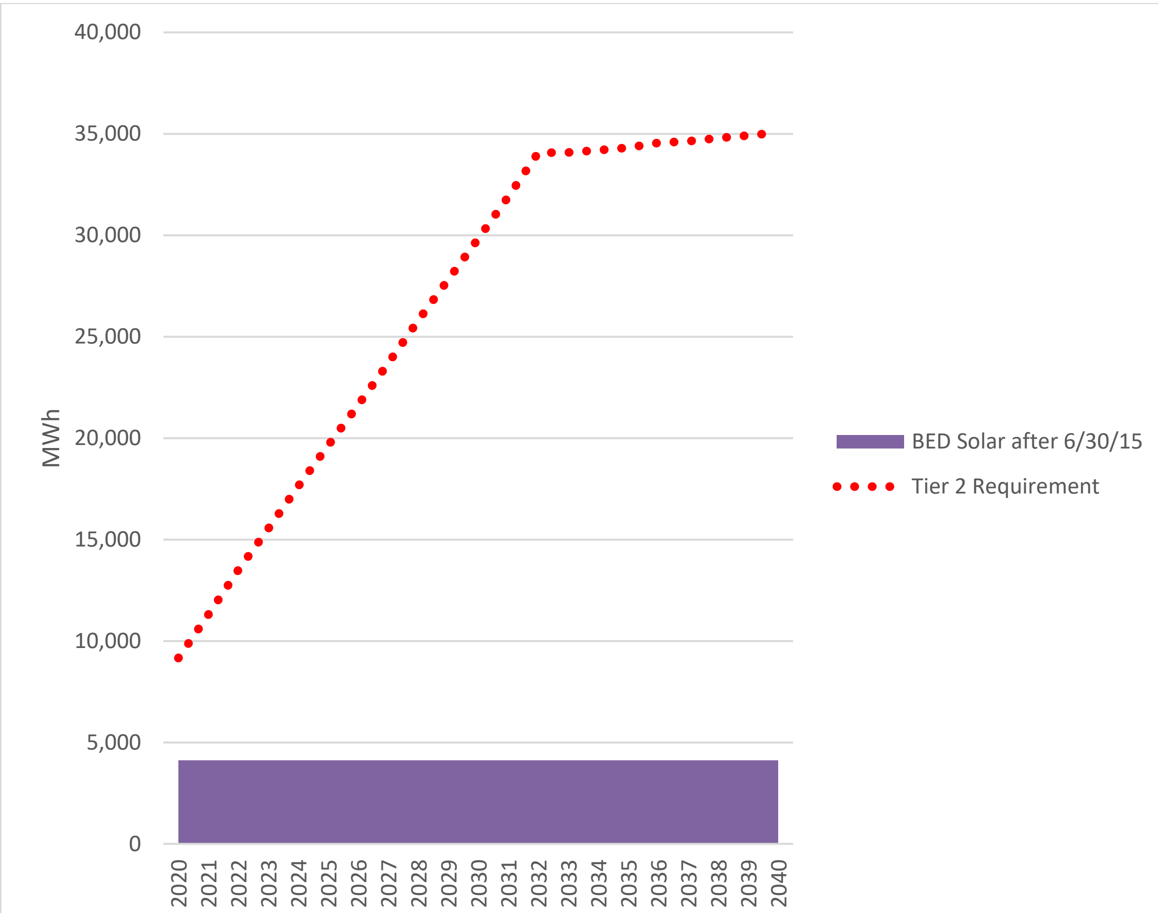
Figure 3.5: BED Tier 1 Requirement and Eligible Resources as of July 2020



RES Tier 2

Because of its renewability, BED has also been able to modify its RES Tier 2 requirement. Without such modification, the RES would have required 1% of BED's retail sales (increasing annually to 10% by 2032) to be met with distributed renewable generation. Because of the Tier 2 modification, BED will be able to apply non-net metering Tier 2 resources to its Tier 3 requirements. To comply with Tier 2, BED will still need to accept net-metering installations and retire the associated RECs it receives. As Figure 5.5 shows, if BED does not maintain its 100% renewability, there may be a large gap between its Tier 2 requirement and Tier 2 eligible resources. In that situation, BED does not anticipate that excess net metering credits would be available to apply to its Tier 3 requirement.

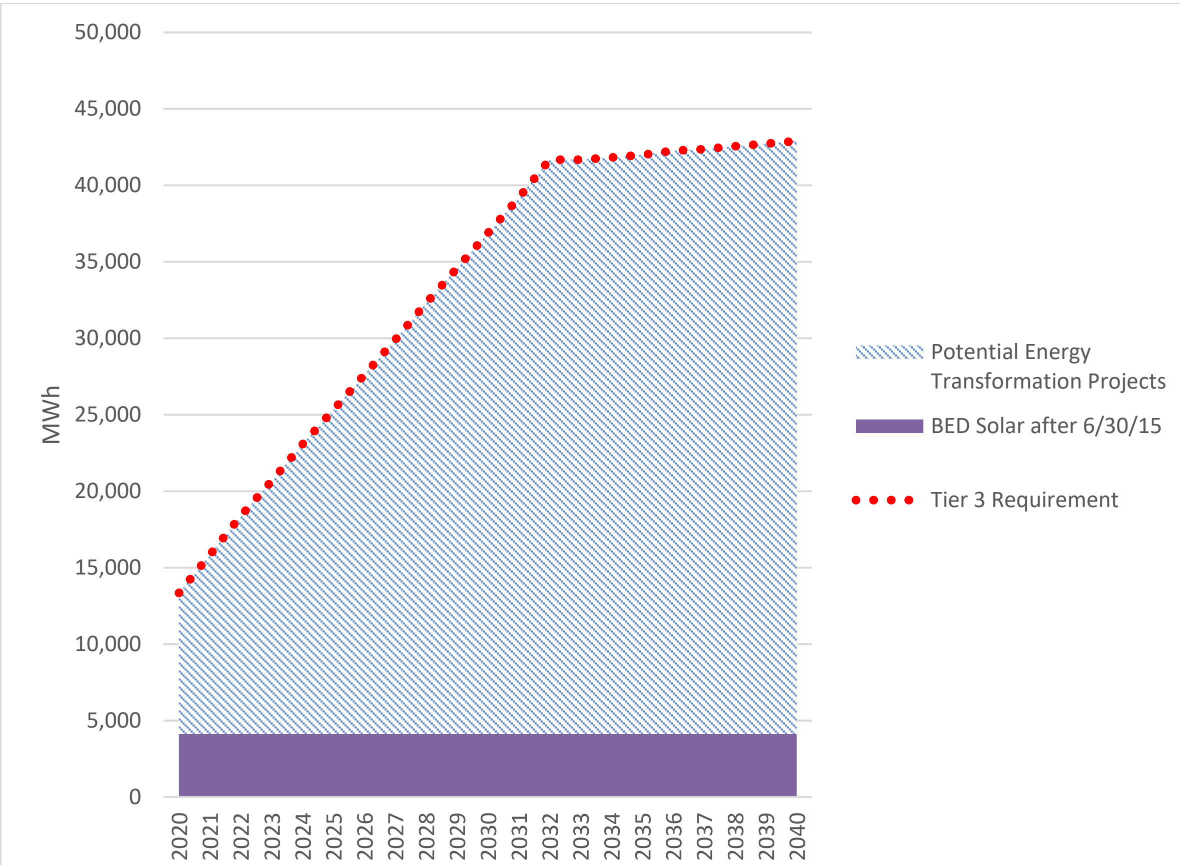
Figure 3.6: BED Tier 2 Requirement and Eligible Resources as of July 2020



RES Tier 3

The Tier 3 requirement, which began at 2% of retail sales in 2017 and increases annually to 12% by 2032, can be satisfied with non-net metered Tier 2 distributed renewable energy, additional distributed renewable resources, or with "energy transformation" projects that reduce fossil fuel consumption. As Figure 5.6 shows, even when Tier 2 resources are applied to Tier 3, there is a large gap between BED's Tier 3 requirement and its eligible resources. BED has a statutory right to pursue reductions in its Tier 3 requirement (based on its renewable status and status as an Energy Efficiency Utility). However, through analyses contained in the Energy Services chapter of this IRP, BED has concluded that sufficient Tier 3 potential in Burlington exists. For the first three years of the RES, however, BED did not reach its Tier 3 requirement with projects and relied on REC retirements to avoid alternative compliance payments. BED continues to advance energy transformation projects and has forgone its option to request modifications of its RES requirements thus far.

Figure 3.7: BED Tier 3 Requirement and Eligible Resources as of July 2020



Gap Analysis Findings

A comparison of BED's projected energy and capacity requirements against its available supply resources reveals several key issues:

- Although flat load growth is anticipated to continue well into the future, BED expects that it will need to continue making monthly capacity payments to comply with regional reliability requirements. The price of wholesale capacity could increase substantially if not hedged or actively managed.
- Loss of McNeil, the Gas Turbine or both would create a significant financial risk, as BED would be required to make up additional energy and capacity deficits by purchasing resources at wholesale market prices.
- Continued reliance on REC revenue exposes BED to REC market volatility.

- Maintaining BED's status as a 100% renewable distribution utility costs more than purchasing wholesale market/system power which is at historically low prices.
- As a 100% renewable provider, BED complies with Tiers 1 and 2 of the state's renewable energy standard ("RES"). The potential loss of McNeil, which generates up to 40% of BED's renewable energy, could undermine BED's ability to comply with the RES.
- Even if BED maintains its 100% renewability status, current Tier 2 resources can only meet about 10% of its Tier 3 requirements in the later years of the RES. Thus, BED will need to pursue energy transformation projects or Tier 2 resources.
- If BED is unable to maintain its 100% renewability status and cannot modify its Tier 2 requirement, then it will need to acquire significantly more Tier 2 eligible distributed renewable generation resources.

Tier 3 Activities Impact on Energy and Capacity Needs

As described in the Energy Services chapter, BED intends to pursue multiple energy transformation projects to comply with Tier 3 of the RES. Many of these projects will add energy loads and peak demands to the system over time. In its base case, however, BED expects that the annual electric energy consumption and peak demand requirements of these projects will be minimal relative to the total resources we have on hand. Additionally, energy efficiency resources will continue to help offset increases in load from such energy transformation projects, as will active demand resources and new net metered PV arrays. In general, the inclusion of Tier 3 anticipated loads does not change BED's resource questions substantially.

Alternatives Analysis Methodology

The gap analysis highlighted three major issues that needed additional consideration and analysis. These included:

- Effectiveness,
- Accessibility, and
- Costs

The following section provides an overview of BED's methodology and processes for assimilating data as they pertain to its assessment of a potential resource's overall effectiveness, accessibility and cost. In general, a resource is deemed effective based on its ability to reliably produce energy and capacity when needed, and if it is renewable. In terms of accessibility, BED considered whether the alternative resource would be available for acquisition during the IRP planning horizon and, if so, at what cost. As an example, BED's efforts did not consider coal as a resource since pursuing a coal strategy would have been incongruent with BED's overall objectives and Vermont's values.

Resource Effectiveness

The extent to which a specific resource can meet BED's projected energy, capacity, or renewability needs is a critical evaluation component. As noted in the gap analysis, BED has unmet needs for both energy and capacity, and has ongoing renewability targets. Generally, the ability for a single resource to meet multiple supply needs is advantageous. However, the difference in magnitude between BED's energy and capacity supply needs suggests identifying a single resource to meet both in a cost-effective manner could be challenging. Additionally, the generally poor performance of renewable resources as capacity providers further suggests that it will be difficult to meet renewable energy goals and capacity needs with the same resource.

Energy

There are many types of energy supply resources ranging from highly controllable and dispatchable generators (such as biomass and combined cycle natural gas) to intermittent and uncontrollable renewable resources like wind turbines and run of the river hydro units. Those resources that are controllable and dispatchable generally have a higher capacity factor and are viewed as more reliable energy resources.

Capacity

Traditional "peaker" resources such as fossil fuel fired generators may be cost-effective capacity supply resources but are rarely a cost-effective energy supply resource. Some energy producing resources (typically dispatchable resources) also provide significant capacity, but if the full energy output is not needed or desired, the energy would have to be sold, which leaves a utility vulnerable to wholesale energy market volatility. For the purposes of this alternative analyses, a resource that effectively meets both BED's energy and capacity needs would be ideal. However, renewable resource capacity supply options are limited and require sales and purchases in the fluctuating wholesale capacity market.

Renewable Energy Standard – Tier 1

In addition to meeting locally developed goals, BED's current 100% renewable position provides important benefits with respect to meeting Vermont's RES and avoiding costly alternative compliance payments ("ACP"). Under RES Tier 1, starting in 2017, Vermont utilities were required to source 55% of their energy from renewable resources, increasing annually to 75% by 2032. If a utility is unable to meet this requirement it is subject to an ACP for each kWh it is short of the requirement. Therefore, Tier I renewable resources are a valuable component of BED's portfolio.

Renewable Energy Standard – Tiers 2 & 3

As of 2017, Tier 2 of the RES requires utilities to meet 1% of their retail sales with new Vermont distributed renewable generation with plant capacity of five MW or less. This 1% requirement increases annually up to 10% by 2032. Tier 3 of the RES requires utilities to encourage their customers to reduce fossil fuel consumption by an amount equal to 2% of their retail sales in 2017, increasing annually to 12% by 2032. If BED maintains its 100% renewable position, it can meet an alternate Tier 2 requirement as provided in 30 V.S.A. § 8005(b). For both Tiers 2 and 3, any failure to meet the requirements leaves utilities vulnerable to an ACP six times higher than the Tier 1 ACP of $10. Therefore, resources that meet the Tier 2 or Tier 3 requirements provide significant value to BED.

Resource Access

BED's ability to access a type of resource affects its attractiveness and effectiveness with respect to other resource alternatives. Each resource alternative is assessed for its availability, meaning that BED could access it through typical utility mechanisms and without extraordinary measures or unusual circumstances. Each resource is also evaluated based on whether BED could reasonably expect to have the opportunity to own it (or a portion of it) or conversely, whether BED would have to own it in order to have access to it. In all cases, greater availability is viewed positively.

Resource Cost

Resource cost analysis of a potential resource is composed of an evaluation of any initial and ongoing costs, as well as an assessment of whether the resource is consistent with BED's internally developed goals. In all cases, lower initial and ongoing costs are preferable.

Initial Cost

In most cases, the initial cost is the upfront capital cost associated with purchasing or constructing a resource. These costs are typically financed over a long period of time and are fixed as opposed to ongoing cost which can be variable based on resource output.

Ongoing Costs

Ongoing costs can be fixed and variable. Fixed ongoing costs can include property taxes and standard operating and maintenance costs. Variable costs can include transmission and wheeling fees. Most ongoing costs apply whether the resource is owned or a PPA.

Consistency with BED Goals

BED and the City of Burlington have a long-standing commitments to innovation and the protection of the environment, as demonstrated by its achievement of 100% renewability and commitment to achieve the City's NZE by 2030 goal. To ensure the ongoing achievement of such goals, BED must consider the extent to which each potential resource will BED's goals. While it is not necessarily feasible to quantify this value, consistency with BED's goals may make an otherwise more expensive resource based on initial and ongoing costs more attractive than a lower cost resource. While non-renewable resources will not advance BED's renewability goals, consideration of such resources does, at a minimum, provide a useful benchmark for cost comparison with renewable resources.. Additionally, non-renewable resources provide value as capacity providers provided they are not used for production of any material amount of energy annually (i.e. are being used to serve reliability versus energy needs).

Resource Risk

There are cost risks associated with every generation and supply resource alternative. Some risks, such as variable fuel, maintenance, or capital costs, are easy to quantify while others are more difficult such as potential regulatory changes. BED has completed the following review of known and anticipated risks of each potential resource to assess the most likely financial and societal costs.

Resource Analysis Summaries

Each of the following resource analyses summarizes the resource's effectiveness at meeting BED's goals, and their accessibility, costs and risks.

Resource Environmental and Locational Considerations

BED staff has been working on a draft metric that combines resource direct land use requirements and weighted distance from load metric to include when evaluating competing resource options. This metric does not monetize this value but does reduce it to a numeric value for comparisons. This metric is available in draft format for discussion in future decisions but could use additional development. BED's Strategic Direction calls for expanding local generation and serving energy needs in a socially responsible manner. The majority of BED's energy is now produced in Vermont, and about half is in Burlington. BED continues to work on tools to explicitly calculate the relative merits of power portfolios based on both their location and environmental impacts.

Alternatives Analysis

This section provides a description of each resource followed by a summary of each resource's overall effectiveness, accessibility, and cost. These summaries are used to complete the Generation & Supply Alternatives Matrix located at the conclusion of this chapter which provides an overview of how selected resources compare to one another. This comparative analysis helps to determine which resource options have the greatest potential for meeting the public's need for energy services at the lowest present value costs, including environmental and economic costs.

The following list of potential resource alternatives was developed with the 2020 IRP Committee. To help the committee evaluate and compare resource options, BED assembled the capital cost, fixed and variable operating and maintenance ("O&M") cost and levelized costs using the levelized cost of energy analysis performed by Lazard in 2019,[6] and well as the Battery Energy Study for PacifiCorp's IRP.[7]

Table 3.3: Potential resource alternatives

Plant Type	Net Output (MW)	Capital Cost ($/kW)	Fixed O&M Cost ($/kW-year)	Variable O&M Cost ($/MWh)	Levelized Cost ($/MWh)
Solar-Utility Scale-Crystalline	100	$900-$1,100	$9-$12	$0	$36-$44
Wind-Onshore	150	$1,100-$1,500	$28-$36.50	$0	$28-$54
Wind-Offshore	210-385	$2,350-$3,550	$80-$110	$0	$64-$115
Storage	10	$1,548-$2,322	$0.3-$18	$0	$142-$193
Gas Peaking	50-240	$700-$950	$5.50-$20.75	$4.75-$6.25	$150-$199
Gas Combined Cycle	550	$700-$1,300	$11-13.5	$3-$3.75	$44-$68

In order to evaluate the value of capacity supply options across all types of resources, the 2019 capital cost per kW of each resource was converted into a cost per kW-month value, as shown below. This analysis indicates that the lowest discounted cost resource is any natural gas plant located in New England. By way of comparison, ISO-NE market processes have also estimated that the cost to construct a new natural gas fired power plant would be approximately $11.95/kW-month to build.[8] This cost benchmark is oftentimes referred to as the "cost of new entry" or the CONE value. However, in the most recent forward capacity auction, FCA 14, generation actually cleared at $2.00/kW-month, well below the current CONE value.[9] This data suggests that new generators are able to enter the New England market for capacity at or below today's CONE values. Although wholesale capacity costs may be relatively low at present, BED remains concerned that current low prices may be fleeting. To reiterate, BED's capacity-related price exposure is low for the next 3-4 years due to decreasing cleared capacity market prices. At this point BED's capacity price risk after the currently cleared auctions would be mostly "up side" risk, but the current capacity market structure would reveal price changes with three years warning which would allow for potential mitigation activities prior to incurring capacity charges.

---

[6] https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-130-vf.pdf, accessed August 2020

[7] https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/integrated-resource-plan/2017-irp/2017-irp-support-and-studies/10018304_R-01-D_PacifiCorp_Battery_Energy_Storage_Study.pdf

[8] https://www.iso-ne.com/markets-operations/markets/forward-capacity-market/, accessed July 2020

[9] https://www.iso-ne.com/about/key-stats/markets#fcaresults, accessed July 2020

Table 3.4: Alternative Resources capacity cost evaluation

Plant Type	Capital Cost ($/kW)	Cost ($/kW-month)	Assumed ISO-NE Discount (Nameplate MW to Forward Capacity Market MW)	Discounted (ISO-NE) Cost ($/kW-month)
Solar-Utility Scale-Crystalline	$900-$1,100	$5.77	14%	$41.22
Wind-Onshore	$1,100-$1,500	$7.50	25%	$30.01
Wind-Offshore	$2,350-$3,550	$17.03	36%	$46.99
Storage	$1,548-$2,322	$11.17	100%	$11.17
Gas Peaking	$700-$950	$4.76	100%	$4.76
Gas Combined Cycle	$700-$1,300	$5.77	100%	$5.77

In addition to the resources listed below, BED has access to energy and capacity resources through the wholesale markets operated by ISO-New England. Net wholesale energy and wholesale capacity purchases occur automatically under the ISO-NE market structure and can be viewed simply as a "do nothing" option.

Below BED analyzes a series of resources types: Biomass, Solar, Wind, Storage, Combined Cycle Natural Gas, Traditional "Peaker", and Long-Term contracts.

Biomass

Resource Description

In this analysis, "biomass" refers to using waste wood or sustainably sourced/harvested wood/plant-based materials to generate energy. For the purposes of the alternatives analysis, BED's current share of McNeil is classified as "existing biomass" while term "additional biomass" refers to the procurement of some portion of the 50% share of McNeil not currently owned by BED.

Resource Analysis

Resource Effectiveness

Energy

BED has direct expertise with generating biomass energy at its McNeil facility. For 36 years, McNeil has provided reliable and flexible energy supply resource and participated in the day ahead and real time wholesale energy markets. McNeil's capacity factor ranges from 55-70%, allowing BED to meet approximately 40% of its energy needs with McNeil. For the purposes of this analysis, we increased the share of BED's energy needs produced by McNeil proportionally over time. On a day-to-day basis, however, BED tends to be long on energy when McNeil is running, and short when it is not. Acquiring an additional share of McNeil would exacerbate this issue.

Capacity

McNeil's qualified capacity rating according to ISO-New England's Forward Capacity Market ranges from 52 to 54 MW (full nameplate capacity). McNeil is entered into the FCM as a self-supply resource for BED; providing 26 MW of capacity supply that BED can consistently rely on to meet its capacity requirement.

Renewability

McNeil is equipped with a series of air quality control devices that limit the particulate stack emissions to one-tenth the level allowed by Vermont state regulation. McNeil's emissions are one one-hundredth of the allowable federal level. The only visible emission from the plant is water vapor during the cooler months of the year. In 2008, McNeil voluntarily installed a $12 million Regenerative Selective Catalytic Reduction system, which reduced the Nitrogen Oxide emissions to 1/3 of the state requirement. Due to these measures, McNeil energy qualifies under the Connecticut Renewable Portfolio Standard and each MWh of energy generated creates a Connecticut Class 1 REC. Additionally, McNeil's energy qualifies as renewable under Tier 1 of the Vermont RES.

Resource Access

Availability

While BED has a 50% ownership share of McNeil, the other 50% is shared among two entities: Green Mountain Power (31%) and Vermont Public Power Supply Authority (19%). The three owners meet quarterly and maintain open lines of communication regarding the facility's operations and finances. In that regard, BED has direct and frequent access to the parties who could make additional biomass resources available. BED could discuss options with the joint owners to access a greater share of McNeil's energy, capacity, or both.

Ownership

As noted above, BED has an existing ownership share and a direct relationship with the other joint owners, making ownership of additional biomass possible from an access standpoint.

Resource Cost

Initial Cost

If BED pursued a greater ownership share, there would be potential for significant initial costs related to "buying out" current joint owner shares. This cost would be less if instead BED were to enter into a contract to purchase a joint owner's share of energy or capacity, but not full ownership rights.. However, the price of a buy-out is dependent on the potential seller's interest.

Ongoing Cost

BED has firsthand knowledge of McNeil's current operating and maintenance costs. When compared to other controllable and dispatchable energy supply resources, McNeil's variable costs are relatively high. As BED manages the sale of McNeil's Connecticut Class 1 RECs for both BED and GMP, BED is aware of the importance of REC revenue in helping McNeil remain a cost-effective energy supply resource by offsetting the cost of production. Falling REC prices would essentially make McNeil more expensive to operate. McNeil is also an aging plant and increased maintenance costs and additional capital expenses are anticipated in the coming years.

Consistent with BED Goals

Acquisition of additional biomass would further BED's renewability and sustainability goals by assisting with maintaining 100% renewability, meeting RES Tier 1 requirements, and helping to achieve the City's NZE by 2030 goal.

Resource Risk

Biomass is different from other renewable resources like solar and wind because it requires fuel and generates emissions. Accordingly, the renewability classification of biomass is tied in large part to the sustainability of its fuel as well as its level of emissions. More stringent regulations with respect to fuel, emissions or biomass generally could alter its renewability classification and potentially impact the availability of high value RECs and RES compliance eligibility. With BED already relying on McNeil for 40% of its energy supply, greater reliance on McNeil could increase BED's exposure to the resulting market impacts in the event of such regulatory changes.

Resource Conclusion

The most viable option for BED, if it were to desire additional biomass energy, would likely be to seek to buy out some or all of one or more of the other Joint Owners entitlements. However, this would carry some additional single resource risk and BED does not intend to pursue this at this time.

Potential impacts of acquiring additional biomass resources from McNeil are:

- McNeil is a reliable renewable energy and capacity resource that furthers BED's goals and current RES requirements.
- BED has a high level of access to the resource and could investigate shorter term non-ownership options to avoid high initial costs or a higher share of future capital expenditures. BED could also consider increasing its ownership share of McNeil, if one of the other Joint Owners sought to reduce their ownership share.

Potential risks of acquiring additional biomass resources from McNeil

- In terms of cost, McNeil already has relatively high operating costs, with the potential for its net expenses to increase in the event of declining REC revenue in the future.
- Increased reliance on McNeil would expose BED to greater risk in the event of regulatory changes and resulting REC market impacts.

Solar

Resource Description

For the purposes of this analysis, any solar array where BED would be entitled to some portion of the output is analyzed.

Resource Analysis

Resource Effectiveness

Energy

In northeastern US, stand-alone solar has a capacity factor of approximately 15%. It's relatively low capacity factor means that solar alone would be unlikely to provide a good hedge for energy prices. As BED tends to be long on energy in the winter, and short on energy in the summer, solar has the potential to help BED hedge its energy needs on a seasonal basis.

Capacity

Small solar facilities that are less than 5 MW generally do not participate in ISO-NE's FCM. Passive reductions of BED's loads from solar at times when charges for capacity are set allow smaller solar to serve as a capacity resource. Increased behind the meter solar has shifted the ISO-NE peak to later in the day which has reduced its capacity benefit. Larger solar can also provide capacity, however, ISO-NE's current market rules recognize solar at approximately 10% of nameplate capacity.

Renewability

Solar PV is a Tier I eligible renewable resource. Additionally, distributed generation facilities that are less than 5 MW in capacity are Tier 2 eligible resources. Such facilities that are not net metered[10] are also Tier 3 eligible (BED must retire all net metering RECs to retain its exemption from the remainder of Tier 2). Alternatively, RECs produced by solar resources can also be sold to provide revenue to BED.

Resource Access

Availability

BED has supported development of several solar projects in the City of Burlington. By its nature, solar distributed generation is smaller in scale and requires less land for siting purposes than utility-scale generation. While Burlington is a densely populated area with limited open land, there are further opportunities for solar development on rooftops and brownfields within the City. With additional siting potential and the continued decline of the cost of solar panels, BED views solar PV development as an available resource.

Ownership

BED currently owns two behind the utility meter solar arrays and has experience developing such projects. The City of Burlington owns many buildings and land within the City making BED acquisition and development of additional solar PV arrays feasible.

Resource Cost

Initial Cost

Among the renewable resource options considered, a distributed generation solar PV array has the highest initial cost at approximately $1,000 per kW of installed capacity.

Ongoing Cost

The ongoing costs of a solar array consist solely of fixed O&M costs of $9-12 kW-year. The levelized cost of energy for utility-scale solar ranges from $36-$44 per MWh in the Lazard study, though in practice the range will be substantially larger due to regional variation in capacity factor. Distributed generation resources of less than 5 MW are eligible under Tier 2 and could be applied to Tier 3, helping BED avoid an alternative compliance payment under the RES.

---

[10] 30 V.S.A. § 8005(b)

Consistent with BED Goals

Solar arrays would be consistent with BED's renewability goals and could directly support its NZE target.

Resource Risk

With a capacity factor of only around 15% in Vermont, the effectiveness of solar as an energy resource is limited. Because ISO-NE is currently summer peaking during daylight hours, solar functions as a reasonable capacity resource, reducing load during peak periods. As more solar resources have come online, the ISO-NE peak has shifted later in the day, moving beyond the time of the greatest solar production. Therefore, there is a risk that the energy and capacity value of solar could decrease over time as more solar is deployed.

Resource Conclusion

While solar has a low capacity factor, particularly in the northeast, solar can serve as a capacity resource by reducing load during the ISO-NE peak or by directly participating in the ISO-NE Capacity Market. Solar PV under 5 MW is also an eligible Tier 2 resource and could help BED meet its RES Tier 3 requirement. In terms of BED's renewability goals and NZE target, solar PV could be a very effective resource. However, given BED's urban landscape and ISO-NE market rules, BED expects that solar development in Burlington will, in large part, be net metered solar on building rooftops. The cost-benefit analysis of solar generation resources that are developed in other utility service territories, are severely hinders by the imposition of transmission (i.e. "wheeling") charges by the host utility, except when the solar generation is directly connected to the high voltage transmission system.

Wind

Resource Description

For the purposes of this analysis, utility scale wind refers to onshore and offshore wind farms consisting of multiple large wind turbines that have a combined nameplate capacity of 10 MW or more. According to ISO-NE, as of 2019 there were 1,400 MW of grid connected wind resources installed in the ISO-NE region with an additional 14,200 MW in its interconnection queue, the vast majority of which is offshore.[11]

Resource Analysis

Resource Effectiveness

Energy

Wind generation is an intermittent resource that can exhibit rapid changes in its production due to weather. Onshore utility-scale wind farms have historically

[11] "2020 Regional Electricity Outlook," page 10, ISO-New England, February 2020.

sustained capacity factors of 25-35% over time. Offshore wind is expected to achieve even higher capacity factors. For example, the Block Island Wind Farm attained a 45% capacity factor in 2019.[12]

Capacity

Due to its intermittent nature, ISO-NE does not define wind as an effective capacity supply resource. Because wind resources are not controllable and, thus, cannot be assumed to be available at times when energy demand is highest, ISO-NE "de-rates" wind generators nameplate capacity when it assigns its qualified capacity ("QC") rating. However, it is worth noting that during ISO-NE's pay-for-performance event,[13] all three of BED's wind resources produced above their ISO-NE's capacity ratings and commitments.

Renewability

Wind is a fuel- and emission-free renewable resource. Wind resources qualify for high value RECs in multiple markets throughout New England and nationally. Wind therefore qualifies as an eligible resource to meet BED's RES Tier 1 requirement.[14]

Resource Access

Availability

There are currently five utility-scale wind farms in Vermont; Searsburg Wind Facility (6 MW), Georgia Mountain Community Wind (10 MW), Sheffield Wind (40 MW), Deerfield (30 MW) and Kingdom Community Wind (63 MW). BED currently purchases energy from Georgia Mountain Community Wind, Vermont Wind, and Hancock Wind for 100%, 40%, and 26% of their respective outputs. As noted above, BED views wind resources favorably on multiple levels (i.e. energy output, cost, renewability, access etc.), but new resources are unlikely to be available at the utility-scale in Vermont.

Ownership

While BED has three existing wind contracts, it does not currently own any utility scale wind facilities. However, as new resources are built in the ISO-NE

---

[12] EIA Form 923, https://www.eia.gov/electricity/data/eia923/

[13] As of July 2020, the only pay-for-performance event occurred on Labor Day 2018. More information on Pay-for-Performance is here: https://vimeo.com/257500308, accessed August 2020.

[14] Due to restrictions on facilities 5 MW and greater, large scale wind is not available for Tier 2 or 3 purposes.

region, BED may consider additional purchase power arrangements if warranted.

Resource Cost

Initial Cost

Of the renewable resources evaluated, wind has the potential to provide some of the lowest cost energy on a per kWh basis due to its moderate initial cost and low ongoing costs (i.e. its absence of a fuel cost) . According to the above tables, capital costs range between $1,100 and $1,500/kW for onshore wind. Our research also indicated that the cost of wind turbines has decreased in recent years and is anticipated to continue falling over the next several years.

Ongoing Cost

Compared to other fuel-free renewable resources, the fixed O&M costs of wind can be relatively high. However, on a levelized energy cost basis, onshore wind appears to be among the lowest cost renewable energy resources and is reaching cost parity with combined cycle natural gas generators. Offshore wind costs are also expected to continue to decline as developers gain experience building systems and larger systems reach economies of scale relative to conventional generators.

Consistent with BED Goals

As a renewable and zero emission resource, wind is consistent with and supportive of BED's goals. The existence of wind resources in Vermont and the continued development of new wind resources in New England also suggests that wind resources would continue to be available as a component of NZE aspirations for the City of Burlington. However it should be noted that the effective moratorium on new VT wind resource development will result in a conflict with the desire for resources located as close to BED's load as practical.

Resource Risk

As noted, wind generation production is subject to weather conditions. As a utility increases the proportion of its load met with such intermittent resources, it must consider methods to smooth out intermittency. Increasingly affordable storage technologies could help address the issue in the future, but in the meantime, greater reliance on intermittent resources like wind could increase BED's exposure to wholesale energy prices to supplement BED's energy resources during low wind production periods. In the past, development of utility scale wind in Vermont has faced public opposition so any BED investments in prospective Vermont-based wind resources would likely be subject to permitting and construction delays.

Resource Conclusion

Despite its intermittency, BED views wind generation as a moderately strong energy resource, and a less effective capacity supply resource. Levelized energy costs for wind are becoming increasingly competitive, and offshore wind is beginning to become a cost-competitive resource for helping other New England states reach their respective renewability targets. Additionally, wind generates high value RECs that can generate utility revenue or be used to meet RES Tier 1 requirements.

Storage

Resource Description

Energy storage can take many forms, including several types of batteries, pumped hydro, and flywheels, among others. Storage can be viewed as a unique resource because many of the technologies operate both as a supply resource and a load resource.[15] This analysis discusses a 10 MW of capacity/40 MWh of energy storage ("10 MW/40 MWh"), utility-scale, ISO-recognized lithium ion battery storage system that could replace a fossil-fuel powered peaking unit.

Resource Analysis

Resource Effectiveness

Energy

A battery storage system does not generate electricity, but rather serves as a control device that allows a utility to dispatch its stored energy when needed or to capture and store energy at times of surplus intermittent renewable generation. Further advantages of storage are its ability to respond quickly to rising demand, participate in the day ahead and real time energy markets, as well as provide various grid services such as regulation services.[16]

Lithium ion batteries are considered to have relatively high energy density, meaning the amount of energy capable of being discharged is high compared to its physical volume.[17] While lithium ion batteries are among the most efficient batteries available, with efficiency ranging from 80-93%, losses do occur when energy is stored and later discharged (meaning that storage is not "generation" itself but in fact increases net generation needs). The battery configuration

---

[15] "How Energy Storage Can Participate in ISO-New England's Wholesale Electricity Markets," page 3, ISO-New England, March 2016.

[16] "How Energy Storage Can Participate in ISO-New England's Wholesale Electricity Markets," page 5, ISO-New England, March 2016.

[17] "Levelized Cost of Storage Analysis – Version 5.0", Lazard, November 2019.

considered in this analysis is intended to offset a peaker unit, and therefore is not anticipated to serve as an energy supply resource, other than by adding supply during BED's on-peak periods and decreasing supply during BED's off-peak periods.

Capacity

A battery's power density, or its capacity to discharge energy over a specific timeframe (i.e. 1 hour, 1 day etc.) is an important consideration when assessing it in the context of a utility's capacity obligations. While battery storage may not be a net producer of energy, as discussed above, it does have the ability to move energy in time and, as a consequence, can act as a capacity resource for distribution utilities. The battery system considered in this analysis could discharge a sustained 10 MW for four hours. At this time, however, minimal battery storage has cleared as capacity resource in an FCA. To compare battery storage to other capacity supply resources, it is important to consider the cost per kilowatt-month. The battery storage peaker unit is estimated to cost $11.17/kW-month, which is well above both the $4.76/kW-month of a traditional peaker unit and the most recent FCA clearing price of $2.00/kW-month. A battery storage facility, though, could potentially provide value streams by providing frequency regulation or transmission cost reduction.

Renewability

The renewability of a battery storage system depends on the source of energy used to charge the batteries. Because 100% of BED's energy is from renewable resources, a battery storage system located within the BED distribution system would assume that same level of renewability. If BED no longer sourced 100% of its energy from renewable resources, and assuming the batteries were not directly charged from a renewable resource, the storage system would be assigned the same proportion of renewability as the rest of the BED load. However, because battery storage is not an energy generator, it would not help BED meet its Tier 1 or 2 requirements. It could, however, help meet BED's Tier 3 requirements based on reducing the need for peaking generators and emissions during on-peak times.

Resource Access

Availability

Storage technologies are continually evolving. As of February 2020, 2,400 MW of battery storage was proposed in the ISO-NE region,[18] although only 20 MW are recognized by ISO-NE at this time. It does not appear that storage capability from existing facilities is available to BED, but it is likely that BED could acquire access to storage in the future. The siting of such a storage facility within the ISO-NE region, with future availability to BED, appears to be feasible with locating such a resource in Burlington appearing viable as well.

Ownership

While not immediately anticipated, BED's ownership of a 10 MW/40 MWh battery storage system or shared ownership of a larger system is possible in the future. ISO-NE has indicated it anticipates energy storage to become an increasingly important part of the regional power system and has released information on how battery storage units can participate in its wholesale energy markets. BED anticipates battery storage systems to become more prevalent in future years as costs continue to decline.

Resource Cost

Initial Cost

Like renewable technologies, the cost of battery storage has fallen substantially in recent years and continued falling prices are expected over the next several years. At present, at $1,548-$2,322/kW, battery storage is around double the cost of a traditional peaker unit. Note this estimated initial cost appears to be consistent with the ongoing costs estimated for a full tolling storage PPA (discussed inn greater length in the Decision Chapter).

Ongoing Cost

The estimated levelized cost of storing and discharging energy from a battery storage peaker unit is $142-$193 per MWh. This cost is well above all the other supply resource options evaluated apart from gas peaking plants. As noted above, capital cost reductions are anticipated, which will help make battery storage more economical on a levelized cost basis in the future. ISO-NE's external market monitor recently stated that, "storage is becoming the most

[18] "2020 Regional Electricity Outlook," page 14, ISO-New England, January 2020.

economic dispatch technology."[19] The ability for a single battery storage unit to serve multiple functions, such as capacity and regulation, could also improve its economic feasibility, although attempting to capture one value stream may decrease the ability to capture another. BED's evaluation of the economics of storage contained in the technology chapter is predicated on this ability to access multiple value streams.

Consistent with BED Goals

When paired with a renewable portfolio or specific intermittent renewable resources, battery storage may be consistent with and supportive of BED's goals. Battery storage has the potential to smooth out intermittent renewable generation curves, making it possible to rely on intermittent renewable resources for a larger portion of BED's power supply needs.

Resource Risk

Unlike a typical generator, a battery storage system has a finite ability to discharge power before it must be recharged. For the 10 MW/40 MWh peaker replacement storage system, its runtime at maximum power would be four hours. If there were a long duration event, or two back-to-back events requiring peaking capacity, reserves, or emergency back-up, it is possible that a battery storage system would fail to provide the same level of energy output as a fossil fuel fired peaker.

Resource Conclusion

Using battery storage as a peaking unit is economically competitive with a fossil fuel fired peaker unit. But, given the recent clearing prices of the New England FCM, however, it would not be cost effective, in the near term, to install a battery storage system in BED's territory as a new resource (see additional discussion in Decision Chapter). Declining capital costs and the potential for battery storage to fulfill multiple revenue-producing roles could make battery storage a more cost-effective method than a traditional peaker to meet Burlington's capacity needs and net zero goals over time. In addition, where storage can leverage additional value streams such as postponing transmission and distribution upgrades or by providing critical reliability for properties such as the UVM Medical Center or Airport, systems could provide additional value to BED's customers. Storage would be evaluated as an alternative or complement to major transmission upgrades if BED was to see significantly increased loads due to electrification.

---

[19] https://www.iso-ne.com/static-assets/documents/2020/06/npc_2020062324_composite_day1.pdf, accessed July 2020

Combined Cycle Natural Gas

Resource Description

The late 1990s ushered in a steady shift to natural gas fired generation in New England. These resources are easier to site, cheaper to build, and generally more efficient to operate than oil-fired, coal-fired, and nuclear power plants.[20] A combined cycle natural gas facility uses both gas and steam powered turbines to produce electricity. The waste heat from the gas turbine is used to generate steam, which then powers the steam turbine. The use of waste heat from the gas turbine increases electricity output without additional fuel use, and therefore increases the efficiency of the facility as compared to simple cycle plants.

Resource Analysis

Resource Effectiveness

Energy

Combined cycle natural gas facilities are viewed as strong energy supply resources due in large part to their efficiency from the use of waste heat. They are controllable and dispatchable facilities and can participate in both the day ahead and real time wholesale energy markets. While historically natural gas generators operated as intermediate resources, advances in equipment allow them to now operate as baseload generators while maintaining the flexibility to quickly ramp up and down to balance intermittent renewable resources.

Capacity

Combined cycle natural gas plants are generally excellent capacity supply resources. As a non-intermittent generator, these units generally operate at a high capacity factor (85-90%) and their qualified capacity values are not de-rated, as would be the case with an intermittent generator. In 2019, 45% of the summer and winter capacity in the ISO-NE region was provided by natural gas generators.[21]

Renewability

The overwhelming majority of natural gas used in energy production in the United States is non-renewable and comes from conventional drilling or hydraulic fracturing ("fracking"). To a much smaller degree, renewable natural gas (also known as sustainable natural gas) is available. Renewable natural gas is

[20] "2020 Regional Electricity Outlook," page 9, ISO-New England, January 2020.
[21] "CELT Report: 2020-2029 Forecast Report of Capacity, Energy, Loads, and Transmission," ISO-New England, April 2020.

a biogas (biomethane) that is purified to a level where it is essentially interchangeable with standard natural gas. Sources of renewable natural gas include landfills, wastewater treatment plants and livestock. While Vermont Gas Systems ("VGS") recently began offering a renewable natural gas option to its customers, utility scale quantities sufficient to meet major power plant demands do not appear feasible at this time and it is significantly more expensive than standard natural gas.

Accordingly, the cost analysis below assumes the use of standard, non-renewable natural gas. As such, a combined cycle natural gas facility would not assist BED with meeting its RES requirements.

Resource Access

Availability

In 2019, natural gas powered facilities provided 49% of the energy in the ISO-NE region[22], but only 5% of the proposed resources in the ISO-NE generator interconnection queue are natural gas fired generators so access to new resources may be limited.[23] While there are no natural gas market participant generators in Vermont, given the number of existing facilities in New England, it is likely that BED could have access to a combined cycle natural gas generator through a purchase power contract ("PPA"). Natural gas is not widely available within Vermont, but Burlington and most residents of Chittenden County are within the VGS service territory and have access to a natural gas pipeline that might power a natural gas generator. In fact, natural gas is already available via pipeline at the McNeil biomass facility.

Ownership

Owning a natural gas generator or acquiring natural gas fired power through a PPA would be inconsistent with BED's strategic vision. Even if BED was not pursuing a NZE strategy, siting a new combined cycle natural gas generator in Vermont would be challenging. VGS' recent pipeline expansion project faced highly vocal opposition from environmental organizations and residents along the pipeline route, making the prospect of further expansion to supply a power generator highly unlikely.

---

[22] https://www.iso-ne.com/about/key-stats/resource-mix/

[23] "2020 Regional Electricity Outlook," page 13, ISO-New England, February 2020.

Resource Cost

Initial Cost

Of the resources summarized above, a combined cycle natural gas generation facility has the lowest initial cost per kW, at $700-1,300. Despite its low construction costs relative to other resources, combined cycle natural gas generators have some initial cost risk, due to unplanned costs or delays during the project's estimated three-year development process.

Ongoing Cost

The ongoing costs of a combined cycle natural gas generator are also quite moderate compared to other resource options. The fixed O&M costs are in line with some of the lowest cost renewable resources while there are some variable O&M costs. In terms of its ongoing cost risk profile, combined cycle natural gas was rated as having a high fuel cost risk due to the potential for natural gas prices to spike or to be unavailable due to pipeline constraints in the northeast, particularly in the winter months.

Consistent with BED Goals

As noted above, combined cycle generators using standard natural gas are non-renewable resources, and as such do not meet BED's renewability goals. At this time, utility-scale supply of renewable natural gas would likely be challenging from both a supply and cost standpoint.

Resource Risk

The high proportion of natural gas fired generators in ISO-NE as well as limited pipeline capacity has raised concerns about the availability of natural gas in New England. In its 2020 Regional Electricity Outlook, ISO-NE indicated, "during cold weather, most natural gas is committed to local utilities for residential, commercial, and industrial heating. As a result, we are finding that during severe winter weather, many power plants in New England cannot obtain fuel to generate electricity."[24] Therefore, reliance on a combined cycle natural gas generator would expose BED to risks of higher fuel costs (spiking natural gas prices, oil prices, or high wholesale energy prices) and higher emissions. Additionally, all the New England states have passed their own renewable portfolio standards, which incentivizes utilities increase or maintain their use of renewable resources. It is likely that potential future increases in renewability targets will make non-renewable resources such as a combined cycle natural gas generation less desirable over time.

[24] "2020 Regional Electricity Outlook," page 11, ISO-New England, February 2020.

Resource Conclusion

Combined cycle natural gas plants function as strong energy and supply resources and offer utilities high efficiency and relatively low projected initial and ongoing costs (assuming the fuel is non-renewable natural gas). BED's access to this type of resource is limited by the absence of any combined cycle natural gas plants in Vermont and the general alignment between population centers and pipeline natural gas availability, which limits suitable areas for siting a generating facility. Additionally, because standard natural gas is non-renewable and renewable natural gas is likely not to be a viable option at this time, a combined cycle natural gas facility would not be consistent with BED's renewability goals.

Traditional "Peaker" Unit

Resource Description

Facilities referred to as traditional "peaker" of "peaking" units are fossil fuel-fired simple-cycle generators. The primary fuels used in their operation are oil and natural gas, but other fossil fuels can also be used. Many units can run on multiple fuels to adjust to fuel availability and take advantage of cost differences. Additionally, the potential for these generators to run on biodiesel or renewable natural gas may offer other opportunities. For the purposes of this analysis, a 50-240 MW natural gas conventional combustion turbine has been used to determine the benefits, costs and risks of a "peaker" unit.

Resource Analysis

Resource Effectiveness

Energy

Traditional peaker units are rarely a cost-effective energy supply resource, unless the waste heat can be used. The equipment and design of these facilities is not intended for baseload or even intermediate resource operations. Rather, these facilities are intended to only operate during peak hours or as occasional back-up resources. Therefore, because of their limited operation, fixed costs must be recovered over a small number of hours, which drives the levelized price per MWh higher than generators designed for frequent and consistent energy production. The main source of revenue for these units is the capacity and reserve markets, not the energy market.

Capacity

Peaker units are designed and constructed to serve as capacity resources. Thus, BED could, by constructing a peaking unit, likely meet whatever capacity need it had at the lowest initial cost.

Renewability

Peakers are fossil fuel-fired units and therefore they are not renewable resources. As noted above, renewable gas is now available in Vermont, but not in a quantity or at a cost that would make utility-scale use feasible. As the cost to operate increases, the unit becomes less competitive with other resources and will run less, which would make it an relatively high cost Tier 1 resource, even though the use of renewable gas for a peaker, due to the relatively low energy production, would result in less increased costs than for a combined cycle plant. The cost analysis below assumes the use of standard, non-renewable natural gas. Unless fueled by RNG, a peaker unit would not assist BED with meeting its Tier 1 RES requirement. If such a unit were fueled by RNG the energy price would be high enough that the unit would not run often and thus would not contribute much renewable energy Tier 1 goals.

Resource Access

Availability

BED currently owns a 25 MW peaker generator, known as the Burlington Gas Turbine ("GT")[25] which is located along the waterfront in the City of Burlington. Due to its infrequent operation and moderate size compared to other generating resources, siting a peaker unit is generally not as challenging as other types of resources. In addition to the GT, peaker units are located throughout Vermont and the ISO-NE region. For these reasons, BED views a peaker generator as reasonably available.

Ownership

Multiple "peaker" units are located in Vermont; all of the peaker units within Vermont serve as important capacity resources for the utilities that own them. BED is not presently aware of any plans by any Vermont utilities to sell existing peaker units in the State. Therefore, BED's ownership of another peaker unit would likely be tied to the construction of a new facility in Burlington or a contract with an existing facility outside Vermont. The most recent peaker unit built in Vermont was a facility in Swanton, constructed by the Vermont Public Power Supply Authority in 2008.

---

[25] The Burlington Gas Turbine can currently only use oil fuel.

Resource Cost

Initial Cost

Compared to the other resource alternatives reviewed, a peaker unit has a relatively low initial cost on a per kW basis. At $700-950 per kW, only the larger combined cycle natural gas generator has an equally low range of capital cost per kW as a peaker unit. This simplicity suggests a relatively low capital cost risk related to project length or delay.

Ongoing Cost

The fixed O&M costs for a peaker are the lowest among the resources reviewed while the variable O&M costs are relatively high. Because capital costs must be recovered over a small number of generation hours, the levelized energy costs of a peaker are quite high and are by the far the highest among the non-renewable resources considered. Although, it is important to remember that a peaker is not intended to serve as a primary energy supply resource. Rather, the ongoing economics of a peaker are tied to whether its cost of operation and upkeep is less than the cost to purchase market capacity or capacity from another resource, which if initial costs are ignored they generally are.

Consistent with BED Goals

As a fossil-fuel powered generator, a peaker is not consistent with BED's renewability goals. However, unlike baseload or intermediate non-renewable resources that produce significant amounts of energy, the magnitude of non-renewable energy generated by a peaker is quite small. The potential exists to use renewable natural gas for peaking purposes, or the output from a peaker could be "greened" using replacement or excess RECs (or other emission offset tools) equal to the unit's annual MWh output, as is currently done with BED's GT.

Resource Risk

Because peakers derive their financial value from the capacity and reserve markets and do not generally generate revenue from energy production, their economics are vulnerable to clearing prices of market auctions each year. A low clearing price could dramatically reduce revenue for a peaker for an entire year with little opportunity or ability for a utility to improve it. Past history has seen extended periods where the capacity market revenues would not support peaking generation or where capacity value was zero, though revisions to FCM structure should moderate price swings through demand curves, and reward peakers' quick availability through pay-for-performance.

Resource Conclusion

Peakers are intended to serve a narrow yet important primary function: the provision of capacity supply to a utility and the grid. In terms of this specific function, peakers are highly efficient and cost-effective. As expected, when compared to resources intended to serve as energy-producers, they do not appear economically attractive for acquiring energy. The current low capacity market prices have made BED's acquisition of additional traditional peaking capacity unlikely in the near term.

Long-Term Renewable Contract (Non-wind)

Resource Description

For the purposes of this analysis, a generic utility scale hydroelectric generator (over 5 MW) is used to evaluate the merits of a long-term renewable resource contract.

Resource Analysis

Resource Effectiveness

Energy

Run of the river hydro is an intermittent uncontrollable resource. BED can minimize its risk of receiving an undetermined quantity of energy by choosing to contract for either a firm or unit contingent PPA with a hydro generator. Additionally, hydro units with storage capability can be excellent providers of capacity under present market rules due to their ability to move the output to different times of the day.

Capacity

Hydro contracts can be crafted to include capacity in addition to energy, however, like other intermittent resources; run of the river hydro is not a strong capacity resource, while hydro with ponding can be.

Renewability

Run of the river hydro is a Tier 1 renewable resource. Additionally, depending on the particular hydro resource, the unit(s) could produce higher value RECs that can be sold by BED (as is the case with the Winooski One facility).

Resource Access

Availability

There are many existing hydroelectric generators of varying sizes and classes throughout Vermont and the ISO-NE region. BED has entered contracts for hydropower in the past and believes hydro contracts continue to be available as a supply resource at least for the near future.

Ownership
This option is intended to evaluate a contract, not ownership.

Resource Cost

Initial Cost
Not applicable.

Ongoing Cost
For the purposes of this analysis, BED assumes the contract price for hydro energy would reflect market costs.

Consistent with BED Goals
From a renewability standpoint, a contract for existing hydro energy is consistent with BED's goals. If the unit is within close proximity to Burlington or within Vermont, such a contract could also be consistent with BED's desire to increase its reliance on local resources.

Resource Risk
Because this resource analysis is limited to additional PPAs for hydropower, it is possible to avoid some of the normal renewable resource intermittency issues by entering into a firm delivery contract. Nonetheless, even with a firm contract, some risk of non-performance remains, which would expose BED to wholesale market energy prices. A defaulting counter-party would be liable for liquidated damages intended to make BED whole (covering any resulting increased energy costs), but there is a risk that a counter-party would not be in a financial position to pay the liquidated damages.

Resource Conclusion
A contract for hydro would allow BED to efficiently match its energy supply resources to its needs. Hydro can also provide capacity supply, although it is quite minimal relative to the energy supplied in run-of-the-river units. Conversely, capacity value can be quite substantial for units with significant ponding capability. In addition, BED's recent hydro purchases have involved multiple assets delivering under one contract. The energy purchased through an additional hydro contract, provided it includes the related RECs, would qualify under Tier 1. Given the number of hydro units throughout Vermont and the ISO-NE area, BED believes hydro is a resource with ample availability. Assuming contract prices are similar to the wholesale cost of energy, a contract for hydropower would be cost-competitive with other renewable supply options.

Long-Term Non-Renewable Contract

Resource Description

For the purposes of this analysis, a nuclear facility was used to evaluate a long-term contract for a non-renewable resource.

Resource Analysis

Resource Effectiveness

Energy

Nuclear generators provide constant baseload energy and are regarded as strong energy producers with a capacity factor in the 80-90% range. Nuclear generators in New England are not well-suited to provide the fast start and flexible output to balance supply changes related to intermittent resources.

Capacity

Due to their reliable nature and consistent output, nuclear generators are strong capacity supply resources.

Renewability

While a nuclear generator does not produce measurable air emissions, its use of non-renewable uranium classifies it as non-renewable resource. If BED wished to retain its 100% renewability, it would need to purchase RECs to cover the purchased non-renewable energy.

Resource Access

Availability

The number of nuclear generators in the ISO-NE region and the share of regional energy supplied by them has been in decline for several years and is expected to continue to decline.

Ownership

This option is intended to consider a contract for energy, not resource ownership because of BED's net zero goals.

Resource Cost

Initial Cost

Under a contract, BED would not be directly responsible for initial capital costs. Nonetheless, nuclear has high initial costs and risks which are frequently reflected in contract terms due to their magnitude .

Ongoing Cost

Similar to long-term renewable options, it is likely that BED's costs would be based on market prices rather than a unit's specific economics.

Consistent with BED Goals

Due to its non-renewable classification, nuclear power is not consistent with BED's renewability and NZE goals.

Resource Risk

If natural gas prices remain at historically low levels, natural gas generators are expected to continue to out-compete nuclear generators in the wholesale energy markets.[26] Thus, nuclear power would expose BED to additional cost risks that could result in upward rate pressure.

Resource Conclusion

As more economically feasible natural gas generation and wind resources are on the rise in the ISO-NE region, nuclear power is on the decline, as two major plants were retired in recent years. While BED could benefit from having access to additional consistent energy and capacity supply, such supply from a nuclear facility would be inconsistent with BED's strategic direction.

Overall Conclusion

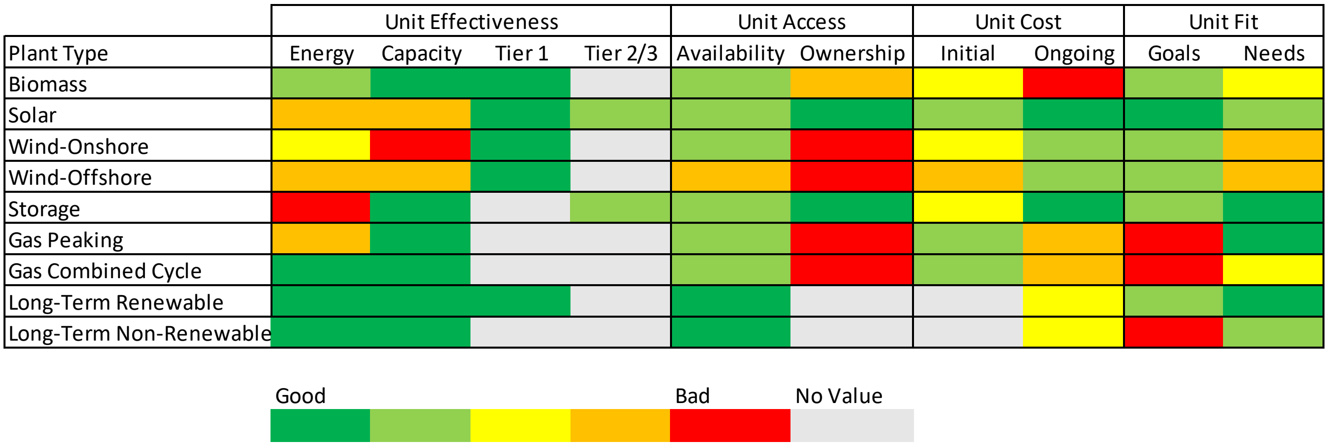
BED currently has a sufficient quantity of energy supply to reliably serve its customers in accordance with 30 V.S.A. §218c. Indeed, BED maintains ownership and/or control over resources that can supply all its energy requirements through 2024. However, because BED's energy comes from renewable resources, BED is substantially short on capacity. This shortfall or capacity gap is a function of ISO-NE's reliability protocols which significantly de-rate resources that are intermittent, such as wind, solar (if ISO-NE recognized) and run-of-river hydro dams.

BED is highly dependent on the continued operation of the McNeil biomass plant to maintain BED's status as a 100% renewably-sourced energy provider. However, the economic viability of the McNeil plant has faced challenges in recent years with the fall in wholesale market energy prices. Furthermore, the plant will likely need additional capital investments to maintain its reliability. As noted elsewhere, BED is researching its options to improve the economic viability of the McNeil plant such as seeking to construct a district energy system using the waste heat from the plant. If a district energy system were to be fully implemented, the efficiency and economic value of the McNeil plant would be enhanced. On the other hand, if McNeil were to be retired, BED would need to acquire cost-effective replacement energy and capacity, which may not be readily available in the short-term.

[26] "2020 Regional Electricity Outlook," page 9, ISO-New England, February 2020.

To summarize the costs and benefits of various resources, BED performed a comparative analysis shown below. Those resources with green shaded boxes have been identified as creating the most benefits in terms of their effectiveness, accessibility, and costs.

Table 3.5: Resource Comparisons



Unit effectiveness is shown as function of capacity factor for energy, market capacity received for the resource as a percentage of the facility's nameplate capacity for Capacity, and whether the resource is eligible for each of the RES tiers under the Tier 1 and Tier 2/3 columns. Unit access is shown based on this chapter's analysis regarding availability and ownership. Unit cost is based on the initial and ongoing costs assumed in each analysis on a per kW basis. Unit fit is based on the description of how the resource would or would not meet BED's needs and goals as described in this chapter.