

# **Beyond participation and savings – leveraging quantitative metrics for insight into C&I project and population trends**

*Anthony Davis, Richard Crowley, Suman Gautam, DNV GL*

*Riley Hastings, Eversource*

*Whitney Brougher, National Grid*

## **ABSTRACT**

Since 2011, the Massachusetts Program Administrators (PAs) have published an annual profile of the commercial and industrial (C&I) customer base and participation in the statewide energy efficiency programs. The C&I Customer Profile has evolved from reporting standard single-year descriptive statistics, such as savings and participation, to a multi-year, advanced analysis platform used by PAs, evaluators, and regulators to better understand population and participation trends. In 2012, the PAs introduced new quantitative metrics that address questions or trends identified in the previous year's profile. It presents the complex statistical analysis in an understandable, graphical format and highlights nuanced differences in PA populations and participation levels.

This paper shows a selection of advanced quantitative metrics deployed by the PAs to gain detailed insight into C&I efficiency performance and offers examples of how this data can be used at a very granular scale. For example, prediction ellipse plots were added to the analysis in 2015 to investigate trend differences for the report's primary analysis statistics (i.e., account participation, consumption weight participation, population savings achieved and participant savings achieved). These new graphics assess and report on individual record data while preserving confidentiality which allows stakeholders to gain insights into the data to help determine possible changes in programs. Another example is the PA contribution ratio analysis, developed to discern high-level differences among the PAs that could impact comparisons between PAs. Identifying these types of difference among the PAs can be critical when making across PA conclusions about the results of a program or offering, as what works for one PA may not necessarily work for another.

## **Background**

The annual C&I Customer Profile is a report commissioned by the Massachusetts Program Administrators (PAs) to provide key insights into the population and participation trends characterizing the Commonwealth's C&I energy efficiency programs (DNV GL 2016). The foundation for this analysis is the C&I Evaluation Database—a tool developed in 2012 under the direction of the PAs and Energy Efficiency Advisory Council (EEAC) Consultants. The database standardizes otherwise disparate data sources from each of the seven electric and natural gas PAs to provide consistently defined metrics which can be compared and contrasted across all of Massachusetts. Figure 1 provides a graphic overview of the process of moving from PA provided data to a unified C&I Evaluation Database.

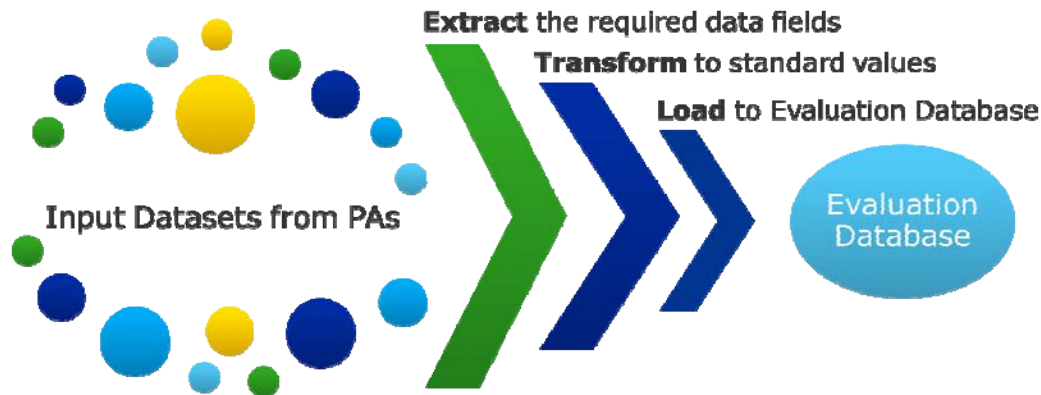


Figure 1. Moving from PA specific-data to the C&I Evaluation Database

The C&I Evaluation Database is maintained and regularly updated to support the changing needs of the PAs. Active and direct communication between the PAs and the database consultant allows for faster response time for data queries and the ability to proactively improve the data. Having an independent contractor manage the database provides a number of benefits:

- **Data warehouse for research projects.** Once the yearly tracking and billing datasets are provided from the PAs, all future research and evaluation projects are able to use the database as a starting point for the project’s specific needs, which substantially reduces the data request burden on the PAs.
- **Comparable data across the different PAs.** Each PA has its own specific way of capturing account billing and efficiency program tracking data. Through the standardization process the PA specific data is brought into common formats with common definitions, so that the data are comparable.
- **Integration of 3<sup>rd</sup> party datasets.** PA billing and tracking data is supplemented with GIS libraries and tax assessor data to identify and target specific areas and customers with high savings potential.

Each year (since 2012, using 2011 data) a Customer Profile report is published to present an up-to-date view of C&I program trends, including the types and quantities of customers participating and contributing the most program savings. Statistical trends are reported for a range of metrics at different levels of granularity — including statewide, by PA, and within PA— to provide both broad and detailed views of the C&I efficiency landscape (see Figure 2 for a visual representation of this analysis). The report evolves each year to meet the ever-changing needs of the PAs and EEAC consultants. Since 2012, the profile has reported time-series views for all of the metrics provided in the profile, revising each as data is improved and expanded upon yearly.

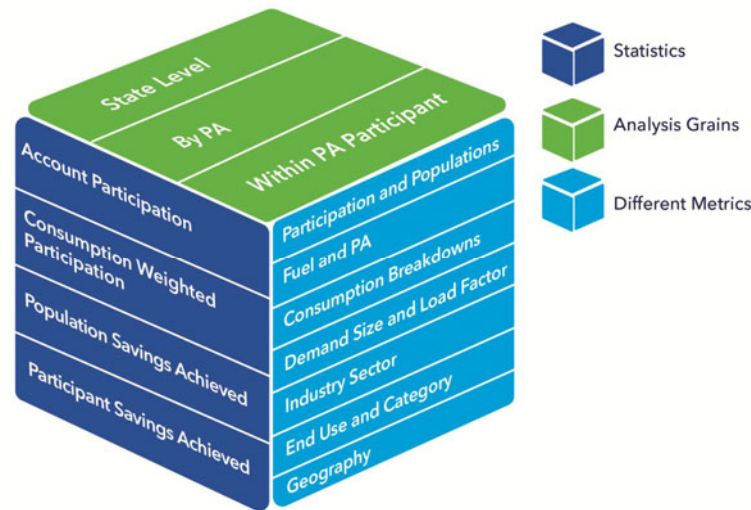


Figure 2. C&I Customer Profile Analysis Cube

The C&I Customer Profile project provides valuable features that help to improve the efficiency and performance of the Massachusetts non-residential programs, enabling the PAs and EEAC to:

- **Examine changes over time.** Each year past years' data are updated with new information provided as part of the current year's data request. This allows for a yearly historical analysis and ensures that comparisons of statistics across years are comparable and reflect the current reality.
- **Pinpoint savings opportunities.** The Customer Profile report leverages several different analysis platforms (such as SAS, GIS, and Tableau) to create a variety of lenses and visualizations of each PAs data to provide insight into the differing levels on engagement (as presented in Figure 2).
- **Provide new views into customers.** Each year the report adds new sections that provide new and advanced metrics and views into each PAs customers and participants. The new analysis is designed to address pressure points that have been identified by stakeholders since the previous Customer Profile and allow the PAs and EEAC to gain further insights.

The 2014 Customer Profile expanded on a key topic of discussion among the PAs and EEAC regarding whether or not absolute breakpoints (i.e. Large = 5,000 kW or above) were always appropriate when comparing PA results. This becomes an important question when there may be fundamental differences in each PA's unique population of billed customers. The analyses presented below help to isolate and begin identifying the differences between the PAs which can cause different results from their numerous EE programs. The analyses presented in this paper are:

- **Box Plots** allow the PAs and EEAC to compare the middle 50% of each PA's accounts using a number of different categorical variables.

- **Contribution Ratio Analysis** compares the proportional savings to the proportional usage of customers each PA-specific percentile bins to determine different levels of engagement.
- **Prediction Ellipse Analysis** offers a unique view into the relationships between participating accounts across the PAs by using individual customer’s data to create a “data cloud” where it is possible to visualize where an account may fall for a given PA.

## Identifying Differences between PAs

The analyses presented in this section are a limited subset of the analysis that goes into the full C&I Customer Profile report each year. This data serves as a first step for the PAs and EEAC to identify further questions about yearly program results and difference between PAs and years. The information provided below focuses on electric data only, but full depth analysis for both electric and gas PAs can be found in the 2014 C&I Customer Profile report (DNV GL 2016). These analyses are designed for informational and contextual purposes in order to help lay a foundation of understanding about key differences which exist between the PAs which can directly impact the results that are seen in their energy efficiency efforts across the State.

### Box Plots

Box plots are used to compare the middle 50% of each PAs account population in a variety of ways. To provide context on underlying differences between the PAs which may influence PA-specific savings results, box plots using various categorical variables combined with consumption or savings information are created to show any underlying differences in either the PAs entire customer population or in a specific year’s population of efficiency program participants. If the boxes have a large degree of overlap, it is likely there is a similar potential for savings in the market each year. Comparing the medians of each PA can help ascertain the importance of extremely large accounts for each PA. To protect the identity of customers, the box plots focus on the middle 50% of the customers for each PA, ranging from the 25<sup>th</sup> to the 75<sup>th</sup> percentile for each PA. Figure 3 3 shows the key information provided in the box plots, which can be compared and contrasted across each PA.

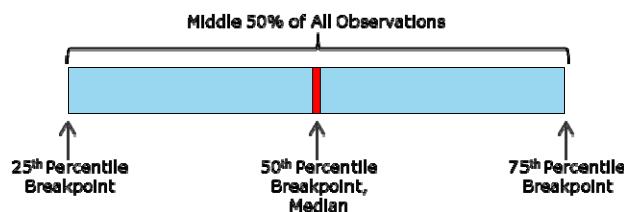


Figure 3. Anatomy of a Box Plot<sup>1</sup>

### Electric Industry Sector Populations

Figure 4 shows the middle 50%, by number of accounts, for each of the Massachusetts electric PAs broken out by industry sector<sup>2</sup>. This box plot has a number of key benefits:

<sup>1</sup> It should be noted that while this will show 50% of all a PA’s accounts, it will not necessarily show 50% of the total usage the PA has each year. In general, C&I usage is heavily biased towards large customers.

<sup>2</sup> Industry sector is based off 2 digit NAICS codes descriptions. NA and Unknown are categories which represent artifacts in the PAs data which could not be resolved. The No Data bin represents all accounts in the PAs population without any information to fill the industry sector variable.

- Since it represents an entire population, the differences between the PAs likely to impact any analysis based on the industry sector variables.
- The relationship between the median breakpoint and the 25<sup>th</sup> and 75<sup>th</sup> percentile breakpoints allows for general conclusions to be drawn about the impact of accounts below the 25<sup>th</sup> or above the 75<sup>th</sup> percentiles.
- It is easy to discern and digest patterns in the difference across the PAs at a high level.

Figure 4 shows that Cape Light Compact tends to have smaller accounts in the middle 50% of their population when compared to the other PAs across multiple sectors. Most of the sectors have a high degree of overlap between the PAs, with a notable exception being the Accommodation and Food Service sector, where Cape Light Compact and Eversource are drastically larger consuming accounts making up the middle 50% of their customer population when compared to National Grid and Unitil. The sizes of the boxes are different so that it clearly displays the entire plot for each PA and does not have any inference to the size of the PA itself<sup>3</sup>.

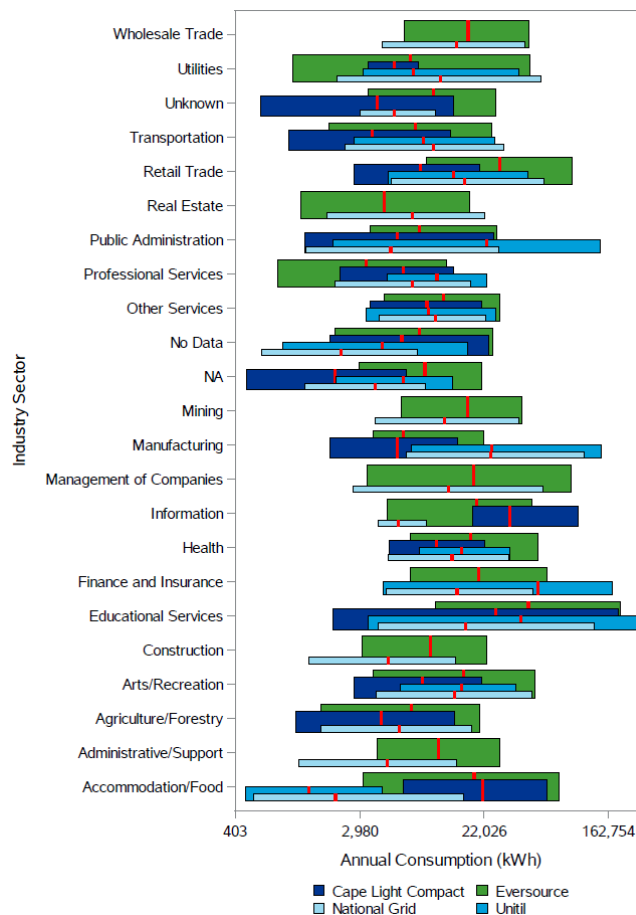


Figure 4. 2013 annual consumption for electric billing accounts by 2 digit NAICS code categories<sup>4</sup>

<sup>3</sup> In order to ensure all PAs could be seen in a single stacked box plot it was necessary to change the size of each PAs box. This was done for visual purposes only.

<sup>4</sup> In all cases, the study compares previous years billing to current year tracking data so that savings for newly installed measures are not present in the data.

## Electric Demand Bin Breakdowns

Yearly annual savings by Demand Size category provides insight into the range of savings each PA is achieving from accounts with similar annual peak demand. One of the key benefits of the C&I Evaluation Database is the ability to link efficiency program tracking and billing data across time without any additional work for the PAs. Figure 5 shows the 2014 tracking data linked to the 2013 billing data and binned into a demand size category based on each participating account’s peak demand for 2013. The 2013 billing data is used so that the effects of the savings measures installed in 2014 are not present in the data. As in Figure 4, the box plots are still showing the middle 50% of each PAs population, except now it is only the linked tracking participant population<sup>5</sup>. Figure 5 draws a number of different conclusions which may warrant additional investigation by the PAs, EEAC consultants and the study team.

- Until achieved higher savings in the 1,000 - 5,000 kW demand bin, with their median savings being greater than or close to the 75<sup>th</sup> percentile savings for the other three electric PAs
- Cape Light Compact has much lower savings in the 750 – 1,000 kW demand bin.

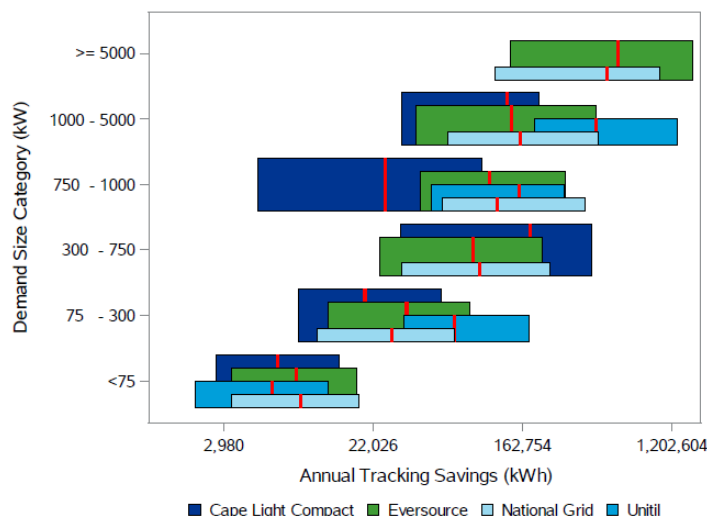


Figure 5. 2014 account-level savings by demand size category

## Contribution Ratio Analysis

In the 2013 Customer Profile report the “Contribution Ratio” was introduced for the first time. This ratio allows comparison across the PAs of savings relative to consumption that is not dependent of the absolute size of PA accounts. Instead, the analysis normalizes each PA’s population so that accounts fall into PA-specific percentile bins, and the bins can be compared across the PAs. In the 2014 Customer Profile study, this ratio was used in many of the tables where PA savings and consumption were broken out by a categorical bin. This metric allows stakeholders to determine the level of engagement within a bin and determine if this is reasonable, unexpected, under engagement, over engagement, or some combination of these options.

<sup>5</sup> Due to confidentiality rules in MA, PAs with fewer than 15 accounts in a given bin cannot be shown which is why two PAs are missing from the largest bin.

$$\text{Contribution Ratio} = \frac{\text{Proportion of Total Savings}_{PA, Bin}}{\text{Proportion of Total Consumption}_{PA, Bin}}$$

The contribution ratio is a unit-less number, but the magnitude of the number can aid in comparing both across PAs or within a PA and across bins:

- Ratio < 1, Bin is contributing less to overall PA savings than it does to overall PA consumption
- Ratio = 1, Bin contributed as much to overall PA savings as it does to overall PA consumption
- Ratio > 1, Bin is contributing more to overall PA savings than it does to overall PA consumption

### Electric Bins.

How data is binned will determine the detail of the analysis presented. When deciding on how to break out the billing population it is important to be able to show a number of key factors which have the potential to influence an analysis. Each PA’s population was broken into 10 percentile bins, which divides the populations from extremely small accounts to the PA’s largest accounts without violating confidentiality rules.

Table1 shows the number of accounts, by PA, in each of the percentile bins for the 2014 Customer Profile; by multiplying the number of accounts by 10 it is easy to see the actual size of each PAs customer population.

Table1. Accounts per 10 percentile bin, 2013 billing data

PA	Cape Light Compact	Eversource	National Grid	Unitil
Billed accounts per bin	2,562	16,215	15,826	400

Eversource and National Grid are the two largest PAs in Massachusetts and with this large population the amount of diversity in accounts and size of accounts will likely allow for more consistent results across time. Cape Light Compact and Unitil have smaller populations and the smaller a population becomes the more impact a few large participating accounts can have on the amount of savings a PA achieves each year.

**Electric Breakpoints.** Once each PA’s population is binned, the annual kWh breakpoints can be determined and compared across the PAs. There are a number of benefits to looking at the bin breakpoints in each PA:

1. Show how the annual consumption breakpoint within a bin compares across the PAs. This allows the stakeholders to easily visualize where PAs begin to have differences in annual consumption which may influence how an account participates in an energy efficiency program.
2. Allows for comparisons across PAs and bins, which can help provide a basic explanation of why PAs are seeing different contribution ratios across bins.

- a. For example: Cape Light Compact and Unitil’s 70<sup>th</sup> percentile bins are more comparable to Eversource and National Grid’s 60<sup>th</sup> percentile bin breakpoints. So these bins may be participating in energy efficiency programs in similar ways.

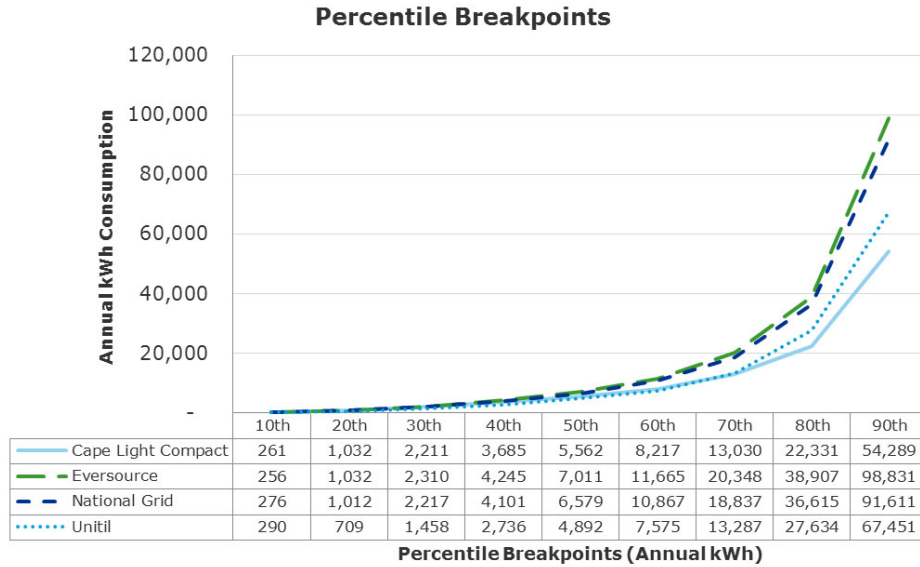


Figure 6. 2013 consumption breakpoints across PA percentile bins

Figure 6. shows the breakpoints for each of the electric PAs using their 2013 billing data. From this chart there are a number of conclusions that can be reached:

- Unitil begins to differ in size from the other PAs at the 20<sup>th</sup> percentile, Cape Light Compact at the 40<sup>th</sup> percentile.
- National Grid and Eversource have very similarly sized accounts across their bin, which implies they are more likely to be comparable to each other in an analysis using absolute values.
- Cape Light Compact and Unitil converge in size at the 60<sup>th</sup> percentile. By the 70<sup>th</sup> percentile Unitil’s accounts become larger than Cape Light Compact’s.

**Contribution Ratio by PA, 2014.** Figure 7 shows the contribution ratio analysis using percentile bins for the 2014 tracking program participating accounts compared to the 2013 billing account population for each of the electric PAs. The electric PAs have historically shown two different types of patterns for the contribution ratio analysis:

1. **Ski Slope Pattern**, which can be seen for National Grid, implies that the smaller an account becomes, the less likely it is that the PA will generate a proportional amounts of savings from that account.
2. **Saw Pattern**, such as with Unitil, implies that the PA is engaging and achieving different savings across the bins in a way that is less predictable. This generally leads to a greater depth of savings for accounts in the smaller bins, though these bins still do not contribute as much savings as they do annual consumption.



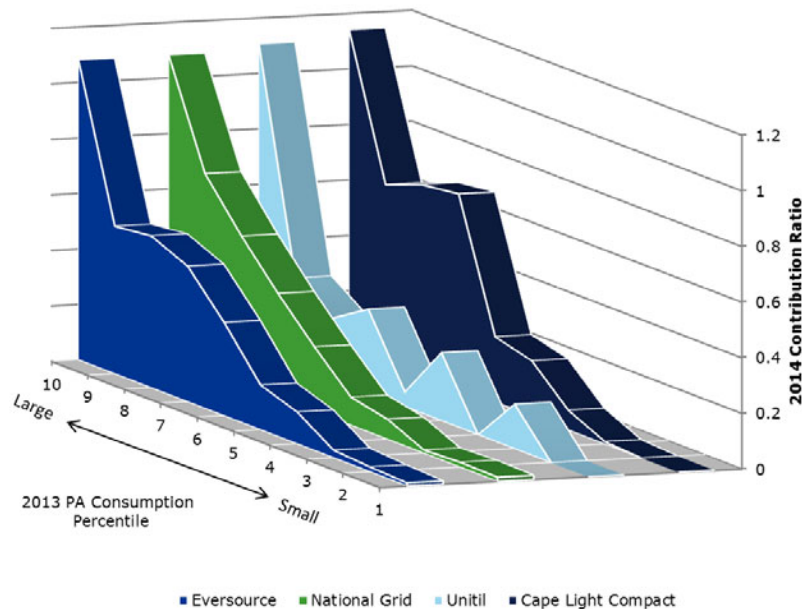


Figure 7. 2014 contribution ratio distributions by electric PA

Some of the conclusions that can be drawn from Figure 7 include:

- All the PAs derive a higher proportion of savings from their largest accounts. These large accounts are seeing a greater depth of savings when compared to any of the other bins.
- Cape Light Compact had higher engagement in their 70<sup>th</sup> and 80<sup>th</sup> percentile bins, which would indicate that they found a successful way to reach out to these customers in 2014.
- Until achieved deeper savings from their smaller bins in 2014 than the other PAs.

### Prediction Ellipse Analysis

Included for the first time in the 2014 Customer Profile was a section that used 95% prediction ellipse plots across the PAs and a variety of categorical lenses (such as end use or industry sector) to help readers visualize each PA's participating population as a whole. These plots have the advantage of showing the entire population, with its specific variation and possible difference in outcome, without violating customer data confidentiality rules. The ellipses can be evaluated using the following steps:

- The **length of the ellipse** is largely determined by the range of the size of participating accounts: the greater the difference between the minimum and maximum usage the longer the ellipse will be.
- The **width of the ellipse** is determined by the variation in savings for accounts that are similar in size. The more variable the savings achieved for each account the wider the ellipse plot will be.

- The **overall slope of the ellipse** is determined by the correlation between savings and consumption. Positive slopes indicate that larger accounts are likely to have larger savings based on the 2014 annual savings results.

Figure 8 shows the overall prediction ellipse plot for each of the Massachusetts electric PAs and Table provides additional statistical details pertaining to the ellipse. The following findings can be drawn for Figure 8:

- Cape Light Compact does not have linked participating accounts as large as the other electric PAs.
- Unitil engages a larger spread of accounts than the other PAs, reinforcing the results from Figure 7.
- Eversource and National Grid have similar ellipses, although Eversource’s ellipse is wider, which indicated that the depth of savings for accounts with comparable annual consumption was more variable than National Grid in 2014.

The details contained in Table 2 add more context that cannot be easily seen from the ellipse plots, such as the total number of participants, along with median savings and usage data for each PA. Statistical details are provided as supporting information but are not used for prediction purposes<sup>6</sup>.

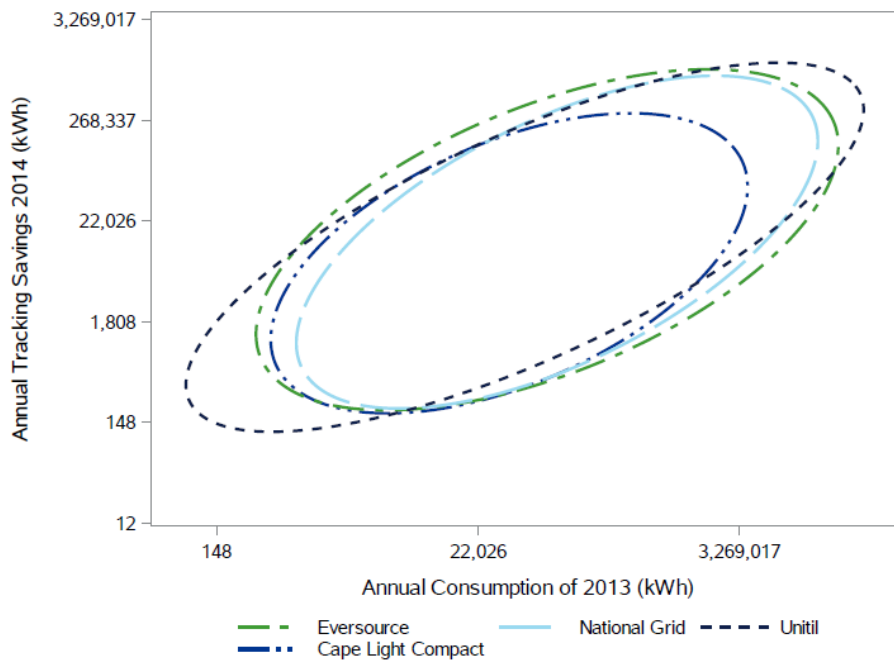


Figure 8. Savings to consumption predictive ellipse by PA

<sup>6</sup> While the  $R^2$  values in Table 2 are low, this is not a cause for concern since there is only a single explanatory variable and the purpose of the analysis is not to provide a predictive tool.

Table 2. Savings to consumption predictive ellipse summary by PA

Electric PA	Number of participants	Median Savings (kWh)	Median Usage (kWh)	Log regression of savings to consumption	R <sup>2</sup>	Significant at the 90% confidence level
Cape Light Compact	546	7,546	32,175	4.54+0.42*(kWh)	0.26	Yes
Eversource	3,371	12,492	66,208	4.77+0.42*(kWh)	0.31	Yes
National Grid	3,624	12,425	86,480	3.70+0.50*(kWh)	0.37	Yes
Unitil	77	10,062	58,480	3.60+0.53*(kWh)	.56	Yes

## Conclusions

Every year, new quantitative metrics are added to the C&I Customer Profile that address new questions or trends identified by the PAs. It presents complex statistical analysis in an understandable, graphical format and highlights nuanced differences in PA populations and participation levels. The annual C&I Customer Profile report goes into great depth and detail, far exceeding the charts presented here. Some of the conclusions that can be distilled from this type of analysis include:

1. Cape Light Compact accounts tend to be smaller than the other PAs; this is likely to manifest itself in the PA achieving smaller absolute savings numbers. In particular, they will likely see different results in the manufacturing, retail trade, and transportation sectors in terms of absolute savings and depth of savings for accounts.
2. Unitil has also found ways to engage customers in smaller consumption percentile bins, these strategies may be of use to the other PAs as account sizes are increasingly similar as the percentile bins get smaller.
3. All the PAs have contribution ratios above 1 for their largest percentile bin, showing that the PAs are realizing deeper savings from their largest accounts.
4. Savings from accounts with annual peak demand between 75 - 300 kW per year are highly variable across the PAs and may warrant further investigation.

These types of charts would not be possible without the substantial effort that goes into the development and maintenance of the MA C&I Evaluation Database each year. This database allows meaningful comparisons across the PAs, especially regarding categorical variables such as industry sector and end use, which can have various values and meanings across each PA that need to be standardized before any analysis can be performed. Each year new time series analysis and advanced charts such as the prediction ellipse plots are added to the Customer Profile and help push the previous boundaries of what can be shown without violating custom data confidentiality.

Future improvements to the database are already being planned and include the addition of third-party datasets to increase the details known about each account and advanced linking of

accounts across PAs that share a location or customer. These improvements will increase the types of analysis the PAs in Massachusetts are able to conduct to include likelihood to participate analyses and program participation in economically depressed areas of the State.

The investment that the PAs make in maintaining and adding data to the C&I Evaluation Database has impacted how the PAs, EEAC, and other stakeholders determine where to make programmatic improvements. For example, the 2014 Customer Profile report showed a marked improvement in the engagement of Mid-Sized customers, which provided quantitative support to the PAs and EEAC regarding this area of the PAs populations which had previously been identified as under engaged (DNV KEMA 2013).

As the energy efficiency landscape matures, many customers will begin to have shifting needs for how and why they participate in energy efficiency programs. The annual Customer Profile report allows PAs to see the trends as they occur across the State so that they can effectively and efficiently focus their future efforts on maintaining and growing customer participation in energy efficiency programs.

## References

DNV GL. 2016. “2014 C&I Customer Profile” Prepared for: Massachusetts Program Administrators. <http://ma-eeac.org/wordpress/wp-content/uploads/FINAL-2014-Customer-Profile-1.pdf>

DNV GL. 2015. “How PA Differences Affect CI Outcomes Phase 2 Final” Prepared for: Massachusetts Program Administrators. <http://ma-eeac.org/wordpress/wp-content/uploads/How-PA-Differences-Affect-CI-Outcomes-Phase-2-Final-Report.pdf>

DNV KEMA. 2013. “Mid-size Customer Needs Assessment Final Report” Prepared for: Massachusetts Program Administrators. <http://ma-eeac.org/wordpress/wp-content/uploads/Mid-Size-Customer-Needs-Assessment-Final-Report-12.22.13.pdf>