2023 Forecasting Benchmark Survey

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October 31, 2023

2023 Forecasting Benchmark Survey

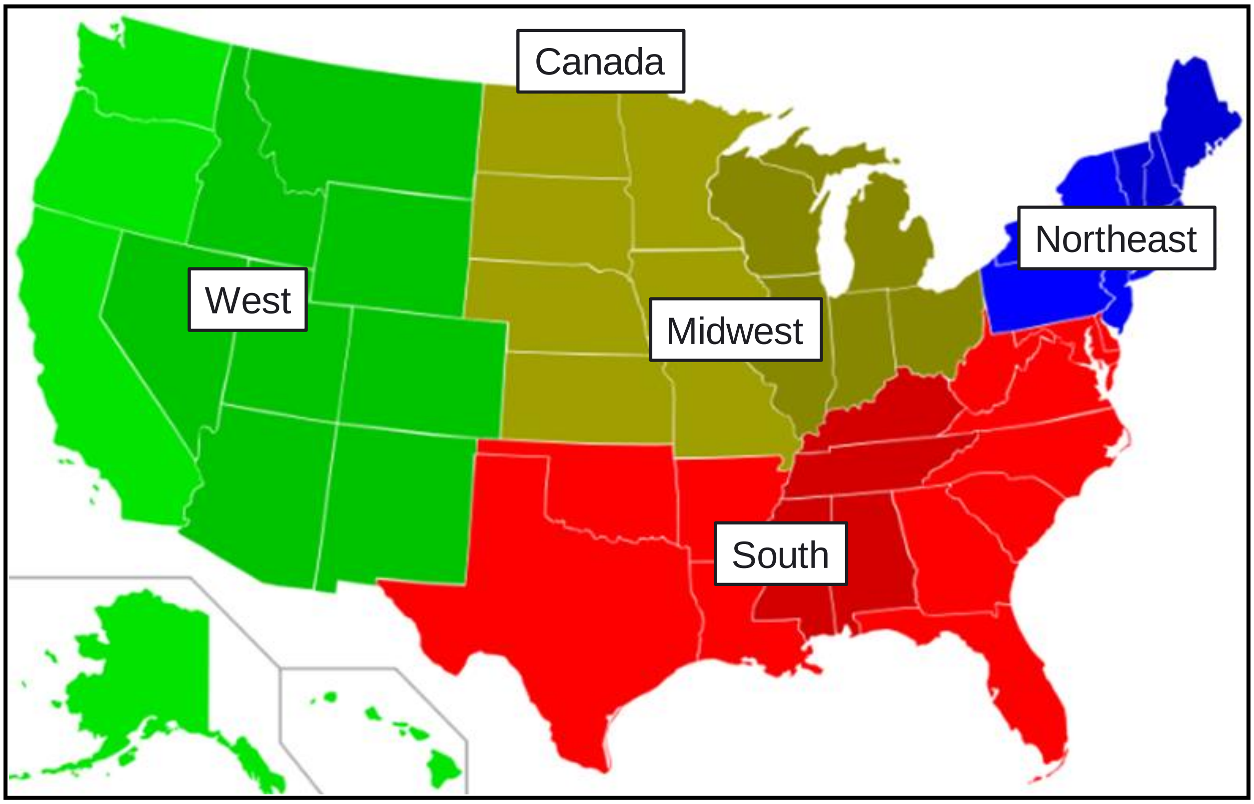
Itron's Annual Benchmarking Survey reports a broad picture of the electric and natural gas industry forecasting practices. The survey collects data from February through July and culminates with this report. This year, the survey included 123 respondents, the largest number of respondents since Itron began the surveys in 2012. The respondents represent over 2,800 TWh of electricity and 1,300 BCF of natural gas. Figure 1 shows the number of survey responses for 2023 and the prior years.

Figure 1: Survey Respondents

Year	Electric	Natural Gas	Total
2012	77	NA	77
2013	74	NA	74
2014	71	10	81
2015	75	9	84
2016	64	8	72
2017	73	13	86
2018	78	16	94
2019	61	12	73
2020	48	11	59
2021	85	10	98
2022	73	13	88
2023	97	16	123

Survey results are presented by geographic region and are weighted by sales unless otherwise noted. The geographic regions are shown in Figure 2. Weights are developed based on self-reported 2022 annual sales of electricity and natural gas.

Figure 2: Survey Regions



This report includes the following sections.

- Forecast Accuracy Overview
- Electric Forecast Growth Overview
- Natural Gas Forecast Growth Overview
- Customer Growth
- Residential Sales Growth
- Commercial Sales Growth
- Industrial Sales Growth
- System Sales Growth
- System Peak Growth
- COVID Impacts
- Electric Forecast Accuracy
- Natural Gas Forecast Accuracy
- Key Forecast Characteristics

Forecast Accuracy Overview

Since 2012, Itron has asked companies to provide forecast accuracy statistics. Like last year, this year's results continue to be impacted by COVID-19 recovery.

When the first COVID-19 healthcare orders appeared in 2020 (i.e., stay-at-home, and work-from-home orders), residential sales increased, and non-residential (commercial and industrial) sales decreased. These unanticipated changes created larger-than-normal errors in 2020 and 2021.

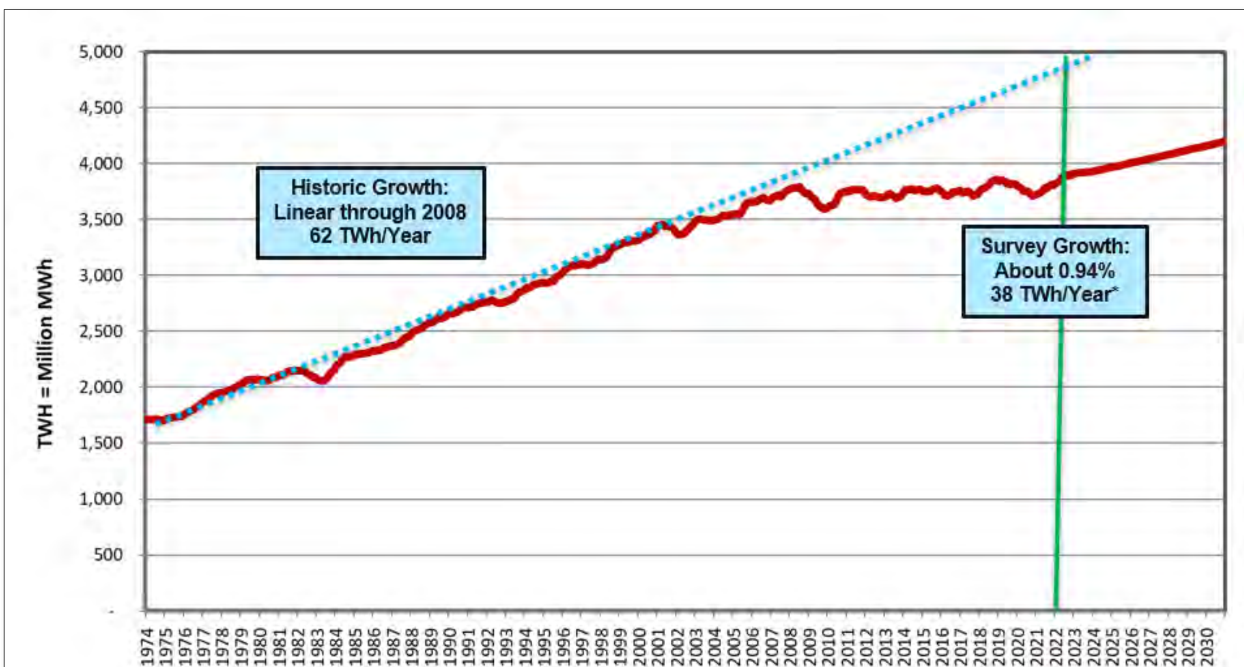
Forecasts for 2022, generated in 2021, show higher than historical average errors but are trending toward pre-pandemic averages as shown in Figure 18 and Figure 19.Figure 23

Electric Forecast Growth Overview

As the industry moves beyond the pandemic, residential sales growth is flattening while commercial and industrial sales continue to recover. Industrial sales are further strengthened from onshoring production and securing domestic supply chains. Overall, the electric systems are showing robust sales growth. Figure 9 through Figure 13 show 2022 growth rates and the long-term forecast growth rates.

Figure 3 shows historical sales from 1974 through 2022 as 12-month rolling sums. The red line shows historic sales through 2022 with forecast sales based on the survey's retail projections through 2030. The blue dash line shows the long-term growth trend through 2008 and extrapolated from 2009 through the forecast period. This figure shows that 2021 and 2022 sales are accelerating back to pre-pandemic levels with a long-term forecast growth rate of 0.94% per year.

Figure 3: Survey Electric Sales Growth



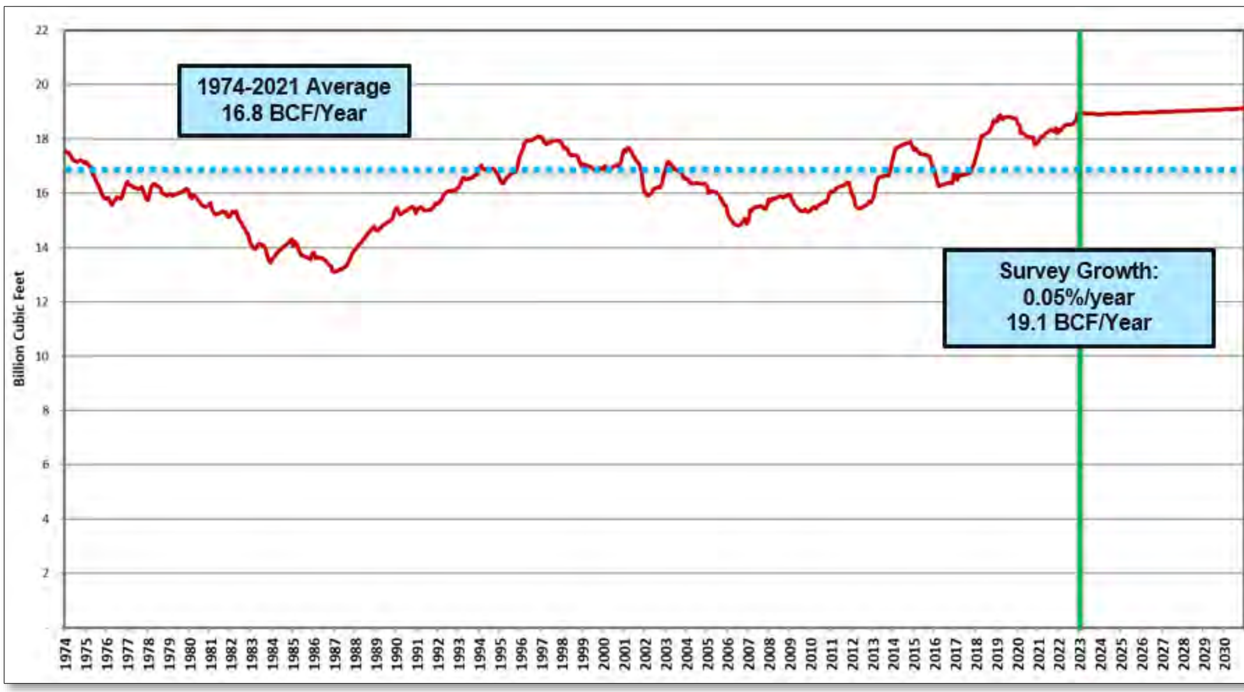
Natural Gas Forecast Growth Overview

COVID-19 impacted 2020 natural gas sales less than the electric industry. The reduced impact is due to two effects. First, COVID-19 healthcare orders began in March 2020 after the early (January through March) heating season. Second, many COVID-19 restrictions were removed by the late winter heating season (November and December).

2022 natural gas sales are at a historical high level based on the strong consumption across the retail classes and a colder than normal winter season. Figure 9 through Figure 13 show 2022 growth rates and the long-term forecast growth rates.

Figure 4 shows a 12-month rolling sum of monthly retail gas sales. The forecast is based on reported forecast growth rates through 2030. Despite the recent strong growth, future expectations are for "flat" growth.

Figure 4: U.S. Historical Natural Gas Sales

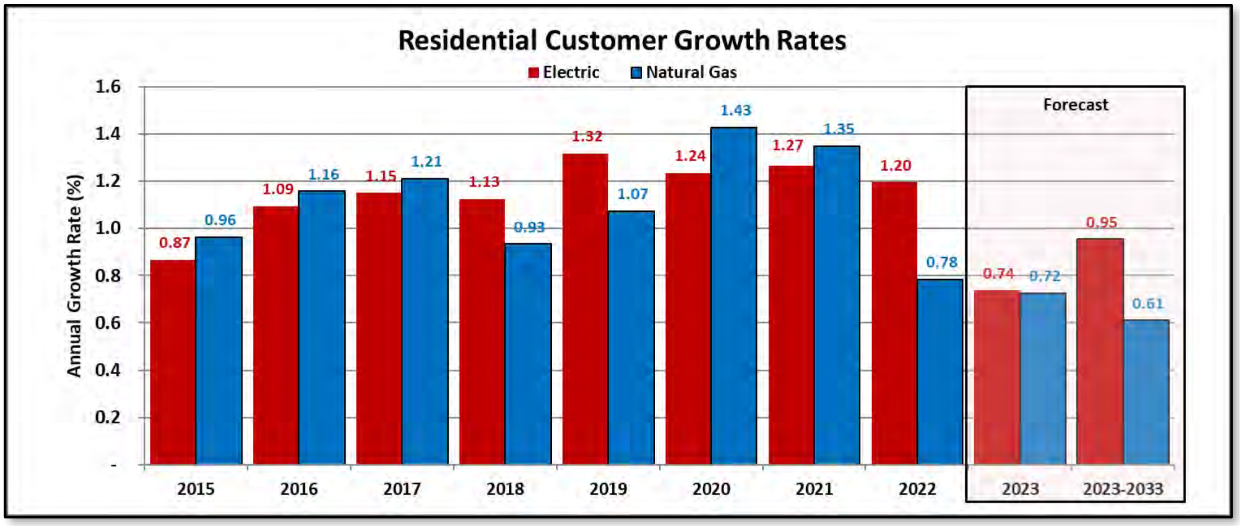


Customers Growth

Historical and forecast customer growth rates for the residential and commercial classes are shown in Figure 5 through Figure 8. Forecast growth rates for 2023 and the long term (2023-2033) are highlighted. For comparative purposes, growth rates from the 2015 through 2019 (pre-COVID-19 growth) surveys are displayed with the 2023 survey results.

Residential Customer Growth. Figure 5 shows residential customer growth rates for electric and natural gas respondents. In 2022, electric customers increased 1.20% and natural gas customers increased 0.78%.

Figure 5: Residential Average Customer Growth (%)



2022 residential electric customer growth (1.20%) is consistent with pre-2019 average growth rate (1.11%) indicating that customer growth has returned to pre-COVID-19 levels. However, the 2023 forecast (0.74%) and the long-term forecast (0.95%) are lower than the pre-2019 average growth reflecting the long-term expectation of slow population growth.

Residential natural gas growth in 2022 (0.78%) is weak relative to the pre-pandemic average growth (1.07%). Both the 2023 forecast (0.72%) and the long-term forecast (0.61%) continue to show slow growth. 73% of natural gas respondents forecast long-term growth lower than their historical 5-year growth rates.

Figure 6 shows the regional growth rates. The figure shows the continued pattern of strong residential customer growth in the South and West relative to the Northeast and Midwest regions. The figure also shows the 2023 forecast growth rate, the ten-year forecast growth rate, and the pre-pandemic 5-year average (2015-2019) growth rate.

Figure 6: Residential Average Customer Growth by Region (%)

Region	Actual 2015	Actual 2016	Actual 2017	Actual 2018	Actual 2019	Actual 2020	Actual 2021	Actual 2022	Forecast 2023	Forecast 2023-2033	Average 2015-2019
Canada	0.81	1.21	1.04	0.94	0.96	1.12	1.16	1.32	1.09	0.88	0.99
Midwest	0.55	0.82	0.77	0.61	0.72	0.92	0.71	0.66	0.50	0.91	0.69
Northeast	0.27	0.40	0.57	0.72	0.61	0.29	0.49	0.40	0.38	0.40	0.51
South	1.30	1.21	1.35	1.43	1.67	1.61	1.53	1.43	0.65	0.99	1.39
West	1.05	1.43	1.49	1.32	1.45	1.54	1.71	1.44	1.30	1.22	1.35
Total Electric	0.87	1.09	1.15	1.13	1.32	1.24	1.27	1.20	0.74	0.95	1.11
Natural Gas	0.96	1.16	1.21	0.93	1.07	1.43	1.35	0.78	0.72	0.61	1.07

<u>Commercial Customer Growth</u>. Figure 7 shows commercial customer growth rates for electric and natural gas respondents. In 2022, electric customers grew 1.25% and natural gas customers grew 0.39%. Respondents forecast lower 2023 commercial customer growth (0.84%) and long-term growth (0.66%); this is lower than pre-COVID-19 customer growth.

The commercial natural gas customers show low growth in 2022 (0.39%) with forecast growth significantly below the pre-COVID-19 average growth (0.57%).

Figure 7: Commercial Average Customer Growth (%)

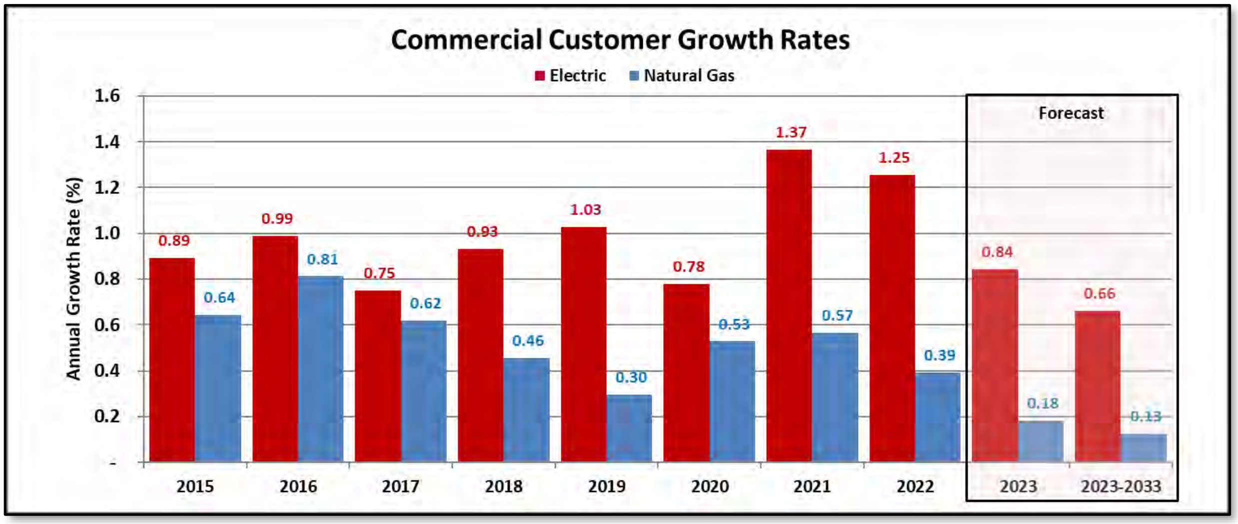


Figure 8 shows the regional growth rates. This figure shows strong commercial customer growth in the South and West relative to the Canadian, Northeast and Midwest regions. The figure also shows the 2023 forecast growth rate, the ten-year forecast growth rate, and the pre-pandemic 5-year average (2015-2019) growth rate.

Figure 8: Commercial Average Customer Growth by Region (%)

Region	Actual 2015	Actual 2016	Actual 2017	Actual 2018	Actual 2019	Actual 2020	Actual 2021	Actual 2022	Forecast 2023	Forecast 2023-2033	Average 2015-2019
Canada	0.68	0.94	0.25	0.45	0.47	0.55	0.80	0.72	0.30	0.44	0.56
Midwest	0.83	1.08	0.71	0.66	0.72	0.46	0.77	0.53	0.16	0.76	0.80
Northeast	0.51	1.10	0.53	0.50	0.54	0.14	0.77	0.90	0.61	0.27	0.64
South	1.19	0.91	1.17	1.24	1.35	1.16	1.90	1.84	1.41	0.65	1.17
West	1.02	1.27	0.16	0.91	0.89	1.06	1.43	1.11	1.02	0.91	0.85
Total Electric	0.89	0.99	0.75	0.93	1.03	0.78	1.37	1.25	0.84	0.66	0.92
Natural Gas	0.64	0.81	0.62	0.46	0.30	0.53	0.57	0.39	0.18	0.13	0.57

Residential Sales Growth

Figure 9 shows historical and current reported weather-normalized residential sales growth rates. The figure also shows the 2023 forecast growth rate, the ten-year forecast growth rate, and the pre-pandemic 5-year average (2015-2019) growth rate.

Figure 9: Residential Sales Growth

Region	Actual 2015	Actual 2016	Actual 2017	Actual 2018	Actual 2019	Actual 2020	Actual 2021	Actual 2022	Forecast 2023	Forecast 2023-2033	Average 2015-2019
Canada	(0.97)	1.12	0.79	1.37	1.02	2.90	0.82	0.54	1.71	1.34	0.66
Midwest	(1.24)	(0.15)	(0.45)	0.09	0.19	3.71	(0.82)	(0.58)	(0.31)	0.88	(0.31)
Northeast	(1.25)	0.09	0.27	1.27	(0.57)	4.54	(0.85)	(0.17)	0.90	0.23	(0.04)
South	1.27	0.12	0.07	1.85	(0.22)	4.12	(0.09)	0.76	1.39	1.01	0.62
West	(1.11)	1.29	0.80	0.18	(0.10)	4.09	1.61	0.21	1.09	2.11	0.21
Electric Total	(0.38)	0.33	0.16	1.19	0.03	3.80	0.11	0.31	0.94	1.12	0.27
Itron WN	0.31	0.17	0.74	0.62	(0.42)	4.78	-0.52	2.03			0.28
Natural Gas Total	(0.72)	0.91	1.53	(1.88)	1.08	1.15	(0.80)	2.01	(0.21)	(0.01)	0.19

Electric. Weather-normalized residential sales grew 0.31% in 2022, consistent with the pre-COVID-19 annual average growth rate (0.27%). However, both the 2023 forecast growth (0.94%) and the long-term forecast growth (1.12%) are very strong relative to the pre-COVID-19 average. The high forecast growth implies increasing electric intensity (i.e., kWh/Customer). This is the first time since Itron began conducting the survey that respondents have forecasted increasing intensity.

The increasing forecast electric intensity is contrary to EIA's long-term intensity forecast (2023 Annual Energy Outlook, or AEO) and may be a reporting anomaly since only 36% of electric utilities report increasing intensities. However, some companies are expecting strong intensity growth which may be driven by electric vehicle adoption and the electrification response to decarbonization. Whether electric intensities are increasing or decreasing is an issue to monitor in future surveys.

Natural Gas. Weather-normalized residential natural gas sales increased 2.01% in 2022 with several respondents showing strong growth. Despite the 2022 growth, expectations show slight declines or "flat" growth consistent with the very low pre-COVID-19 growth trends.

Commercial Sales Growth

Figure 10 shows historical and current reported weather-normalized commercial sales growth rates. The figure also shows the 2023 forecast growth rate, the ten-year forecast growth rate, and the pre-pandemic 5-year average growth rate.

Figure 10: Commercial Sales Growth

Region	Actual 2015	Actual 2016	Actual 2017	Actual 2018	Actual 2019	Actual 2020	Actual 2021	Actual 2022	Forecast 2023	Forecast 2023-2033	Average 2015-2019
Canada	0.51	1.14	0.51	1.86	0.81	(4.00)	0.68	3.32	2.15	1.16	0.97
Midwest	(0.48)	0.03	0.13	0.06	(1.22)	(4.91)	3.55	1.84	(0.60)	0.17	(0.30)
Northeast	(0.58)	(0.47)	(0.47)	(0.07)	(0.82)	(7.35)	1.41	4.04	(0.60)	(0.92)	(0.48)
South	1.07	0.24	0.24	1.88	(0.47)	(5.09)	2.82	2.76	0.52	0.89	0.59
West	0.43	0.24	0.24	0.55	(0.24)	(4.70)	4.09	2.90	2.93	2.82	0.24
Electric Total	0.28	0.32	0.32	1.25	(0.42)	(4.95)	2.51	2.71	0.72	0.89	0.35
Itron WN	0.04	(0.07)	(0.01)	1.34	(1.03)	(4.92)	3.20	3.10			0.05
Natural Gas Total	(0.58)	0.69	3.99	(1.04)	2.13	(2.97)	2.52	3.42	(0.89)	(0.08)	1.04

Electric. Weather-normalized commercial sales increased 2.71% in 2022. The 2022 growth rate is much larger than the pre-pandemic growth rate and continues to display the recovery from the 2020 sales decline. The forecast growth for 2023 and the long-term are significantly higher than the pre-COVID-19 trend driven by strong growth in the West in areas with high technology growth.

Natural Gas. Weather-normalized commercial natural gas sales increased 3.43% in 2022. Despite the 2022 growth, expectations show a decline in 2023 with “flat” growth in the long-term.

Industrial Sales Growth

Figure 11 shows past and current reported weather-normalized industrial sales growth rates. The figure also shows the 2022 forecast growth rate, the ten-year forecast growth rate, and the pre-pandemic 5-year average growth rate.

Figure 11: Industrial Sales Growth

Region	Actual 2015	Actual 2016	Actual 2017	Actual 2018	Actual 2019	Actual 2020	Actual 2021	Actual 2022	Forecast 2023	Forecast 2023-2033	Average 2015-2019
Canada	(1.57)	(1.41)	(1.06)	(1.59)	(0.27)	(0.93)	2.53	1.16	0.35	1.09	(1.18)
Midwest	(0.71)	0.41	0.20	1.29	(2.59)	(5.12)	4.30	1.65	0.93	(0.30)	(0.28)
Northeast	(3.44)	(1.74)	1.33	(1.15)	(2.63)	(5.96)	1.89	0.76	0.51	(0.87)	(1.53)
South	1.75	0.36	1.26	1.95	1.56	1.13	3.99	4.47	(1.02)	1.32	1.38
West	(1.47)	(1.89)	(1.97)	0.11	2.06	1.04	0.99	(2.62)	0.52	0.90	(0.63)
Electric Total	(0.33)	(0.23)	0.33	0.76	0.21	(1.09)	3.42	2.28	(0.05)	0.70	0.15
Natural Gas Total	(0.13)	4.61	2.33	(0.33)	3.23	(6.94)	(1.07)	2.37	2.75	(0.24)	1.94

Electric. Weather-normalized electric industrial sales increased 2.28% in 2022. Compared with 2020 the decline in sales, the 2021 and 2022 growth rates show a full recovery and strong continued growth. Despite the 2023 forecast decline (0.05%), the long-term forecast shows strong growth (0.70%) relative to the historical average. Future growth expectations are attributed to the impacts of manufacturing onshoring and the strengthening of domestic supply chains.

Natural Gas. Natural gas companies saw average weather normal sales increase of 2.37% in 2022. Despite the strong 2022 growth and the 2023 forecast growth, natural gas companies expect sales to be slightly declining in the long term.

System Sales Growth

Total system growth includes all utility classes and may include wholesale, resale and agricultural classes. Figure 12 shows system growth with the 2023 forecast growth rate, the ten-year forecast growth rate, and the pre-pandemic 5-year average growth rate.

Figure 12: System Energy

Region	Actual 2015	Actual 2016	Actual 2017	Actual 2018	Actual 2019	Actual 2020	Actual 2021	Actual 2022	Forecast 2023	Forecast 2023-2033	Average 2015-2019
Canada	(1.41)	(0.02)	0.21	0.26	(0.08)	(0.31)	1.64	1.80	1.33	1.15	(0.21)
Midwest	(0.34)	0.35	(0.14)	0.14	(1.22)	(2.56)	2.02	0.84	0.17	0.48	(0.24)
Northeast	(1.59)	(0.41)	0.36	0.21	(1.22)	(3.55)	0.57	1.59	0.20	0.21	(0.53)
South	1.54	0.35	0.42	2.56	0.11	(0.26)	2.26	2.62	1.23	0.94	0.99
West	(1.18)	0.07	0.34	0.15	0.24	(0.31)	2.39	1.12	1.26	3.18	(0.08)
Electric Total	(0.12)	0.21	0.26	1.24	(0.25)	(1.14)	2.02	1.85	0.95	1.06	0.27
Itron WN	(0.17)	(0.22)	0.48	1.07	(0.51)	(1.10)	2.01	2.05			0.13
Natural Gas Total	1.50	1.48	1.54	(0.56)	2.82	(1.79)	0.59	1.89	(0.22)	0.05	1.36

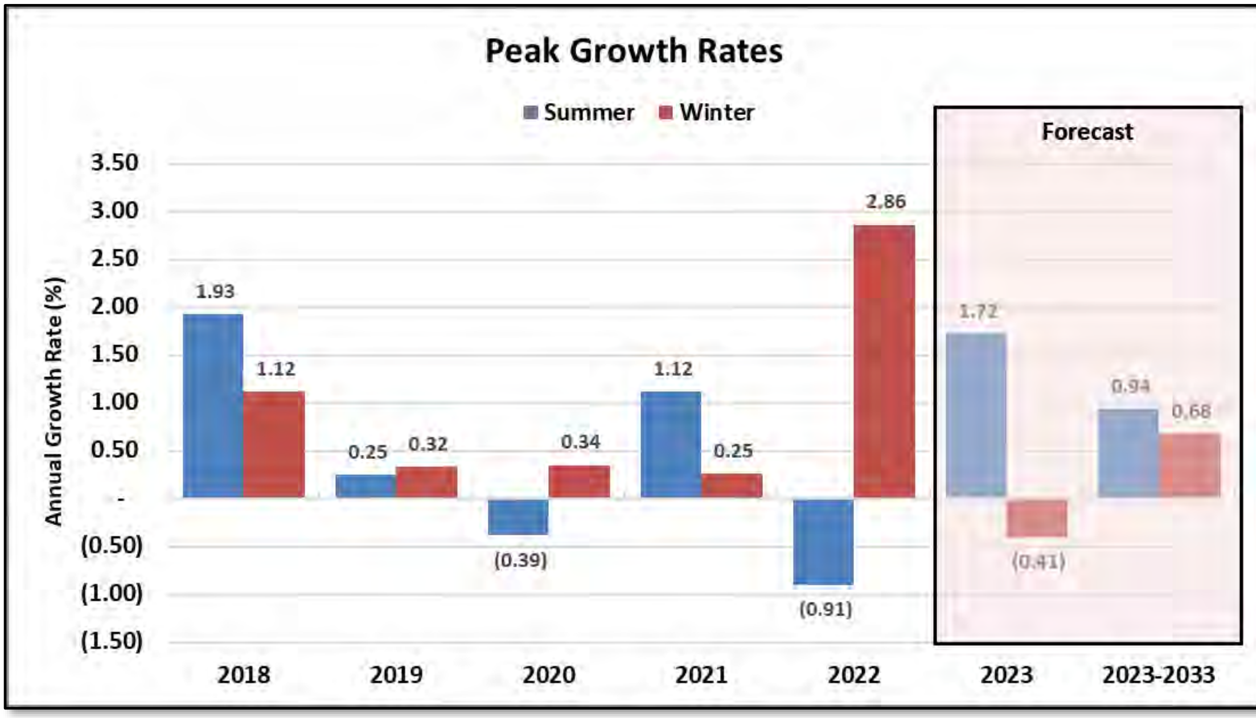
Electric. Weather-normalized system energy increased 1.85% in 2022. The strong sales growth reflects the strong commercial and industrial sector growth. Forecast growth continues to be strong with long-term growth (1.06%) higher than the pre-pandemic growth rate (0.27%).

Natural Gas. Weather normalized natural gas system sales increased 1.89% in 2022. The increase reflects the strong commercial and industrial growth and demonstrates a full recovery from the COVID-19 sales decline. In the long-term, growth is expected to be flat (0.05%) which is significantly below the pre-pandemic 5-year average growth rate (1.36%).

System Peak Growth

System weather-normalized peak forecast growth is shown in Figure 13. This figure shows historical and forecast peaks for summer and winter peaking companies. Pre-pandemic 5-year average growth rates are not available for historical peak because Itron did not begin asking for summer and winter peak information until 2018.

Figure 13: Electric Peak Growth



Summer peaks decreased 0.91% in 2022. The decrease is driven by half of the companies' reporting declines and 22% reporting declines greater than 2%. The long-term forecast growth rate (0.94%) is expected to be within the historical range of growth rates between 2018 and 2021.

Winter peaks increased 2.86% in 2022. The strong growth is driven by the unusual December 2022 storm event. The large number of outages from the winter storm event makes weather normalization difficult. As a result, the 2022 growth may reflect weather normalization methods and not be indicative of an underlying change in growth patterns. The long-term forecast growth rate (0.68%) is expected to be within the historical range of growth rates between 2018 and 2021.

COVID-19 Impacts

The COVID-19 emergency began in January 2020 and ended in March 2023. Through this period, COVID-19 ushered in quarantines, product shortages, and business closures. U.S. GDP fell by 8.9% in the second quarter of 2020 and electric sales declined by 2.4% in 2020.

Since March 2020, Itron tracked the COVID-19 impact through a series of web seminars, industry presentations, and impact memorandums. In this survey, Itron asked companies about how COVID-19 impacted their forecasting methods.

COVID-19 Modelling and Forecasting. The largest COVID-19 impacts occurred in 2020 with impacts waning through 2021 and 2022. The evolving impacts challenged forecasters with the "best" solution to account for both historical and forecast changes. Like the prior years, this year's survey asks two modeling/forecasting questions. First, the survey asked companies how they model COVID-19. Second, the survey asked whether companies needed to make further forecast adjustments after modeling.

Figure 14 shows how companies modeled COVID-19. The approaches included in this question are defined below.

- **Binaries**. Binaries are variables that can either (1) remove the impact of a historical data point from the model estimation period or (2) capture an average level shift in the historical estimation period. In both cases, binaries represent the impact of COVID-19 on historical sales.
- **Google Mobility Data**. Google Mobility Data reported movement trends by geography across different categories such as retail, workplaces, and residential. These data are developed into regression variables that represent COVID-19 impacts on sales. Google ceased to update these data in October 2022.
- **Residual**. Residual variables are created by forecasting sales assuming that COVID-19 did not occur and comparing it with actual data. The residual variable is inserted into a regression model to model the COVID-19 impact.
- **Remove Data**. Removing data assumes the COVID-19 data are outliers. The outliers are removed from the model estimation period and the model forecasts assuming COVID-19 did not occur.
- **Other**. Several companies reported using multiple methods or blending methods to model the COVID-19 effects. One company reported using Moody's "Back-to-Normal" index which is a constructed variable developed by Moody's Analytics that measures how the economy is trending back to pre-COVID-19 levels.

Figure 14: COVID-19 Modeling Approaches

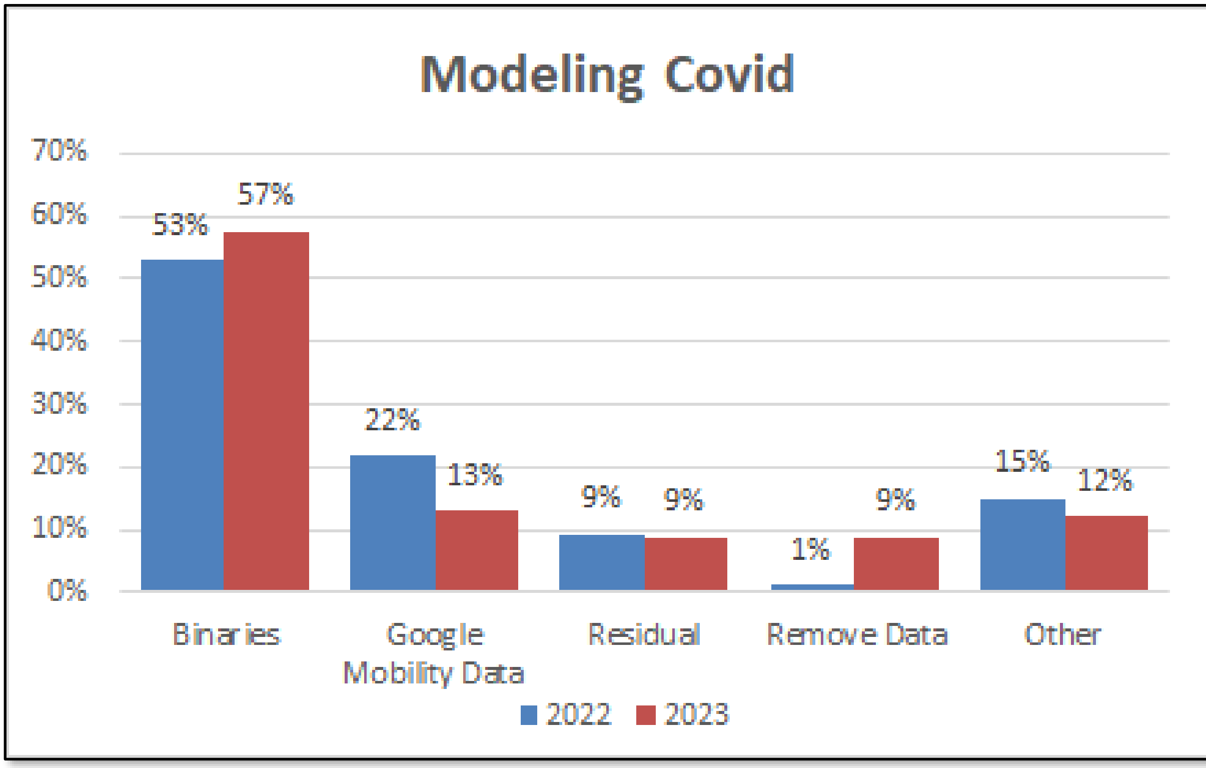
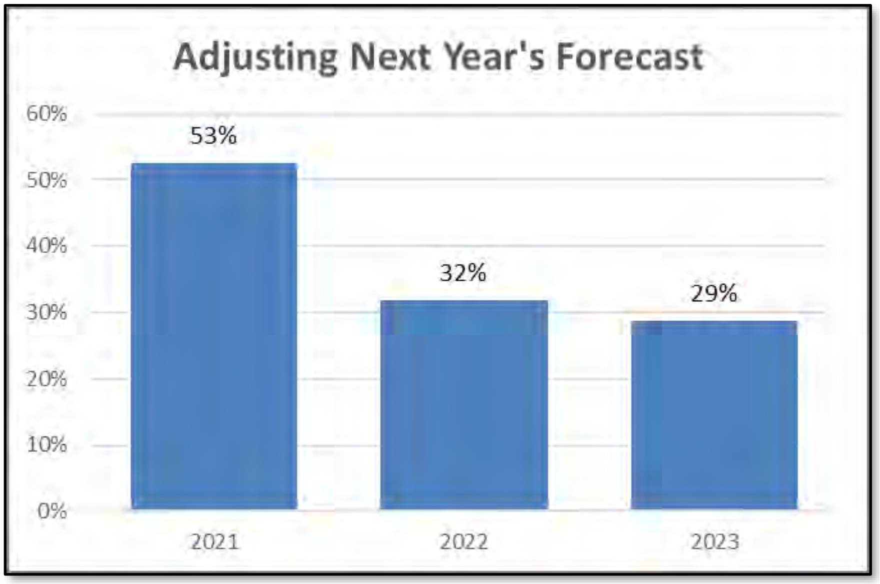


Figure 14 compares 2022 and 2023 survey responses. In 2023, 57% of companies use Binaries. This result is not surprising because Binaries are often used to capture short-term effects and remove data outliers. With COVID-19 largely behind us, Binaries effectively remove the COVID-19 effects from the historical dataset. Coupled with the Remove Data option (9%), 66% of respondents are effectively removing COVID-19 from their datasets.

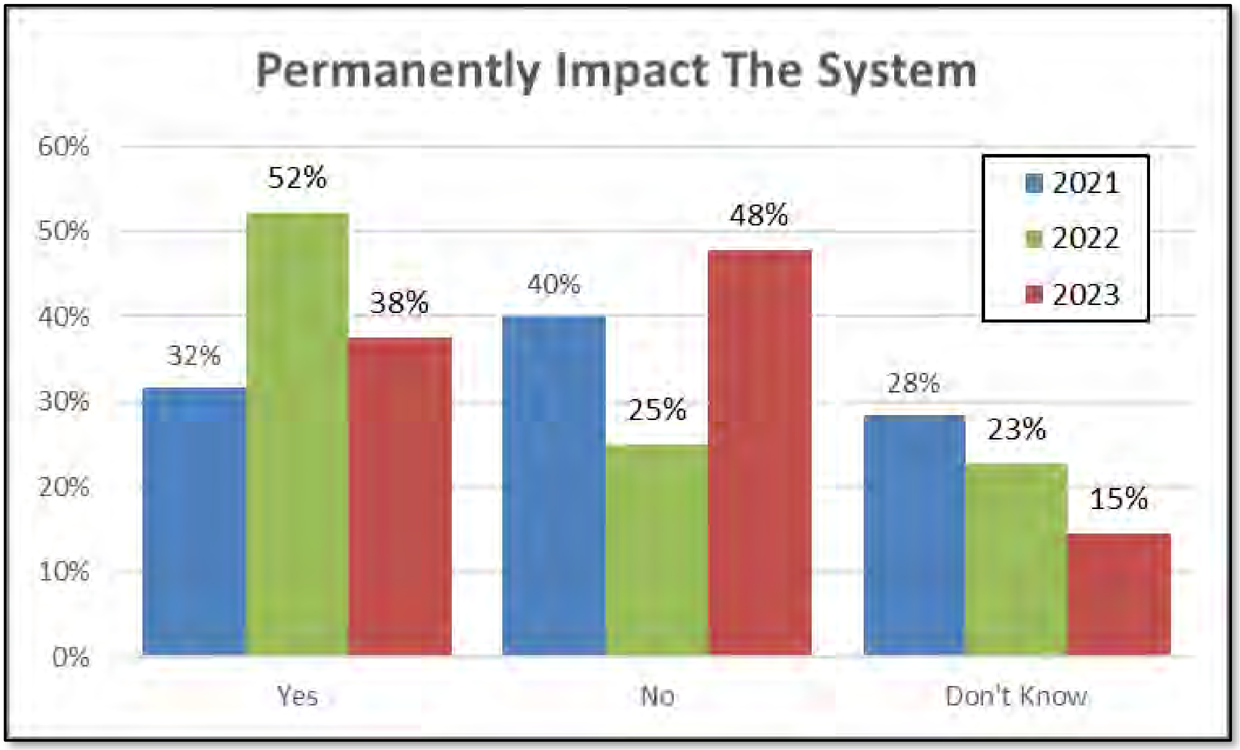
Through the pandemic, forecasters adjusted results when their statistical models did not generate reliable results. In 2021, the high degree of uncertainty around COVID-19 effects resulted in 53% of respondent making manual changes to their forecast. In 2022 and 2023, COVID-19 effects waned resulting in significantly fewer manual adjustments. In 2023, 29% of respondents made manual adjustments. Of these respondents, 50% used the Google Mobility Data or Residual modeling approaches. Figure 15 shows the percentage of respondents making manual forecast adjustments.

Figure 15: Manually Adjusting Next Year's Forecast



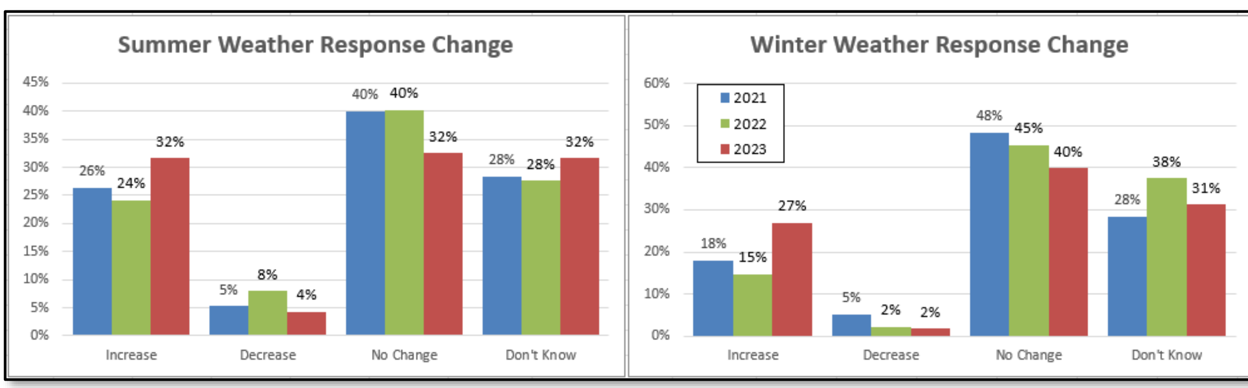
COVID-19 Permanence. Regardless of the approach used to model COVID-19 impacts, companies still must decide how long the historical impacts will last. Since 2021, the survey asked whether the COVID-19 impacts have permanently changed system demand. Figure 16 shows that 38% of respondents in 2023 believe that COVID-19 permanently impacted their energy demand. The response is a significant decline from the 52% response in 2022 suggesting that energy consumption is returning to pre-COVID usage patterns.

Figure 16: Did COVID-19 Permanently Change System Demand?



While Figure 16 shows that systems are may be changing, the exact nature of the change is uncertain. One area of potential change is the system weather response. In other words, are the systems becoming more or less responsive to temperature changes due to COVID-19. Figure 17 shows that 36% of respondents think their summer weather response changed and 29% think their winter response changed. These responses have remained consistent since 2021.

Figure 17: Summer and Winter Weather Response Change



Electric Forecast Accuracy

Three types of errors are reported in the survey. First, companies are asked to compare their 2022 forecast (generated in 2021) against weather normalized 2022 sales. Second, companies are asked to compare the same forecast and against actual 2022 sales. These calculations report errors on an annual basis. For the third calculation, companies are asked to compare the same forecast and report the weather normalized errors on a monthly average basis.

Annual Forecast Accuracy. The average forecast errors, calculated as the Mean Absolute Percent Error (MAPE), are shown in Figure 18 and Figure 19. The figures show the 2023 survey result compared against the 2021, 2022 and pre-pandemic 5-year survey average results. Figure 18 shows the annual forecast errors compared against weather normalized actual values. Figure 19 shows the annual forecast error compared against actual values. All MAPE values are unweighted.

Figure 18: Annual Electric MAPE - Forecast vs. Weather Normal Actuals

Class	2023 Survey	2022 Survey	2021 Survey	2016-2020 Mean
Residential	1.88	2.37	3.78	1.59
Commerical	2.74	3.09	6.53	1.66
Industrial	3.79	3.14	8.32	2.90
System	1.78	1.69	3.13	1.43
Peak	3.06	3.14	2.76	2.61

Figure 19: Annual Electric MAPE - Forecast vs. Actuals

Class	2023 Survey	2022 Survey	2021 Survey	2016-2020 Mean
Residential	3.45	2.64	3.53	2.62
Commerical	3.00	3.27	6.83	1.67
Industrial	3.73	3.48	8.12	2.97
System	2.34	1.94	3.65	1.61
Peak	3.97	4.67	4.88	3.47

Figure 18 reports that weather normalized errors are higher than the pre-pandemic average errors, but generally lower than in the prior 2 years. With the exception of the industrial class, this result shows that the industry is returning to pre-pandemic conditions, but still struggles with pandemic influenced data. The industrial class error increase, relative to 2022, stems from the unexpected 2022 growth attributed to the stronger than expected growth.

Figure 19 reports actual errors which include weather deviations from normal. When compared to Figure 18, the difference in errors illustrate the impact of weather deviations from normal. Generally, error increases when weather error is included. The variation in actual errors over time capture changing weather conditions.

Monthly Forecast Accuracy. Figure 20 shows the monthly average errors by class with comparative values from prior years' surveys. Like the annual errors, 2023 residential and commercial errors are lower than 2021 and 2022 errors capturing a return to pre-pandemic levels. Similarly, industrial errors are surprisingly high and reflect the unexpectedly strong growth in the industrial sector.

Figure 20: Monthly Average Electric Error Results (Unweighted)

Class	2018 Survey	2019 Survey	2020 Survey	2021 Survey	2022 Survey	2023 Survey
Residential	3.76	4.26	3.02	6.08	4.48	3.93
Commerical	3.03	3.45	2.57	7.34	4.62	3.82
Industrial	3.87	3.86	4.70	8.88	4.33	5.15

Natural Gas Forecast Accuracy

Similar to the electric forecasting errors, natural gas companies are asked to compare their forecast for 2022 (generated in 2021) against actual and weather normalized sales in 2022. Figure 21 and Figure 22 show the companies' unweighted annual MAPEs. The figures show the 2023 survey result compared against the 2021, 2022 and pre-pandemic 5-year survey average results. Figure 23 shows the unweighted monthly MAPEs.

Annual Forecast Accuracy. Figure 21 and Figure 22 show the class forecasting errors. In 2023, all classes report weather normalized, and actual errors lower than the pre-pandemic average errors. Unlike the electric industry, natural gas was not as impacted by COVID-19 resulting in more consistent forecast accuracy.

Figure 21: Annual Natural Gas MAPE - Forecast vs. Weather Normal Actuals

Class	2023 Survey	2022 Survey	2021 Survey	2016-2020 Mean
Residential	2.40	2.40	2.01	2.66
Commerical	4.05	3.39	4.78	4.16
Industrial	5.86	6.12	6.58	8.20
System	1.90	1.58	2.42	4.23

Figure 22: Annual Natural Gas MAPE - Forecast vs. Actuals

Class	2023 Survey	2022 Survey	2021 Survey	2016-2020 Mean
Residential	4.85	6.04	3.52	8.68
Commerical	6.15	4.01	7.60	6.01
Industrial	6.31	6.55	8.39	8.19
System	3.87	4.44	4.74	7.26

Monthly Forecast Accuracy. Like the annual accuracy, monthly accuracy is consistent with prior year results. Monthly forecast accuracy is considerably higher than annual accuracy because variations in monthly errors are not offset when aggregated to the annual totals. The monthly MAPEs are shown in Figure 23.

Figure 23: Monthly Average Gas Error Results (Unweighted)

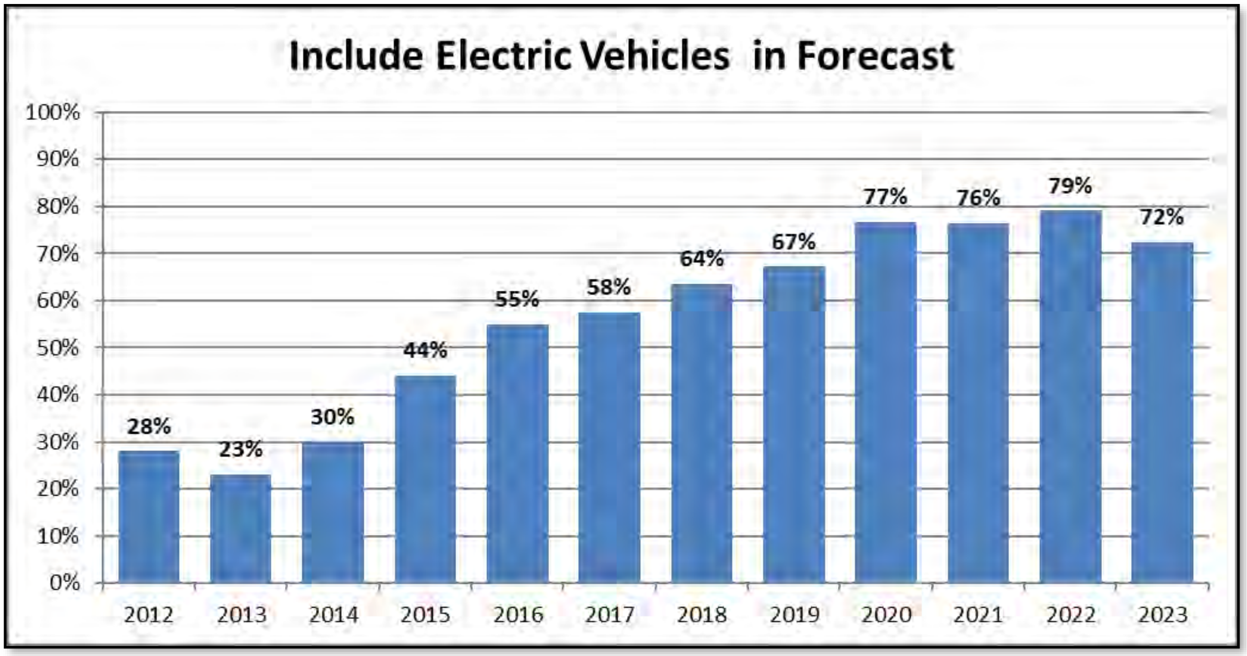
Class	2018 Survey	2019 Survey	2020 Survey	2021 Survey	2022 Survey	2023 Survey
Residential	7.28	6.82	9.87	11.96	10.20	8.52
Commerical	6.68	8.84	10.98	12.12	8.08	11.30
Industrial	10.17	10.33	13.58	8.38	11.58	14.62

Key Forecast Characteristics

As part of the annual survey, Itron tracks changes in forecasting practices. This year's survey includes forecasting practices for new technologies, normal weather calculations, peak scenario development and economic data sources.

Electric Vehicles. The electric vehicle (EV) industry is rapidly evolving with increased adoption and new vehicle models. In 2022, EVs accounted for over 800,000 vehicle sales (Source: kbb.com), and in 2023 approximately 40 battery-electric vehicles models are available in the US market (source: evadoption.com). Figure 24 shows that over 70% of companies have explicitly include EVs in their forecast since 2020.

Figure 24: Include Electric Vehicles in the Forecast

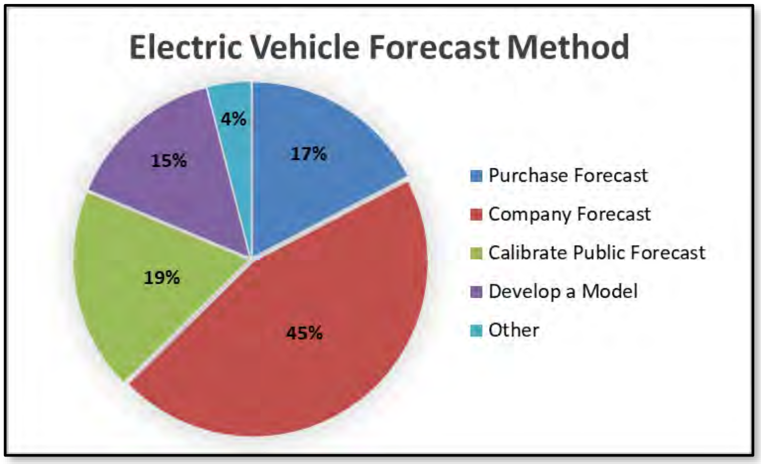


This year, in addition to asking whether EVs are included in their forecasts, participants were asked how they are forecasting EVs. The following five responses were offered.

- **Purchase Forecast**. The company outsources the EV forecast and relies on external experts to forecast EV adoption. The company then integrates the external forecast into the long-term sales forecast.
- **Company Forecast**. The company forecast relies on internal corporate experts to develop the long-term forecast of EV adoption. The company forecast is then integrated into the long-term sales forecast.
- **Calibrate a Public Forecast**. In this method, the forecaster uses a publicly available EV forecast and adjusts it to the characteristics (i.e., number of EVs) in the service territory.
- **Develop a Model**. In this method, the forecaster develops a model for EV adoption and electric sales. The model may be a statistical model or some other model. This response differs from the Company Forecast response because the forecaster, not internal company experts, develops the model.
- **Other**. This response may include blended methods of any (or all of the previous) responses.

Figure 25 shows the prevalence of forecasting methods. In this figure, 62% of respondents rely upon experts (i.e., Purchase Forecast or Company Forecast) to develop the EV forecast. These responses are dominated by larger companies with financial resources to outsource or hire internal experts.

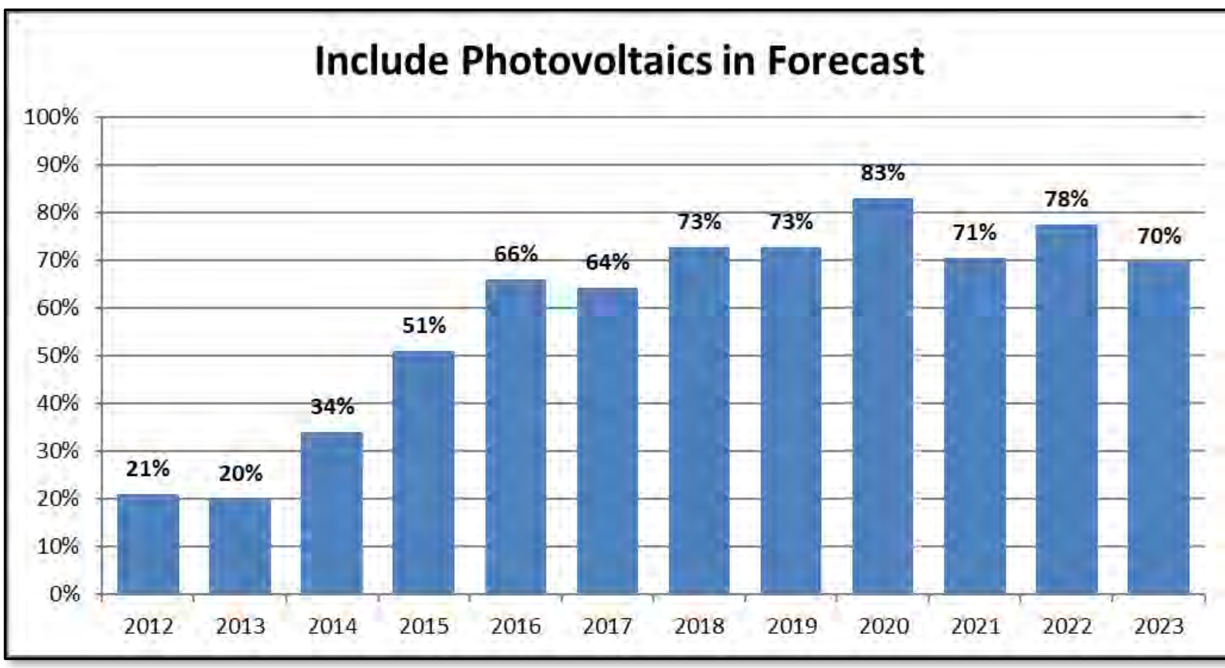
Figure 25: Electric Vehicle Forecast Method



Electric Vehicle Forecast Method	
Purchase Forecast	17%
Company Forecast	45%
Calibrate Public Forecast	19%
Develop a Model	15%
Other	4%

Photovoltaics. The photovoltaic (PV) industry continues its rapid growth. According to the Solar Energy Industries Association (SEIA), residential capacity grew 25.5% between 2021 and 2022. Additionally, the U.S. Energy Information Administration (EIA) projects PV growth for all sectors to average 8.3% per year through 2050. Figure 26 shows the share of companies that include PVs in their forecast. This year, 70% of respondents include PV forecasts in their forecasts. Since 2018, over 70% of companies include PVs in their forecast.

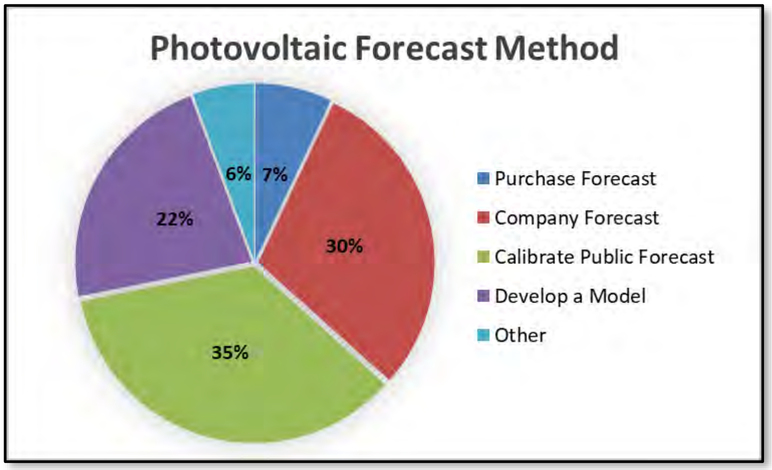
Figure 26: Include Photovoltaics in the Forecast



Like EVs, this year, companies were also asked how they are forecasting PVs. Figure 27 shows that 58% of forecasters generate the PV forecast themselves (i.e., Calibrate Public Forecast and/or Develop a

Model). The high percentage of self-forecast development implies the availability of reasonable data for model development or forecast calibration.

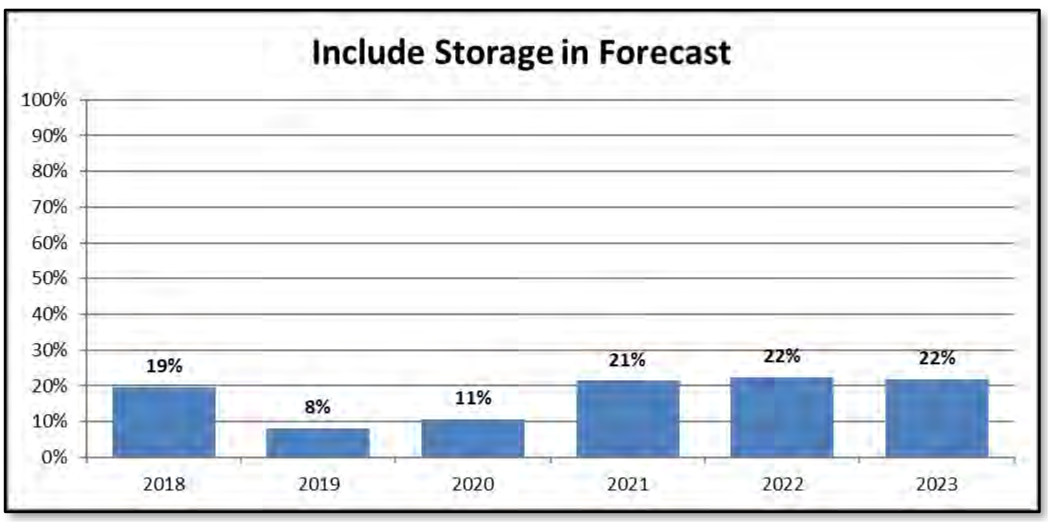
Figure 27: Photovoltaic Forecast Method



Photovoltaic Forecast Method	
Purchase Forecast	7%
Company Forecast	30%
Calibrate Public Forecast	35%
Develop a Model	23%
Other	6%

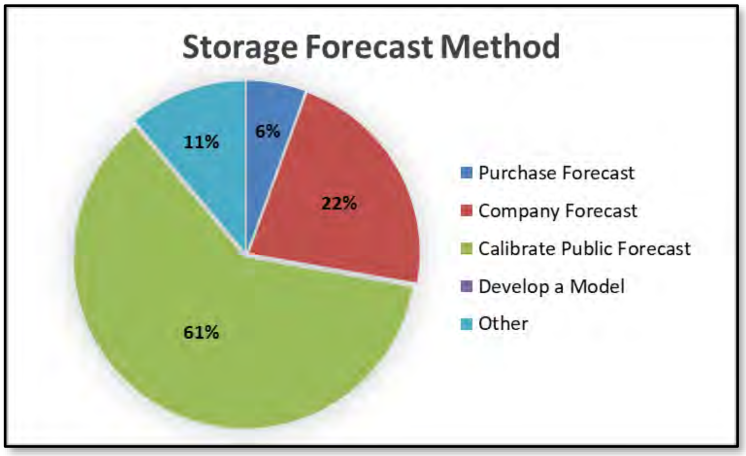
Battery Storage. The storage market continues to be nascent making forecasting technology penetration and usage difficult. As with any new technology, companies should closely monitor the market to identify signs and factors that will assist them in forecasting this technology. Figure 28 shows only 22% of companies are including storage in their forecasts. The percentage has not significantly changed since the survey began asking this question in 2018.

Figure 28: Include Battery Storage in the Forecast



Like EVs, this year, companies were also asked how they forecast battery storage. To the extent that companies include a storage forecast, Figure 27 shows that 61% of forecasters use a public forecast and calibrate to internal data. This response implies the heavy reliance of public policy forecasts and the dearth of storage experts.

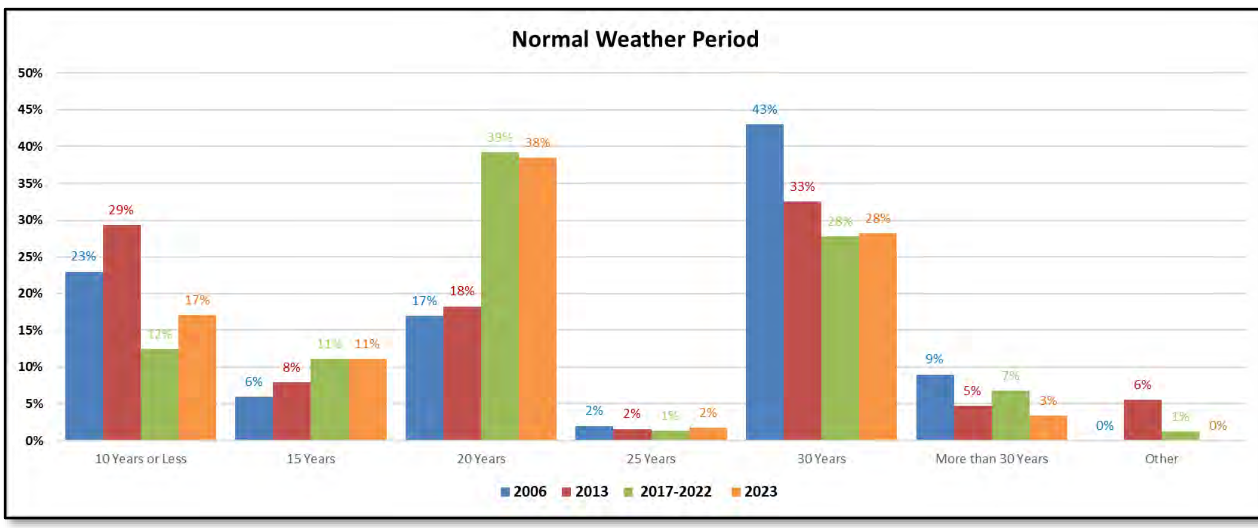
Figure 29: Storage Forecast Method



Storage Forecast Method	
Purchase Forecast	6%
Company Forecast	22%
Calibrate Public Forecast	61%
Develop a Model	0%
Other	11%

Normal Weather. The 2023 survey asked respondents how many years of historical weather data they use to calculate normal weather. Itron has periodically asked this question in various studies since 2006. This year's result is shown in Figure 30 compared to prior years. Survey results from 2017 through 2022 are averaged because there are no substantial differences between those survey results.

Figure 30: Normal Weather Calculation Period

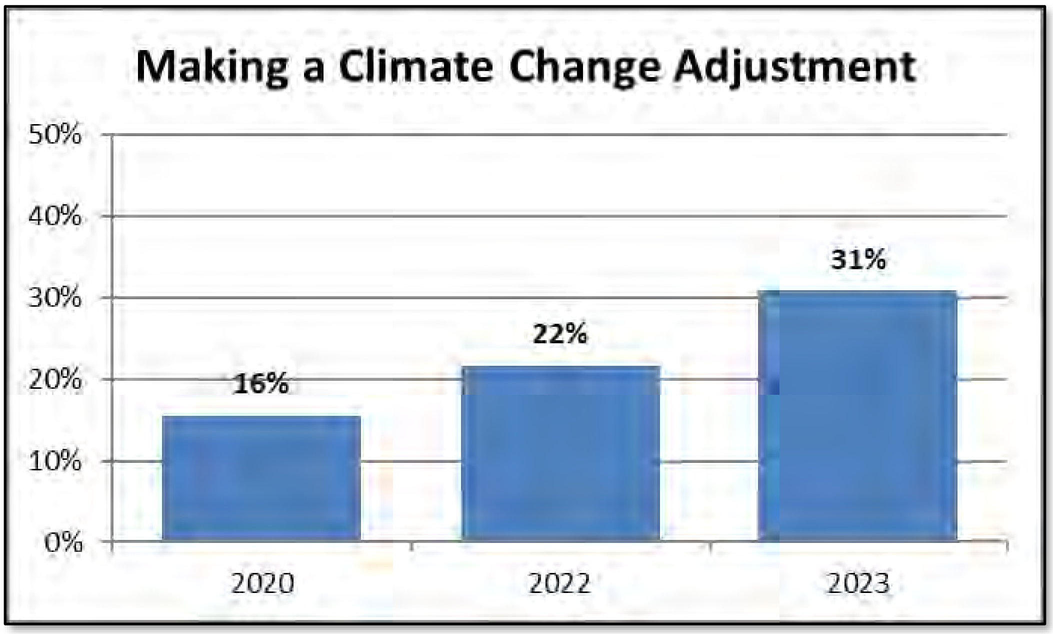


Historically, companies have favored 30-year averages to represent normal weather. In 2006, 43% of companies used the 30-year average. In 2013, the survey shows movement away from the 30-year average toward the 10-year average. Beginning in 2017, the 20-year average becomes the dominant normal weather period. In the 2017 through 2022 surveys, 39% of the companies reported using the 20-year average. The 2023 survey shows results very similar to the 2017 through 2022 surveys with 20-year averages being the dominant number of years.

Beginning in 2020, Itron began asking questions about how companies are managing climate change. First, companies are asked whether they are making changes to their normal weather calculations to account for climate change. Second, companies who are making changes are asked how they are making their changes. These results are shown in Figure 31 and Figure 32.

Figure 31 shows that 31% of companies are adjusting their normal weather for climate change. Since 2020, the percentage of companies adjusting for climate change has been steadily increasing. The results capture both internal and external pressures to represent climate change in their forecasts.

Figure 31: Normal Weather Climate Change Adjustment

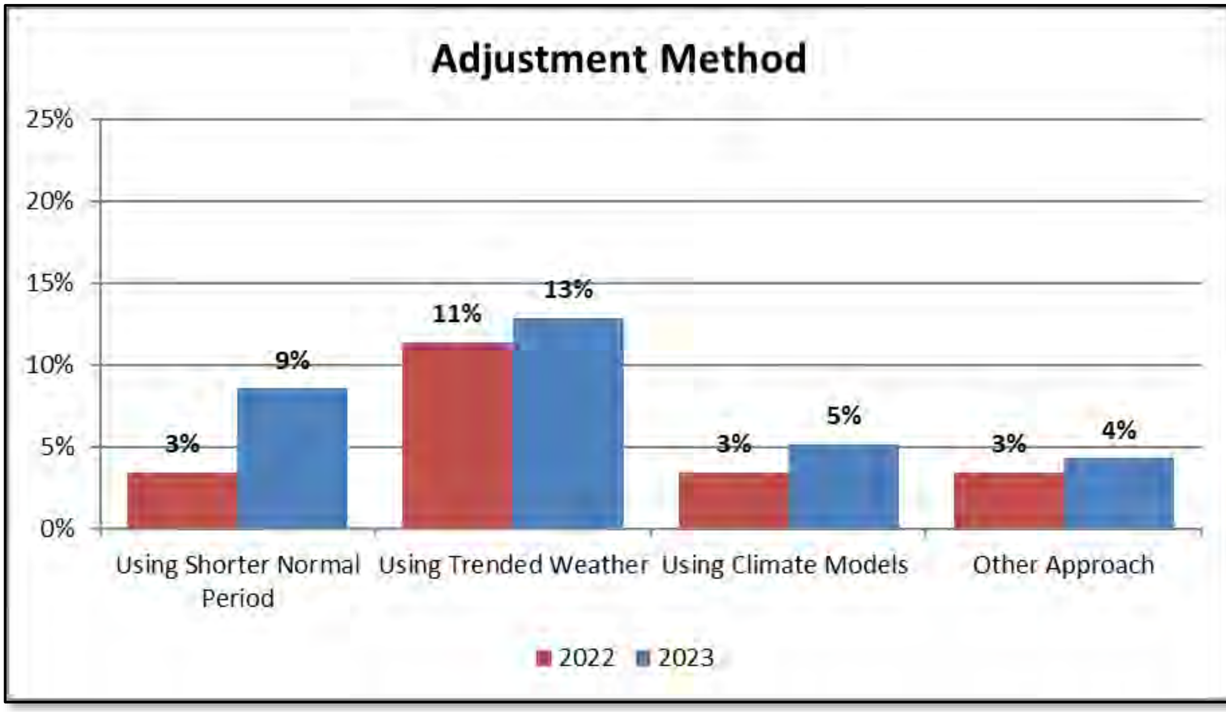


From 2022, companies who were making adjustments were asked how they made their adjustments. The survey provided four options as defined below.

- **Using Shorter Normal Period**. The simplest method for adjusting normal weather is to calculate normal weather using fewer historical years. By shortening the historical period, more recent weather data dominates the normal weather calculation.
- **Using Trended Weather**. The trend approach applies a growth trend to the existing normal weather calculation. The trend is developed by estimating how historical temperatures are changing over time and then applying that change in the forecast period.
- **Using Climate Models**. Sophisticated climate models simulate surface, atmospheric, and ocean conditions to predict how the earth's climate is changing. These models generate a long-term forecast of future temperatures. Climate model results may be transformed into variables that are used in the forecast models.
- **Other**. This option allows companies to describe an alternative approach.

Figure 32 shows the respondents results.

Figure 32: Normal Weather Climate Change Adjustment Method



The 2022 and 2023 results do not show substantial changes. Of the methods used, most companies either shorten the historical period for normal weather calculation or use trended weather approach. Both of these adjustments are simple to apply relative to working with Climate Model results.

Peak Weather Scenarios. Typically, the long-term forecast is a point forecast of the most likely future. Sometimes, the point forecast is referred to as a 50/50 forecast suggesting that there is a 50% chance the actual results are above or below the forecast. To manage risk, some utilities develop scenarios representing alternative future assumptions based on key risk factors such as weather, economics, or new technologies.

In light of recent extreme weather events, several companies are seeking to manage their risk by understanding extreme weather effects on their system peaks. This year's survey asked companies how they develop peak weather scenarios. Specifically, Itron asked whether they generate peak weather scenarios as part of the regular forecasting process, and if so, how do they develop their peak weather scenarios.

Figure 33 shows that half of companies do not develop peak weather scenarios as part of their regular forecasting process. Despite the risks of extreme weather events, this result is not surprising. In Itron's 2017 survey, Itron asked whether companies developed economic scenarios. In response, 65% of utilities responded that they did not develop economic scenarios. The lack of scenario development is indicative of the forecast requirements. In other words, the users of the point forecasts are generally not asking for scenarios.

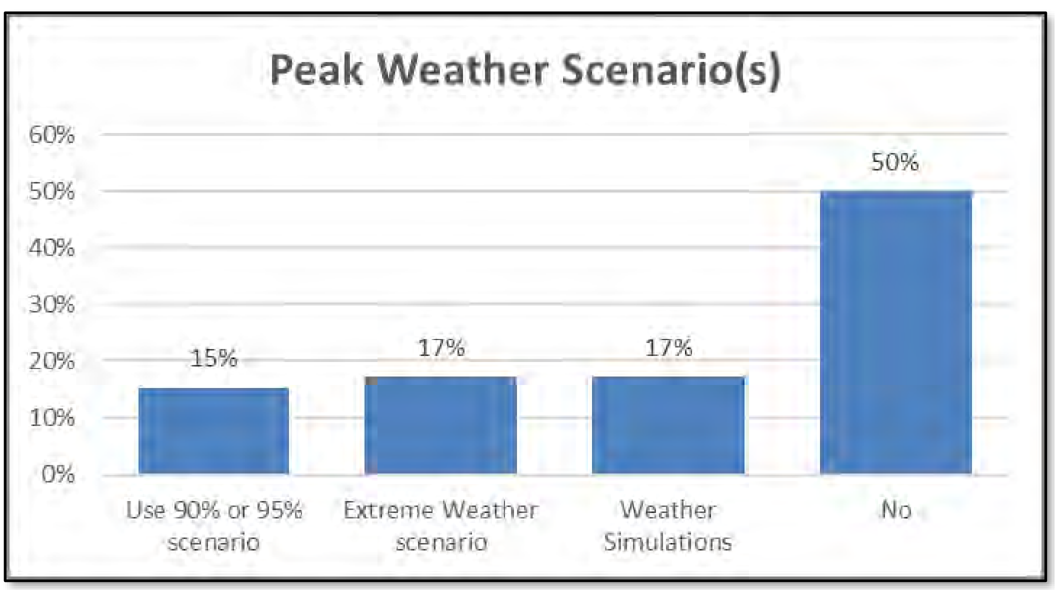
However, several utilities discussed the need for scenarios at Itron's 2023 Annual Energy Forecasting Meeting. The discussion was driven by specific questions about the point forecast and a desire to see an alternative-based forecast on a future set of assumptions. Many utilities stated that these requests were "ad hoc" and not part of the typical forecasting process.

For companies that regularly forecast peak weather scenarios, Figure 33 show three general methods for capturing peak weather uncertainty. These methods are described below.

- **Use 90% or 95% Scenario**. This method replaces the 50% normal peak weather scenarios with more extreme weather representing a 90% (or 95%) chance of occurring. Typically, this method develops a historical distribution of weather occurrences and selects the 1 in 10 (or 1 in 20) occurrence point on the distribution.
- **Extreme Weather Scenario**. Like the 90% or 95% Scenario method, this method replaces the 50% normal peak weather scenario with an extreme weather scenario. Unlike the 90% or 95% scenario, the extreme weather scenario is developed using the most extreme historical weather or a recent extreme weather event.
- **Weather Simulation**. The weather simulation method applies a series of historical weather events to the statistical model that forecasts peaks. The result is a distribution of peak forecasts. The peak scenario is identified by selecting a point on the distribution of peak forecast.

Figure 33 shows that the methods are equally applied among companies that regularly develop peak weather scenarios.

Figure 33: Peak Weather Scenario(s)

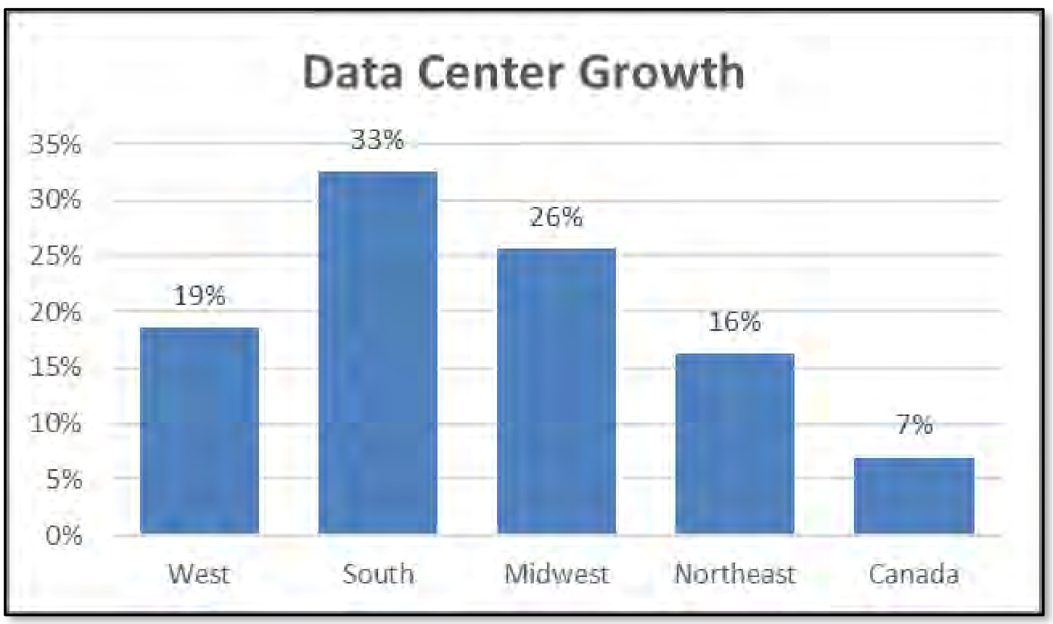


Data Centers. Data Centers are centralized computing facilities that manage IT operations for the purposes of storing, processing, and disseminating data. These facilities are effectively warehouses of computers and consume a large amount of electricity. In 2021, CBRE estimated 17% year-over-year growth in primary data centers markets (i.e., northern Virgina, Dallas, Silicon Valley, Chicago, Phoenix, New York Tri-State, and Atlanta). In northern Virginia alone, over 300 MW of data centers were added in 2021.

While other regions do not show the same dramatic year-over-year growth as northern Virginia, data centers additions can potentially have large effects on utility energy and demand growth. This year, the survey asked utilities whether they are seeing data center growth in their service territory. While the question does not attempt to ascertain the size or timing of these additions, the question seeks to understand the prevalence of data center growth.

In 2023, 45% of respondents indicated that they are experiencing data center growth. This response indicates that data center growth is more geographically dispersed than the primary markets. Figure 34 shows the geographic dispersion.

Figure 34: Data Center Growth Locations



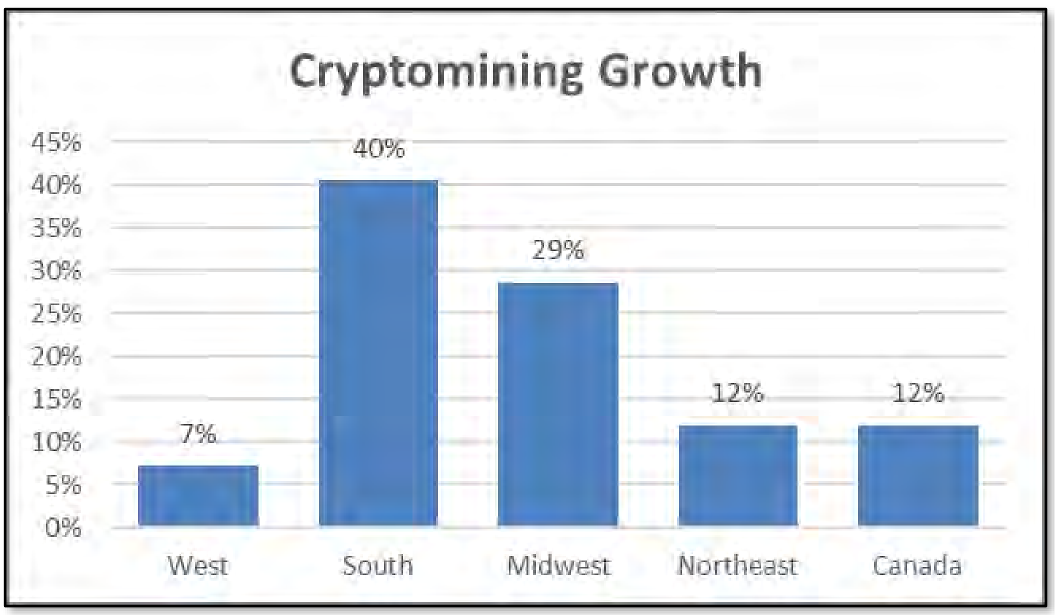
Data Centers and Crypto-Mining. Cryptocurrency mining is a process of creating new digital coins. Generally, the process involves using computing power to solve complex puzzles, validate cryptocurrency transactions on a blockchain network, and adding transactions to a distributed ledger. Like data centers, cryptocurrency mining is generally housed in a large warehouse with computers, computationally intensive, and requires a large amount of electricity.

The cryptocurrency mining industry grew with skyrocketing cryptocurrency value. Between January 2020 to November 2022, bitcoin's value increased by almost 800%. In 2022, the Texas Blockchain Council (TBC) estimated that the current electricity consumption of the entire global bitcoin network to be between 16 GW and 25 GW with approximately 1.5 GW in Texas alone. Additionally, TBC expects Texas to attract approximately 2 GW per year of additional bitcoin mining capacity. The dramatic growth and energy intensive nature of this industry has captured the attention of several utilities.

This year, the survey asked utilities whether they are seeing cryptocurrency mining growth in their service territory. While the question does not attempt to ascertain the size or timing of these additions, the question seeks to understand the prevalence of cryptocurrency mining growth.

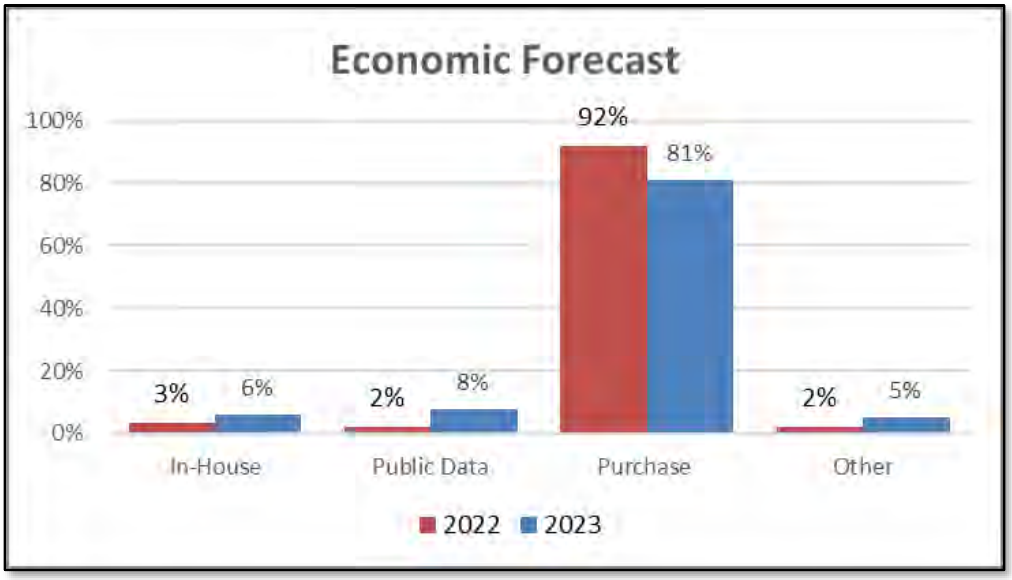
In 2023, 39% of respondents indicated that they are experiencing cryptocurrency mining growth. Figure 35 shows the geographic dispersion. Cryptocurrency mining is most prevalent in the South and Midwest driven by low electricity prices.

Figure 35: Cryptocurrency Mining Growth Locations



Economic Forecast. For the scend year in a row, Itron asked how companies develop their economic forecasts. Figure 36 shows that 81% of respondents acquire their economic data. Very few companies seek to use publicly available data or develop the economic data themselves.

Figure 36: Economic Forecast Source



Conclusion

The 2023 survey shows the electric and natural gas industries have returned to pre-pandemic patterns with COVID-19 effects largely behind us. With forecast accuracy improving and forecast growth returning to pre-pandemic levels, managing COVID-19 effects is largely a historical data management issue.

However, the industry continues to face transformative challenges. These challenges include forecasting new technologies (e.g., EVs, PV, and storage), addressing climate change and peak weather risk, and understanding the prevalence of data centers and cryptocurrency mining. Using this survey, Itron will continue to monitor these transformative challenges in future surveys.