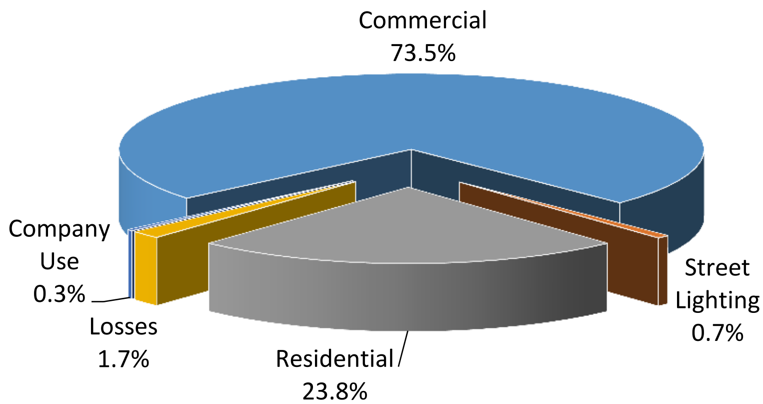
Chapter 2 – Burlington's Demand for Electricity

The City of Burlington Electric Department (BED) provides electricity in its service territory of approximately 16 square miles, and the Burlington International Airport, located in South Burlington. BED is the third largest utility in Vermont, accounting for 6.1 percent of total retail kilowatt-hour sales.

BED currently serves about 16,760 residential accounts, and 3,830 commercial customers. BED's customers required 350,157 megawatt-hours (MWhs) of electricity during 2015 including roughly 343,146 MWh in sales, with distribution losses and company use making up the remainder. The commercial customers account for the largest share of electricity use, with more than 73% of the total (Figure 2-1). The residential class accounts for roughly 24% of the total energy requirements.

Figure 2-1: System Energy Requirements 2015



The 2016 Long Range Forecast is a composite of individual forecasts prepared for each of BED's major classes of service (residential, commercial/industrial, and street lighting). Estimated losses and company use were added to these forecasts to determine how much energy must be generated to supply sales at the customer meter. Table 0-1 shows the BED energy and demand forecast, after accounting for the effects of future energy efficiency and net-metering.

Table 0-1: Annual Energy Requirements & Peak Demand, 2016-2036

	2016	2021	2026	2031	2036	CAGR
Residential	83,680	85,468	83,605	83,597	84,894	0.07%
Commercial & Industrial	259,881	273,071	272,132	274,269	276,364	0.31%
Street Lighting	2,547	2,572	2,509	2,460	2,416	-0.26%
Total Energy Use (MWh)	346,108	361,111	358,246	360,326	363,674	0.25%
Peak Demand (MW)	66.9	68.2	67.4	67.6	67.9	0.08%

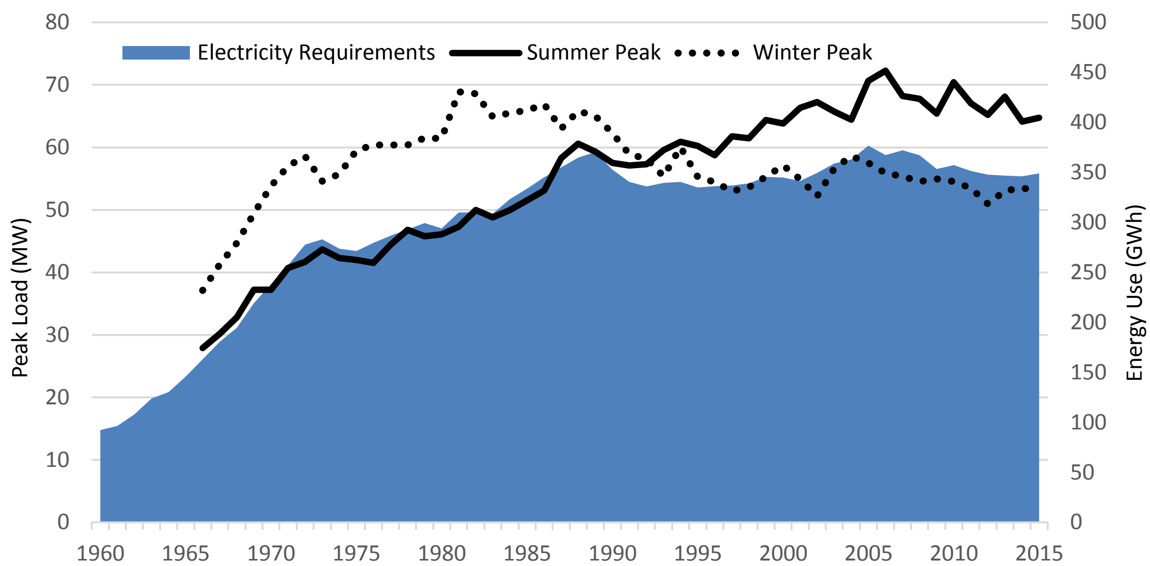
Over the next ten years (2016 to 2026), energy deliveries and system peak demand are projected to average 0.35% and 0.08% annual growth respectively. The system is expected to see relatively strong growth in 2017 to 2019 as a result of the completion of several large projects currently under construction. Over the twenty-year planning period, annual energy averages 0.25% annual growth and peak demand averages 0.08% annual growth.

2 Background and History

From 1960 to 2015 electricity requirements in Burlington increased almost four fold. Overall, sales grew at an annual growth rate of 2.45 percent per year. However, as can be seen in Figure 2-2, this growth has not been uniform.

In the years prior to 1973, Burlington experienced rapid sales growth (9.0 percent per year) during a period of declining real electricity prices. Rising oil and coal prices and the delayed operation of Vermont Yankee would contribute to higher energy costs in the region by the early 1970s. By the end of 1973, the nation was in the midst of an energy crisis, and the era of aggressive load building was coming to an end.

Figure 2-2: System Peak & Energy Requirements, 1960-2015



The next two decades would be characterized by sharply higher retail prices for electricity and moderating demand for energy. Utility regulators embraced the idea of seasonal rates, and utilities began offering conservation and load control programs.

Several factors have combined to cause a plateau in sales since 1989. This leveling off of electricity use can be attributed in large part to more vigorous DSM activities by the

Department, but also has roots in fundamental demographic changes and changing economic conditions. The demand-side programs implemented by BED have suppressed demand in all sectors, having a cumulative impact on sales of roughly 76,000 megawatt-hours by 2015.

In 1993, Burlington's annual peak demand occurred in July. This was significant, since it was the first time BED had its annual peak demand occur during the summer. Beginning in the mid-1980s, the decline in the winter peak demand can be attributed to the decline in electric space heating and water heating and the switch to more efficient lighting. The summer peak has been driven by the growth in commercial sector and the increasing use of air conditioning in the residential sector.
Figure 2-3 and Figure 0-4 provide a view of the City's hourly demand on the summer and winter peak days in 2015. Seasonal differences are readily apparent from these two plots. The summer peak day is characterized by one daily peak period with load rising gradually until around 1 pm, then leveling off before gradually declining after 5 pm. The summer peak demands occur most often between 2 and 4 pm. On this particular summer peak day, the load fell sharply in the afternoon due to dramatic drop in temperature (92 to 73 degrees F), during an afternoon storm. During the winter months, there are two distinct peak periods during the day. The system load increases rather abruptly in the morning, peaking by around 1 pm, then drops slightly before increasing again by 5 pm, peaking around 6 or 7 pm. On the 2015 winter peak day, the load at 1 pm was only 700 kW lower than the evening peak.

Figure 2-3: Summer Peak Day (September 9, 2015)

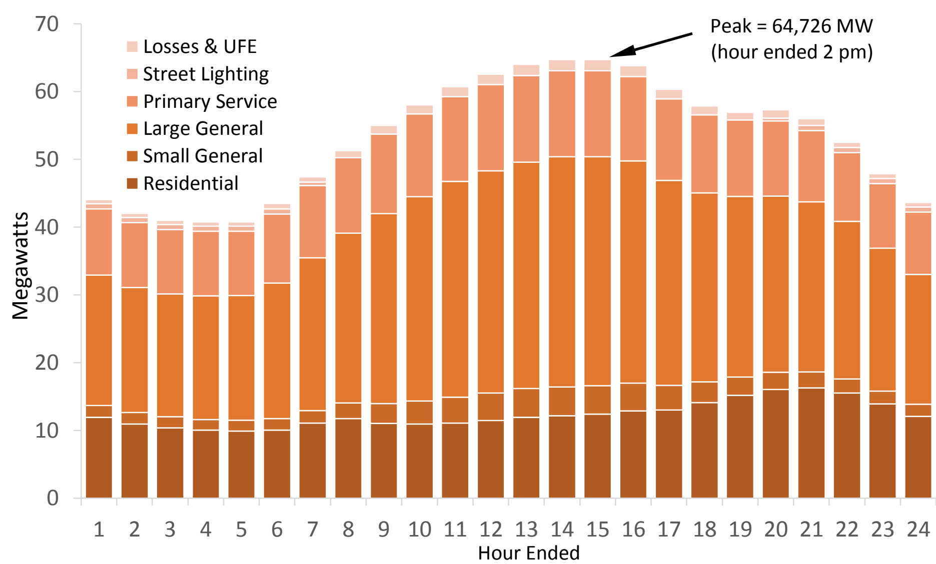
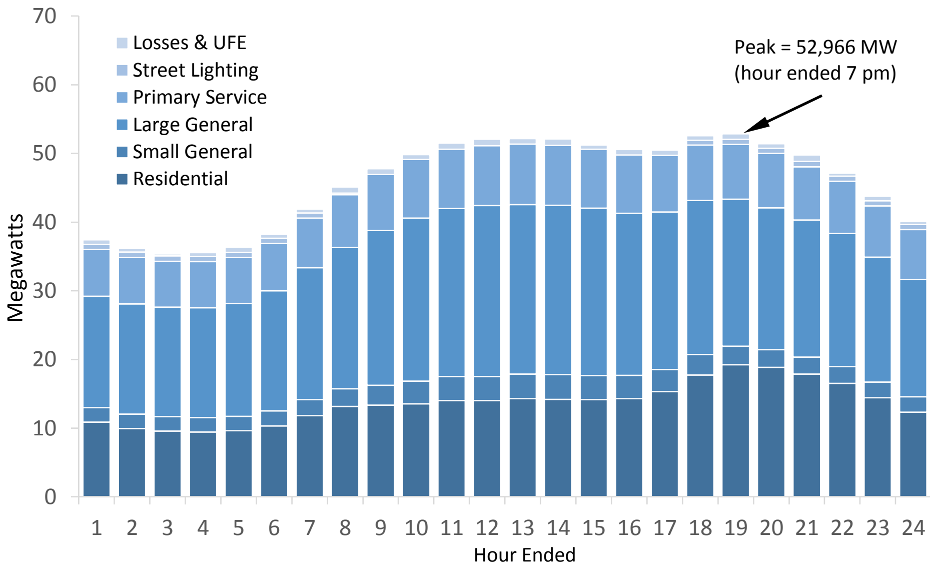


Figure 0-4: Winter Peak Day (February 2, 2015)



2.1 **Forecast Approach**

In the development of its load forecast, BED employs Statistically Adjusted End-Use (SAE) models that use historical data and inputs such as regional economic growth, weather, seasonality, and other customer usage and behavior changes[1]. The advantage of the SAE approach is that it combines the benefits of end use models and econometric models. The end use approach models energy sales with a bottom-up approach by building up estimates of end use energy consumption by appliance type, appliance penetration, and housing unit or business type. These models are useful at forecasting energy because they can be used to estimate the effects of future changes in saturations or efficiency levels of equipment and appliances which may be driven by policy, economics, or consumer preferences, even if the changes are not present in observable history. In a traditional econometric model, it can be difficult to model precisely how the changing appliance efficiency standards will affect sales if the standards have been unchanged during the estimation period.

Econometric models are typically estimated against a longer period of time rather than calibrated sales from a single year, and it is therefore easier detect and correct systematic errors or biases in the forecasting model. For that reason, a system that combines the bottom-up approach of the end use models with an econometric approach should produce more accurate forecasts.

Once the sales forecasts have been developed, the system load shape forecast flows from the class sales forecasts. The process is to use customer class load shapes and fit the sales

(1) For a more in-depth discussion of the forecasting methodology, please refer to Appendix A: Itron's "2016 Long-Term Electric Energy and Demand Forecast Report"

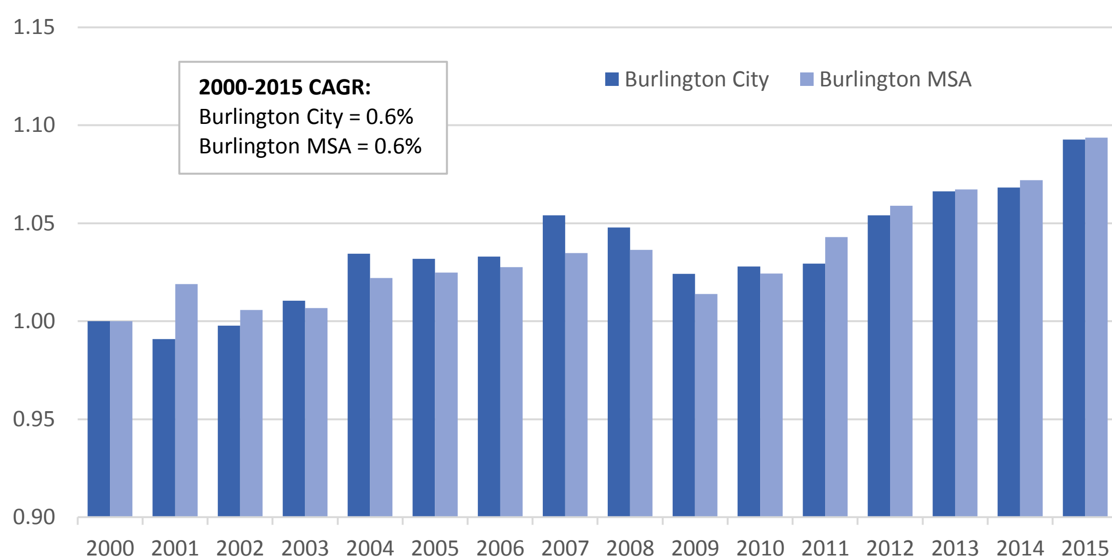
requirement by customer class as forecasted to these class load shapes. For the base year of the load shape forecast (2015), the sum of the class load shapes was calibrated to the historical BED system load shape. For each of the forecasted years the customer class load shapes were fitted to the energy forecast for that class and summed to get the total BED system load shape for each year of the forecast. This system load shape is then employed in developing an integrated resource plan that balances resources with the forecasted energy and capacity requirements of the load forecast.

3.1 **Base Case Assumptions**

Several economic indicators were used as independent variables (forecast "drivers") in our energy forecasting process. For the residential class, income, population and number of households in the region were used as drivers. In the commercial sector, gross metro product and employment were used as drivers. These drivers are consistent with ones used in our previous IRP forecasts. As in the prior IRPs, the economic forecasting firm Moody's Analytics was the source for the forecast of these economic drivers. Moody's Analytics is a highly reputable firm in the macroeconomic forecasting arena with specialized competency in doing the work.

Economic forecast were not available for Burlington City, so BED relied on forecasts for the Burlington-South Burlington Metropolitan Statistical Area as a proxy. The economies of Burlington City and the broader metropolitan area tend to track fairly closely. For example, Figure 0-5 compares the employment growth rates for Burlington City and the Burlington MSA for the recent 15 year period. The year-to-year change and overall growth over the period was very similar.

Figure 0-5: Total Employment Growth by Region (2000 = 1.0)

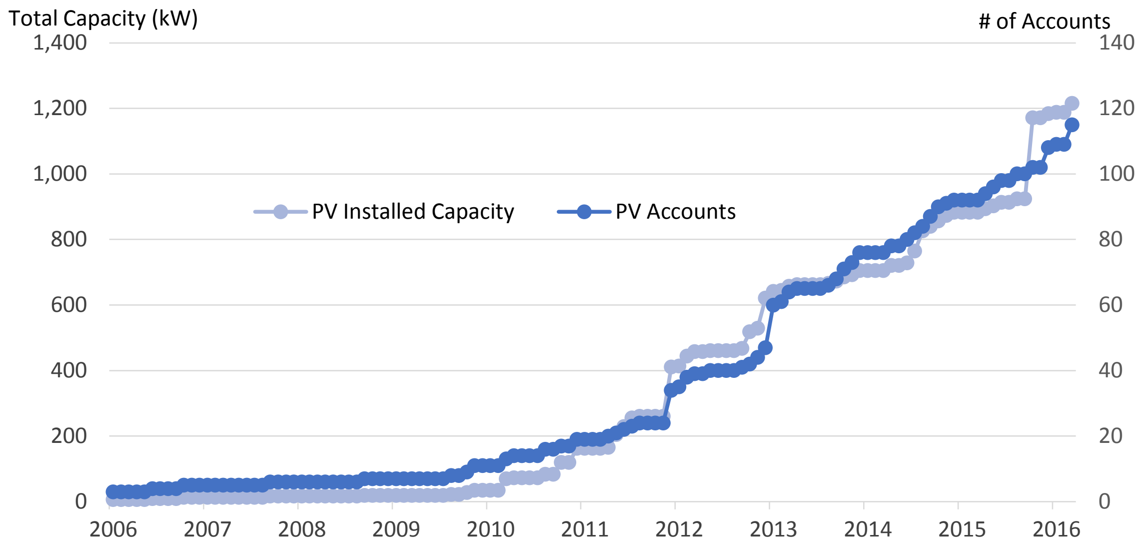


BED's projected data are weather normalized. Historic daily weather data was available for the Burlington weather station for the period January 1978 to March 2016. Normal degree days were calculated using this data from the 20-year period 1996 to 2015. The heating and cooling degree variables were customized (from the typical 65 degree reference) separately for the residential and commercial sectors by evaluating daily kWh use and daily temperature. For the residential sector, cooling degree days were calculated with a 65 degree base, and heating degree days with a 60 degree base. The degree days were customized for the commercial sector in the similar fashion.

The residential sector incorporates saturation and efficiency trends for seventeen end-uses. The commercial sector captures end-use intensity projections for ten end-use classifications across ten building types. The models rely on an analysis of EIA's Annual Energy Outlook forecast performed by Itron. EIA saturation projections were adjusted to reflect BED appliance saturation surveys and the mix of multi-family and single-family homes in Burlington. Care must be taken not to "double count" energy efficiency program impacts when using a methodology like SAE that accounts for efficiency trends on its own. To avoid double counting, efficiency savings projections were adjusted to reflect future efficiency savings embedded in the baseline sales forecast. The efficiency adjustment factors for each sector are estimated by incorporating historical efficiency savings as a model variable. For example, in the residential model, the efficiency savings variable is statistically significant with a coefficient of -0.187 indicating that 81.3% (1-.187) of future efficiency savings is embedded in the model; the efficiency adjustment factor is 0.187.

Emerging technologies such as photovoltaic (PV) systems, electric vehicles, cold climate heat pumps, energy storage, and other technologies will likely have an impact on future demand for electricity. Over the past few years, there has been an increasing penetration of customers owning solar photovoltaic generating systems in Burlington. By March 2016, there were 115 customers (84 residential, 31 commercial) that installed solar or were part of a community based system, for a total solar capacity of 1.2 megawatts.

Figure 0-6: Solar PV Adoption in Burlington City



The base case forecast incorporates the impacts of expected PV adoption as there has been enough historical adoption to reasonably model and forecast future adoptions. Other emerging technologies where there is little historical adoption are addressed in Chapter 3 – emerging technologies – of this IRP.

Once the sales forecasts are developed, the system load shape forecast flows from the class sales forecasts. The process is to use customer class load shapes and fit the forecasted sales requirement by customer class to these class load shapes. In the previous IRP, BED relied on class load shape data developed from a sample-based load study. In 2012, BED began installing AMI meters on all customers and currently is collecting 15 minute interval data on approximately 95 percent of its customers. The interval data was used to develop class load shapes to construct the system load shape forecast.

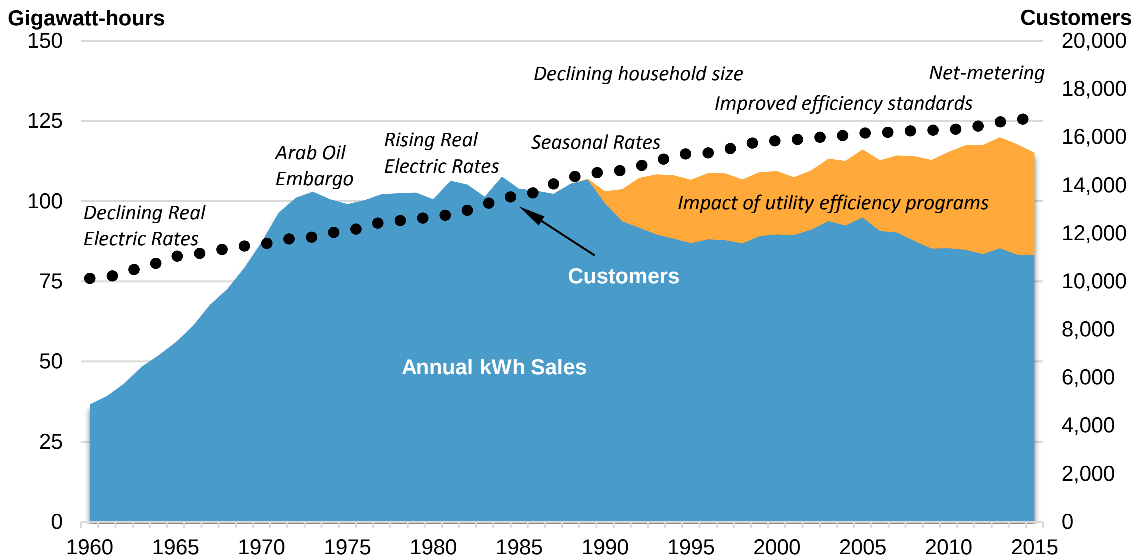
4.1 **Residential Sector**

Figure 0-7 shows annual residential sales and customer trends from 1960 to 2015. During the 1960s, the utility industry enjoyed a persistent decline in real electricity prices, and began promoting "all electric living". Predictably, the proliferation of appliances and the use of electricity for space and water heating in the residential sector caused consumption per household in Burlington to rise dramatically (6.3% annually). Electric space heating, virtually unheard of in 1960, was used in over 1,200 Burlington households by 1970.

Following the energy crisis of the mid-1970s, residential sales slowed dramatically, to a mere 0.2 percent per year through 1989. A number of special factors have had varying degrees of influence on residential sales during this period. The introduction of seasonal rates and other factors contributed to a decline in the reliance on electricity for space heating and water heating.

The oil crisis also set in motion some actions that had long term effects on demand, like manufacturers beginning to offer appliances that use less electricity.

Figure 0-7: Residential Sales & Customers, 1960-2015



Since 1990, the Department's efficiency programs have had a significant impact on residential electricity use. In March 1992 the City issued $11.3 million in electric revenue bonds to finance comprehensive energy efficiency programs. These efficiency programs have dropped residential sales by an estimated 28 percent over the period. The improved efficiency standards mandated by the Energy Independence and Security Act (EISA) of 2007, have also had an impact on electricity sales and will continue as those standards continue roll through the appliance stock.

Although relatively small in magnitude compared to the rest of Vermont, Burlington has experienced a steady growth in the number of photovoltaic (PV) systems over the past few years. By the end of 2015, there were 77 residential PV accounts in Burlington generating just over 400,000 kWh annually.

The two main drivers of the residential forecast are the forecast of number of residential customers, and the forecast of use rate (electricity consumption per residential account). The residential average use and customers are modeled separately and then the residential sales forecast is generated as the product of the average use and customer forecast.

5.1.1 RESIDENTIAL CUSTOMERS

The City had a population of approximately 42,452 people, or about 6.8 percent of the Vermont total in 2015. The University of Vermont and Champlain College are located in Burlington, and St. Michaels is located in nearby Colchester. Students attending these local educational institutions who live off campus constitute a substantial component of apartment renters in Burlington, and help explain the 59 percent renter population in the City.

The Burlington area has seen substantial increases in the number of housing units prior to the year 2000 in in spite of low household population growth rates (Table 0-2). This is because of a dramatically declining average household size in Burlington. The average household size has experienced a 32 percent decline between 1960 and 2000.

The declining average household size is the result of some basic social and demographic trends: (1) an increasing divorce rate has led to greater numbers of single person and single parent households, (2) a declining birth rate means families generally have a smaller number of children, and (3) landlords sub-dividing existing housing units into smaller apartments to accommodate the growing off-campus student population. In general, the impact of these social trends has already occurred, so the rate of change in average household size appears to have slowed down. On the other hand, if Burlington's relative attractiveness to young adults continues, a greater concentration of small, young adult households could continue downward pressure on average household size.

Table 0-2: Housing & Population Data: Burlington City[2]

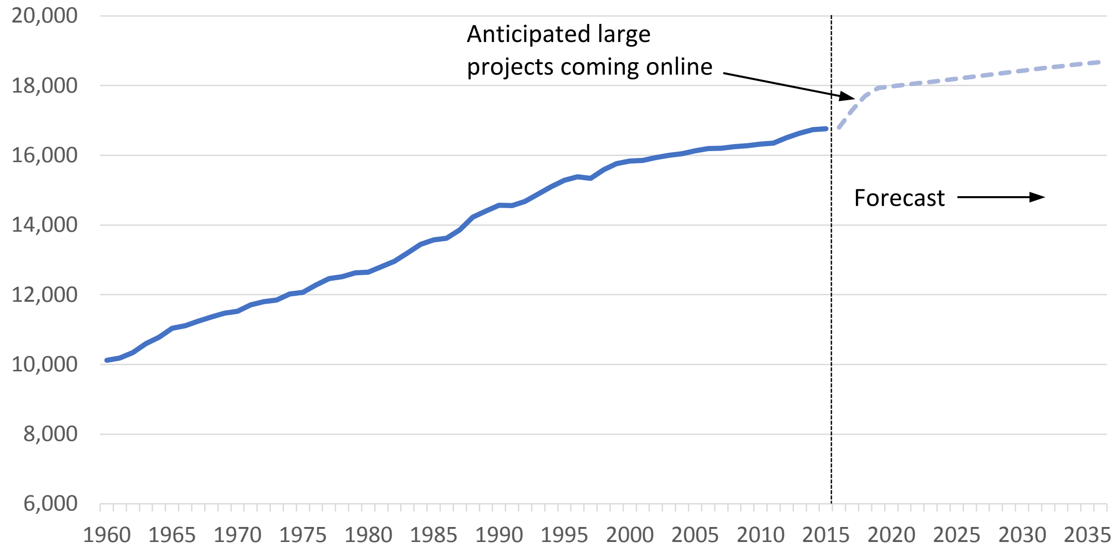
Year	Occupied Housing Units	% Change	Household Population	% Change	Average PPH	% Change	Owner Occupied	Single-Family Units
1960	10,091	---	32,702	---	3.24	---	48%	43%
1970	11,328	12.3%	33,874	3.6%	2.99	-7.7%	48%	42%
1980	13,107	15.7%	32,043	-5.4&	2.45	-18.1%	44%	42%
1990	14,680	12.0%	33,654	5.0%	2.29	-6.5%	40%	38%
2000	15,885	8.2%	34,876	3.6%	2.20	-3.9%	42%	39%
2010	16,119	1.5%	35,357	1.4%	2.19	-0.5%	41%	38%

The forecast of Burlington's residential customers was driven by regional housing unit projections developed by Moody's Analytics. This baseline forecast was then adjusted to account for a couple large residential projects, one project that is currently underway (266 units), and the other project expected to come online in the next two years (750 units total, half online in 2017 and half in 2018).

Figure 0-8 provides the adjusted residential customer forecast. The number of residential customers is expected to grow at a rate of 0.5 percent per year. After the strong customer growth in the next few years, we are expecting the forecast to follow the growth rates that are closer to 0.2 percent per year.

Figure 0-8: Number of Residential Customers

(2) U.S. Census Bureau, https://www.census.gov/quickfacts/table/PST045215/5010675

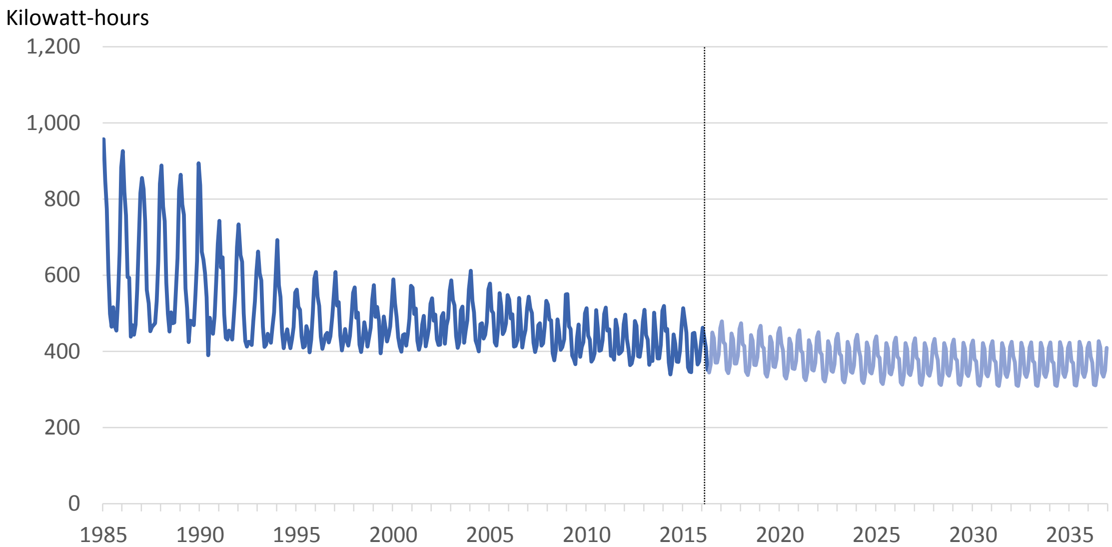


5.1.2 AVERAGE USE PER CUSTOMER

Figure 0-9 shows the average monthly kWh use per customer for Burlington's residential sector for the period 1985 to 2015. Overall, the average use per customer has declined significantly, dropping 34 percent since 1985 (from 7,533 kWh per customer to 4,989 kWh per customer in 2015). This decline can be attributed to a number of factors but the most significant are the decline in the use of electricity for space heating, water heating and lighting.

Average use per customer is projected to decline further in the forecast period, albeit at a slightly slower rate. This is largely due to the continuing phase-out of the most common types of incandescent light bulbs mandated by the Energy Independence and Security Act (EISA) and new end-use efficiency standards recently put in place by the Department of Energy. Average use begins to decrease at a slightly slower rate in the later years as the EIA baseline intensity projections only include those end-use standards that are currently law.

Figure 0-9: Monthly Residential kWh Use per Customer



5.1.3 RESIDENTIAL SALES FORECAST

Residential sales projections are readily obtained by the combination of the customer projections and average use projections. Electric sales to residential customers are expected to remain relatively flat between the base year of 2016 and 2036, for an average growth rate of 0.06% per year. Table 0-3 displays the annual residential sales forecast.

Table 0-3: Residential Sector Forecast

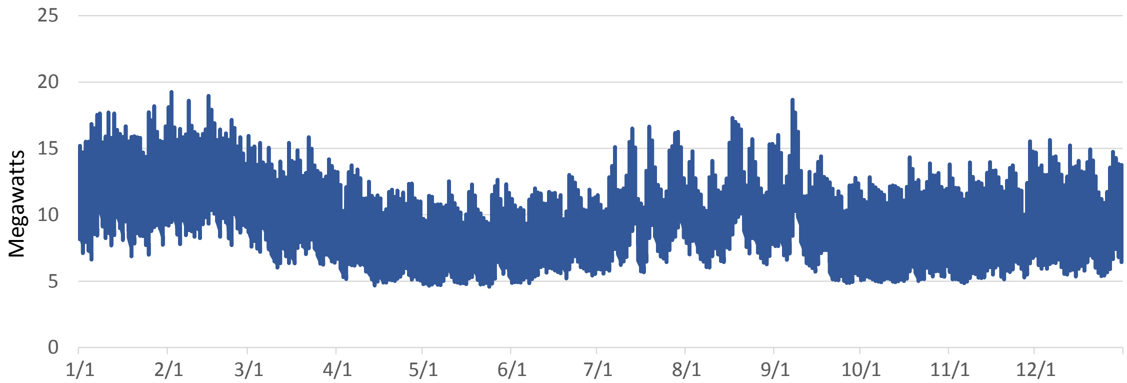
Year	Total Sales (MWh)	Customers	Avg. Use (kWh)
2016	81,402	16,802	4,845
2017	83,652	17,290	4,838
2018	84,709	17,699	4,786
2019	84,715	17,928	4,725
2020	84,025	17,977	4,674
2021	83,012	18,021	4,606
2022	82,427	18,065	4,563
2023	82,005	18,107	4,529
2024	82,014	18,150	4,519
2025	81,406	18,195	4,474
2026	81,199	18,239	4,452
2027	81,160	18,284	4,439
2028	81,433	18,329	4,443
2029	81,353	18,375	4,427
2030	81,210	18,422	4,408
2031	81,191	18,468	4,396
2032	81,466	18,512	4,401
2033	81,386	18,554	4,386
2034	81,593	18,595	4,388
2035	81,882	18,637	4,394
2036	82,453	18,677	4,415
Compound Growth Rates			
2016-2026	-0.02%	0.82%	-0.84%
2016-2036	0.06%	0.53%	-0.46%

5.1.4 RESIDENTIAL LOAD CHARACTERISTICS

Figure 0-10 provides a view of the 2015 hourly load shape developed for the residential sector using interval data collected from BED's AMI meters. Residential electricity use is typically higher during the winter months, on average, when the heating and lighting needs are greater. The fact that people may also tend to spend more time indoors during the winter months also leads to greater electricity use during those months.

Residential customers also show a higher demand for electricity during the warmest months of the summer. The saturation of room air conditioning units in the residential sector was estimated at greater than 80 percent in 2015, pushing demands to levels that are similar to those seen in the winter.

Figure 0-10: Residential Sector: 2015 Hourly Load Profile



During 2015, the residential sector reach a maximum demand of 19,249 kW during the hour ended 7 pm on February 2, 2015, which also happened to be the system peak day and hour. The residential sector's maximum demand in the summer was not too far below the winter levels, reaching 18,664 kW on September 7, 2016 at hour ended 9 pm.

Figure 0-11 shows the daily kilowatt-hour use plotted against average daily temperature. The points are coded with symbols that separate weekends and holidays (triangles) from weekdays. As is clear from this plot, there is significant nonlinear relationship between daily electricity use and temperature. Specifically, in the winter months when it is cold, increases in the temperature reduce load. This reflects reductions in loads related to heating. In contrast, during the summer, increased temperature values are strongly correlated with increased loads.

Figure 0-11: Residential Daily kWh Use vs. Average Daily Temperature

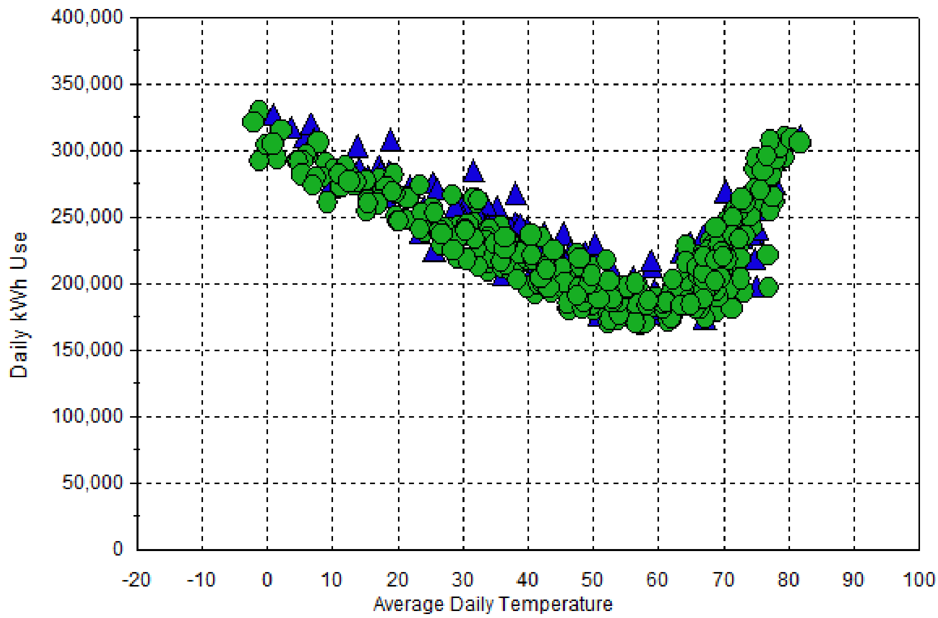


Figure 0-12 and Figure 0-13 provide the residential sector "typical day" load profile plots for the summer and winter seasons. On average, residential loads tend to increase sharply during weekday mornings until around 8:00 am, followed by a slight decline until 4:00 pm. After 4 pm, loads rise again peaking between 6 and 9 pm (depending on the season), and then taper off during the late evening hours. The weekend load profile is very similar to the weekday load profile, with the exception of the more gradual increase in the morning load.

Figure 0-12: Residential Typical Day: Summer (Jun-Sep)

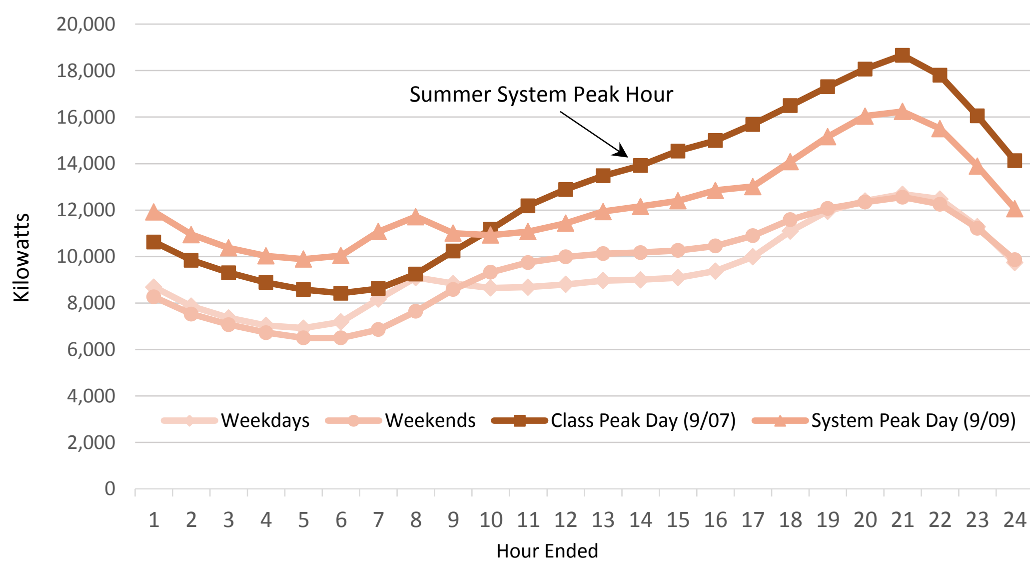
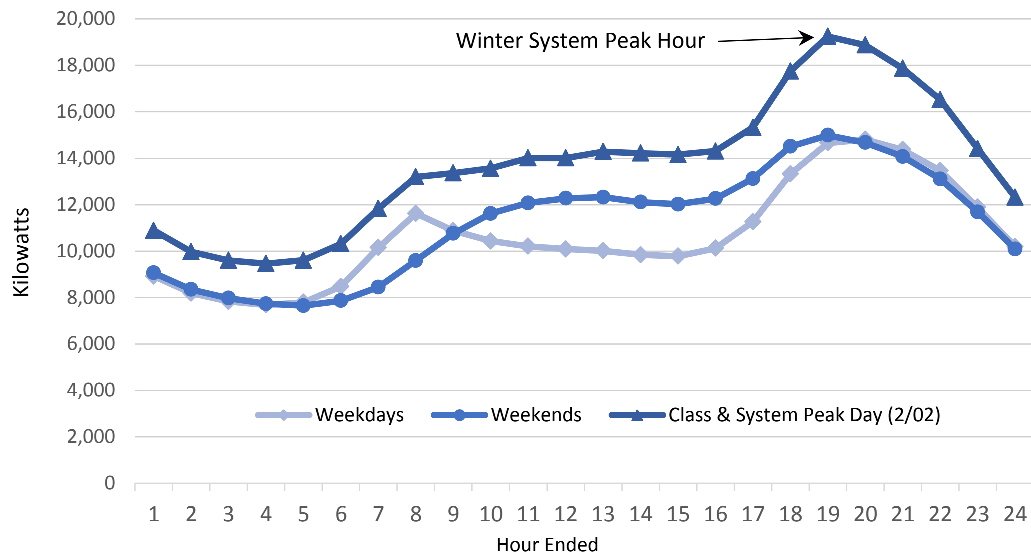


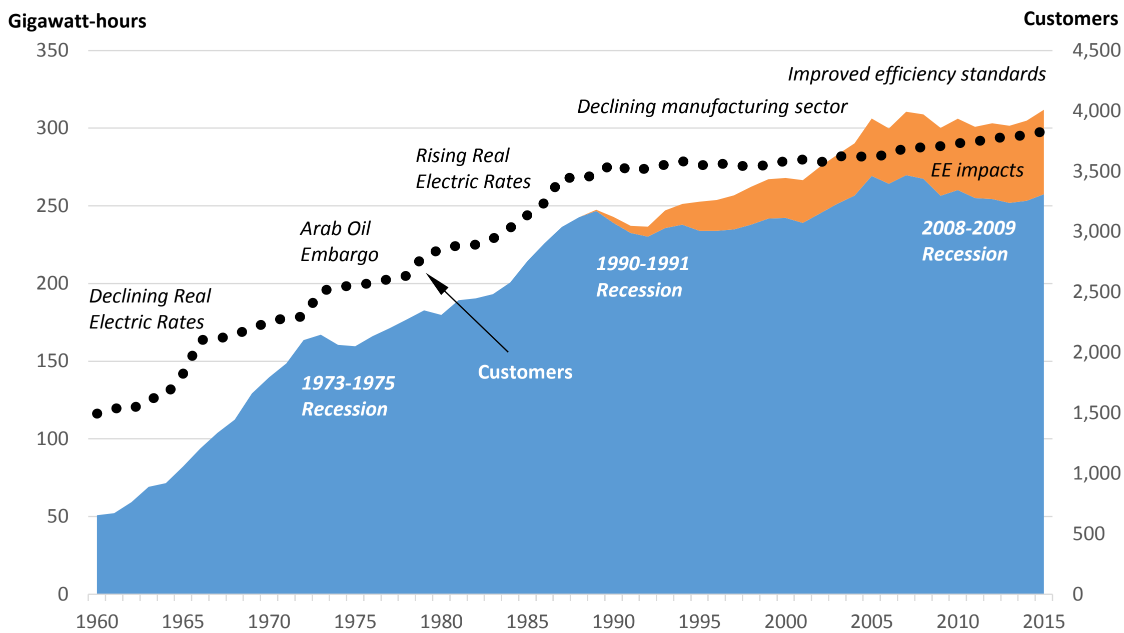
Figure 0-13: Residential Typical Day: Winter (Dec-Mar)



5.1 **Commercial Sector**

BED's commercial sector includes Small General Service, Large General Service, and Primary Service customer classifications. In 2015, this sector accounted for only 19 percent of total customers but 74 percent of the total kilowatt-hour sales. Figure 0-14 provides historic annual kilowatt-hour sales and customers for the commercial sector.

Figure 0-14: Commercial Sales & Customers, 1960-2015



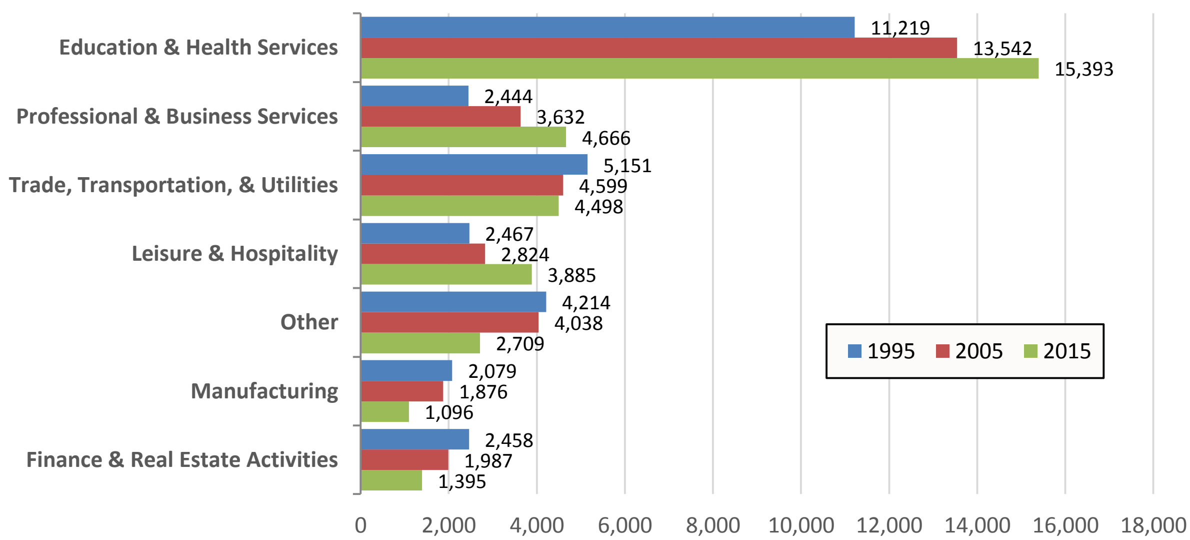
Commercial sales increased at a rate of 9.6 percent per year between 1960 and 1973, more than tripling during the period. The first oil crisis was followed initially by a period of relatively slow growth, with an actual decline in sales between 1973 and 1975. Commercial sales then grew at an average annual rate of 3.2 percent between 1975 and 1989 - roughly two and half times the residential rate of 1.3 percent over the same period, although still much more slowly than during the previous decade. The change from the prior decade can be attributed to a variety of factors, but perhaps most significant among them were prices changes.

Since 1989, commercial sector electricity sales have slowed dramatically, to a rate of 0.2 percent per year. This pattern can be attributed to changing economic conditions and BED's energy efficiency programs. The cumulative impact of BED's energy efficiency programs have resulted in reduced commercial sales of approximately 55 million kilowatt-hours by 2015 (17 percent lower).

The major recessions have had a significant impact on employment in Burlington, particularly in the manufacturing sector. Manufacturing has traditionally been vital to Burlington because it creates well-paying jobs, draws investment into the area, and strengthens other sectors of the economy. Presently 3.2 percent of Burlington's jobs are in manufacturing – down from 15.3 percent in 1980.

Figure 0-15 provides a look at the employment trends by sector in Burlington over the last 20 years. The Services sector, that includes Education and Health Care Services, represents one of the fastest growing employment categories in Burlington. The University of Vermont Medical Center (7,500 employees) and the University of Vermont (4,355 employees) are the largest employers in the City, highlighting the importance of the health and education services to both the growth and level of employment, as well as to electricity sales. The growth of the information age, aging baby-boomers (who will require proportionally more health care services), and continued emphasis on education suggests that this sector will continue to grow.

Figure 0-15: Burlington City Employment by Sector[3]



By the end of 2015, there were 31 solar PV installations in the commercial sector. The average size of these installations was 36 kW, yielding a total of capacity of 900 kW and an estimated 1.1 million kilowatt-hours per year.

(3) Vermont Department of Labor, Covered Employment & Wages (http://www.vtlmi.info/indareanaics.cfm?areatype=12)

5.1 COMMERCIAL SALES FORECAST

Table 0-4 shows the annual megawatt-hour sales forecast for the commercial sector. Total sales to the commercial customer classes at BED is expected to grow from 253,767 MWh in 2016 to 265,323 MWh in 2026 and 269,434 MWh in 2036. The compound annual growth rate between 2016 and 2026 will be 0.45 percent and between 2026 and 2036 the rate will be 0.15 percent. Current projects underway at the University of Vermont and the UVM Medical Center, are expected to contribute to increased sales growth during the early years of the forecast.

Table 0-4: Commercial Sector Forecast

Year	Total Sales (MWh)	Customers	Avg. Use (kWh)
2016	253,767	3,846	65,981
2017	262,031	3,862	67,845
2018	265,556	3,878	68,471
2019	268,770	3,890	69,086
2020	268,135	3,896	68,825
2021	266,254	3,901	68,250
2022	265,584	3,909	67,941
2023	265,150	3,917	67,688
2024	265,535	3,925	67,647
2025	264,960	3,934	67,354
2026	265,323	3,943	67,295
2027	265,876	3,952	67,275
2028	266,870	3,962	67,357
2029	266,949	3,973	67,192
2030	267,067	3,985	67,025
2031	267,396	3,997	66,905
2032	268,174	4,009	66,900
2033	267,927	4,021	66,635
2034	268,143	4,034	66,479
2035	268,487	4,047	66,341
2036	269,434	4,061	66,340
Compound Growth Rate			
2016-2026	0.45%	0.25%	0.20%
2016-2036	0.30%	0.27%	0.03%

5.2 COMMERCIAL LOAD CHARACTERISTICS

Figure 0-16 provides a plot of the aggregate hourly load for the commercial sector for 2015. We see increased loads during the summer months, which can be attributed to increased cooling requirements for these customers. The loads are quite consistent from day-to-day during the other times of the year, showing a consistent weekly pattern, with higher weekday loads and lower loads on weekends and holidays.

The commercial sector reached a maximum load of 50,896 kW on September 9, 2015, hour 2 pm, which was also the system peak day and hour. During the system peak hour, the load was 22 percent higher than the typical weekday load for this sector at this hour.

Figure 0-16: Commercial Sector: 2015 Hourly Load Profile

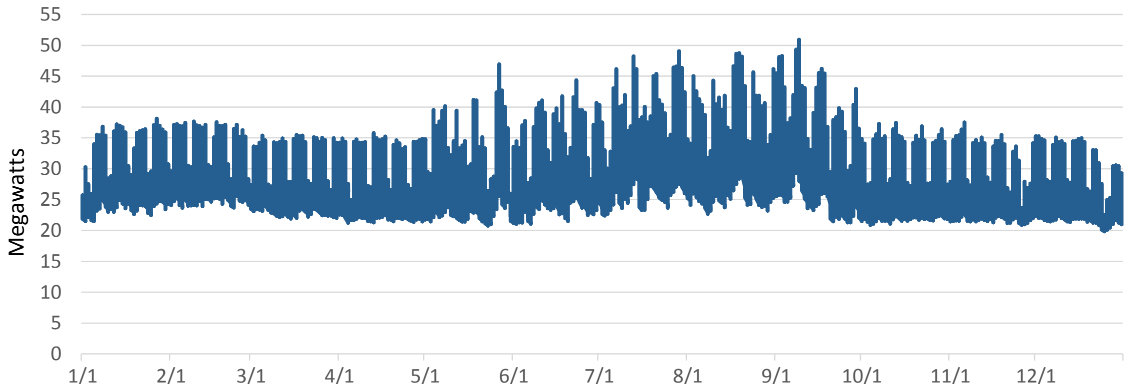


Figure 0-17 plots the daily electricity use of the commercial sector versus the average daily temperature. The points are coded with symbols that separate weekends and holidays from weekdays, and it is clear that this sector has lower daily kWh use on weekends. This plot shows that this customer sector has loads that are more sensitive to the warmer temperatures in the summer than it does the cooler temperatures.

Figure 0-17: Commercial Daily kWh Use vs. Daily Temperature

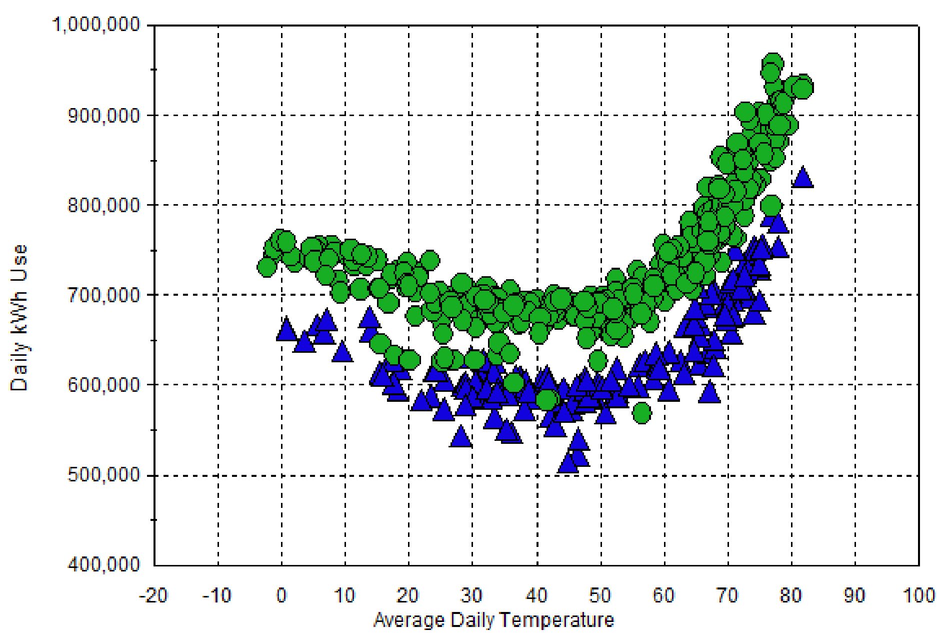


Figure 0-18 and Figure 0-19 provide the commercial sector "typical day" load profile for the summer and winter periods during 2015. During the weekdays, the commercial sector's load profile is characterized by one peak period, regardless of the season. During the day, loads increase sharply between 6 am and 12 pm, remain at high levels until about 4 pm, before gradually tapering off into the evening hours. During the summer months the commercial sector typically peaks around 2 pm during the weekdays, and slightly earlier in the winter months. Weekend loads are much lower in both the summer and winter months

Figure 0-18: Commercial Typical Day: Summer (Jun-Sep)

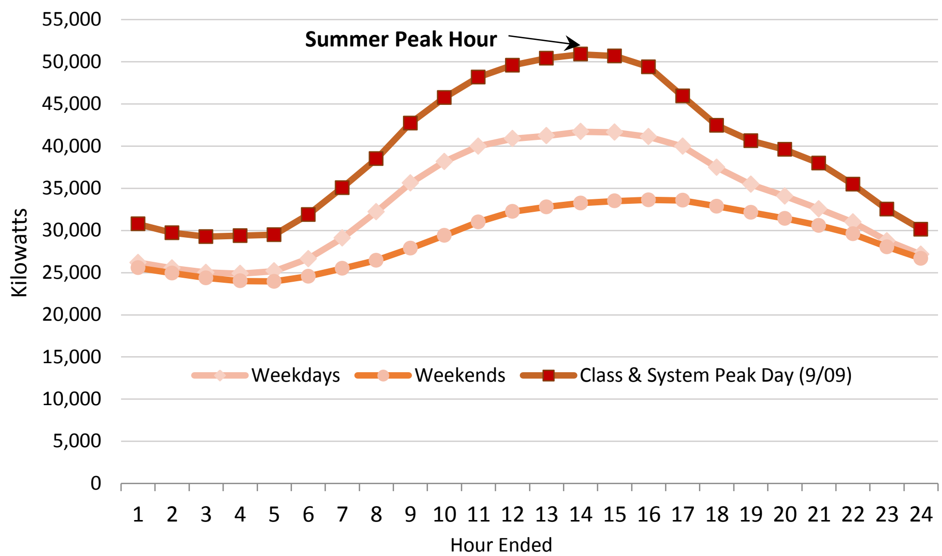
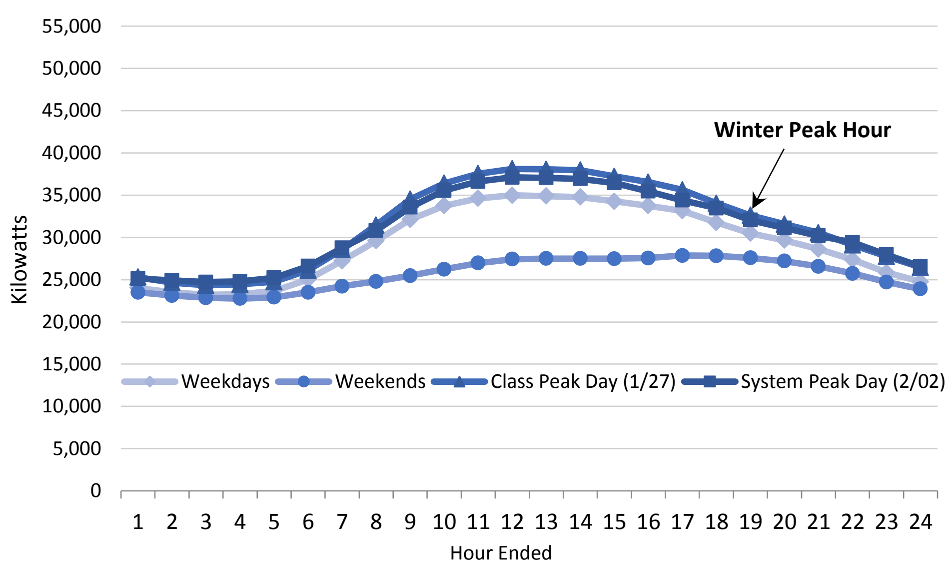


Figure 0-19: Commercial Typical Day: Winter (Dec-Mar)



6.1 **Street Lighting**

There are approximately 3,350 street lights in the city of Burlington, and they accounted for less than 1 percent of total retail sales in 2015 (2,525 MWh). Since 2010, the Department has increased efforts to replace street light fixtures with LED fixtures. By the end of 2015, more than 1,300 street lights (39 percent) were converted to LED fixtures, resulting in a decline in street lighting sales of more than 17 percent during the period. Street Lighting sales are fitted with a simple regression model driven by outdoor lighting energy intensity and seasonal variables. Between 2016 and 2036, street lighting sales are expected to decline by 0.3% per year.

7.1 **System Load Shape Forecast**

After developing the forecasts of monthly energy sales by customer class, a forecast of hourly system loads is developed in three steps. First, a monthly peak forecast is developed. The monthly peak model uses historical peak-producing weather, and incorporates the impact of weather on peak loads through several weather variables that drive heating and cooling usage. The weather variables include the average temperature on the peak day. The peak forecast is based on average monthly historical peak-producing weather for the 20-year period, 1996 through 2015. Next, class hourly load forecasts are derived by combining load profiles estimated from AMI data with class sales forecasts. Hourly loads are expressed as a function of daily HDD and CDD, binary for day of the week, month, seasons and holidays, and hours of light. Class sales forecasts are then combined with these hourly profile forecasts; the forecast is also adjusted for line losses.

Finally, the system hourly load forecast is generated by adding the residential, commercial, street lighting and solar load forecasts and calibrating the resulting system hourly load forecast to the system peak. Class and system hourly load forecasts extend through 2036. Table 0-5 and Table 0-6 show the potential levels of energy output requirements and summer and winter peak demand for the period 2016-2036, along with the class contribution to the peak and energy. The twenty-year compound annual growth rates for energy and summer and winter peak load are 0.25 percent, 0.07 percent and 0.18 percent, respectively.

Table 0-5: System Energy Forecast

Year	System Energy (MWh)	Residential Energy (MWh)	Commercial Energy (MWh)	Street Lighting Energy (MWh)
2016	346,108	83,680	259,881	2,547
2017	357,437	86,120	268,697	2,620
2018	362,158	87210	272,325	2,623
2019	365,460	87,219	275,628	2,612
2020	364,091	86,513	274,995	2,583
2021	361,111	85,468	273,071	2,572
2022	359,811	84,868	272,383	2,560
2023	358,922	84,431	271,938	2,552

2024	359,314	84,442	272,336	2,537
2025	358,094	83,818	271,756	2,521
2026	358,246	83,605	272,132	2,509
2027	358,767	83,564	272,700	2,503
2028	360,058	83,844	273,717	2,497
2029	360,055	83,760	273,801	2,495
2030	360,018	83,613	273.925	2,480
2031	360,326	83,597	274,269	2,460
2032	361,395	83,880	275,069	2,447
2033	361,053	83,796	274,814	2,443
2034	361,480	84,006	275,036	2,438
2035	362,124	84,303	275,391	2,429
2036	363,674	84,894	276,364	2,416
Compound Annual Growth				
2016-2026	0.35%	-0.01%	0.46%	-0.15%
2016-2035	0.25%	0.07%	0.31%	-0.26%

Table 0-6: System Peak Demand Forecast

Year	Summer Peak MW	Residential CP MW	Commercial CP MW	Lighting CP MW	Winter Peak MW	Residential CP MW	Commercial CP MW	Lighting CP MW
2016	66.9	14.7	52.2	0.0	51.2	20.0	30.7	0.6
2017	68.2	15.0	53.2	0.0	52.3	16.4	35.2	0.6
2018	68.9	15.3	53.6	0.0	53.1	16.7	35.8	0.6
2019	69.2	15.1	54.0	0.0	53.6	16.8	36.2	0.6
2020	68.7	15.9	52.8	0.0	54.0	16.7	36.6	0.6
2021	68.2	14.8	53.4	0.0	53.7	16.4	36.7	0.6
2022	67.9	14.7	53.2	0.0	52.9	16.1	36.2	0.6
2023	67.6	15.6	52.0	0.0	53.2	16.3	36.3	0.6
2024	67.6	15.7	51.9	0.0	52.9	16.2	36.0	0.6
2025	67.4	15.7	51.7	0.0	53.2	16.1	36.4	0.6
2026	67.5	15.6	51.8	0.0	53.3	16.1	36.6	0.6
2027	67.5	15.6	51.9	0.0	53.1	15.9	36.6	0.6
2028	67.6	14.7	53.0	0.0	52.6	15.7	36.3	0.6
2029	67.6	15.8	51.8	0.0	53.0	16.0	36.4	0.6
2030	67.6	15.9	51.7	0.0	52.7	15.8	36.2	0.6
2031	67.6	15.8	51.8	0.0	53.0	15.9	36.5	0.6
2032	67.8	15.8	52.0	0.0	53.4	15.9	36.9	0.6
2033	67.7	14.8	52.9	0.0	52.7	15.2	36.9	0.6
2034	67.7	15.9	51.8	0.0	53.1	15.8	36.7	0.6
2035	67.8	16.0	51.7	0.0	52.8	15.8	36.4	0.6
2036	67.9	16.2	51.7	0.0	53.1	15.9	36.6	0.6
Compound Annual Growth								
2016-2026	0.09%	0.60%	-0.08%	0.00%	0.40%	-2.15%	1.77%	0.00%
2016-2036	0.07%	0.49%	-0.05%	0.00%	0.18%	-1.14%	0.88%	0.00%

8.1 **Forecast Uncertainty & Sensitivity Analysis**

The long-range forecast of peak load and energy is necessary for long-range planning. The development of such a forecast requires the analysis of the system in order to determine the relationships between system sales and peak load and various economic and demographic factors, and projection of those factors into the future. As a general rule, the major events that perturb economic factors, and thus have the greatest impact on system growth, are those events that cannot be accurately predicted.

A high and low growth scenario was generated for each forecast to offer a reasonable bound which attempts to assess the uncertainty prevalent in the forecast. In the high case we assume that the economy (using GDP or output as a proxy) increases 1.0% faster than the base case growth and 1.0% lower growth in the low case. We also assume that the relationship between GPD growth and other economic drivers (including employment, number of households, and real income) is the same in the high and low case as it is in the base case. These low probability scenarios are used to indicate the forecast range, or dispersion of possible future trajectories.

As shown in Figure 0-20, the annual growth rates for the low and high energy scenarios are about 0.22 percent lower and 0.33 percent higher than the base scenario, respectively. The trajectories for peak demand in the low and high scenarios are similar to the electricity requirements trajectories.

Figure 0-20: System Energy Forecast – High & Low Economic Growth Scenarios

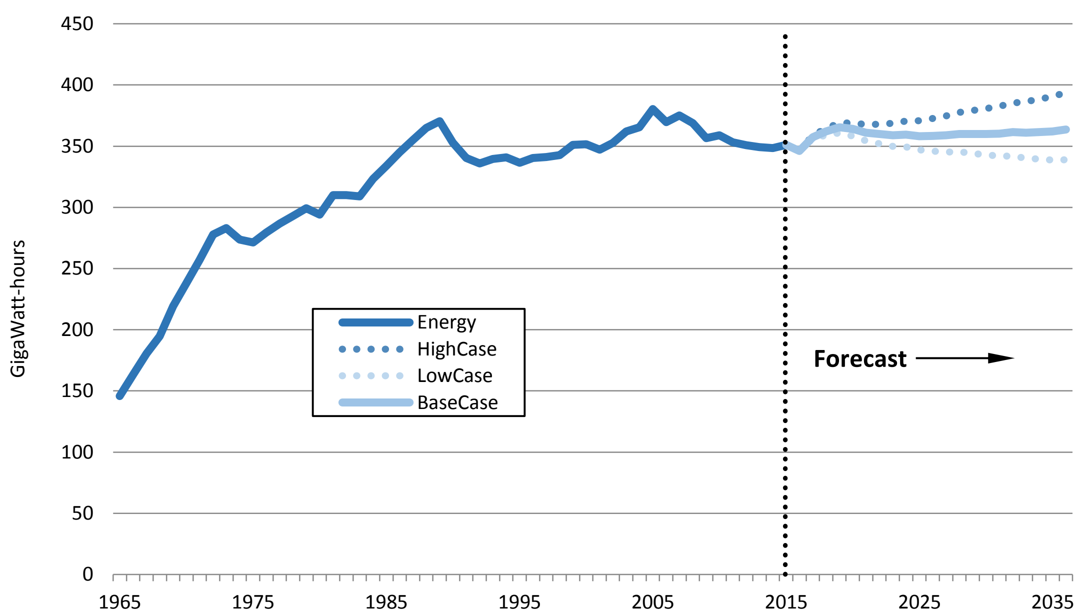
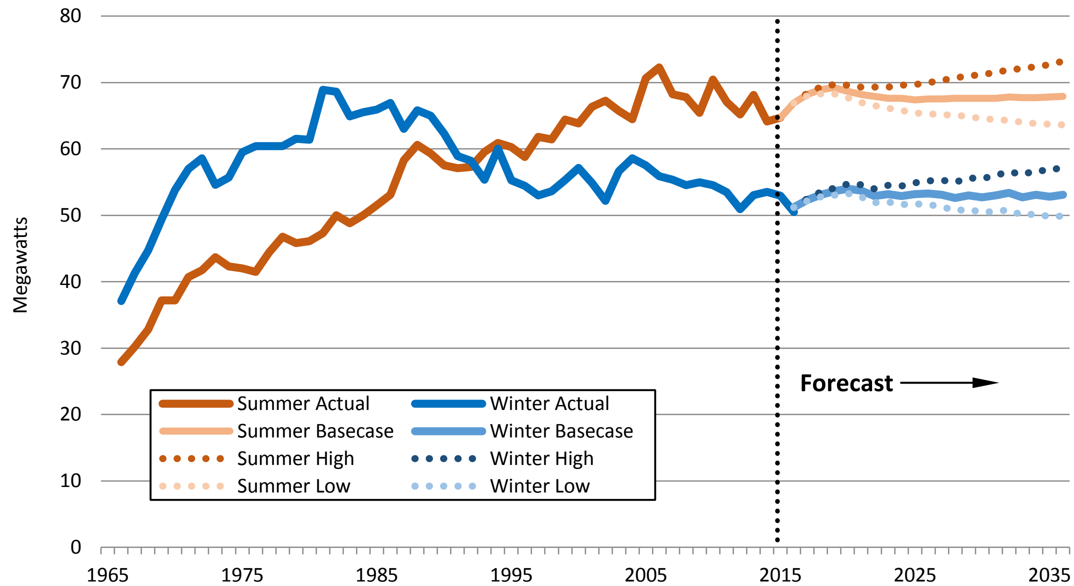
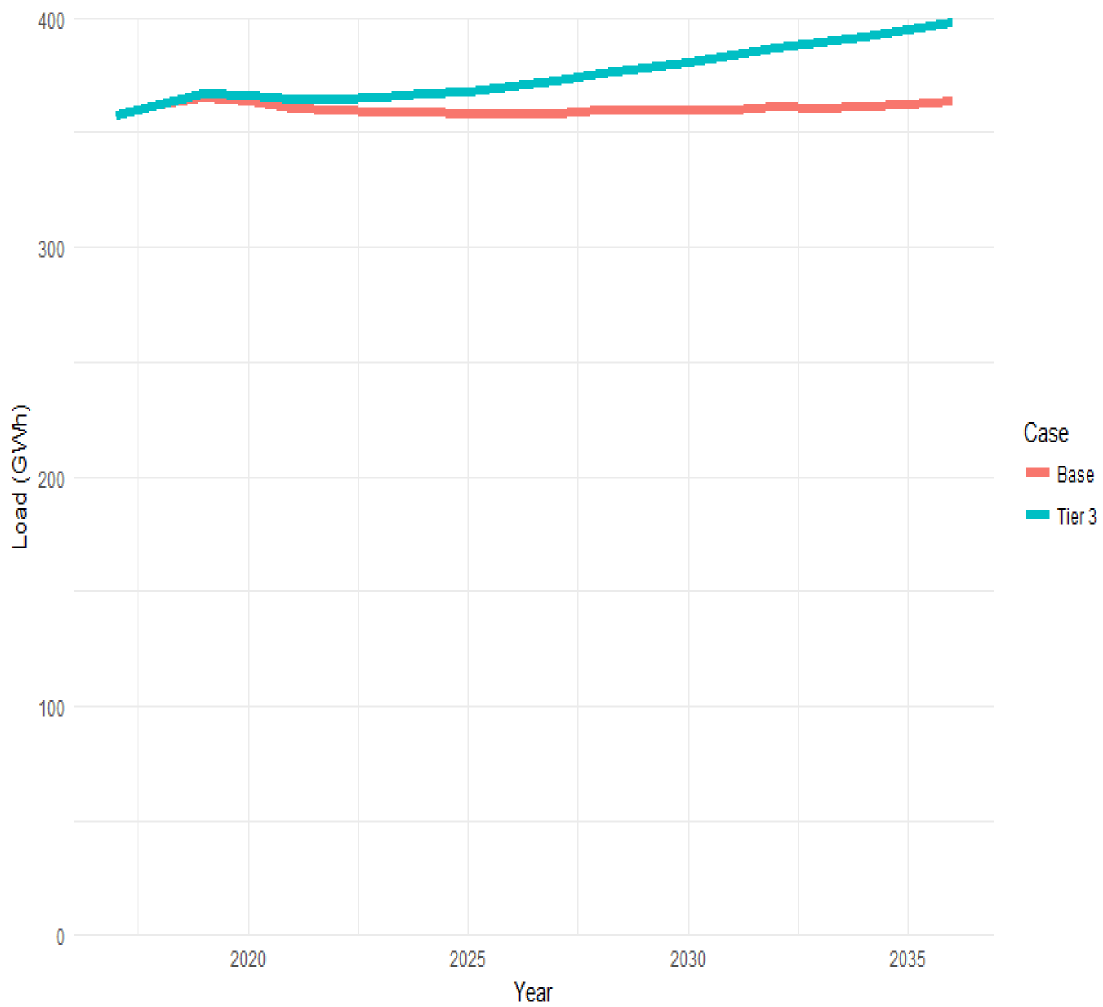


Figure 0-21: System Peak Demand – High & Low Economic Growth Scenarios



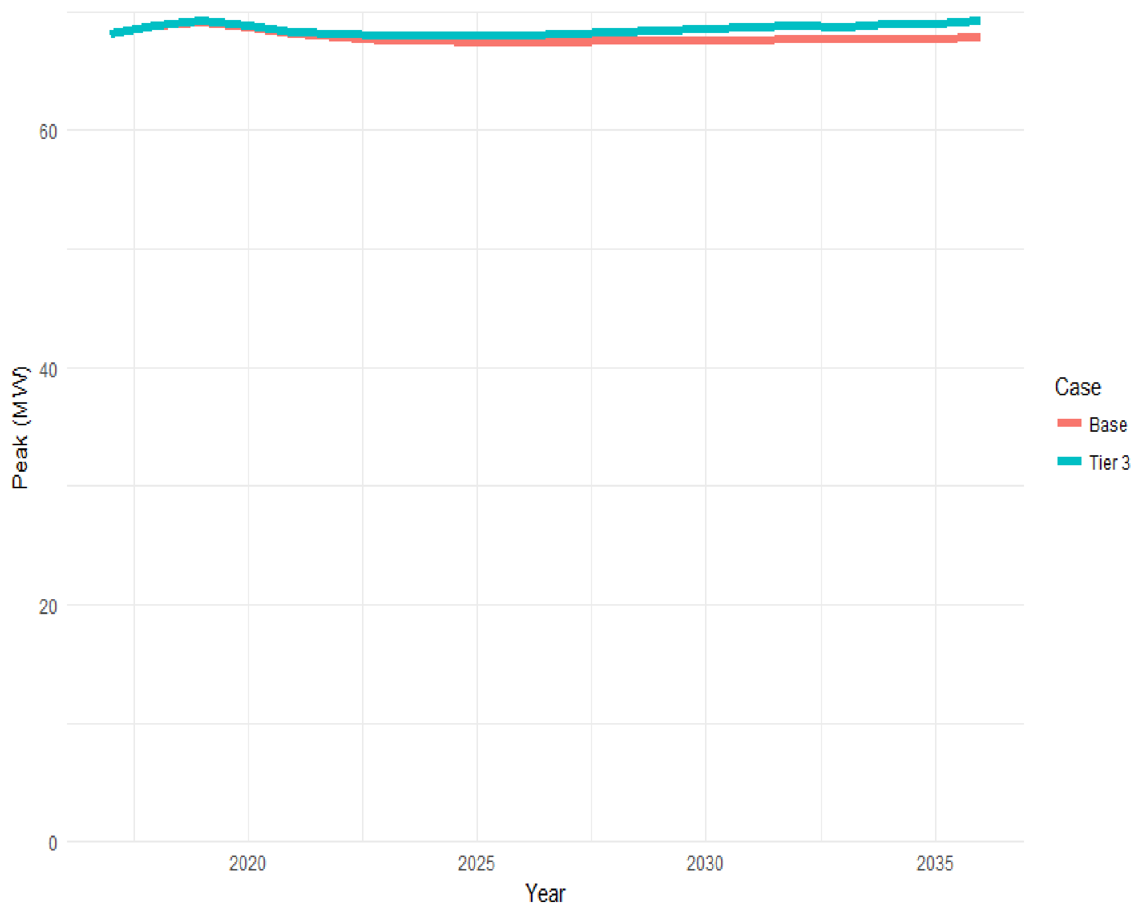
In addition to economic and demographic uncertainties, DU requirements under the Renewable Energy Standard also impose additional forecasting challenges onto BED. As described further in subsequent chapters, BED expects that its RES obligations will drive up load and peak demand over time as new strategic electrification measures such as cold climate heat pumps, EVs, E-buses and EV chargers are adopted by customers. If BED successfully achieves its escalating annual goals, load growth could be dramatic, especially since the legislation has a feedback mechanism that requires distribution utilities to increase their goals as more load building measures are adopted each year. As highlighted in the graph below, cumulative load growth could increase by as much as 9.6 percent above current forecasts that do not include electrification measures.

Figure 22: Strategic Electrification impacts on load



Although its RES obligations are expected to result in fairly significant load increases overtime as energy transformation measures are adopted, BED does not expect peak load to increase dramatically. This is so because most measures are expected to increase demand for energy during off peak periods of the year. As energy transformation programs measures are implemented, BED's peak is projected to increase to 69.3 MW in 2036, as highlighted in the graph below.

Figure 23: Strategic electrification impacts on Peak demand



Weather was included as a sensitivity case for the system energy forecast. Weather patterns tend to be random, and tend toward an average over the long term, which resulted in a minimal change in impact between decision paths for that variable. System peak scenarios were evaluated using extreme peak day temperature (a one in ten chance of occurring). This resulted in peak loads that were about 3.7 percent higher than peaks under typical peak weather conditions. Table 0-7 provides a summary of the forecasts for the various scenarios.

Table 0-7: System Peak & Energy Forecast Scenarios

	System Energy (MWh)			System Peak (MW)			90/10 Peak
Year	Low	Base	High	Low	Base	High	Base
2016	346,108	346,108	346,108	66.88	66.88	66.88	69.51
2021	354,382	361,111	367,738	66.98	68.18	69.34	70.73
2026	345,902	358,246	372,593	65.28	67.45	69.97	69.92
2031	341,912	360,326	382,484	64.62	67.65	71.52	70.08
2036	338,930	363,674	393,844	63.61	67.93	73.16	70.33
20-Year Growth Rate:	-0.10%	0.25%	0.65%	-0.25%	0.08%	0.45%	0.06%