nationalgrid

Demand Reduction
REV Demonstration Project
in
Clifton Park

Q1 2020 Report

April 30, 2020

nationalgrid

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1.0 Executive Summary

On January 17, 2017 Niagara Mohawk Power Corporation d/b/a National Grid ("National Grid" or the "Company") filed an implementation plan for the Demand Reduction REV Demonstration Project in Clifton Park (the "Project"), which is designed to provide residential customers in the Town of Clifton Park ("Clifton Park" or the "Town") with price signals, tools and information, enabled by infrastructure investments and distributed energy resources ("DER"), to reduce electric demand during peak times and inform the Reforming the Energy Vision ("REV") Proceeding.[1] The total number of customers affected (*i.e.,* those receiving a meter and those opting out) is approximately 14,400.

The Project aligns with the New York Public Service Commission's ("Commission") *Order Adopting a Ratemaking and Utility Revenue Model Policy Framework* ("REV Track Two Order") wherein the Commission asserts "[o]ne of the most important objectives of REV is improving overall system efficiency including the efficiency of capital investment to create value for customers. Toward that objective, electric peak reduction is among the most immediate priorities for REV implementation."[2] National Grid believes that it is possible to create more responsive relationships with customers by leveraging infrastructure, customer outreach and engagement, deep energy insights and actionable information, as well as price signals and DER products and services, to incentivize customers to reduce peak electric load and overall electric and gas energy use. The Project includes the following elements:

- Infrastructure
    - Advanced Metering Infrastructure ("AMI")
    - Volt/VAR Optimization (includes Conservation Voltage Reduction) ("VVO")
- Customer Outreach & Engagement
- Deep Energy Insights & Actionable Information
- Price Signals
    - Peak Time Rewards ("PTR")
    - Voluntary Time-of-Use ("VTOU") Rate
- DER Services
- Utility-supported Community Choice Aggregation ("CCA")[3]

[1] Case 14-M-0101, *Proceeding on Motion in Regard to Reforming the Energy Vision* ("REV Proceeding"), National Grid Demand Reduction REV Demonstration Project in Clifton Park Implementation Plan (filed January 17, 2017) ("Implementation Plan").
[2] REV Proceeding, Order Adopting a Ratemaking and Utility Revenue Model Policy Framework ("REV Track Two Order") (issued May 19, 2016), p. 72.
[3] Although part of the initial Project proposal, the Town ultimately decided not to pursue the utility-supported CCA option.

Key activities and milestones accomplished this quarter (Q1 2020) include:

Key Activity/Milestone	Outcome
Innovative Pricing	• Continued work to identify and design potential innovative pricing rate test scenarios.
PTR	• Extended PTR within current Project budget for a fourth season beginning in summer 2020.
IT, Advanced Analytics and Energy Forecasting efforts	• Advanced Analytics and Energy Forecasting team, as well as IT continued Project support.
VVO efforts	• VVO testing encountered a system override issue. Data collection efforts will continue for another six months.
Customer Outreach & Marketing	• Conducted customer focus groups addressing proposed innovative pricing rate designs in February 2020.
DER	• Awaiting outcome of innovative pricing demonstration proposal to understand impact on DER promotions.
COVID-19	• Enacted Business Continuity Plan. • Monitoring impacts on vendors, innovative pricing proposal, and customer load shapes. • Adjusting protocols to ensure consistent and effective customer communications throughout the pandemic

Project Elements

A visual depiction of the Project's key services and offerings is provided below. Except for VVO, customers can opt in or opt out of each Project element. A description of each Project element is included with the individual sections of this quarterly report.

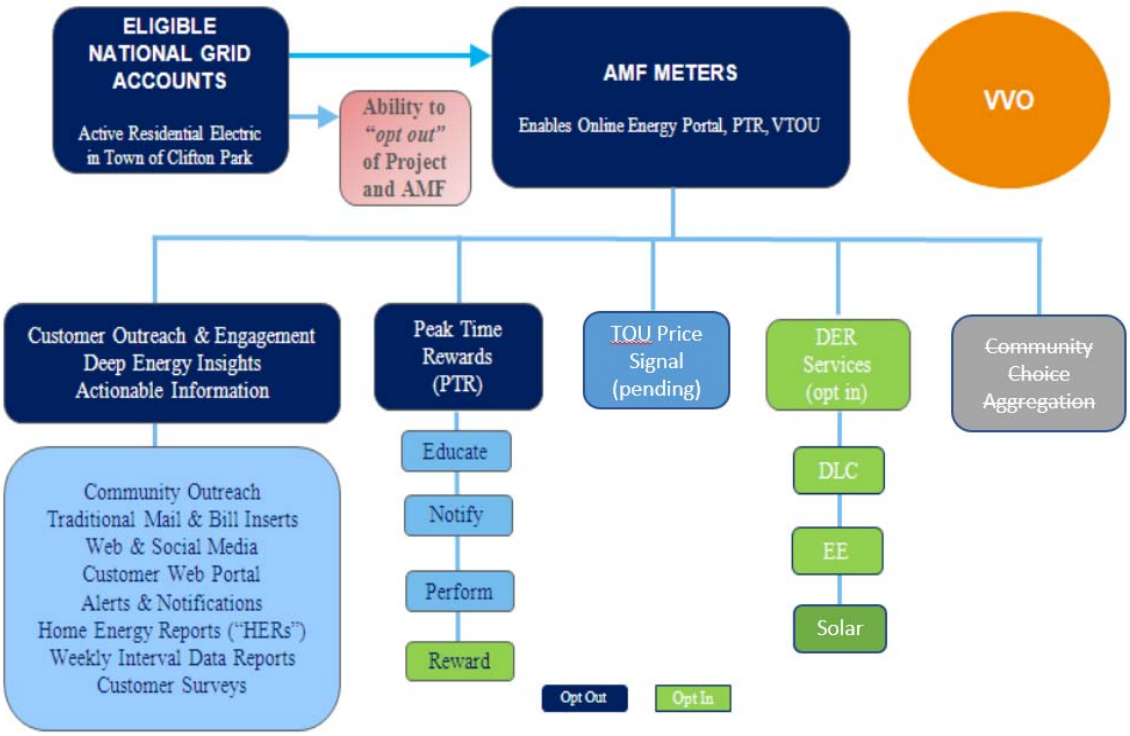


Figure 1: Project Elements

2.0 Highlights Since Previous Quarter

The following highlights key activities accomplished to date on the Project, as well as key activities planned for the next quarter.[4]

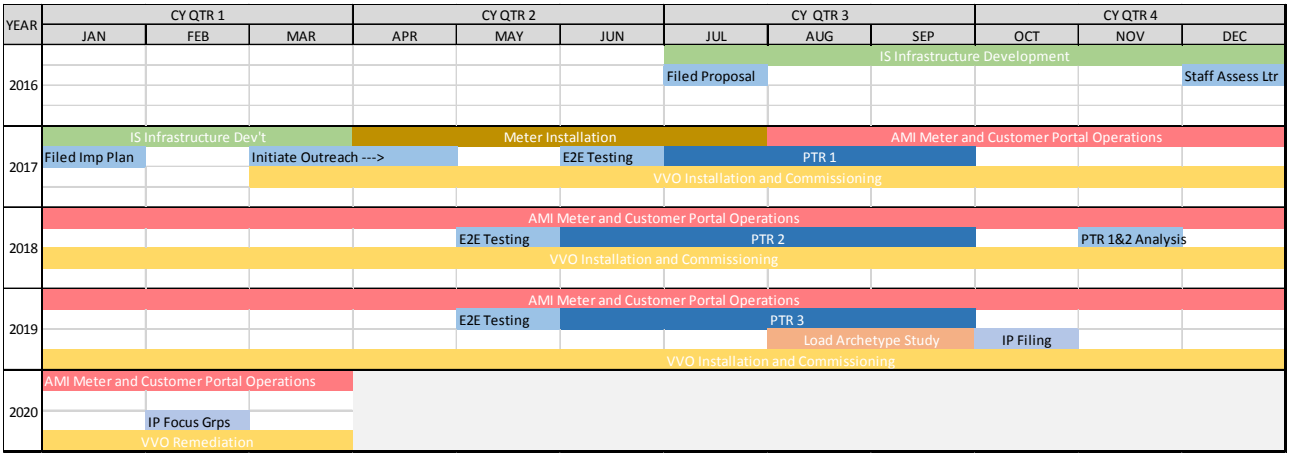


Figure 2: Work Plan Summary

2.1 Major Task Activities

2.1.1 Advanced Metering Infrastructure

AMI deployment in Clifton Park has replaced existing National Grid electric and gas meter reading and billing processes for customers that have not opted out of the Project. AMI meters are read and select portions of data are transferred over the cellular network to National Grid for utility billing. Portions of data are also transferred to the Project's partners over secure networks to enable various elements of the Project, including the customer web portal. Interval data is used for deployment of PTR, all customer billing, and to support authorized Project evaluation activities.

AMI deployment commenced at the end of the first quarter of 2017. Letters introducing Clifton Park customers to "Smart Energy Solutions," the customer-facing name of the project, and postcards alerting customers of the AMI installation timeframe were distributed prior to installations. This allowed for a period during which customers could opt out of the AMI metering technology, as well as certain other aspects of the Project.

Customers choosing not to have AMI installed were directed to a specialized team at the National Grid Contact Center, who informed Customer Meter Services ("CMS") not to install AMI technology for those customers. Instead, the opt-out customers retain their existing meter (*i.e.*, automated

[4] The effects of the COVID-19 pandemic may impact the project schedule. As those impacts become better understood, the Company will adjust the schedule accordingly.

meter reading ("AMR") meter or standard non-AMR meter). Additionally, during the Project term, customers may also have their AMI meter removed and replaced with an AMR meter at no additional cost.

The initial AMI opt-out rate was 8.8 percent, which equals approximately 1,256 premises. AMI meter opt-outs include customers who: 1) opted out through the National Grid Customer Contact Center; 2) informed CMS field workers in-person that they did not want the meter; or 3) were unable to provide access to the meter after three (3) attempts by the Company without success.

National Grid continues to monitor AMI opt-outs throughout the term of the Project, as part of normal customer fluctuations in the Town (*e.g.*, new growth and customers moving). The National Grid Customer Contact Center is also accepting customer requests to install or remove the AMI technology and process orders.

The Company also commissioned a load archetype study to leverage AMI data to understand the typical electricity consumption patterns of residential customers in Clifton Park. A copy of the study is attached to this report as Appendix B.

2.1.1.1 Information Technology ("IT") Activities

Timeframe	Completed Milestones
1st Quarter 2020	• Continued Project support via National Grid's IT Support team. • Planning for changes in file transfer processes.

2.1.1.2 Meter Installation Activities

Timeframe	Completed Milestones
1st Quarter 2020	• Continued to support business practices related to move-in/out of customers.

2.1.2 Volt/VAR Optimization ("VVO") Device Installations

National Grid will enhance the efficiency of the electric distribution system through the installation of software and devices that better regulate the voltage of the distribution system. These system enhancements will benefit all customers connected to those substations being upgraded. Working with the Project's VVO partner, Utilidata, National Grid started installing devices on the electric distribution system that monitor voltage along with advanced controllers for voltage regulators and reactive capacitors.

National Grid will evaluate the extent to which optimized regulation of the voltage and power factor of the electric distribution system benefits customers, ultimately reflected by improved feeder power factor, flatter voltage profiles, reduced feeder losses, reduced peak demand, and reduced

energy consumption by customers. National Grid's targeted efficiency gain through the VVO portion of the Project is approximately three percent (3%).

VVO installation scope includes:

- Three (3) substation transformer load tap changers;
- Eleven (11) feeders, including:
  - Twelve (12) line voltage monitors;
  - Thirty-one (31) advanced switching capacitors; and
  - Five (5) pole top regulators.
- A central controller and data concentrator installed at the National Grid Control Center in Liverpool, New York;
- Supervisory control via National Grid's Supervisory Control and Data Acquisition ("SCADA") and Energy Management System ("EMS"); and
- Cellular connectivity between all field, substation devices, and the data concentrator.

While all VVO equipment is installed and commissioned, the previous system instability due to the consecutive tap failures has been remediated by increasing the polling intervals. Measurement and verification efforts will follow site acceptance testing.

Timeframe	Completed Milestones
1st Quarter 2020	• Consecutive tap failure issue has been remediated.

2.1.3 Customer Outreach

National Grid has engaged residents of the Clifton Park community to learn about the Project and solicit input. The strategies include:

- Community outreach;
- Mail and bill inserts; and
- Web and social media.

Community Outreach

The National Grid marketing team performed studies of Clifton Park residential customers to assess areas of concern and to present recommendations. The studies were conducted by Market Probe moderators, a third-party market research group, via:

- Outreach sessions with Clifton Park residents in June 2018;
- Phone and online annual surveys; and
- Testimonial campaign with radio and billboard outreach launched in 2018.

Mail and Bill Inserts

Prior to the installation of AMI, National Grid delivered a set of communications via standard mailings to introduce Clifton Park customers to Smart Energy Solutions and notify them of the imminent arrival of the AMI technology. Customers were asked to contact National Grid if they did

not want to receive a new AMI meter. Each letter spoke to the benefits of the Project and touched upon key Project elements available immediately and in the near future. The Company sent the communications as direct mail and bill inserts.

Thereafter, National Grid also sent a series of meter installation notifications letting customers know when the new meters would be installed. Included in the communications was an invitation to attend one of the Company's customer outreach and education meetings to learn more about the Project, ask questions, and interact with the National Grid team.

Following the installation of an AMI meter, customers received educational materials focused on the various Project elements, such as enrolling in PTR. Bill inserts will continue to be incorporated four (4) times per year as Project elements are developed and implemented. The Company will also provide ongoing Project updates throughout the year using local media. Additionally, the Company created video tutorials that are posted on the National Grid website.

Web and Social Media

National Grid continues to expand the existing Clifton Park micro-site (https://www.nationalgridus.com/Upstate-NY-Home/Energy-Saving-Programs/Clifton-Park), a component of the Company's website (http://www.nationalgrid.com), to include information on the Project for Clifton Park residents.

The Project website includes the following information:

- Frequently Asked Questions Video overview of the Project;
- Frequently Asked Questions pdf;
- Information about PTR;
- DER product and service options available (*e.g.*, New York Solar Marketplace); and
- Updates throughout the year to announce the rollout of new products and services.

National Grid also proactively monitors open social media sites to join any conversations regarding the Project and to help answer questions about it.

The Company also tracks customer interaction with the Opower web portal as part of the Project. Emails, bill inserts, direct mailings, and social media contributed to raising awareness of the information available to customers, as evidenced by increasing levels of customer interaction throughout the PTR seasons. Customer outreach activities continue outside of the PTR season to encourage ongoing customer engagement.

Areas of the portal experiencing common customer interaction include:

- My Energy Use;
- Ways to Save;
- Compare My Bills;
- Dashboard; and
- Home Energy Audit.

The following key performance indicators ("KPIs") have been created to track and measure the success of Customer Outreach:

- Customer Acceptance of AMI Technology;

- Awareness;
- Customer Control of Energy Usage;
- Customer Satisfaction with National Grid; and
- Portal Engagement (*e.g.,* login creation, enrollment in PTR, and profile completion).

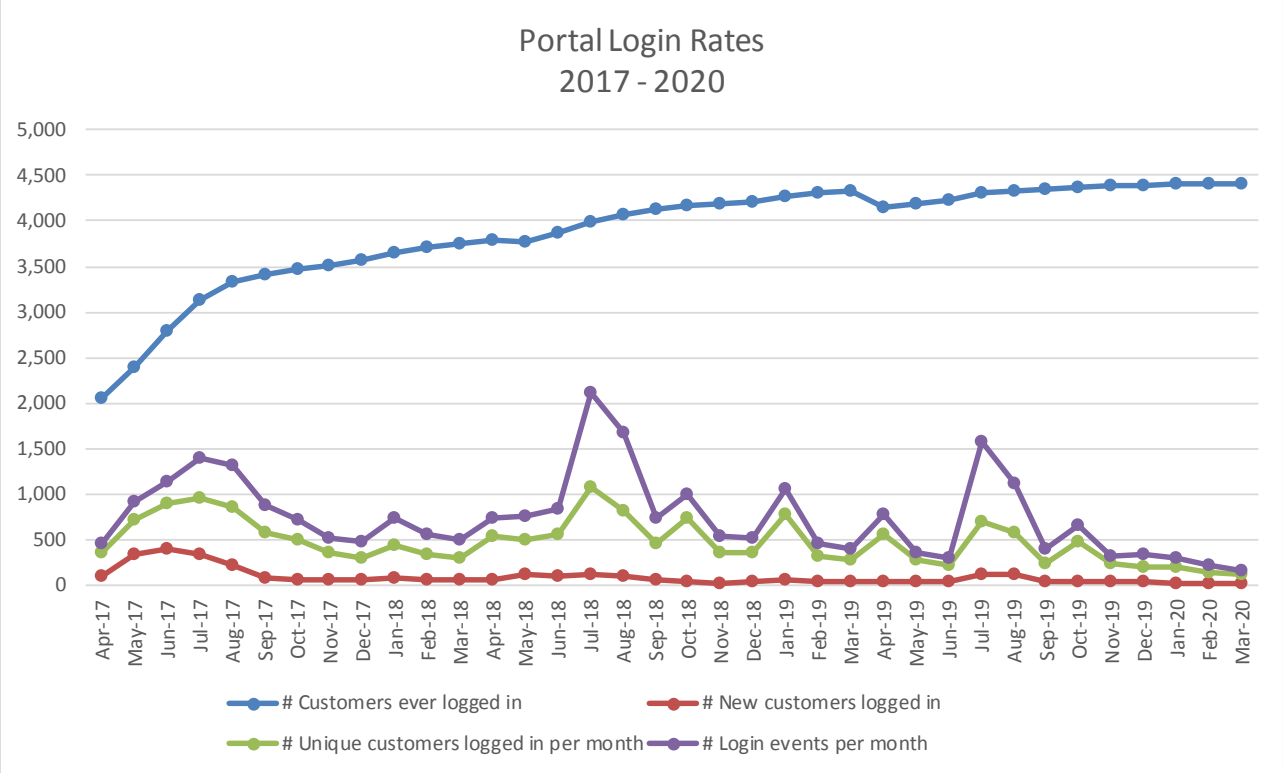


Figure 3: Portal Activity

Timeframe	Completed Milestones
1st Quarter 2020	• Continued outreach on energy saving tips, checking usage and general portal engagement.
	• Communication regarding PTR season 4 and points expiration extension.
	• Plans developed for PTR season 4 (summer 2020).
	• Innovative pricing focus groups completed in February 2020.

In February 2020, the Company engaged customer focus groups to analyze the response to rate designs proposed in the Company's October 2019 innovative pricing filing. The focus groups helped the Company understand customer response to the proposed rate design and initial marketing collateral design developed to educate customers about the proposed innovative rates. In addition, the Company will ensure customer communications reflect consistent messaging in line with the Company's COVID-19 response.

2.1.4 Peak Time Rewards ("PTR")

National Grid seeks to incentivize Clifton Park customers to reduce electric use during specified peak times. Participating customers are rewarded for curtailing electric load through behavioral actions such as turning off lights and adjusting thermostats or utilizing customer-controlled technology.

Key elements of PTR include:

- Event performance analytics performed on all customers with AMI;
- Pre-event and post-event email notifications;
- Rewards earned by those enrolled in "Points and Rewards";
- Rewards awarded based on participation in up to twenty PTR events per year; and
- No penalties for failure to reduce load during PTR events.

National Grid reviews load forecasts for the New York Independent System Operator ("NYISO") system and Zone F, which includes Clifton Park, as well as local Clifton Park weather forecasts, to determine whether to call a PTR event, also referred to as a "Conservation Day."

PTR events are entered into two systems: one triggers customer event notifications to Clifton Park customers; and the other sets in motion the energy use predictive model, which will compare predicted values to actual AMI metered usage. The second system is used to determine curtailment participation. Over 8,000 pre-event emails notifying customers that a conservation event is scheduled are sent to Clifton Park customers for each event.

Once the Company determines the curtailment performance for the Conservation Day, each customer electric service account is assigned a value of 'true' or 'false' for each event, based on whether it curtailed during the event. Accounts enrolled in the Points-and-Rewards program which are assigned a value of 'true,' are then awarded points.

National Grid tracks customer enrollments in PTR as a measure of customer engagement. Enrollment in Point-and-Rewards has increased each month as the Project has progressed. PTR enrollment enables customers participating in Conservation Days to earn rewards.

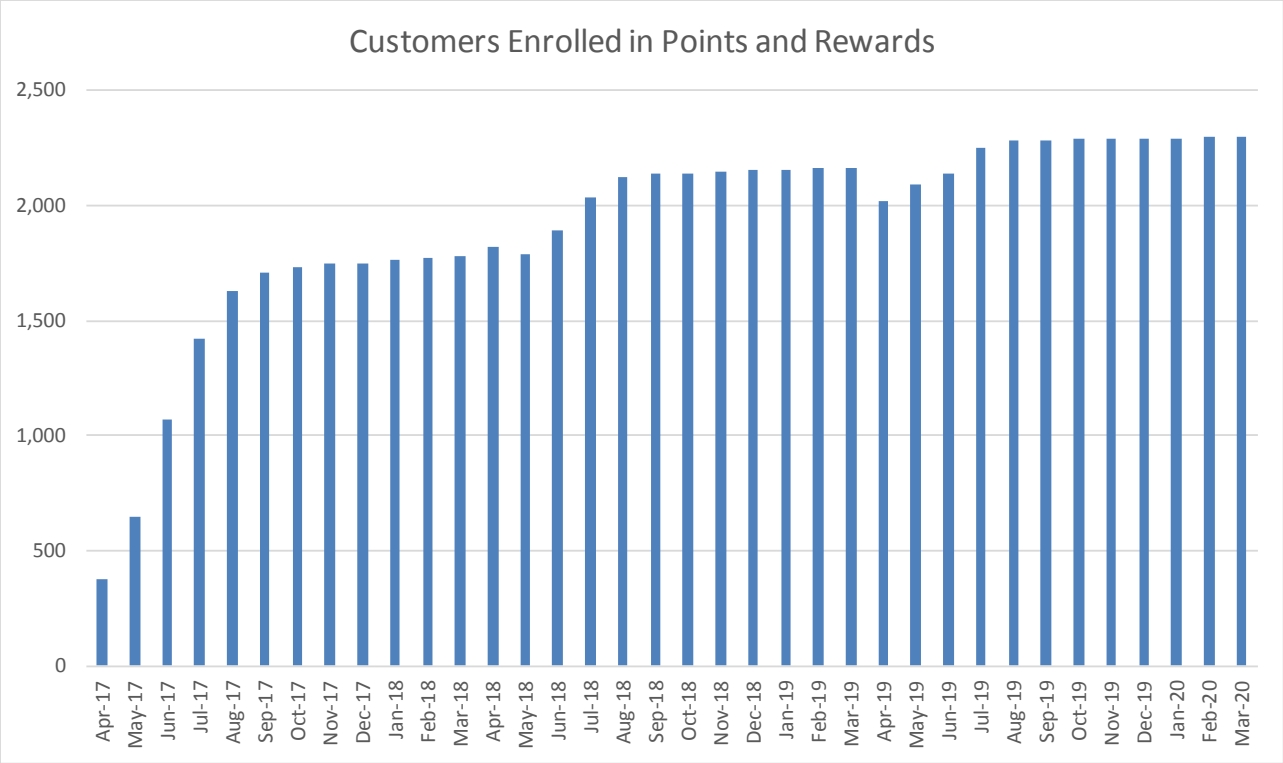


Figure 4: Points and Rewards

The Company will implement a fourth season of PTR during the summer of 2020 within the original Project budget. The Company sent a customer communication informing customers of the summer 2020 program extension and that the expiration date for PTR points would be extended one year. In addition, initial procurement discussions have taken place to assure continued operation of AMI and portal functionalities.

Timeframe	Completed Milestones
1st Quarter 2020	• PTR will be continued for a fourth season in summer 2020 within the existing Project budget. • Procurements associated with PTR extension for SaaS and services.

2.1.5 Advanced Analytics and Energy Forecasting

National Grid's Advanced Analytics and Energy Forecasting team developed the residential energy use predictive model to determine the expected energy use during PTR events. The predictive model uses prior customer level energy consumption data and event weather conditions to predict customers' energy consumption during events. The predicted values are compared to the actual AMI data to determine whether customers curtailed energy use and to ascertain which customers earned points. The results of the analyses are also used to determine if the aggregated community load meets certain threshold requirements for bidding into the NYISO wholesale electricity market. In addition, the Advanced Analytics and Energy Forecasting team has supported the development of innovative pricing rate designs.

Timeframe	Completed Milestones
1st Quarter 2020	• Continued to support normal business operations. • Support of innovative pricing rate designs.

2.1.6 Time-of-Use ("TOU") Price Signals

As a result of the AMI collaborative, National Grid is continuing to look for opportunities to align the Project with the AMI Business Case[5] and its beneficial electrification and Smart Home Rate ("SHR") initiatives.

Timeframe	Completed Milestones
1st Quarter 2020	• Continued strategic alignment of Clifton Park, AMI Business Case, and SHR.

2.1.7 Distributed Energy Resource ("DER") Opportunities

National Grid seeks to animate the market by facilitating DER provider opportunities as part of the Project. DER products and services will be opt-in offerings to customers, publicized via the customer engagement channels outlined above (*e.g.*, the National Grid Marketplace and related Solar Marketplace. DER services may include energy efficiency, demand response, or renewable distributed generation opportunities. The Company is continuing to monitor the COVID-19 situation and adjust its proactive outreach and communications strategies with customers as necessary.

[5] *See* Case 17-E-0238, *Proceeding on Motion of the Commission as to the Rates, Charges, Rules and Regulations of Niagara Mohawk Power Corporation d/b/a for Electric Service,* Report on the Proposed Implementation of Advanced Metering Infrastructure (November 15, 2018).

Timeframe	Completed Milestones
1st Quarter 2020	• 2020 DER promotions dependent on innovative pricing demonstration design.

2.1.8 Community Choice Aggregation ("CCA")

In 2017 National Grid engaged with Clifton Park officials and community members on the potential adoption of a utility-supported CCA. The Town ultimately decided not to pursue the CCA option.

2.1.9 Project Management

A group of individuals in the Company work to manage the Project, keeping it on track regarding scope, schedule, and budget, while also lending visibility into processes, accomplishments, and financial tracking. The project managers regularly engage in, and promote, the following:

- Weekly Core Team Status Reporting;
- Monthly General Staff Meetings;
- Quarterly Commission Reporting;
- Issue Tracking;
- Lessons Learned Recording and Review;
- Change Log Processes; and
- Financial Reporting activities.

Timeframe	Completed Milestones
1st Quarter 2020	• Conducted weekly status reviews with core team leads, monitoring progress, providing corrective measure(s), and escalating issues, as needed.
	• Provided Project updates for management review.
	• Continued Project strategy efforts related to the Innovative Pricing proposal.

2.1.10 Innovative Pricing

On October 22, 2019, National Grid submitted a petition to implement an innovative pricing demonstration to leverage the status of the current Project. The petition, which includes proposed tariffs, rate design options, and a related budget, remains pending before the Commission.

Timeframe	Completed Milestones
1st Quarter 2020	• Continued discussions with Department of Public Service Staff on innovative pricing demonstration design.

2.2 Challenges, Changes, and Lessons Learned

Qtr	Issue or Change	Resulting Change to Project Scope/Timeline?	Strategies to Resolve	Lessons Learned
Q1.20	Split electric and gas utility bills were issued when a data file failed to upload in a timely manner occurred again but for a different bill cycle.	No change.	The Company implemented system modifications so any future instances will result in off-cycle bills, meaning both electric and gas services will be billed together if the issue recurs.	This issue has been resolved and programming changes will assure it will not be repeated. The experience informs preparation for contingencies in full scale AMI deployment.
Q1.20	Continued refinement of approach for innovative pricing.	Project timeline is unknown.	Continue discussions and refine rate design proposals.	Identifying potential default mass market rates to test requires coordination among regulators, internal company functions, and analysis of potential customer impacts.

3.0 Next Quarter Forecast

During the second quarter of 2020, the Project team will procure necessary resources for PTR season 4 and prepare for system testing prior to PTR season launch. In anticipation of regulatory approval of the Innovative Pricing demonstration, the Project team will continue to develop plans related to scope, schedule, budget, and resources for testing rate designs. The Company will also continue to monitor potential COVID-19 related impacts and adjust, as necessary, any customer communications.

3.1 Check Points/Milestone Progress

3.1.1 Summary

	Checkpoint/Milestone	Anticipated Start-End Date	Revised Start-End Date	Status
1B	Phase 1: Network Configuration and Meter Deployment	1/2/17 – 6/16/17	1/2/17 - 7/17/17	Complete
1B	PTR Operations	7/1/17 - 9/30/19	7/1/17 – 9/30/20	
2	Phase 2: VVO; REV Operations and Evaluation	6/19/17 – 3/31/20	6/19/17 – 3/31/21	
3	Phase 3: Project Wrap-up	10/1/19 – 9/30/20	10/1/2020 – 3/31/2021	
4	Phase 4: Innovative Pricing	6/1/20- 4/1/2024		

Key

- On-Track
- Delayed start, at risk of on-time completion, or over-budget
- Terminated/abandoned checkpoint

3.1.2 Work Stream – 2nd Quarter 2020

Work Stream	Future Milestones	Status
IT	• Support Project via National Grid's IT Support team. • File transfer process changes from MPLS to internet-based system.	

Work Stream	Future Milestones	Status
AMI	• Support normal business practices related to move-in/out of customers.	
	• Load archetype study finalized.	
VVO	• Continue study to evaluate overall system performance, leveraging AMI data for additional efficiencies. • VVO site acceptance testing (SAT), followed by initiation of measurement and verification (M&V) period.	
Customer Outreach	• Continue customer communications and education engagement.	
	• Engage customer with actionable information via the portal. • PTR 4 season welcome letter to be sent.	
PTR	• Complete PTR end-to-end user testing. • Launch PTR season early June 2020.	
Advanced Analytics and Energy Forecasting	• Provide continued support to Project team. • Participate in PTR end-to-end testing. • Prepared to calculate PTR curtailment results.	
TOU Price Signal	• Not pursued under initial Project; however, Project team anticipates transition to innovative pricing.	
DER	• Not continued due to anticipated transition to innovative pricing.	
Project Management Group	• Conduct weekly Project update meetings.	
	• Monitor and report Project Key Performance Initiatives.	
	• Continue tracking, monitoring and controlling the Project schedule, tracking on a weekly basis.	
	• Continue tracking, monitoring and controlling the Project financials, tracking on month-by-month basis.	
	• Continue to identify, monitor and manage risks and issues as they arise.	
	• Work with AMI team on future rate structure strategies.	
	• Strategize on integration of SHR in Clifton Park.	
Project Evaluation	• Develop Project evaluation plan.	
	• Evaluate additional AMI data analytics to capitalize on availability of meter data.	

4.0 Work Plan and Budget Review

4.1 Updated Work Plan

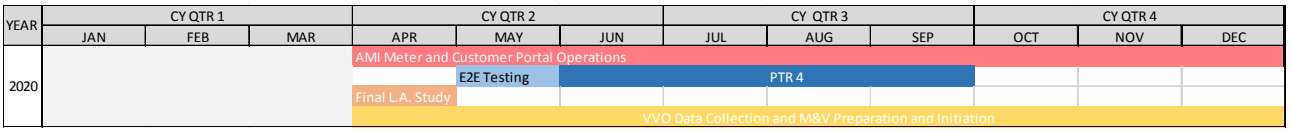


Figure 5: Current Year Work Plan

Figure 5 represents the current year work plan for the Project. AMI meters and the customer portal will remain operational, PTR operations will continue, and VVO data collection will commence to support measurement and verification efforts. Approval of the Innovative Pricing demonstration would result in additional work streams associated with programming and testing rate structures, customer outreach and education, and filing of an updated project implementation plan.

4.2 Updated Budget

Project Task	4th Quarter 2019 Actual Spend	Project Total Spend to Date	Project Budget	Revised Budget	Remaining Balance
	CapEx				
	($ 9,017)	$ 8,694,206	$ 12,516,057	$ 8,766,057	$ 71,851
	OpEx				
	$ 716,789	$ 8,731,798	$ 14,437,176	$ 13,936,353	$ 5,204,555
Total	**$ 707,772**	**$ 17,426,004**	**$ 26,953,233[6]**	**$ 22,702,410**	**$ 5,276,406**

Note: 4th quarter spend includes $432,736 payment for software services through March 31, 2021 to support the customer portal and PTR.

[6] A difference between the Implementation Plan budget ($26,819,336) and the current revised budget ($26,953,233) is due to an increase in actual meter costs and associated fees. The overall difference is $133,897.

5.0 Progress Metrics

Checkpoint[7]	Progress / Target Completion
Infrastructure	
AMI Acceptance vs. Opt Out	Continuing to monitor opt-out rates as Project progresses, and through the life of the Project. Current opt-out rate is 8.8 percent.
VVO System Benefits	Established infrastructure required to enact VVO and monitor progress. Equipment installation and commissioning completed. Initiated VVO evaluation period.
Customer Outreach and Engagement / Deep Energy Insights and Actionable Information	
Customer Outreach and Engagement	Continuing engagement through life of the Project. Annual surveys tracked against initial baseline survey.
Customer Energy Portal Engagement	Continue customer engagement metrics related to portal use, PTR participation, etc.
Price Signals	
PTR	Began PTR in July 2017; continue evaluation through life of the Project regarding participation rates and curtailed load.
TOU Price Signal	Strategic transition to innovative pricing demonstration.
DER	
DER Opportunities	Promotion of Connected Solutions demand response and related technologies, National Grid's Solar Marketplace, and energy efficient pool pumps and pool pump timers.

[7] *See* Implementation Plan, pp. 24-26, for specific metrics.

6.0 Appendix A – One Page Summary

nationalgrid **Clifton Park REV Demo** **4/30/2020 (Q1 2020)** **Overall Status (Active)**

Project Start Date: 01/17/2017 **Project End Date:** 03/31/2021 for initial phase
Budget: $22,702,410 **Current Quarter Spend:** $707,772 **Cumulative Spend:** $17,426,004

Project Summary: Address REV principles to reduce peak demand, increase DER adoption and give customers greater insight into their energy usage so they can make more informed energy decisions. Primary deliverables include: installation of approx. 13,300 AMI electric meters and 11,500 gas ERTs, energy management education and engagement; implementation of a Peak Time Rewards (PTR) program; improve system-wide efficiency. Partners include Itron, Opower/Oracle, Utilidata; vendors include Wipro, Verizon, Navigant. A petition proposing transitioning the Project into an innovative pricing REV demonstration project was filed October 22, 2019.

Cumulative Lessons Learned		
The Customer	**Market Partner**	**Utility Operations**
• Customer participation has been moderate despite specific marketing campaigns and customer outreach meetings. • Meter acceptance rate > 90% • Portal usage is at ~24% • Points-and-rewards enrollment ~16%	• DER promotion dependent on available information to disseminate (*e.g.*, Solar Marketplace launch). • Partner system restrictions limit availability to deliver PTR.	• Meter deployment was challenged by temporary workforce hiring. • VVO construction was challenged by reallocation of resources due to storm duty obligations.

Application of lessons learned: National Grid is aligning its AMI opportunities in Clifton Park with its broader AMI Business Case through its proposal to transition Clifton Park into an innovative pricing REV demonstration. An innovative pricing demonstration will include omni-channel marketing, multiple touch-point customer engagement, along with an enhanced customer portal to deliver the benefits of AMI technology to better manage energy usage and succeed on innovative pricing designs.

Issues Identified: Rewards-type structure is not sustainable and does not align with other regulatory initiatives. Innovative pricing structures and research design not finalized.

Solutions Identified: VVO consecutive tap failure remediated. PTR rewards points has been extended for one year to bridge build of innovative pricing structures and delivery.

Recent Milestones/Targets Met: All VVO devices have been installed and commissioned. Load archetype study completed. Innovative pricing focus groups implemented.

Upcoming Milestones/Targets: End-to-end user testing for PTR, and launch of PTR summer 2020. VVO measurement and verification to be initiated after site acceptance testing.

COVID-19: Enacted Business Continuity Plan March 12; monitoring vendor/load impacts; adjusting communications.

7.0 Appendix B – Load Archetype Study

Clifton Park Demand Reduction REV Demonstration
Residential Load Archetypes

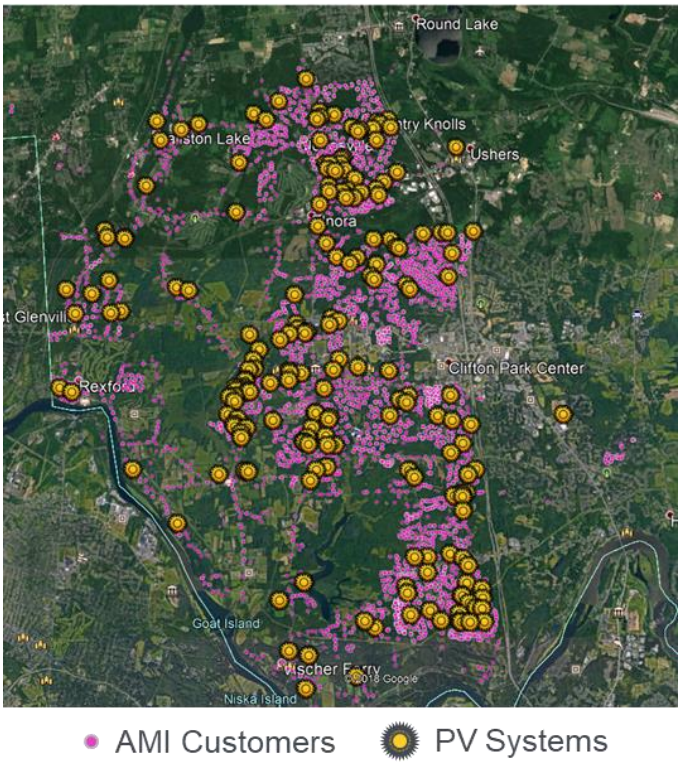
Date: Jan 2020

Background

The Clifton Park AMI deployment launched in 2016 as the setting for National Grid's Demand Reduction REV[1] demonstration. The project was designed to provide residential customers with price signals, tools and information, enabled by AMI, to make informed decisions about energy consumption, including load shaping. From April 2017 to July 2017 approximately 13,300 residential electric AMI meters and approximately 11,500 gas ERTs were deployed.

Over 90 percent of the customers included in the AMI deployment reside in suburban single-family homes. The Advanced Data Analytics (ADA) team at National Grid provided customer indicators, such as the presence of on-site electric vehicle charging and electric heating, to aid in developing customer segments. The Itron team reviewed the provided customer information and AMI data to add multifamily and solar PV indicators. Error! Reference source not found. shows the distribution of AMI customers in Clifton Park as well as the location of customers with PV systems. A summary of all customer indicators obtained for this study is shown in Table 1. While these metrics had limited impact on the analysis due to each having such low representation in the population, the data were valuable in understanding the population and interpreting findings.

Figure 1: Clifton Park AMI Deployment



[1] New York State's Reforming the Energy Vision (REV) initiative

Table 1: Clifton Park Customer Characteristics

Customer Indicator	Count	Fraction of AMI Population
ESCO Customers	1,705	13.0 %
Electric Vehicles*	182	1.4 %
Electric Heating	1,901	14.5 %
Low-Income	253	1.9 %
Multifamily*†	1,102	8.4 %
Net-energy metering (NEM)/Solar PV†	226	1.7 %
Customers on Time-of-Use (TOU) Rates	7	0.1 %

* Estimate

† Itron-derived customer indicator

The primary objective of this load archetypes study is for National Grid to understand the typical electricity consumption patterns of residential customers in Clifton Park as it considers piloting innovative rates that may include time-of-use and demand charges. The resulting load shapes and the propensity of individual sites to exhibit each load shape provides an overview of the population.

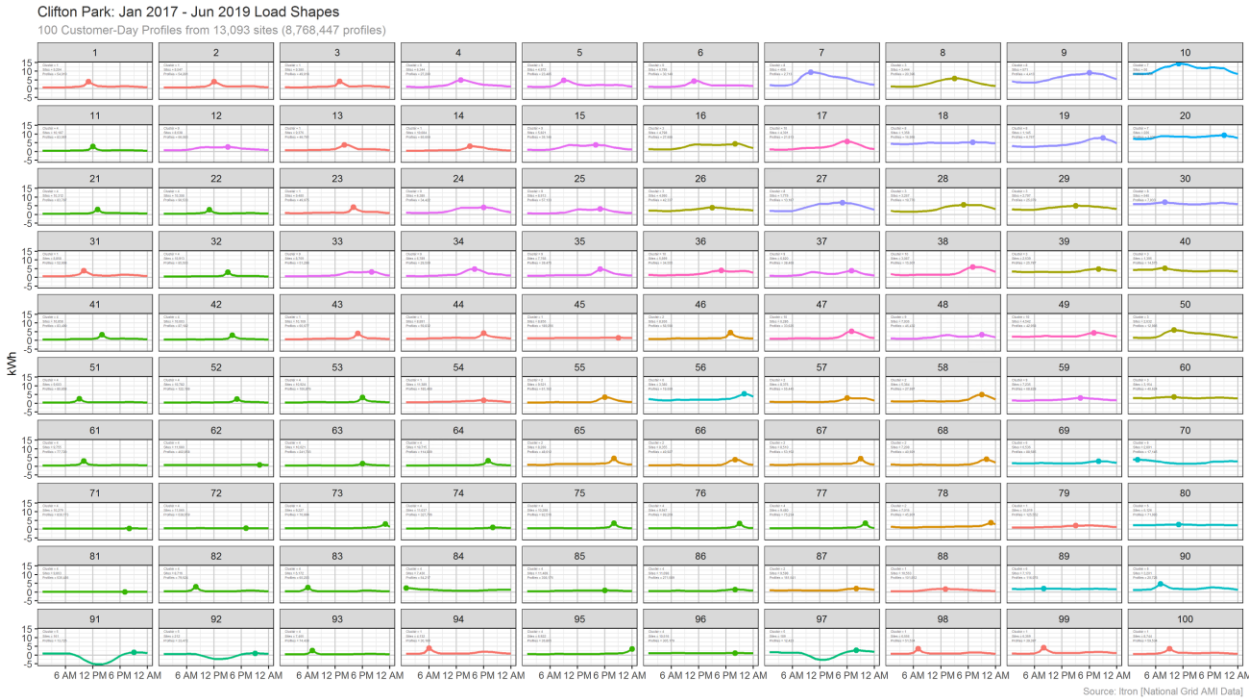
Methodology

AMI interval data were collected for 13,093 sites beginning January 2017 through June 2019 (approximately 2.5 years) and served as the basis to analyze and generate the load archetypes. While the AMI data provided were measured at 15-minute intervals, these data were aggregated to hourly readings for this analysis. Several quality control checks were conducted on these data before they were included in the analysis. Instances of missing data (any of the 15-minute intervals were missing), outliers, and other data anomalies were handled by dropping that entire day's data to avoid potential skew on the results. The final cleaned dataset included 8.7 million daily customer profiles each with 24 hourly kWh readings.

Different methodologies for developing the load archetypes were proposed and discussed with the ADA team. Since one key outcome of this study was to identify the potential impact of new rates with time-of-use and demand charge components, it was critical to preserve both the specific timing and magnitude of the final load shapes. Therefore, the daily profiles used in the analysis were deliberately unaltered, without removing the base load or normalizing the peaks, to observe the magnitude metric in the load shapes characterizing the population.

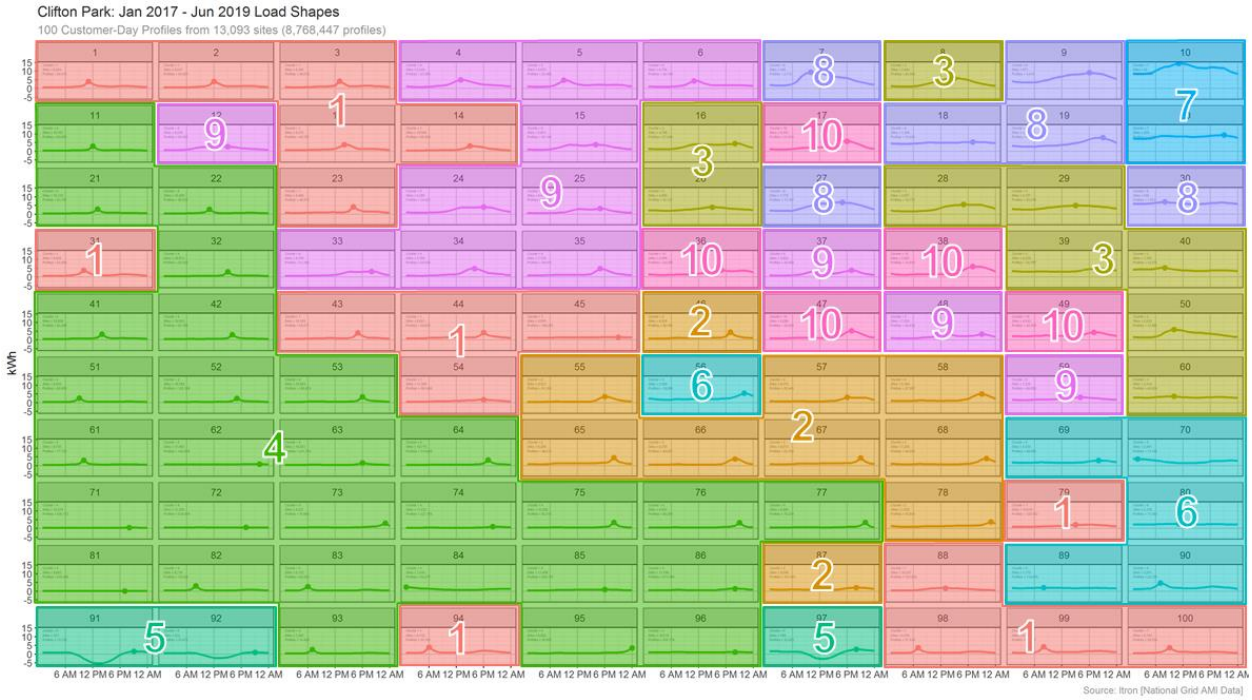
Using a Kohonen neural network, a type of unsupervised data visualization technique, the daily profiles were grouped into 100 bins of similar shape and arranged into a 2-dimensional grid such that each resulting daily load shape was positioned nearest the most similar of the other profiles. Figure 2 shows the 100 organized load shapes from this clustering analysis. These profiles were reviewed for specific patterns, such as identifying PV signatures, as well as the frequency of specific shapes.

Figure 2: First Clustering Results (8.7M Profiles to 100 Load Shapes)



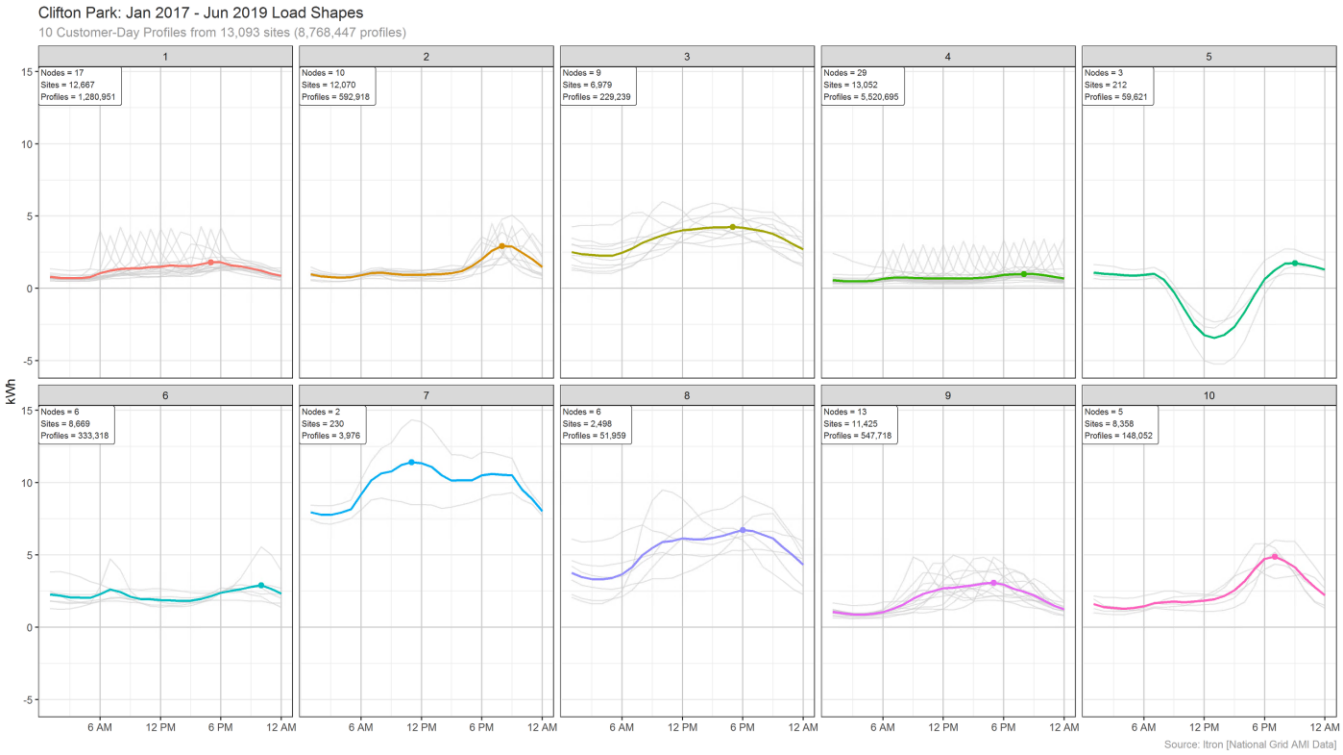
Using another clustering algorithm, K-means, these 100 bins of 24-hour load shapes were then grouped into 10 resulting profiles that became the final load archetypes to represent the Clifton Park residential customers. This approach of successive clustering allowed for manual inspection clusters through the steps and enabled isolating groups with similar metrics. This approach also allowed the less frequent, but still unique, load shapes to remain in the final results and not lost in the averaging of so many more common profiles. Each of the 100 bins of load shapes were then labeled with their final archetype (1-10), as shown in Figure 3.

Figure 3: Second Clustering Results (100 Load Shapes to 10 Archetypes)



Since the original 8.7 million profiles were not normalized, several of the resulting profiles share the overall shape but differ in magnitude of base load. However, this was addressed to some extent by the approach of successive clustering which allowed manual inspection in the interim steps of distilling 8.7 profiles to 100 before bringing down to the final 10. The National Grid team requested the final results include between 6-12 load shapes as a balance between being manageable yet distinctly informative. After several iterations, 10 resulting clusters were selected to capture the most distinct load shapes in the population. Increasing the number beyond 10 resulting in more duplicative shapes, while reducing below 10 removed some of the shapes that were necessary to capture all of the unique behaviors in the population. Figure 4 displays each of the 10 final load shapes, the number of sites within each cluster, and the overall count of daily profiles observed to take that shape.

Figure 4: Resulting Load Shapes after two step Clustering



Load Archetypes

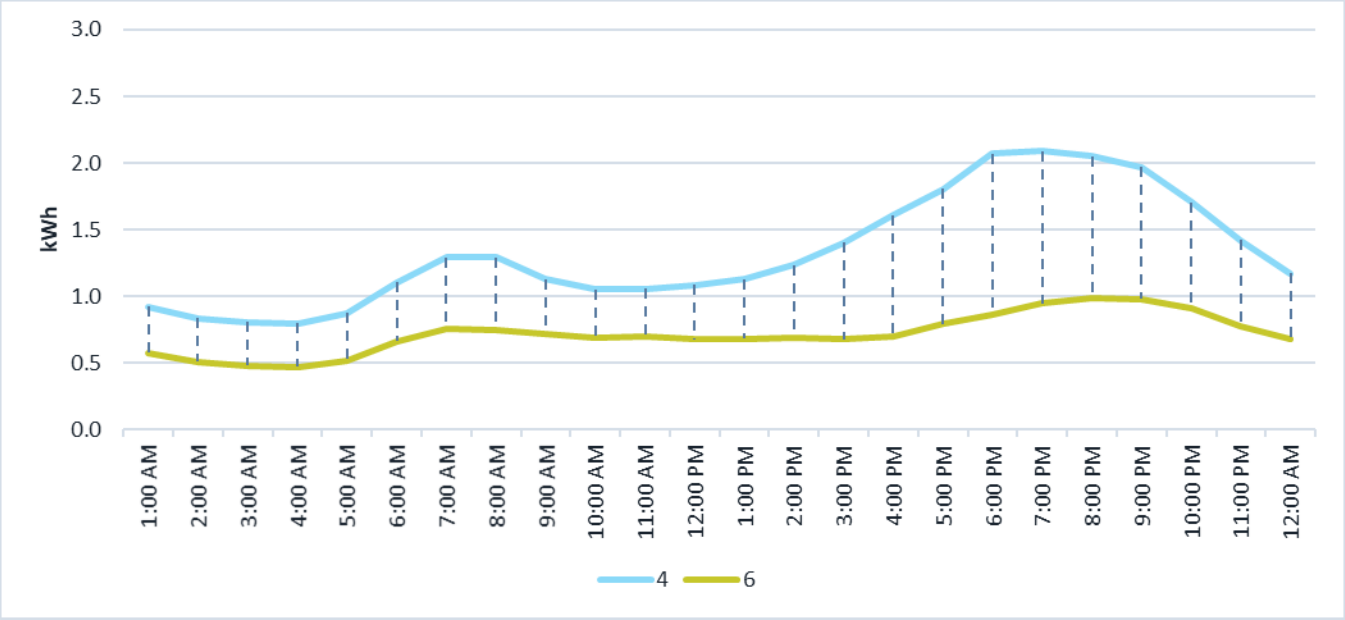
This section provides detailed descriptions and metrics associated with of each of the 10 final load shapes observed in the Clifton Park population.

DUAL-PEAK LOAD SHAPES (CLUSTERS 6 AND 4)

The two dual-peak load shapes were found to be the most prolific of the 10 in the Clifton Park population. This load shape is characterized by two distinct periods of increased usage in between lower use periods. The lower use load shape (#6 in green) was statistically the most prolific. This load shape has increased use 7 to 8 am in the morning followed by a period of lower usage, which peaks again at a higher level 6 to 8 pm in the evening. The higher use profile mimics the same shape with a higher base usage and higher peaks. This load shape can be explained in the typical suburban setting by families that show higher usage during the morning activities of breakfast and leaving the house to a lower occupancy and activity during the day, to a return in the after-work evening peak. This load shape conveys the predominance of internal loads and typical workday schedules as key factors impacting energy use.

Over 40 percent of the sites exhibit this load shape over 75 percent of the times. And almost 70 percent of sites exhibit it 50 percent of the times. These load shapes are exhibited across all seasons and weekday types and holidays. Which makes these load shapes by far the most common load shapes for the Clifton Park residential AMI population.

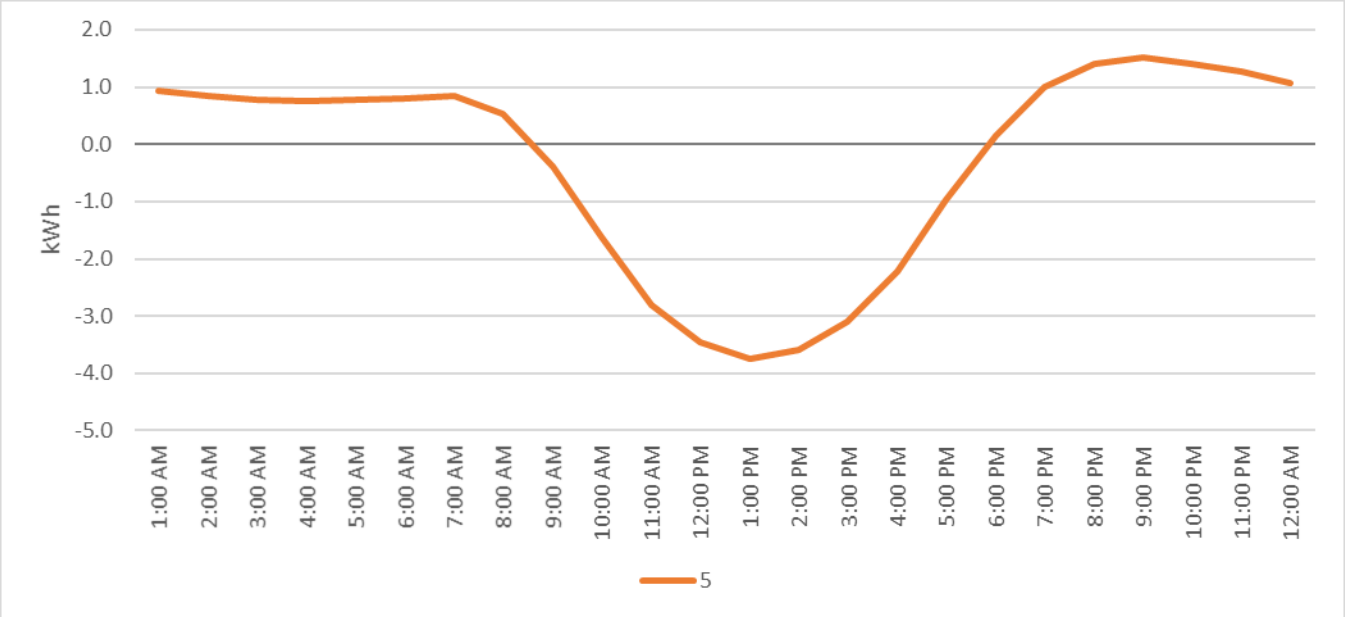
Figure 5: Dual-Peak Load Shape



PV LOAD SHAPE (CLUSTER 5)

This load shape is classic for sites with solar, where maximum PV production occurs in the middle of the day resulting in a net negative load. The load outside of the PV production periods (before sunrise and after sunset) is comparable to other sites. There are 226 known sites with PV in this population and all of them share this load shape at some point. Over 50 percent of the PV sites exhibit this load shape over 50 percent of the time. When a solar customers' load shape does not fall into this archetype, it typically aligns with cluster 6 or 4. This is expected on cloudy days when generation from the PV system is lower or when site load is higher than usual during the middle of the day and exceeds production.

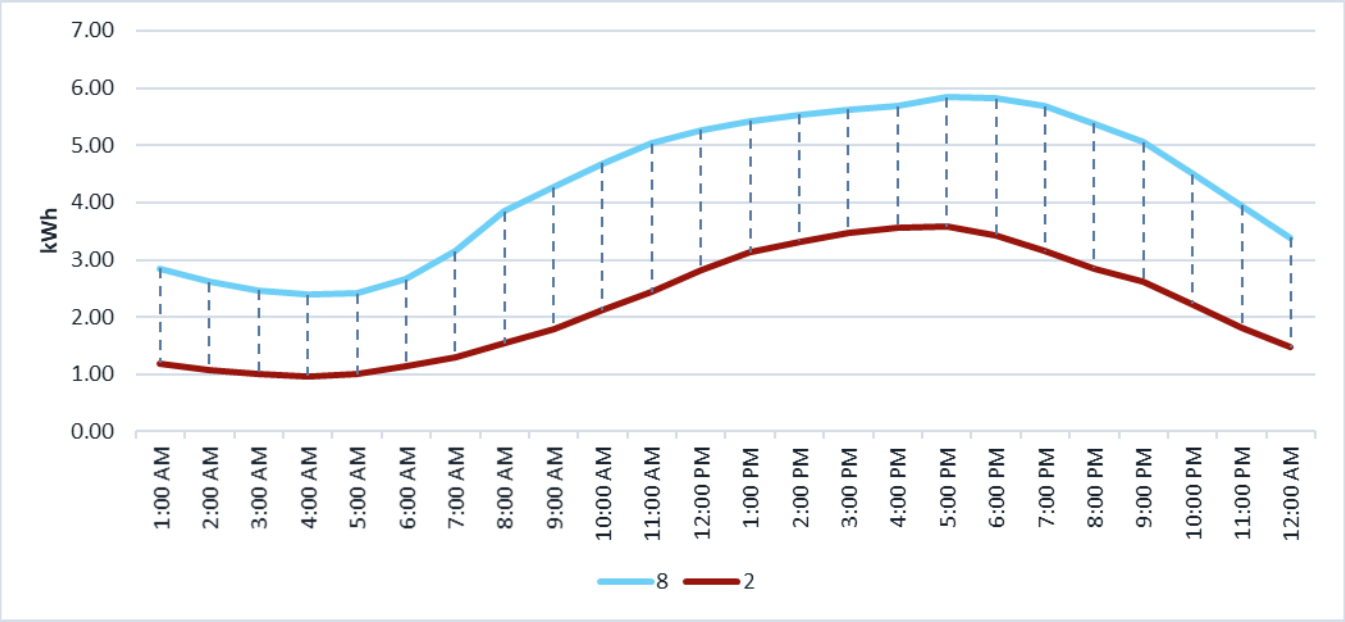
Figure 6: PV Load Shape



TRADITIONAL BELL-SHAPED LOAD SHAPES (CLUSTERS 2 AND 8)

What is widely recognized to be the industry standard "residential average" load shape, the bell-shaped load curve was observed less frequently in the Clifton Park population. This archetype is characterized by low morning usage that gradually increases, peaking between 4-6 pm, and then gradually decreasing into the evening hours. While most of the population exhibited this load shape at some point, it made up less than 20 percent of the total profiles. The two clusters follow a very similar shape with the major difference being the overall magnitude (a flat increase in baseload throughout the day). The lower magnitude cluster 2 is relatively more common, with over 80 percent of all sites belonging to cluster 2 at some point, while about 30 percent of customers are in cluster 8 at least once.

Figure 7: Bell-Shaped Load Shape



MORNING PEAK LOAD SHAPES (CLUSTERS 1 AND 9)

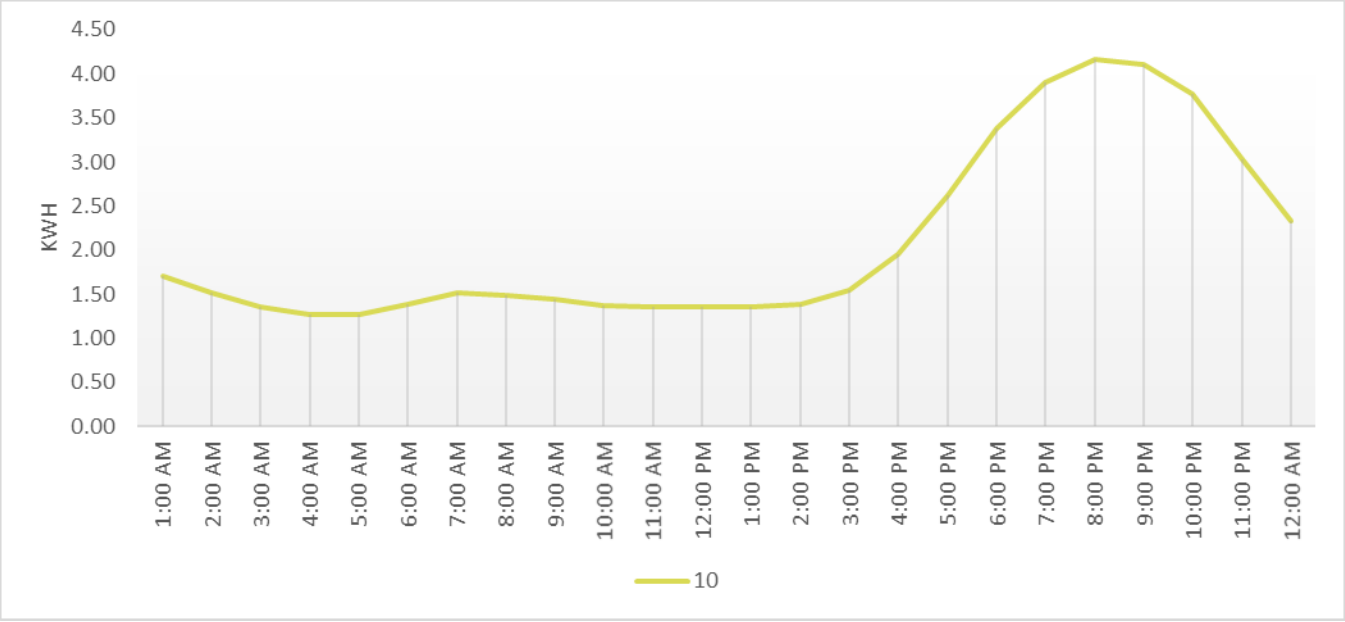
These morning peaking load shapes are observed at some point by nearly all customers, but less than 25 percent of the time. While they are not associated with any attribution characteristics such as seasonal or day types or demographic, the fact that over 90 percent sites exhibit cluster 1 and over 50 percent the high usage cluster 9, is an important highlight for the utility. Cluster 1 is especially interesting as it is characterized by a rapid, late morning (10 am to noon) peak.

Figure 8: Morning Peak Load Shapes

LATE EVENING PEAK LOAD SHAPE (CLUSTER 10)

This late evening peaking load shape is experienced by most households, though very infrequently in the Clifton Park AMI population. This archetype is characterized by mostly flat usage outside of the 4pm-12am window, wherein usage increases rapidly to a peak around 8pm before quickly falling into the late evening hours. While this load shape was only witnessed in about 2 percent of all profiles, it could present a unique challenge for the utility supply stream and needs to be factored into any resource planning and rate design.

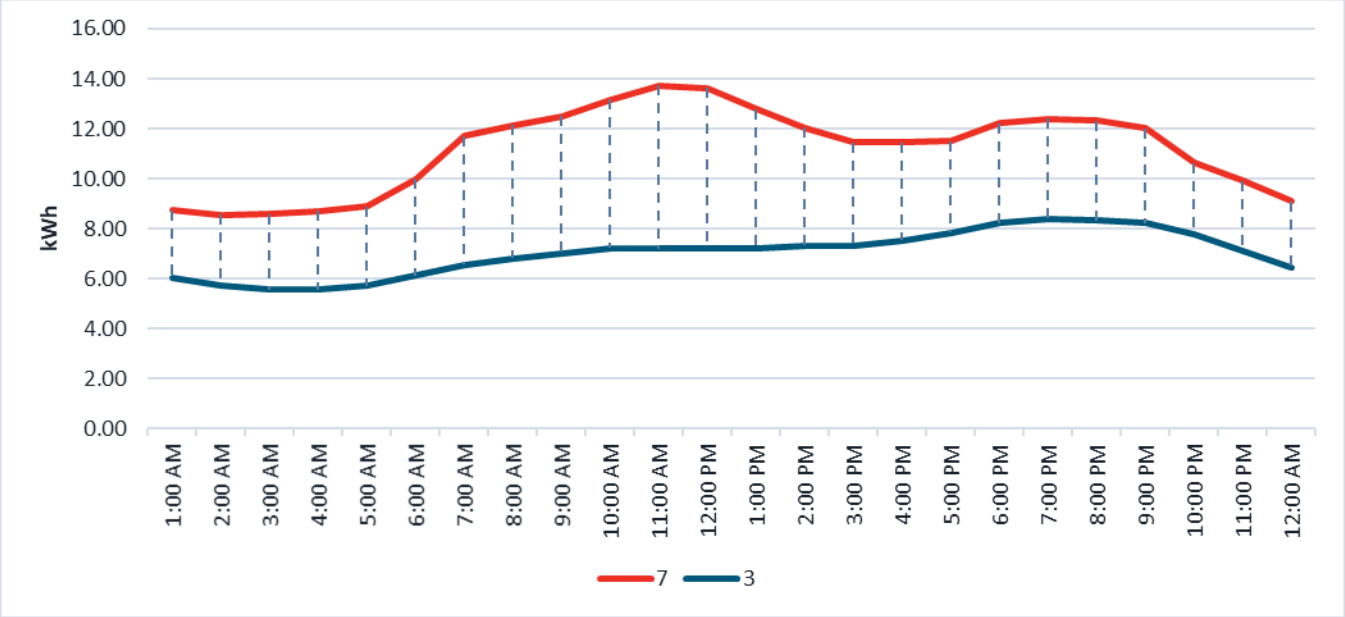
Figure 9: Late Evening Peak Load Shape



HIGH-USAGE LOAD SHAPES (CLUSTERS 3 AND 7)

These high usage load shapes, while infrequent, are seen in a handful of sites. The base and peak usage is much higher than typical single family residential. However, these load shapes, especially cluster 3, appears to have a higher proportion of estimated EV owners, which may explain the higher base load due to in home charging. More data and analysis are needed to confirm this assessment and is a potential area for deeper research. The related impact from EV ownership on load archetypes in the future will be critical since the utility will likely see an increase in EV adoption.

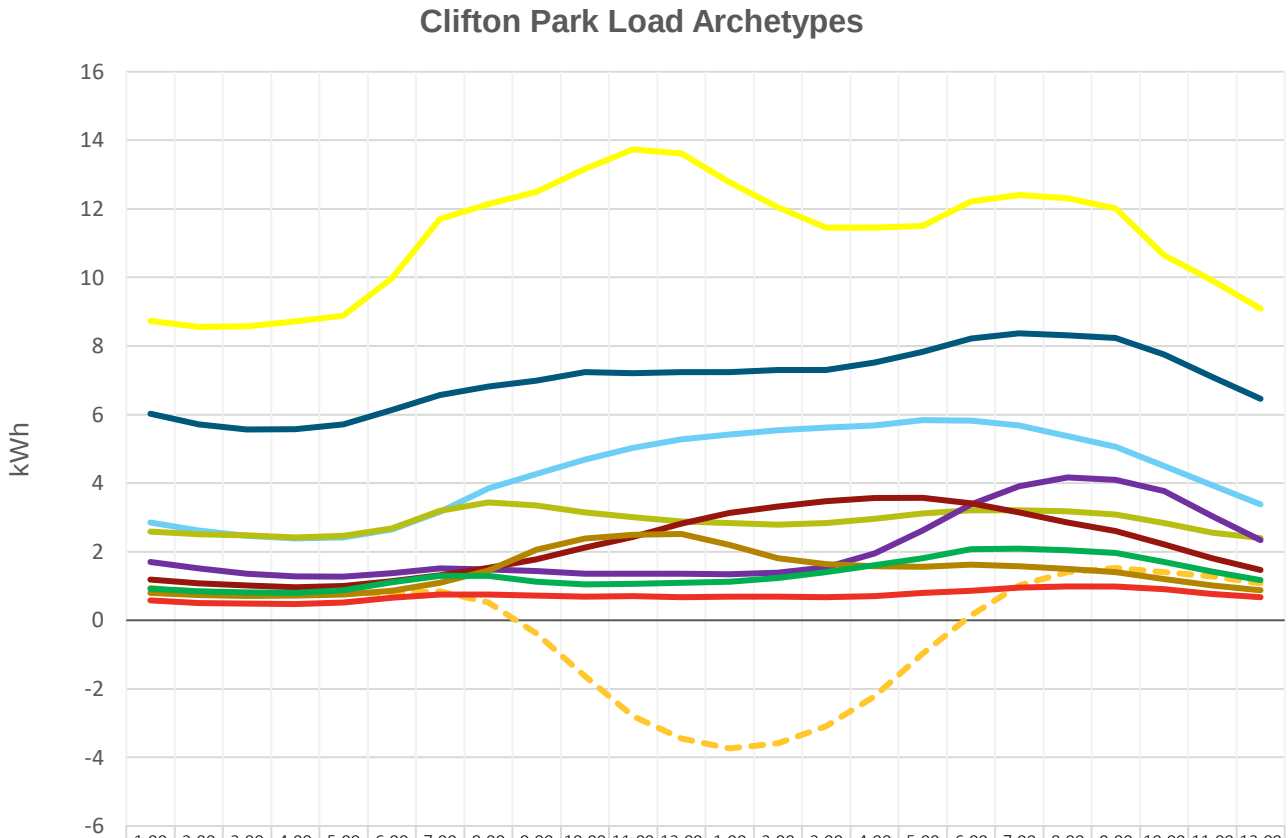
Figure 10: High-Usage Load Shape



Findings

Figure 11 shows the 10 resulting shapes that typify the Clifton Park residential customers. The hourly kWh consumption values for each profile are provided underneath the graph.

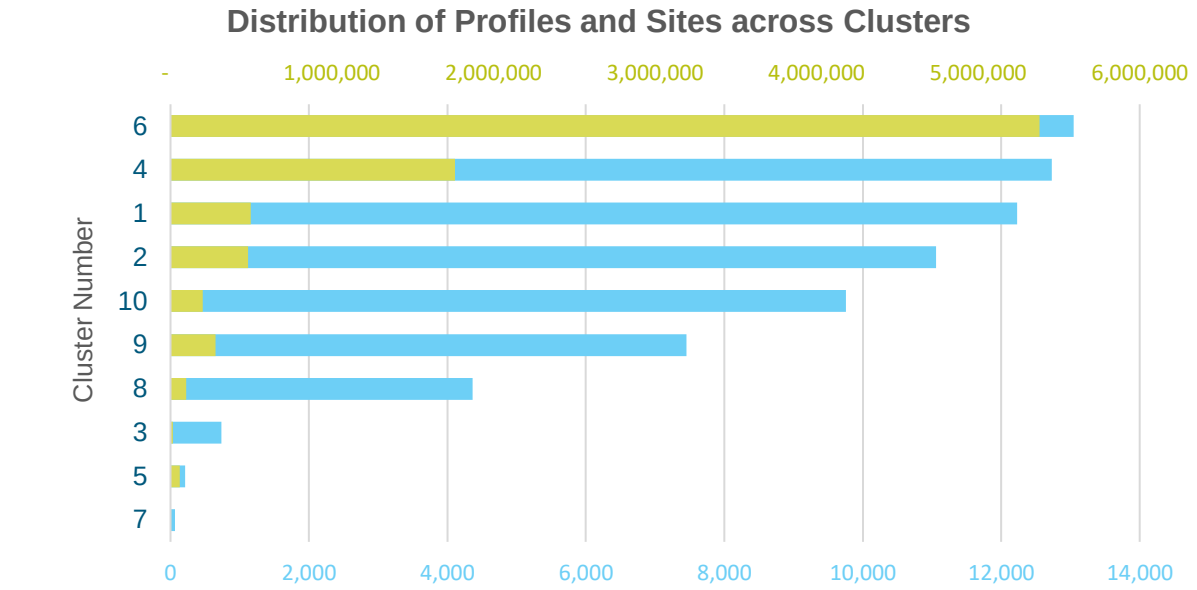
Figure 11: Load Profiles for the 10 Clusters



	1:00 AM	2:00 AM	3:00 AM	4:00 AM	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM	12:00 AM
7	8.73	8.56	8.58	8.71	8.89	9.98	11.71	12.14	12.49	13.16	13.73	13.62	12.78	12.04	11.45	11.46	11.50	12.22	12.40	12.31	12.02	10.64	9.92	9.10
5	0.93	0.84	0.78	0.75	0.78	0.80	0.84	0.52	-0.39	-1.63	-2.80	-3.45	-3.74	-3.59	-3.09	-2.22	-0.98	0.15	1.01	1.41	1.52	1.41	1.27	1.08
3	6.03	5.72	5.57	5.58	5.72	6.14	6.57	6.82	7.00	7.23	7.21	7.24	7.24	7.29	7.30	7.52	7.83	8.22	8.37	8.32	8.23	7.76	7.10	6.47
8	2.85	2.62	2.47	2.39	2.41	2.66	3.16	3.84	4.27	4.68	5.03	5.27	5.42	5.54	5.62	5.68	5.84	5.82	5.68	5.38	5.06	4.50	3.94	3.39
9	2.59	2.52	2.47	2.42	2.46	2.68	3.20	3.44	3.35	3.15	3.01	2.88	2.83	2.79	2.84	2.96	3.11	3.22	3.20	3.18	3.08	2.84	2.56	2.40
10	1.70	1.51	1.36	1.27	1.27	1.38	1.51	1.49	1.44	1.36	1.35	1.36	1.35	1.39	1.54	1.95	2.62	3.39	3.91	4.17	4.10	3.77	3.03	2.33
2	1.19	1.08	1.01	0.96	1.01	1.13	1.31	1.54	1.78	2.12	2.44	2.82	3.13	3.32	3.47	3.57	3.57	3.42	3.15	2.85	2.61	2.22	1.81	1.47
1	0.80	0.74	0.71	0.71	0.75	0.85	1.09	1.46	2.06	2.38	2.49	2.52	2.20	1.80	1.64	1.57	1.56	1.62	1.57	1.49	1.40	1.20	1.01	0.88
4	0.92	0.84	0.81	0.80	0.87	1.11	1.29	1.29	1.13	1.05	1.06	1.09	1.13	1.24	1.40	1.61	1.81	2.07	2.09	2.05	1.97	1.70	1.42	1.17
6	0.58	0.51	0.48	0.47	0.52	0.66	0.75	0.75	0.72	0.69	0.70	0.68	0.69	0.70	0.68	0.70	0.80	0.86	0.95	0.99	0.98	0.91	0.77	0.68

Overall, the daily profiles were distributed across all the 10 clusters, but cluster 6 (dual-peak) had the highest incidence. Of the overall 8.7 million profiles (customer days) that were used in the assessment, over 5 million were binned in the cluster 6 load archetype that represented almost all the sites in the population at one time or another. Cluster 4 (dual-peak) shared the next highest distribution of profiles at just over 2 million. The least common profiles were clusters 3 and 7 (high usage) and 5 (PV). The distribution of individual profiles and unique site counts within each cluster are shown in Figure 12.

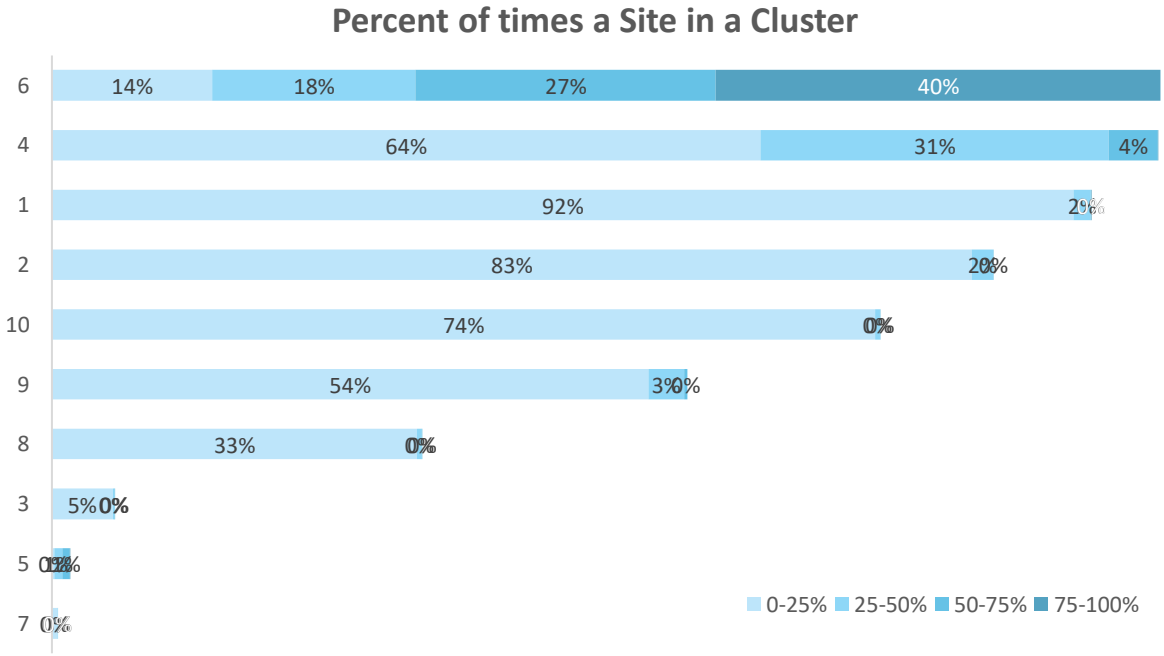
Figure 12: Distribution of Sites and Daily Profiles across the 10 Clusters



	7	5	3	8	9	10	2	1	4	6
CountSites	65	211	738	4,361	7,453	9,753	11,055	12,229	12,728	13,048
CountProfiles	1,101	55,854	14,676	98,700	277,307	200,264	481,065	497,686	1,762,42	5,379,37

Figure 13 shows the propensity of sites in each cluster. For example, the darkest color to the right of bar for cluster 6 shows that 40 percent of the sites exhibit the load shape more than 75 percent (75-100 percent) of the times. Or in other words, over 5,000 sites are predominantly (over 75 percent times) cluster 6 load shape. And the next band in cluster 6 with the 27 percent label implies that 27 percent sites exhibit the load shape of cluster 6, 50-75 percent of times. Other color bands can be read similar through the color code in the legend for the percent of times to the label on the bar which implies the percent of sites of the overall AMI population.

Figure 13: Frequency Distribution of Sites within each Cluster



Key Takeaways

The 10 resulting load shape clusters characterize the Clifton Park residential AMI population as load archetypes. Some key observations about the resulting set are:

- The load shape represented by cluster 6 is by far the most prolific both in terms of number of unique sites it represents as well as the percentage of times each site exhibits that load behavior. This low usage (typically under 1 kW) dual peak (8 am and 8 pm) load profile is the most characteristic load shape and could be considered as the single most representative for the residential population in Clifton Park.
- The solar PV customer load shape in cluster 5 is very distinctly identified despite representing less than 2 percent of the overall population. This stands out due to the significant impact on shaping the reduced (often net-negative) load in the middle of the day, which is clearly different from neighbors without PV.
- High usage profiles (daily peaks between 6 - 14 kW) are outliers as they have very low representation. However, due to the high magnitude, they stand out as distinctly different and manifest in a separate cluster with low frequency. This could signify high usage at specific sites due to special conditions or that these are atypical residential customers.
- Seasonality and day type did not significantly impact the load shape clusters which implies that weather conditions and schedules are not a key indicator shaping load profiles in Clifton Park.