Impacts of COVID-19 on Measurement and Verification (M&V) of Energy Savings: Options for Meter-Based Methods – IPMVP and Beyond

WHITE PAPER

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EVO's Focus Group on COVID-19

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INTRODUCTION

Measurement and verification (M&V) efforts are facing significant challenges from the COVID-19 pandemic due to shifts in energy use at facilities which are impacting the accuracy of energy savings estimates. Projects using meter-based M&V methods[1] are seeing direct impacts from changes in energy consumption which are skewing estimated savings (i.e., includes COVID savings or COVID penalties). In the context of M&V, these unexpected changes in site-level energy consumption are non-routine events (NREs), which, if significant, necessitate making non-routine adjustments (NRAs) as detailed in the *IPMVP Application Guide on Non-Routine Events & Adjustments* (*IPMVP NRE/A Guide*) recently published by EVO.[2]

The *IPMVP NRE/A Guide* details both NRE detection approaches and NRA methods for meter-based M&V (e.g., IPMVP Option C) and is largely the basis for discussions herein. Although fully applicable, COVID-19 is presenting additional complexities not typically encountered when making NRAs and additional strategies may be warranted. Added complications are created because energy impacts from COVID continue to vary as the pandemic and economic recovery progress. The impacts to facilities vary by type, region, and business sector, and largely depend on local responses to the pandemic. Sector-wide recoveries are underway, but for some facilities it is still unclear when occupancy and load patterns will return to a 'pre-COVID normal' or stabilize as a 'new-normal'. This consideration is especially a concern for efforts early in the M&V process.

All M&V efforts at sites whose energy use is significantly impacted by COVID need to ensure reported savings are not adversely affected by changes resulting from COVID. Given level of judgement inherent in making NRAs and the complexities introduced by COVID's ongoing and changing impacts, this paper provides more focused guidance on managing the impacts from the pandemic when using meter-based M&V.

- Section 1 provides the framework to determine if action is warranted. This includes assessing the COVID impacted periods, quantifying energy impacts, assessing their significance, and documenting site level changes.
- Section 2 provides a range of solutions or 'COVID Management Approaches' suitable for different projects and programs to improve the accuracy in meter-based M&V results impacted from COVID-19. Many projects can make an NRA per the *IPMVP NRE/A Guide* and adhere to IPMVP, however non-adherent methods (which are noted) are included because of the challenges sometimes posed by COVID.
- Sections 3 through 5 cover the key risks and discuss the most suitable COVID Management Approaches by the M&V period first impacted by COVID (i.e., baseline, implementation, or reporting period).

[1] Also referred to as 'Advanced M&V' or 'M&V 2.0' as detailed in *IPMVP's Snapshot on Advanced M&V.*

[2] L. Webster, et al*, IPMVP Application Guide on Non-Routine Events & Adjustments*, EVO 10400-1:2020, October 2020.

- The Appendices include additional application notes on using the COVID Management Approaches, which include the IPMVP NRA Methods, reviewing which strategies assume a return to as well as four detailed industry examples.

Additional background and related perspectives from *EVO's Focus Group on COVID-19* are provided in two recent articles in EVO's *M&V Focus*:

> *Impacts of COVID-19 on Measurement and Verification (M&V) of Energy Savings: Market Perspectives*

> *Impacts of COVID-19 on Measurement and Verification (M&V) of Energy Savings: Projects and Programs*

Figure 1 below provides a succinct overview of the recommended process for managing the impacts of COVID-19 in meter-based M&V efforts.

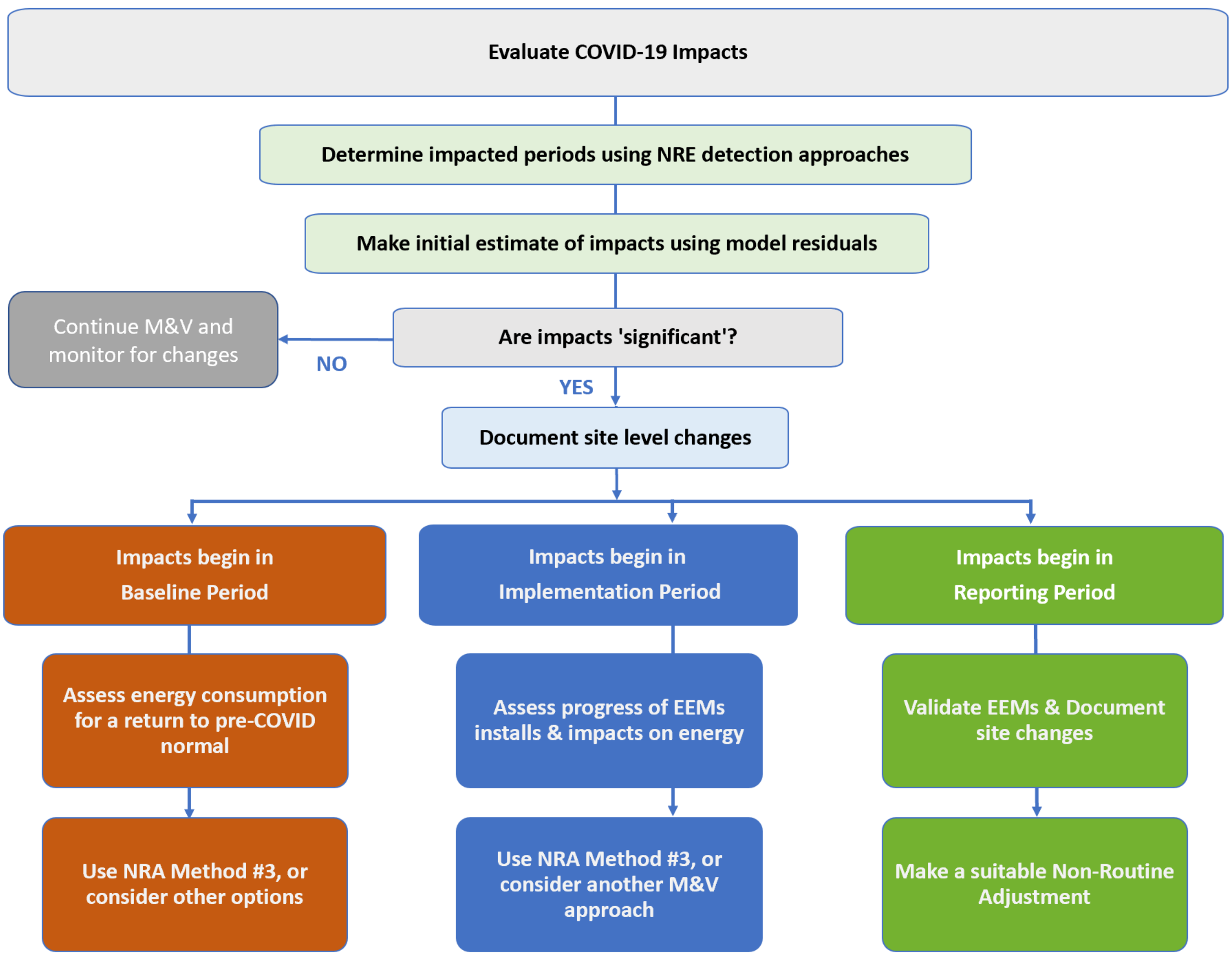

Figure 1: Overview of Managing Impacts from COVID-19 in Meter-Based M&V Efforts

1 IS ACTION WARRANTED?

Although overall impacts to energy consumption due to COVID are obvious in some cases, each project's individual circumstances must be evaluated to determine if action is required. There is not a single path forward for addressing COVID in M&V of energy projects. The contract details, financial impacts from COVID on savings, and individual project goals will determine accuracy needed in reported savings.

> "One of the primary purposes of M&V is to reduce the risk of nonperformance to an acceptable level, which is subjective judgement based on the customer's priorities and preferences." [3]

M&V efforts that track savings across multiple years may have more flexibility and options for addressing COVID than projects with shorter (e.g., one-year) reporting periods. In these cases, however, the long-term technical suitability of the intended M&V approach (e.g., baseline energy model) should be considered.

1.1 Determine Periods Impacted

Although the initial onset of COVID impacts on energy consumption are somewhat predictable based on regional stay-at-home orders, the actual date or dates that changes in energy use patterns become evident must be determined for each site.

In many cases, energy reductions due to COVID are less than expected during affected periods. In others, impacts are not coincident with changes in building occupancy. Unexpected impacts may be seen where:

- Building systems continue to operate without modifications (e.g., lease agreements require normal building operations). In some cases, systems continue to operate automatically, but show anomalous behavior due to overridden building controls.
- Facilities have significant weather-driven energy loads, or have significant internal loads, including hybrid uses (e.g., light occupancy with computer servers or with kitchen operations).

To determine affected period(s), use one or more of IPMVP's *NRE Approaches*[4] detailed in the *IPMVP NRE/A Guide,* which are summarized in Table 1. These NRE detection approaches include data visualization strategies which are effective in identifying multiple changes in energy consumption patterns.

Table 1: Approaches to Identify Non-Routine Events in the IPMVP NRE/A Guide

NRE Approach	Requires	Identifies
1 — Identify Changes in Static Factors	▪ Pre-COVID period static factor data ▪ Site contact(s)	Most significant changes at a site
2 — Use Monitored Site Data	▪ Reporting from on-site monitoring (e.g., EMIS or control systems)	Unusual operating conditions

[3] Section 3.1 of *M&V Guidelines: Measurement and Verification for Performance-Based Contracts Version 4.0,* L. Webster, et.al, Prepared for the U.S. Department of Energy Federal Energy Management Program, November 2015.

[4] Note: NRE detection follows various "approaches" while NRA assessment follows various "methods".

NRE Approach	Requires	Identifies
3 — Evaluate Energy Data for Changes in Use Patterns	▪ Energy data in short intervals (e.g., hourly) ▪ Data visualization tools (e.g., Excel)	Changes in facility operating hours and/or loads
4 — Analyze Data for Outliers	▪ Energy and independent variable data ▪ Statistical analysis tool (e.g., Excel)	Invalid data and potential NREs
5 — Track Energy Savings using a 'CUSUM' Chart	▪ Reporting period energy savings results data	Changes in the rate savings are accumulating
6 — Analyze Residuals from the Model	▪ Predicted energy use from the model ▪ Actual energy use for the period ▪ Data visualization tools (e.g., Excel)	Change in energy use patterns or increasing or decreasing trend in energy use
7 — Reporting Period Energy Savings Are Higher or Lower Than Expected	▪ Expected energy savings (% of baseline) ▪ Reporting period energy savings ▪ Reporting period energy use	Reporting period energy savings are not as expected

NRE Approach #6 is a favorite strategy with practitioners as it can pinpoint the start and end dates (if present) of an NRE and gauge the magnitude of the energy impacts. This approach uses a pre-COVID baseline energy model to find changes in the residual pattern which occur when there is a change in energy use due to factors outside of the independent variables, such as during COVID shut-downs. Many strategies to analyze residuals are included (e.g., *Use Time Series Charts or Heat Map of Residuals, Use Standardized Residuals, Use the Probabilities of Residuals, Use a CUSUM of Residuals, Identify Trends in Residuals)*.

Tip 1: Use CUSUM of Model Residuals to Determine COVID-Impacted Periods

Residuals are the difference between actual metered energy and modeled energy consumption.

Residuals = $Y - \hat{Y}$

Where: Y = actual energy use, and $\hat{Y}$ = predicted energy use

During the baseline or modeled period, the residuals indicate model fit and should be small and normally distributed around zero. Each model has a normal range of model errors as indicated by the residual values during the modeled period and impacts from COVID must be outside of this range to be detected[5]. (When calculating savings in the reporting period, the residuals should be negative and represent avoided energy.)

Several of the residual analyses techniques are useful but a **Cumulative Sum (CUSUM) of Residuals** can be specifically helpful in pinpointing when changes in energy use occur. This strategy is often used during the reporting period to track avoided energy consumption (i.e., NRE Method #5) and can quickly show a trend in the model's residuals. A change in the slope of this time-series indicates a shift in energy consumption patterns, which may represent energy impacts from COVID, the implementation of an energy efficiency measure (EEM), or a change in static factors at a site.

It is good to consider the type of EEMs installed, however, since the slope of a CUSUM chart may vary by season.

[5] The average error in predicted values from a model is indicated by the root-mean square error (RMSE).

The **example CUSUM chart below** highlights multiple distinct changes in energy consumption during the reporting period for a large industrial facility engaged in an ongoing energy improvement program where EEMs are implemented throughout the multiple-year reporting period. The CUSUM of residuals from the baseline model beginning through Year 1 of the reporting period year is shown in Figure 3 (note the CUSUM is shown on the secondary Y-axis as Cumulative Energy Savings and predicted and actual daily energy consumption are shown on the primary Y-axis). In this case, the implementation of each of three individual EEMs is evident during 2019 (note each EEM has a unique impact on the CUSUM line, which could change seasonally for some EEMs).

In mid-March 2020, there is a distinct steepening of the curve which corresponds to a local stay-at-home mandate issued due to COVID and change in facility operations. The changes in operations included closing the office area for several months which resulted in a decrease in energy usage of over 1,100 kWh per day starting 3/15/20 and persisted through the end of SEM[6] Year 1 (6/25/20). This shift (i.e., *COVID savings*) totaled more than 200,000 kWh in just over three months. The baseline energy for the impacted portion of the Year 1 reporting period was adjusted using *NRA Method #5 - Create an 'NRE Adjustment Model'*, which is detailed in an example in Appendix 3.

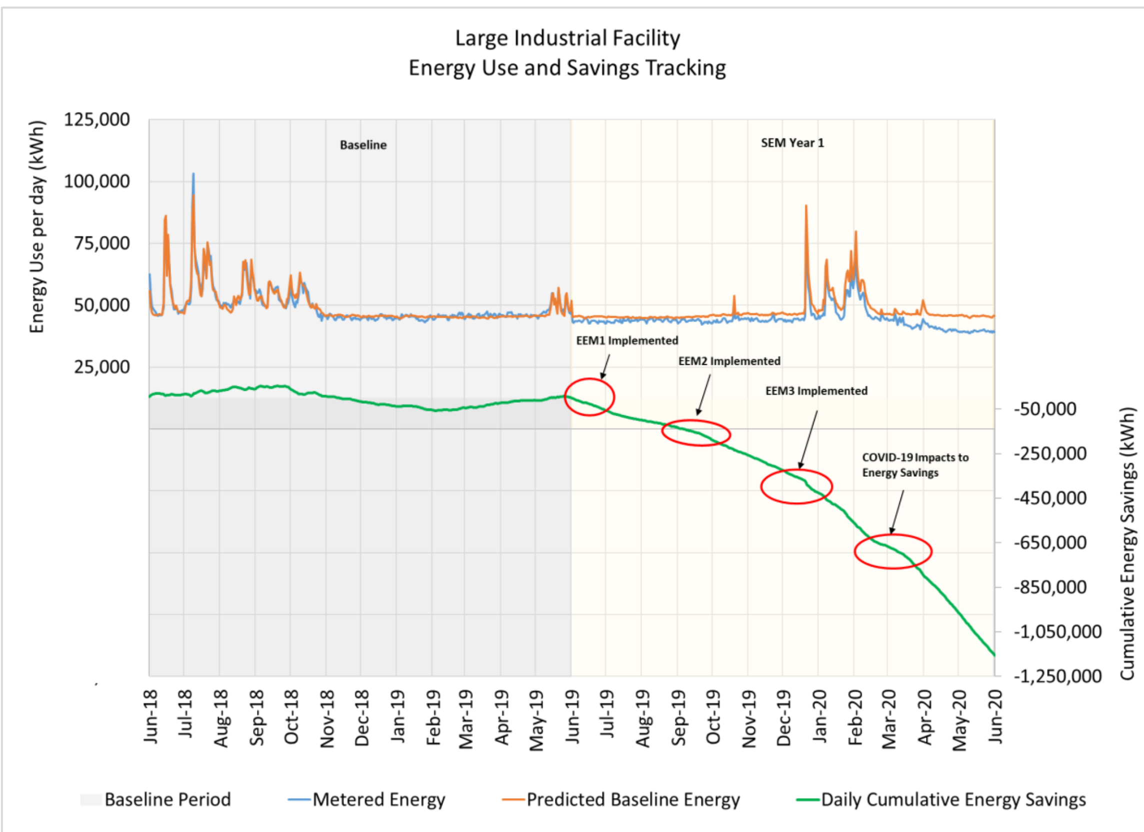

Figure 2: Predicted and Actual Energy Consumption and CUSUM of Residuals from Baseline Model Showing Impacts from EEMs and COVID

[6] SEM stands for Strategic Energy Management.

1.2 Assess if Impacts from COVID are 'Significant'

As discussed in the *IPMVP NRE/A Guide*, the assessment of significance will vary with the situation and parties affected and must be made on a case-by-case basis. In many situations, COVID's impact on overall energy consumption are dramatic, but in others an initial estimate of the impacts is needed to determine if further action is warranted. After the significance of the impacts are validated, a more rigorous assessment is often conducted if an adjustment is made.

Tip 2: Initially Estimate Energy Impacts Using NRA Method #4

It is generally recommended to initially estimate energy impacts using NRA Method #4 — Use Model Residuals from the NRE Period. The sum of the residuals of a model that includes the NRE period provides a rough low estimate of the total impact in energy units, such as kWh.

- ❖ To initially estimate energy impacts, total the residuals from a model that includes the period in which the COVID-impacts occur. This is the most efficient quick assessment for baseline period NREs.
- ❖ If COVID impacts began during the reporting period, a model from reporting period data is preferred (see Tip 3) so the residuals are representative of model accuracy and highlight changes due to NREs (not avoided energy use from EEMs).
- ❖ When COVID impacts begin in the implementation period, however, this method does not apply since savings from EEMs are also present.

If this initial low estimate of the NRE's energy impact during a COVID affected period is considered "significant", then subsequent action should be pursued. If not significantly impacted, continue the M&V effort as normal and monitor for unexpected changes.

After an initial assessment of impacts, more exact quantification is possible using one or more energy models from periods of steady-state operations during the COVID-affected M&V period (e.g., baseline period), but prior to any changes resulting from COVID.

Tip 3: Quantify Energy Impacts Due to COVID Using NRA Method #5

Using NRA Method #5 – Create an 'NRE Adjustment Model' requires creating a new energy model for the M&V period impacted that excludes the data from the NRE period. In some cases, these results can be used directly to make an NRA.

- ❖ If COVID impacts begin during the baseline period[7], create a model from **pre-COVID** data and use it to predict energy consumption during the COVID affected period. The total impact is the difference between predicted and actual energy used during the COVID-impacted period (see Figure 3).
- ❖ Similarly, if COVID impacts begin in the reporting period, creating a model from the reporting period data pre-COVID (or post-COVID) allows a direct assessment of the energy impacts experienced during COVID, assuming otherwise steady operations.
- ❖ When COVID impacts begin in the implementation period, however, this method does not apply.

[7] *Baseline period* generally means prior to the implementation of EEMs.

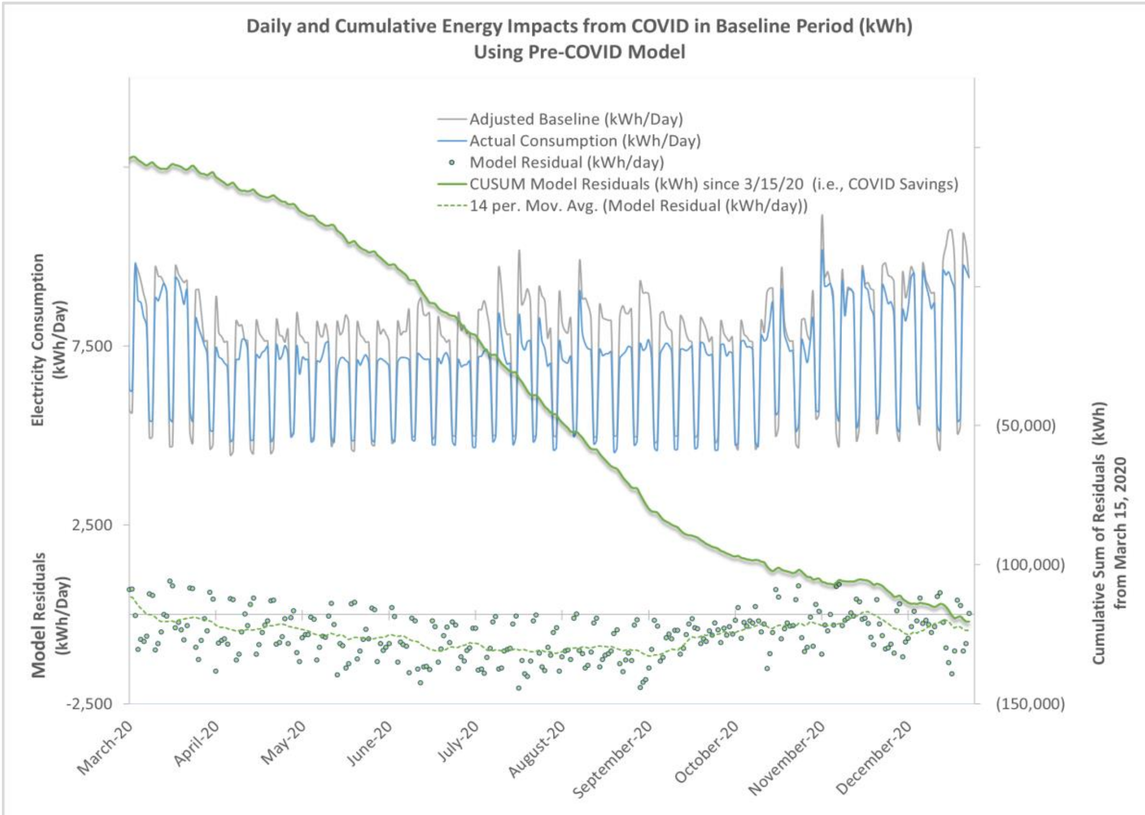

Figure 3: Daily and Cumulative Energy Impacts from COVID in Baseline Period Using Pre-COVID Baseline Model

1.3 Document Site Level Changes Resulting from COVID

As with any non-routine event, the physical and operational changes made should be assessed to validate making an adjustment. Typically, interviews with knowledgeable site contacts are conducted to assess the details of changes in the site's key *static factors* since COVID began, documenting specifics regarding occupancy patterns, equipment schedules and other operational variations such as those in Table 2.

Similarly, the impacts of these changes on installed or planned EEMs should be assessed. Documenting the impacts of COVID on the performance of the systems or equipment that are related to the EEMs (e.g., equipment run hours changed from 100 to 60 hours per week) facilitates a qualitative assessment and validates any NRA made. In some cases, COVID-related changes may disable EEMs or make them no longer feasible, possibly canceling the M&V effort.

Site-level data may help establish metrics to identify when and if there is a return to a *'pre-COVID-normal'*, or if a 'new–normal' is obtained. This is an important consideration for all impacted projects but may be a crucial assessment for some M&V efforts.

Table 2: Example of Changes in Static Factors / Non-Routine Events

Type of Change	Example
Building Changes	Auxiliary classroom is removed
	New exterior doors are installed in the lobby
Operational Changes	Tenant reduces hours and operating hours for related HVAC equipment
	Ventilation rates are increased in main air-handler
	Administrative office areas are temporarily closed
Change in End-Use Loads	Space temperature setpoints are adjusted from 72°F to 76°F
	Section of building changed from office space to warehouse
	Significantly fewer people present in office
Industrial Processes	One production line is temporarily closed

2 Actions on COVID

Once the impacts from COVID have been deemed significant and documented, there are a variety of paths forward. Possible actions depend upon a project's:

- Contractual requirements,
- Timing of COVID impacts within the M&V effort,
- Availability of data and information,
- Consideration if impacts are permanent in relation to the M&V effort (i.e., a new normal).

The strategies to managing COVID during M&V efforts include the non-routine adjustment (NRA) methods detailed in the *IPMVP NRE/A Guide* as well as other approaches identified to ensure reported savings do not include energy impacts from COVID which are unrelated to the performance of the EEMs.

The COVID management approaches identified are shown in Table 3. These are organized based on when COVID impacts first affected the site's energy consumption relative to the M&V effort (i.e., baseline, implementation, or reporting period). Some of these strategies do not adhere with IPMVP but may be appropriate for an effort given the individual challenges posed. The strategies are listed in the general order of preference, with 'Make an NRA' appearing as a single strategy with the specific NRA Methods listed below in green. Strategies to consider based on M&V period initially impacted are marked (X) and those that are not adherent with IPMVP are flagged (*).

Table 3: Summary of COVID Management Approaches Based on Applicable M&V Period

	COVID Management Approaches for M&V *Approach or method is not adherent to IPMVP where noted	Baseline Period	Implementation Period	Reporting Period
COVID Management Approaches	Approach 1 – Do nothing. Project is not significantly affected by COVID	X	X	X
	Approach 2 – Pause M&V reporting. Collect data and monitor conditions	X	X	X
	Approach 3 – Make an NRA (See NRAs below)	X	X	X
	Approach 4 – Use an alternate M&V approach (i.e., Backcasting, Chaining, or IPMVP Options A, B, or D)	X	X	X
	Approach 5 – Calculate payments differently than energy savings		X	X
	Approach 6 – Develop a custom COVID Index*	*	*	
	Approach 7 – Re-baseline or cancel M&V effort		X	X
	Approach #3 – Make an NRA			
Non-Routine Adjustments (NRAs) [8]	NRA Method #1 – Omit data	X		X
	NRA Method #2 – Use Sub-Metered Energy	X	X	X
	NRA Method #3 – Redefine Baseline Using New Variables	X	X	X
	NRA Method #4 – Use Model Residuals from the NRE Period			X
	NRA Method #5 – Create an 'NRE Adjustment Model'			X
	NRA Method #6 – Use 'Mini' Models	*		X
	NRA Method #7 – Develop a 'Pre-Post NRE' Model	*		X
	NRA Method #8 – Adjust for Significant Trends in Residuals	X		
	NRA Method #9 – Use Calibrated Simulation	X	X	X
	NRA Method #10 – Use Engineering Calculations*	*	*	*

[8] NRA Methods are detailed in the *IPMVP NRE/A Guide*.

Note that many of these options determine savings as if COVID had not happened, including NRA Method #s 1 and 4 – 7 (see Table A- 1: Application Notes on COVID Management Approaches Including NRA Methods). These options use pre-COVID energy patterns to estimate the impacts from COVID, which is effectively the same as assuming operations return to pre-COVID conditions. This assumption is often appropriate for M&V efforts first impacted by COVID during the M&V reporting period but can introduce substantial risk to ongoing M&V efforts, especially those affected during the baseline period.

Tip 4: Use NRA Method #3 Where Possible

If impacts are significant and a return to pre-COVID normal is not assured, use **NRA Method #3 – Redefine Baseline Using New Variables** if appropriate data can be identified. This approach may be applied at any time during the M&V process and can provide accurate savings estimates and reduce the risks from not returning to a pre-COVID normal.

NRA Method #3 identifies an independent variable that captures the energy fluctuations introduced by COVID and includes it in a new baseline energy model. The new and existing variables are tracked throughout the reporting period and used in calculating the adjusted baseline energy. Additional discussions on this method are included in Section 3.2 below and in Appendix 3

If NRA Method #3 is not applied, consider suitable actions based on the M&V period impacted, which may include using a different NRA method or an alternate approach. Many utilities or publicly sponsored programs have prescribed using meter-based M&V to estimate savings from EEMs, which can limit feasible options.

Discussions on the risks presented by COVID to M&V outcomes and the strategies to manage them for the baseline, implementation, and reporting M&V periods follow.

3 COVID Impacts Baseline Period

3.1 M&V Risks and Considerations

Meter-based M&V projects impacted by COVID during the selected M&V baseline period or project development can cause significant inaccuracies in reported savings which may last for the duration of a project.

Key Risks to consider include:

- If operating conditions from the baseline period are not fully regained during the performance period, energy savings will be under-estimated or over-estimated:
  - Savings are under-estimated if 'new normal' energy use is higher than the baseline energy use (i.e., *COVID penalties*).
  - Savings are over-estimated if 'new-normal' energy use is less than the baseline energy use (i.e., *COVID savings*).
- The accuracy of the baseline model is diminished due to inclusion of COVID impacted periods and non-impacted periods.

- Participation in programs relying on meter-based M&V may be less due to models not meeting goodness of fit requirements.
- Accuracy in reported savings will be reduced and lower levels of energy savings may not be discerned, or only partially detected.
- NREs in the baseline period and reporting period may go undetected.

All M&V comparisons, however, require a common set of conditions (i.e., static factors must remain static) within the measurement boundary except for the implemented EEMs and independent variables. Problems may be faced by any approach if future site conditions are not assured to return to a pre-COVID normal. With COVID impacting the baseline period, implementing a designated back-up M&V approach may require additional time to collect and document related data, which can be difficult since M&V should generally not affect a project's overall progress.

When dealing with NREs in the baseline period, IPMVP generally suggests using a different continuous 12-month period with normal operations to develop the baseline energy model (e.g., use 2019 instead of 2020). However, given that at many facilities COVID's impacts are ongoing and continue to morph, a return to pre-covid energy consumption patterns is generally not assured and data from a previous time-period should not be used unless analysis of energy data confirms energy use patterns are back to a pre-COVID normal (see Tip 5).

Similarly, using the most recent 12-month period that reflects COVID impacted periods may also be problematic. In many instances, a portion of the operational changes made due to COVID are permanent while others are not. This can result in a 'new normal' in energy consumption patterns which are unlike those during either the pre-COVID or COVID-impacted periods.

Tip 5: Monitor Energy Consumption for Return to Normal

Monitor energy consumption for a return to pre-COVID normal or to a new normal:

- ❖ Create or use a 'baseline' model from pre-COVID period. Routinely adjust the regression model to conditions during the COVID impacted period and compare predicted energy to actual energy (residuals).
- ❖ When a moving average of the residuals (see Figure 3 above) becomes a near-constant value, energy consumption patterns have stabilized. In cases where this value approaches zero, a pre-COVID normal has been reached, whereas a steady CUSUM value indicates a new-normal.

3.2 Options for Managing Covid in the Baseline Period

Options for managing COVID in the baseline period follow. Generally:

- ❖ If a new-normal is reached prior to installing any EEMs, **backcasting** may prove effective in determining avoided energy consumption (see discussion below).
- ❖ If a new-normal is NOT reached prior to installing any EEMs, **to reduce risks avoid using *NRA Method #s 1 and 4 – 7*** which generally use the pre-COVID normal conditions to determine the NRA. These are noted in the Appendix (see *Table A- 1: Application Notes on COVID Management Approaches Including NRA Methods).*

3.2.1 Pause M&V and Collect Additional Data

In some cases, it may be appropriate to pause the M&V for the project, monitor energy consumption, and collect additional site data before finalizing the baseline energy model.

Data collection should include documenting changes in the site's static factors (e.g., occupancy and equipment schedules) and identifying data which captures the major sources of the site's energy use changes (e.g., reduced ton-hours/day, fan speeds, and lighting run-hours). This data may potentially be used as a variable using NRA Method #3 or as the basis for an alternate M&V approach. Tracking key static factors can also help substantiate a return to pre-COVID normal (see *NRE Approach #1 — Identify Changes in Static Factors*). In some cases, static factors can be used to flag when COVID impacts are no longer present (e.g., enrollment levels and class schedules follow 2019 norms).

If the site does not quickly return to pre-COVID normal, a different M&V approach should be pursued. M&V is intended to support energy efficiency projects and delaying a project due to M&V challenges would be unfortunate.

3.2.2 Make an Appropriate NRA

IPMVP limits making NRAs during the baseline period for Option C building-level utility meter data methods to ensure baseline energy data are measured as objectively as possible. Because of this, IPMVP excludes the application of regression-based NRA Methods in the baseline. Of the methods in the NRE/A Guide, *NRA Methods #1, 2, and 3* are generally the most appropriate for use in the baseline period. However, if a new-normal is NOT reached prior to installing any EEMs, to reduce risks avoid using *NRA Methods #s1 and 4 – 7*.

3.2.2.1 NRA Method #1 — Omit Data

This is the simplest but only applies if energy use patterns quickly returned to pre-COVID normal. In these cases, the unstable portion of baseline data may simply be excluded if data impacted is within limits. If sub-metered data is available, *NRA Method #2 —Use Sub-metered Energy* should be evaluated.

3.2.2.2 NRA Method #3 — Redefine Baseline Model Using New Variables

Of the other baseline NRA options for meter-based M&V, *NRA Method #3 — Redefine Baseline Model Using New Variables* is preferred.[9] The risks from not returning to a pre-COVID normal can be somewhat mitigated by adding a site-specific variable that reflects energy fluctuations due to COVID into the baseline model. A 'COVID' or 'occupancy-load' variable that reflects the whole building energy fluctuations due to COVID-related changes (e.g., occupancy levels) can require data not directly related to the number of people at the site (see Field Account 1) such as total weighted motor speed/hour. Review available site-specific data from sources such as building controls, security access, and parking systems.

This method ensures savings estimates are accurate given ongoing fluctuations that are similar in nature. It may not account for future site changes that are a fundamentally different type (e.g., average speed of AHU fans as an occupancy-load variable would not reflect changes from installing a new air-purification system). Identifying an appropriate site-specific variable can sometimes be challenging however, as any new variable

[9] When applied in the baseline period 'NRA Method #3' is not an NRA but rather 'Makes the Non-Routine Routine'.

needs to have a valid correlation with whole building energy (i.e., proven to be statistically significant based on p-value). An example of this method is in the Appendix along with additional considerations on variable selection.

Field Account 1: Impacts on Energy Consumption from COVID-19 Unlike Occupancy Changes

New York City implemented strict restrictions on businesses due to COVID. During the initial stay-at-home orders, occupancy on office buildings dropped from close to full to around 2% of normal, but energy consumption in some unoccupied office buildings decreased by only about 30%[10].

To further understand these impacts, NYSERDA's PropTech Challenge focused on identifying new modeling assumptions which account for impacts to electricity consumption from COVID-19's reduced occupancy levels. The results from this contest to create accurate whole-building energy models using sub-metered electricity consumption and occupancy data for a large office building in Manhattan will be announced in April 2021.

3.2.3 Use an Alternate M&V Method

If other options to manage impacts from COVID are not suitable when using a meter-based M&V approach, a different M&V approach should be considered (i.e., Backcasting, IPMVP Options A, B, or D).

For longer-term projects, meter-based methods can still be utilized in the reporting period for ongoing monitoring for savings persistence and for NREs.

3.2.3.1 Backcasting

If a new-normal is reached with sufficient time prior to installing any EEMs, **backcasting** may prove effective in determining avoided energy consumption. Backcasting is an IPMVP adherent form of estimating avoided energy consumption that uses the baseline period energy and an adjusted reporting period model to determine avoided energy savings but does not apply to normalized energy saving. Backcasting is detailed as an alternate M&V method in the *IPMVP NRE/A Guide*.

3.2.3.2 Retrofit Isolation

A **retrofit isolation** approach may be viable (IPMVP Options A or B) if the energy impacted by the EEMs can be isolated (e.g., fan and pump motor upgrades, lighting efficiency improvements). Where possible to measure system or equipment level energy consumption and any pertinent independent variables, IPMVP's ***Option B*** *– All Parameter Measurement* should be considered. Using sub-metered energy data is effective if the planned EEMs are not significantly affected by COVID, or if all parties agree that the sub-metered data available to apply Option B provides the best opportunity to quantify savings. In these cases, a meter-based M&V approach is still utilized, simply using a smaller measurement boundary (e.g., daily electric motor kWh vs. whole-building kWh). Adhering to IPMVP Option B requirements may be challenging, however, since Option B is intended to use measurements throughout the baseline and reporting periods.

IPMVP's ***Option A*** *– Partially Measured Retrofit Isolation* is more realistic for most projects changing M&V methods. Switching to Option A means using sub-metered energy data while estimating certain parameters which have been impacted by COVID (e.g., equipment run hours). Making appropriate estimates and using

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[10] Preliminary results from NYSERDA study on impacts of COVID mitigation strategies are available here.

measured loads may be complicated by changes made to equipment and systems. In cases where both loads and operating hours affecting EEMs savings are impacted by COVID, adjusting these elements individually is possible but may not adhere to IPMVP.

These Option A-like savings determination methodologies often rely upon **engineering calculations.**[11] For example, estimated pre-COVID baseline conditions could be applied to measured EEM equipment energy performance, such as using measured baseline flow rates and measured VFD energy usage at those flow rates, even if some variables must be estimated. This level of rigor may be adequate for program needs.

3.2.3.3 Calibrated Simulation

A **calibrated simulation** approach, IPMVP Option D, can also be considered but is typically more expensive and requires substantial site level details and understanding of COVID impacts to properly model equipment operations and quantify impacts of COVID on savings from the EEMs. In this case, a simulation model is created and calibrated to 'COVID-period' conditions and another model is calibrated to 'pre-COVID' conditions. The effect of COVID-related site changes on EEMs can be determined using these models, as described in the *IPMVP NRE/A Guide Section 5.9 NRA Method # 9 – Calibrated Simulation*.

For a site with significant energy impacts from COVID, it may be challenging to adequately calibrate a simulation model with site-level energy data. Simulation models are very flexible but require determining if pre-COVID or a new-normal should be used to determine savings. Alternately, whole building energy simulation models could be used on a comparative, percentage basis to estimate the impacts of COVID without formally calibrating the model to utility data.

3.2.4 Develop a Custom COVID Index*

*Approach is not adherent to IPMVP.

Developing an indicator external to a project such as a 'Custom COVID Index' may be considered if relevant building-specific data is not available and other COVID-management approaches are not possible. Two options for applying a COVID index are discussed, and an example of this method is included in the Appendix.

Since a COVID index is an unvalidated proxy not tied to site specific conditions, its continued applicability in the reporting period may be difficult or impossible to confirm, as described below. Additionally, the application of this approach is limited to utilities and portfolio holders due to data access requirements.

If a significant number of similar peer facilities (i.e., 'buddy buildings') can be identified from energy use data and other site-specific details from similar buildings in the same area, it may be possible to develop a custom COVID index for a given facility. A COVID index will track the average change in energy use observed in the selected buddy buildings relative to their adjusted baseline energy models and is used to correct for macro-level impacts seen in the index that are assumed to be the same at the specific facility. Note that if the index should be close to 100% in the pre-COVID period, and the index returning to 100% would indicate a return to pre-COVID normal.

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[11] Using engineering calculations is not an M&V method. See *BPA's Engineering Calculations with Verification Protocol*.

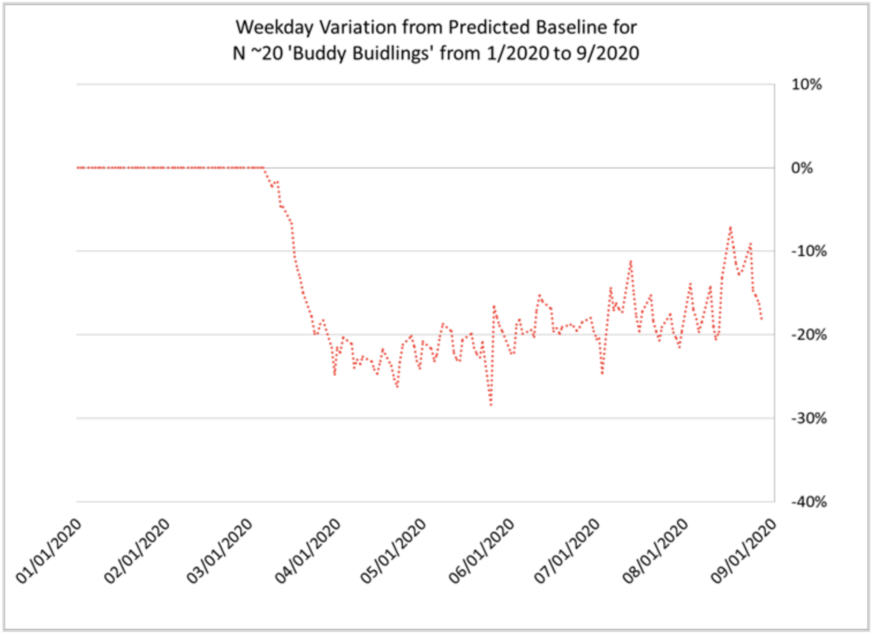

Figure 4: Example of a Custom COVID Index Using the Buddy Buildings' Average Deviation from Adjusted Baseline Energy over Time

3.2.4.1 Add Custom COVID Index as a Variable in Baseline Model per NRA Method #3 *

*Approach is not adherent to IPMVP.

The most robust way to apply an external indicator such as a custom COVID index is to include it as a new variable in the baseline model per NRA Method #3 – Redefine Baseline Using New Variables. The new COVID index must prove to be a statistically significant variable when added to the baseline model that includes COVID-impacted periods.

The challenge in using this method is the need to monitor the index for continued relevance to a specific site, which requires additional analysis. Relevance in the reporting period should be checked periodically by creating a reporting period model using newer data and verifying the continued statistical signific of the COVID index as a variable in the model based on p-value.

3.2.4.2 Use Custom COVID Index as a Ratchet *

*Approach is not adherent to IPMVP.

Once developed, a Custom COVID index could also be applied directly to adjust a facility's energy use rather than use it as a variable in the model. Using an index in this manner is not preferred, however, as it ratchets the adjusted baseline energy data up or down by the corresponding COVID index value.[12] The key shortcoming in this approach is there is no direct way to determine if the individual building continues to

[12] For an example of this method see related EVO Webinar series Managing the Impacts of COVID-19 in Meter-Based M&V, specifically the session entitled *Advanced M&V Methods, and Managing COVID19 — IPMVP & Beyond.*

follow the regional norms captured in the index. While this method may be effective for short-term corrections, it should not be used in long-term efforts.

4 COVID IMPACTS IMPLEMENTATION PERIOD

4.1 M&V Risks and Considerations

Impacts from COVID beginning in a project's implementation period can cause significant problems in meter-based M&V projects with limited effective solutions. Trying to determine whether a sudden drop in energy use is due to an NRE or due to newly implemented EEMs is often not possible.

Key Risks to consider when managing COVID during the implementation period include:

- ❖ Impacts extend from the implementation period into the reporting period and savings from the targeted EEMs cannot be discerned from impacts on energy consumption from COVID.
    - ▪ There is no clear indicator available to gauge if the energy use patterns for a site return to a 'pre-COVID-normal' (e.g., as model's independent variables such as average daily production rates)
- ❖ If impacts are ongoing, the baseline energy model will not reflect 'post-COVID normal':
    - ▪ Savings results will be under- estimated or over-estimated.

4.2 Options for Managing Covid in the Implementation Period

4.2.1 Pause M&V. Collect data and monitor conditions.

If impacted in the implementation period, the best-case scenario is if COVID impacts began early in installation efforts and substantial changes related to the EEMs have not yet been made (e.g., equipment ordered but not installed). In this case, pause the project, if possible, and allow for operations to stabilize. If energy use returns to pre-COVID normal (described in Section 3.1), the assessment of savings from of EEMs can proceed as planned using Option C. If the site does not quickly return to pre-COVID normal, or the installation of EEMs cannot be paused, consider another COVID management strategy.

4.2.2 Use an Alternate M&V Method

When an NRE impacts the energy use at a site during the implementation period it can be best to use a different M&V approach for the EEMs (e.g., IPMVP Options A, B, or D). See additional discussion on alternate M&V methods in Section 3.2.

Other M&V approaches may be ineffective, however, if sufficient baseline data to support a backup M&V option was not collected. Difficulties can also arise if the performance of the systems or equipment related to the EEMs are impacted by COVID, and future site conditions are not assured to return to a pre-COVID normal. IPMVP's Retrofit Isolation methods using **Option A or Option B** is the most realistic alternate M&V option for most M&V efforts affected during the implementation period.

On-Off testing of EEMs is a powerful strategy that can sometimes be applied to retrofit isolation projects that do not have baseline performance data. This strategy is applicable in cases where baseline data is missing and

EEMs can be periodically disabled and then re-enabled (e.g., one week on, one week off) to establish the baseline energy consumption and independent variable data.[13]

Field Account 2: Staged Effort Uses Different M&V Option to Manage COVID Impacts During Implementation Period

An industrial vegetable growth facility serving regional restaurants businesses has been working with the local utility and had planned to implement several EEMs. The project's M&V was just getting underway in mid-March 2020, as the COVID pandemic hit with stay-at-home and restaurant closure requirements taking effect.

The facility has two main food production lines, with one production line able to run at "normal" production rates during the COVID pandemic while the other was unused or operating at part capacity. A whole-facility meter-based M&V approach was originally planned but energy use patterns changed dramatically at the beginning of the implementation phase. Rather than pausing the M&V on the project until COVID passed, a retrofit isolation method was developed, and the M&V effort broken into two phases.

Phase 1: April through September 2020:

Retrofit isolation M&V was implemented as Phase 1 for Production Line 1 running at "normal" production. Phase 1 energy savings were quantified, and Phase 1 project costs documented to allow the utility to provide incentives to the facility as that phase of the project was closed out.

Phase 2: Pending Stable Operations:

Retrofit isolation M&V of Production Line 2 EEMs was delayed. At a later date (TBD) Phase 2 of the project will have retrofit isolation M&V completed when the second line is running at "normal" production levels. At that time, metering and other data collection needed to quantify reporting period energy will begin, allowing the remainder of the project to be closed out with the utility once energy savings were determined.

4.2.3 Make an NRA Using NRA Method #3 — Redefine Baseline Model Using New Variables

This method is preferred if the project is on-going because it reduces the key risk of savings being under- or over-estimated due to impacts from COVID. During the implementation period, use the original pre-COVID baseline period to create a new baseline model that includes an additional variable which explains the variations from COVID. Data from building automation systems' historic trend logs can sometimes be viable.

4.2.4 Calculate payments differently than energy savings.

Some utility sponsored programs or similar efforts may choose to pay participants differently than planned. De-coupling customer incentives from their planned energy savings calculation methods may simplify the project's process in some circumstances without the increase in savings uncertainty being unacceptable.

This approach might apply when affected projects (such as those in custom, retro-commissioning, and industrial energy management programs) are part of a larger portfolio of projects that are using less accurate estimation methods (e.g., deemed savings or prescriptive savings calculators). Where projects using meter-

[13] See related discussion *IPMVP Core Concepts*

based methods represent a small portion of savings in a portfolio, the importance of the energy savings meeting project goals may need to be evaluated. Other priorities such as maintaining customer expectations may prove more important, and the customer incentives could be calculated differently than planned and not use the actual savings achieved.

Rather, programs may be able to use another incentive calculation method for projects where EEM installations have been validated and have the potential to perform. Instead of the actual COVID-adjusted saving, consider using either:

- Average savings determined over several years,
- Previous year's performance, or
- Initially estimated savings for a project based on rough engineering calculations.

In some situations, using these simple assumptions may suffice and could prove more cost effective than other options.

4.2.5 Develop a Custom COVID Index*

*Approach is not adherent to IPMVP.

If data and effort warrant, a Custom COVID Index could be developed and applied as discussed in Section 3.2.

4.2.6 Cancel M&V Effort

Unfortunately, cancelling an M&V effort is sometimes required. COVID may create site conditions that are no longer appropriate for the planned EEMs, make the planned M&V approach unworkable, or changes in operating hours or loads may affect the financial viability of a planned project. In some cases, this involves the dissolving contracts or enacting force majeure clauses, if included. The details of these project closeouts may be contractually specified or may need to be negotiated.

5 COVID IMPACTS REPORTING PERIOD

5.1 M&V Risks and Considerations

COVID impacts beginning during a project's reporting period may be more manageable than those arising earlier in the M&V process since additional NRA methods are applicable. Note that many of these methods, determine savings as if COVID had not happened which may be more readily appropriate for projects in the M&V reporting period, depending on context.

Key Risks to consider when managing COVID during the reporting period include:

- NREs from COVID occur early in reporting period:
  - EEMs cannot be discerned from impacts on energy consumption from COVID due to insufficient data after the EEMs were installed and savings results will be under-estimated or over-estimated.

    - If impacts from COVID are ongoing, the baseline energy model will not reflect 'post-COVID normal' and savings results will be under- estimated or over-estimated.
    - IPMVP NRA Methods typical for Reporting Period NREs will not apply.
- Changes due to COVID impacts are not documented:
    - EEMs failing to perform may go unrecognized.
    - Future non-routine events cannot be validated.
- Payments such as utility incentives are lower or higher than expected due to COVID:
    - Projects' planned financial proformas may not be met.
    - Customer participation in energy efficiency programs may be diminished.
    - Utility program cost-effectiveness metrics may not be as expected.

When dealing with NREs in the reporting period, ongoing projects and projects using normalized energy savings have additional considerations:

> ***Are normalized energy savings required*?** Calculating normalized energy savings based on typical weather (e.g., TMY) is common for utilities and others comparing year-to-year results but can limit options and make correcting for COVID impacts somewhat more complicated.
>
> ***Will savings reporting be one-time or ongoing?*** Projects with subsequent reporting periods may need to take extra steps to ensure ongoing accuracy of reported savings. If impacts from COVID are ongoing into subsequent project reporting periods (i.e., multi-year efforts), it may be appropriate to redefine the baseline model (re-baseline) after the current report.

5.2 Options for Managing Covid in the Reporting Period

5.2.1 Pause M&V. Collect data and monitor conditions.

Longer term and on-going M&V efforts and projects with flexibility in when savings are reported may choose to wait to determine and report savings. Allocating additional time for data collection or allowing site conditions to stabilize and potentially return to a pre-COVID normal may increase reporting accuracy.

Field Account 3: Alternate M&V Methods Possible after Pausing M&V Reports in Reporting Period

For example, SEM projects, cohort meetings and trainings can continue, but utilities may decide that reporting of annual energy savings should be paused until operations stabilize and/or staff bandwidth can return to focusing on energy management activities. This can then lead to returning to avoided energy use (forecasting) or normalized savings, or to use an alternative M&V approach (e.g., chaining or backcasting).

For example, a COVID-impacted time period straddles both an earlier reporting period that was "paused" and extended partially into a current reporting period until transitioning to a "new normal" that, depending on the key independent variable data available and consideration of min/max ranges, a **backcasting** approach could be useful.

Another example could be a "paused" reporting period with both pre-COVID, COVID impacted, and post-COVID "new normal" time periods sandwiched between a pre-COVID baseline and a subsequent reporting period that represents the post-COVID "new normal". In that scenario, a chaining approach, developing an energy model from the "paused" reporting period could be appropriate.

This flexibility in time for a utility to report savings to their regulators should be a benefit to both the utility and the end-use site, and applies not just for COVID, but occasionally for major renovation or new construction projects within the measurement boundary, defined by utility meters.

5.2.2 Make a Non-Routine Adjustment

There are several viable options for making an NRA in the reporting period. Methods vary based on determining avoided energy consumption or normalized energy savings. NRAs may sometimes be applied sequentially, if needed, to address multiple changes.

5.2.2.1 NRA Method # 3 — Redefine Baseline Model Using New Variables

This method of redefining the baseline model using one or more additional variables is preferred because it reduces the key risk of savings being under- or over- estimated due to impacts from COVID. It can be used when reporting normalized energy savings or avoided energy consumption.

See the discussion on this method in Section 3.2.

5.2.2.2 NRA Method #5 — Create an NRE Adjustment Model

NRA methods #5 is relatively simple and is generally recommended if applicable. This method determines savings as if COVID had never occurred. Criteria for using this method to make an NRA are:

- The basis for reported savings is **avoided energy consumption**, and
- The Pre-COVID period during the reporting period is of sufficient duration to include an adequate range of independent variables and operating modes (e.g., includes peak cooling and heating seasons) to be valid during the COVID affected period.
- Is used in a one-time savings report at the end of M&V effort, or in a continuous improvement project that allows for development of new baseline energy model after the savings are reported.

As detailed in the NRE/A Guide, this NRA Method #5 creates an 'NRE Adjustment Model' from the energy and independent variables from the portion of the reporting period unaffected by COVID. A valid regression-based model[14] can be routinely adjusted using the independent variables recorded during the COVID-affected period to estimate what energy use would have been if changes due to COVID had not occurred. The difference in the energy use measured during the COVID-affected period and energy use predicted by the 'NRE Adjustment Model' is equivalent to the COVID impacts.

An example of applying this method is shown in Figure 5 and detailed in the Appendix.

[14] Criteria for statistical validity vary. See *IPMVP's Snapshot on Advanced M&V* for a summary of metrics from industry guidelines.

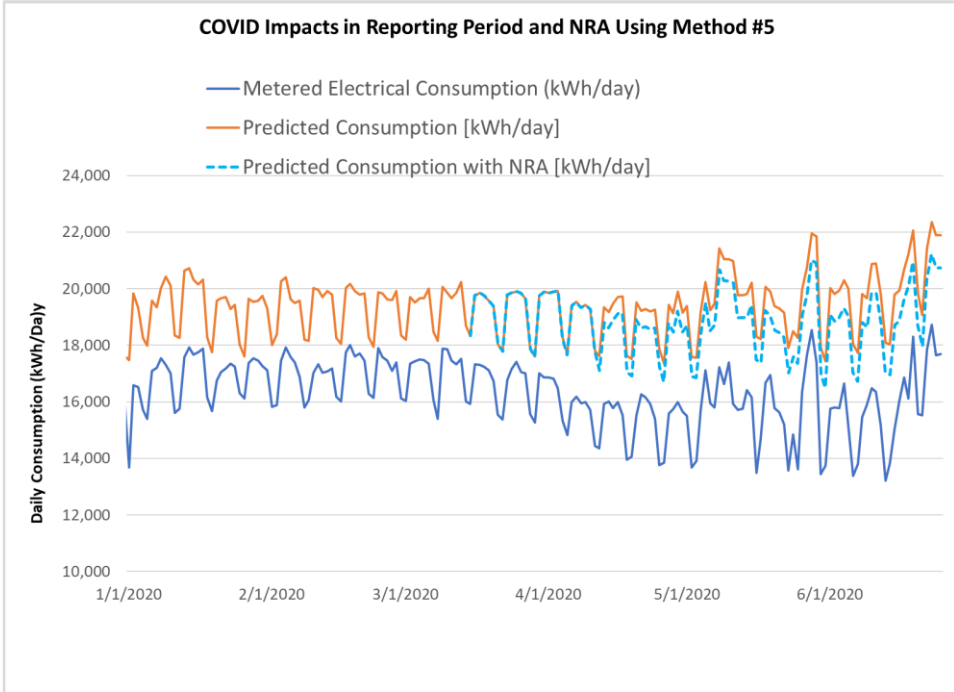

Figure 5: COVID Impacts in Reporting Period Using NRA Method #5 – Create an 'NRE Adjustment Model'

5.2.2.3 NRA Method #6 — Use 'Mini' Models or NRA Method #7 — Develop a 'Pre-Post NRE' Model[15]

When determining avoided energy consumption or **normalized energy savings** one of these regression-based NRA methods can be effective. Both NRA Methods 6 and 7 allow impacts from COVID to be modeled using regression analyses and then adjusted to assess impacts under standard conditions[16]. These methods both create energy models of the COVID impacted periods and non-impacted periods but use different regression modelling strategies.

These NRA methods can be applied where:

- The regression-based models developed are valid and sufficiently accurate to be used; and
- The pre-COVID period included in the current reporting period is of sufficient duration to include an adequate range of independent variables to be valid when applied to the COVID period.

An example of applying this method is provided in the Appendix.

Field Account 4: Staged Non-Routine Adjustments Used to Manage COVID in Reporting Period

The approach taken to manage COVID in one pay-for-performance utility program is a phased, stepwise approach. The projects in question are commercial Strategic Energy Management (SEM) projects using meter-based M&V methods and are in various phases of their multi-year reporting periods.

[15] A similar approach using a whole-project pre-post model can also be used as described in Example z in Appendix.

[16] NRA Method #4 can also apply if residuals have statically significant relationship with independent variables used in model.

To accurately report avoided energy savings achieved during the 2020 performance year, the program manager developed a staged approach that bases the actions taken on the primary phases of COVID experienced locally.

Phase 1 - March to June 2020:

Initial energy impacts in the spring were generally significant but short lived. During this period, all savings are ignored. This follows NRA Method #1 - Omit Data.

Phase 2 - June to Dec 2020:

Building-by building assessments conducted to document actions taken and EEMs implemented in 2020, which include O&M and behavioral changes. This site-specific data is essential to defend claimable savings, after any required NRA is made. Where appropriate, an NRA using the appropriate regression-based method following NRA Methods #4 – #8.

Phase 3 – Jan 2021 & Beyond:

These SEM projects track avoided energy consumption amounts achieved each year. Rather than continuing to use the original baseline model, which determines saving relative to a pre-COVID normal, the projects will create a new baseline model (re-baseline) to use moving forward.

5.2.3 Calculate payments differently than energy savings.

Some utility sponsored programs or similar efforts may choose to pay participants differently than planned. Decoupling customer incentives from their planned energy savings calculation is discussed in Section 4.2.4

5.2.4 Use an Alternate M&V Approach

Projects affected by COVID early in the reporting period may not be able to apply an NRA. If the M&V effort assumed that Option C would be used, there can be significant challenges to changing to another M&V approach (i.e., IPMVP Options A, B, or D) when impacts begin during the reporting period, but it is possible. Where the data is available, needed adjustments may be feasible within the other IPMVP options.

5.2.4.1 Retrofit Isolation with On-Off Testing

IPMVP's *Option A – Partially Measured Retrofit Isolation* is generally most realistic for EEMs without baseline data can sometimes use retrofit isolation M&V methods with On-Off testing. See related discussion in Section 4.2.2.

5.2.4.2 Chaining

Chaining is an Option C method that can be used by projects that report savings for multiple years and are determining avoided energy consumption. Chaining may be needed when the conditions during a targeted year in the reporting period are out of the range of the independent variable(s) included in the baseline period (e.g., production rates). Chaining requires a delay in M&V reporting or otherwise a true up to reported savings is required. The approach is IPMVP-adherent if the models are not used to predict energy beyond their valid range. Details are provided in Section 6.2 of the *IPMVP NRE/A Guide* and illustrated in Field Account 3.

5.2.4.3 Re-baseline and Restart M&V Effort

Redefining a project can be effective if it is part of a longer-term effort such as some utility pay-for-performance programs with 3- to 5-year contract periods. A new energy model can be developed based on a period with stable operating condition representing a new-normal. If the model fit remains adequate, the new model can be used to track changes relative to savings already achieved. This model can be used to verify energy performance remains stable and as a basis to track future energy savings. This approach is sometimes referred to as re-baselining as described in Section 6.3 of the *IPMVP NRE/A Guide* and illustrated below in Field Account 5.

Field Account 5: Re-Baselining Required after Production Levels Drop in Reporting Period

A manufacturing site is participating in an ongoing energy improvement program (Strategic Energy Management or SEM) sponsored by their local utility. A regression model of the baseline energy consumption using the outdoor temperatures and daily productions rates from the previous year was developed and used to gauge energy improvements each year for five years (Reporting Years 1 – 5).

Due to a downturn in their business market resulting from COVID-19 stay-at-home mandates, a steady decrease in the levels of production began during Reporting Year 2 of the five-year program. Production levels dropped well below historic levels, invalidating the use of the baseline energy model.

Rather than pause their M&V efforts, it was agreed to quantify the EEMs planned for Reporting Year 3 using retrofit isolation with end-use metering (IPMVP Option B) and to resume using Option C in Year 4 based on a new regression model.

APPENDICES

TO

Impacts of COVID-19 on Measurement and Verification (M&V) of Energy Savings: Options for Meter-Based Methods — IPMVP and Beyond

CONTENTS

FIGURES & TABLES

Appendix 1 APPLICATION NOTES ON COVID MANAGEMENT APPROACHES

This section provides additional application notes on COVID Management Approaches, which includes IPMVP's NRA Methods #1 – 10 from the *IPMVP NRE/A Guide* in the Table below, and a discussion follows on using NRA Method #3 – Redefine Baseline Using New Variables.

Table A- 1: Application Notes on COVID Management Approaches Including NRA Methods

	COVID Management Approaches for M&V *Approach is not adherent to IPMVP where noted	Baseline Period	Implementation Period	Reporting Period	Assumes Return to Pre-COVID Normal	Application Notes
COVID Management Approaches	Approach #1 – Do Nothing. Project is not significantly affected by COVID	X	X	X	Yes	Projects with limited impacts from COVID should continue monitoring for NREs.
	Approach #2 – Pause M&V reporting. Collect data and monitor conditions	X	X	X	No	Provides flexibility in reporting savings.
	Approach #3 – Make an NRA (See NRAs below)	X	X	X	See NRAs, below	See NRAs, below
	Approach #4 – Use an alternate M&V approach (i.e., Backcasting, Chaining, or IPMVP Options A, B, or D)	X	X	X	No	Option A and D will provide the most flexibility in managing operational differences between baseline and reporting period due to COVID
	Approach #5 – Calculated payments differently than energy savings		X	X	No	Provides flexibility by using uniquely defined criteria.
	Approach #6 – Develop a Custom COVID Index*	*	*		No*	A COVID index is an unvalidated proxy variable needing periodic validation. Application is limited to utilities and portfolio holders due to data access requirements.
	Approach #7 – Re-baseline or Cancel M&V effort		X	X	No	Typically, this is the last option to be considered.

COVID Management Approaches for M&V *Approach is not adherent to IPMVP where noted		Baseline Period	Implementation Period	Reporting Period	Assumes Return to Pre-COVID Normal	Application Notes
Approach #3 – Make an NRA						
Non-Routine Adjustment (NRA) Methods	NRA Method #1 – Omit data	**X**		**X**	**Yes**	Only applies if COVID impacts have clear start and end, impacting less than 25% of the data for the M&V period.
	NRA Method #2 – Use Sub-Metered Energy	**X**	**X**	**X**	**No**	Energy metering may be effective if the energy end-uses impacted by COVID are measured separately. Otherwise, leverage energy sub-metering to implement IPMVP Option A or B.
	NRA Method #3 – Redefine Baseline Using New Variables	**X**	**X**	**X**	**No**	This method will continue to account for similar fluctuations during the reporting periods, but other types of NREs may occur.
	NRA Method #4 – Use Model Residuals from the NRE Period			**X**	**Yes**	Not recommended for use in baseline period. Applies to temporary NREs affecting less than 5 to 10% of data (consider NRA Method #2 instead).
	NRA Method #5 – Create an 'NRE Adjustment Model'			**X**	**Yes**	Method is not IPMVP adherent if used during the baseline period except to gauge impacts from COVID-affected period. Use of estimates are likely to corrupt model.
	NRA Method #6 – Use 'Mini' Models	*****		**X**	**Yes**	Method is not IPMVP adherent if used during the baseline period but is recommended for managing COVID in the reporting period. May be useful in addressing multiple NREs.
	NRA Method #7 – Develop a 'Pre-Post NRE' Model	*****		**X**	**Yes**	Method is not IPMVP adherent if used during the baseline period but is recommended for managing COVID in the reporting period. May be useful in addressing multiple NREs.
	NRA Method #8 – Adjust for Significant Trends in Residuals	**X**			**No**	Adjusts for energy trends using a linear projection of a significant change in energy over the baseline period which may be oversimplified for COVID impacts. (Note this is different than shown in the NRE/A Guide.)
	NRA Method #9 – Use Calibrated Simulation	**X**	**X**	**X**	**No**	Calibrated simulation can be very effective if impacts on operations are well understood and budget allows.
	NRA Method #10 – Use Engineering Calculations*	*****	*****	*****	**No***	Engineering calculations can be effective in modifying Option A methods but should not be used with meter-based M&V methods.

A1.2 Considerations for Applying NRA Method #3 — Redefine Baseline Using New Variables

Some advanced M&V modeling tools do not accommodate including an additional variable (e.g., LBNL's Time of Week and Temperature or TOWT modeling tool) and analysts may need to use different software or modify analyses.[17]

When identifying potential occupancy-load variables, consider which static factors have changed. Focus on the largest energy using system or systems impacted by COVID, and what data may be available. Trends from building automation systems (BAS) have proven to be an effective source of data, but case-studies are limited.

Consider data such as:

- Daily load data from central heating and cooling plants (e.g., tons of cooling and/or therms for heating).
- The average speed of the primary air-distribution fans (e.g., average hourly VFD speed) or the weighted average VFD speeds of significant motors.
- Number of security badges scanned or total number of car-hours parked/day.
- Number of WIFI connections or users logged on to the network per day.

Other considerations in selecting a variable include:

- The frequency of data needs to be meaningful in the context of a model using short duration energy data (e.g., monthly water use, or lease rates may not prove significant in a daily energy model).
- Data is best if it is at the same time increment as the model/energy data, so consider changing the frequency of data used in the model (e.g., change model from hourly to daily) to accommodate available data.
- The data for the independent variables must be available for both the baseline and reporting periods.
- If COVID impacts are deemed permanent during the reporting period (i.e., a new normal), creating a new model without the added variable may be evaluated to reduce data collection efforts. If the fit of a new energy model using data from the reporting period under the new-normal conditions is adequate without including the variable, it can be used to track changes relative to savings already achieved.

When evaluating an additional variable, check the model regression statistics to ensure the variable is significant (i.e., p-value) and confirm the model uncertainty is reduced. Since model statistics represent the entire period, it is good to ensure the new variable has improved predictions consistently. by routinely adjusting the model to the post-baseline period conditions, and then check residuals during the COVID impacted period.

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[17] Note that kW Engineering's *NMEC-R* tool does include the capability to add another variable to the TOWT model. A summary of free AM&V software tools is provided in *IPMVP's Snapshot on Advanced M&V*, 2020. Additional details on the capabilities are available from Facility Energy Solutions in *Assessment of Free Advanced Measurement & Verification Tools*.

Appendix 2 EXAMPLE ADJUSTMENT FOR COVID USING NRA METHOD #3

This example uses *NRA Method #3 — Redefine Baseline Model Using New* Variables[18]. One participant in a multi-year utility program offering using advanced meter-based methods (e.g., 'NMEC'[19]) was in their performance period when COVID impacts lowered energy consumption. The measurement boundary included an office and a performing arts theater. The site's electrical loads were largely from HVAC, lighting, and office equipment.

The baseline energy model used daily energy data with independent variables being temperature and day-of-week (i.e., daily TOWT). After the installation of several capital and operational EEMs, savings were to be determined over two years beginning March 15, 2020. Shut-downs due to COVID occurred coincidently to the substantial completion of the EEMs. This was a worst-case scenario for timing for this M&V effort! The initial energy savings for the EEMs appeared substantially higher than expected, raising concern from the utility that incentives would be vastly overstated.

Discussions with building operators revealed the theatre was the only the portion of the facility largely affected since the COVID shutdown started. Throughout baseline period the theatre varied in occupancy based on scheduled events and associated rehearsals. Since COVID, the theater areas have been largely unused while the office occupancy remained the same. The facility manager indicated the HVAC systems (VAV systems controlled by variable frequency drives on the air handlers and an automated control system) were still running automatically. Luckily, the control system had been set up to trend and store key operational parameters, and the archive included the average daily power from the AHU motors.

The theatre's air handling unit's VFD power readings were used to develop a representative occupancy variable using a weighted average and added as a new variable to the energy model using *NRA Method #3*. The occupancy variable was found to be statistically significant, and the model fit metrics improved as expected (Figure A-2). More importantly, the revised adjusted baseline more closely follows actual energy use patterns during the COVID impacted period (Figure A- 3).

Table A- 2: Statistical Metrics for Original and Revised Baseline Energy Models

Statistical Metric	Original Model	Adjusted Model
Cv (RMSE)	10.3%	8.5%
R^2	59%	72%

[18] Example provided by David Jump from kW Engineering.

[19] NMEC (Normalized Metered Energy Consumption) is an energy efficiency program in California that uses advanced meter-based M&V methods, which have become increasingly common, as discussed in *IPMVP's Snapshot on AM&V*.

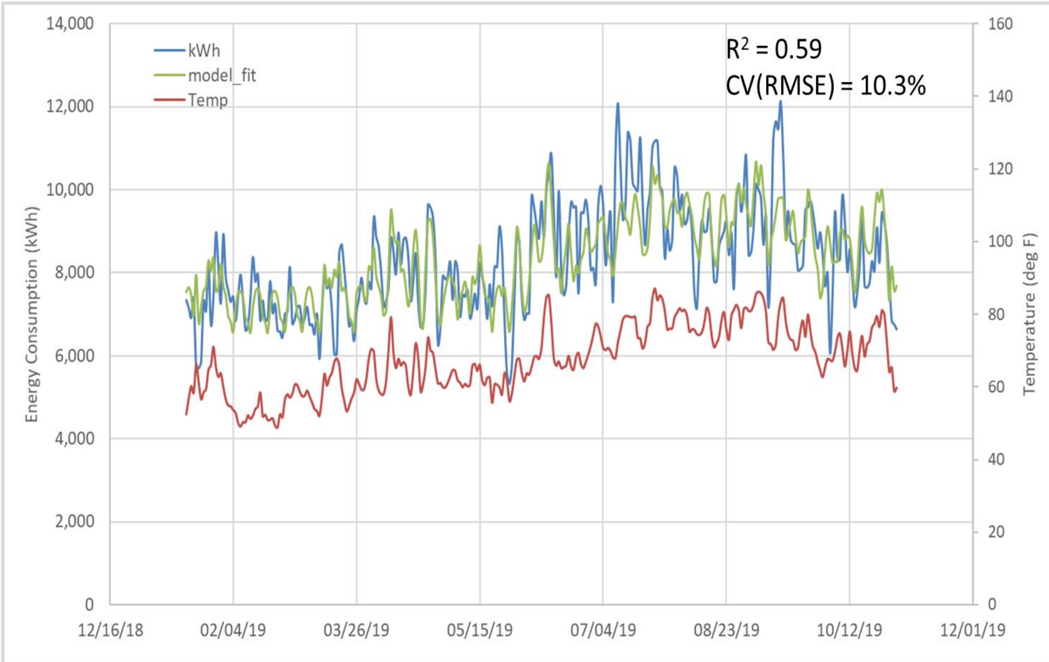

Figure A-1: Original Baseline Model

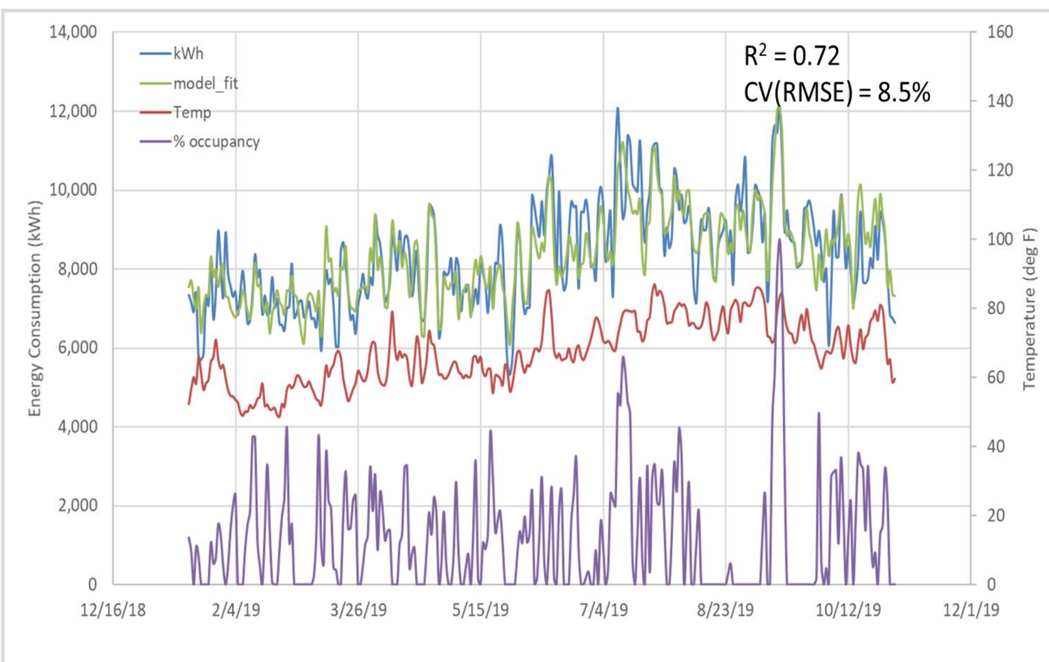

Figure A-2: Revised Baseline Model Including New Variable

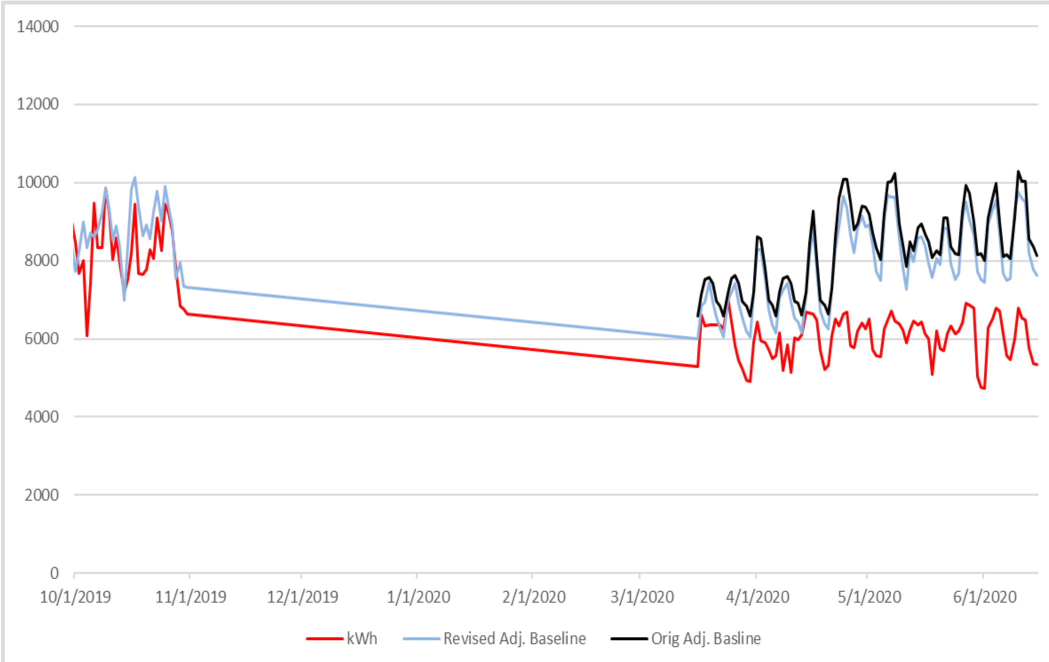

Figure A- 3: Adjusted Baseline Energy from Original and Revised Model, and Actual Daily Energy Consumption (kWh)

Figure A- 3 illustrates the difference in reporting period predictions between the original and revised baseline models, and the actual daily energy consumption. Avoided energy consumption was initially estimated for the first quarter (3-months) to be 204,800 kWh (the difference between black – red lines); savings estimated using the updated baseline energy model were 168,400 kWh (difference between blue – red lines) a decrease of 18% in reported savings (equivalent to ~145,000 kWh/year).

Appendix 3 EXAMPLE ADJUSTMENT FOR COVID USING NRA METHOD #5

This example uses *NRA Method #5 - Create an NRE Adjustment Model*[20]An industrial manufacturing company participated in a multi-year utility SEM program offering. The measurement boundary included their warehouse facility with an electrical load comprised largely of HVAC, lighting, paint booths, conveyors, dust collection equipment, as well as loads from the adjacent office areas. Normal occupied hours for the warehouse were 24 hours per day, seven days per week, and the main offices areas were occupied from 7:30 am to 5:30 pm five days a week.

The baseline model used a four-parameter, multivariable regression change-point model based on daily data, for use throughout the multi-year SEM engagement. The energy models' key independent variables included ambient dry-bulb temperature, day of the week (weekday, Saturday, Sunday, and Holiday).

Several low/no cost operational measures (e.g., controls and VFDs) were completed early in the Year 1 performance period, as shown in Figure A-4. The energy savings reduced consumption by almost 15% of baseline consumption, or just over 1,000,000 kWh/year. This reduction has been consistently maintained though Year 2 of the reporting period evident by the shift in the residual values from an average of zero.

COVID impacts during the second annual performance period of the SEM engagement resulted in declining building energy use in the mid-March through June 2020 timeframe. This was due to reduced building occupancy and identified as a non-routine event.

Avoided energy consumption for the projects second annual performance period, without performing an NRA, was calculated at 1,090,000 kWh for the year, an 9% increase in savings over Year 1, which was not expected.

Efforts to collect building occupancy data to redefine the baseline model using new variables were unsuccessful. Because of this, a decision was made to apply a non-routine adjustment. Of the NRA methods provided in the *NRE/A Application Guide*, there were several considered. *NRA Method #5 – Create an 'NRE Adjustment Model'* leverages the existing baseline energy model to create a new model using the same model variables - while excluding the period when the NRE occurred – seemed straight forward and the most appropriate one to choose (Figure A-5).

[20] Example provided by Todd Amundson from Bonneville Power Administration.

Figure A-4: COVID Impacts Seen in Year 2 of Ongoing M&V Effort

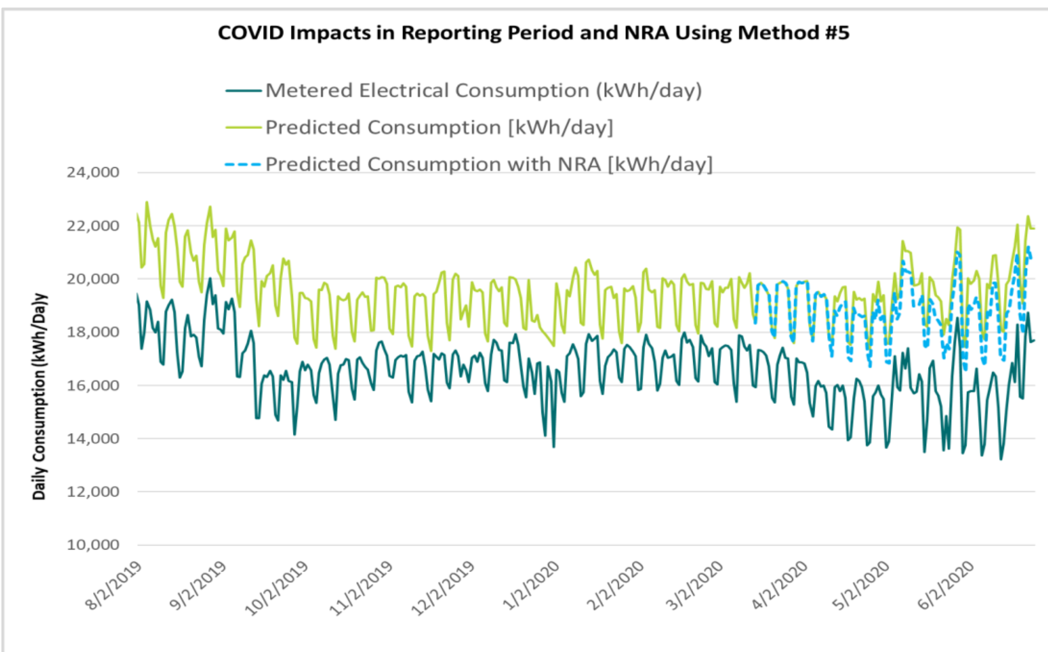

Figure A-5: COVID Impacts With and Without NRA in Reporting Period

This follows *NRA Method #5, Create an 'NRE Adjustment Model'* using the steps outlined in the *NRE/A Guide.*

Procedure:

1. *Identify start and end dates of the NRE period(s):* The period of 3/15/2020 to 6/25/2020 was selected based upon electrical energy data showing a notable change in operation during this period (6/25/20 was the end of the SEM Year 2 performance period).
2. *Gather data from the performance period with the NRE, including metered energy use and independent variables*: 6/26/2019 to 6/25/2020. Since the model included ambient dry-bulb temperature, it was decided a full year of pre-NRE data, 3/15/2019 to 3/14/2020 would better service this analysis.
3. *Ensure range of independent variables during NRE are included in the range of variables covered during the non-NRE period:* No variables during the NRE period exceeded their NRA model period ranges.
4. *Exclude the data from the NRE period. Create an 'NRE Adjustment Model' from the energy and independent variables using advanced modeling strategies.* An NRA model was developed using the same key independent variable data (ambient dry bulb temperature, day of the week indicators). The model was created using a 365-day modeling period, from 3/15/2019 to 3/14/2020.
5. *Use independent variables from the NRE period in new 'NRE Adjustment Model' to predict what the energy consumption would have been during NRE period(s) if no NRE was present:* The NRE Adjustment Model was used with the independent variables from the COVID event period to estimate what the daily energy in the NRE period would have been.
6. *Determine the total value of the NRA. Compare metered energy use for the NRE period with the energy use estimated by the 'NRE Adjustment Model'. Calculate the value of the NRA using time-series of energy impacts, if appropriate:* Summing the energy residuals during the NRE period, a non-routine adjustment of 115,000 kWh was estimated.
7. *Make the NRA. Update the adjusted baseline energy data to account for the impacts from the NRE:* This step creates an energy use time series without the NRE.
8. *Calculate avoided energy consumption using the updated energy data that includes the NRA:* Avoided energy consumption that includes adjustments for the NRE was estimated 975,000 kWh for the second performance year (1,090,000 kWh – 115,000 kWh = 975,000 kWh).
9. *Review the uncertainty in the estimated NRA to ensure the estimate is valid and should be used, as discussed in Section 7 of IPMVP's NRE/A Guide:* With 80% confidence, the combined relative uncertainty from the baseline model and the NRA was estimated to be 15%, with annual savings between 825,000 kWh and 1,125,000 kWh. The method, details, and results were documented in a SEM Completion Report for the 2019 – 2020 performance period.

Appendix 4 EXAMPLE ADJUSTMENT FOR COVID USING NRA METHOD #7

This example uses a pre-post model which is similar to *NRA Method #7 — Use a Pre-Post NRE Model*. The following example is a bank that moved to drive-up only operations during the stay-at-home orders for COVID and then started up to normal operations again in mid-May.

This site's energy use is modeled using a pre-post model assuming weather as the primary driver of consumption for this freestanding facility. In this model form, data from all M&V periods (e.g., baseline and reporting period) are included in the model and indicator variables (0 or 1) are used demarcate time periods with different operations (e.g., reporting period, COVID-impacted period). This approach is very similar to applying NRA Method #7 – Use a 'Pre-Post NRE Model described in *IPMVP's NRE/A Guide*.

This site implemented a utility energy efficiency program project in November of 2019. The chart in Figure A-6 shows electrical consumption data (blue) starting with a 12-month pre-project baseline, and then the adjusted baseline energy (red) in the reporting period.

Before COVID, this model estimated annual savings of approximately 5,000 kWh/year. After COVID began, the model showed this site as saving 8,400 kWh/year, a 40% increase. Additionally, looking at the difference between the actual consumption (blue line) and the adjusted baseline energy predicted (red line), it is obvious that the project is showing more energy saving during COVID than is normal for this project in March – April 2020 (highlighted).

The Cumulative Sum of Savings (CUSUM) chart in Figure A- 7 further exposes the impacts of the COVID NRE with the slope change during COVID. The statistics for the overall pre-post model at this point in the reporting period was showing a CV(RMSE) of 0.16, an R^2 of 0.71, and 10% fractional savings uncertainty at 68% confidence.

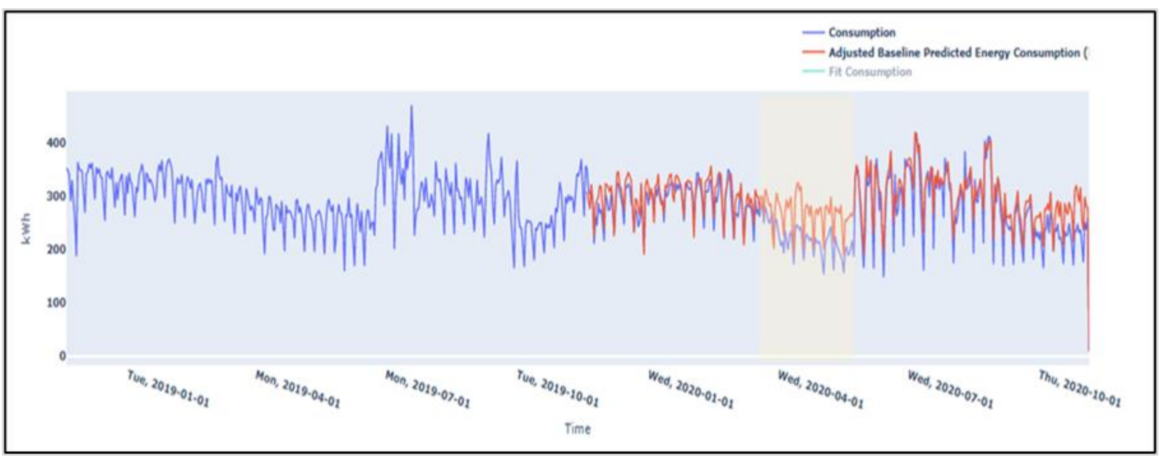

Figure A-6: Actual Energy and Adjusted Baseline Energy before and during COVID

Figure A- 7: CUSUM of Savings before NRA is Applied

Adding an indicator variable to model[21] with a 1 on the start date of the COVID shutdowns and ending on the end date, changes the model significantly. The savings generated during the NRE period are subtracted from the savings found in the first model, decreasing the energy savings to 5,700 kWh, and the model is significantly improved as shown in Figure A- 7. The additional indicator term is flagging the NRE period to be accounted for with the NRA and removed from the savings calculations. The CUSUM graph above still shows some irregularities but is dramatically improved.

Table A- 3: Statistical Metrics for Pre-Post Model

Statistical Metric	Baseline Model	COVID-Impacted Model	Adjusted Model
Cv (RMSE)	0.15	0.16	0.15
R^2	0.67	0.71	0.74
Savings Uncertainty (FSU)	NA	10%	14%
Estimated Savings	5,000 kWh (engineering calcs.)	8,400 kWh	5,700 kWh

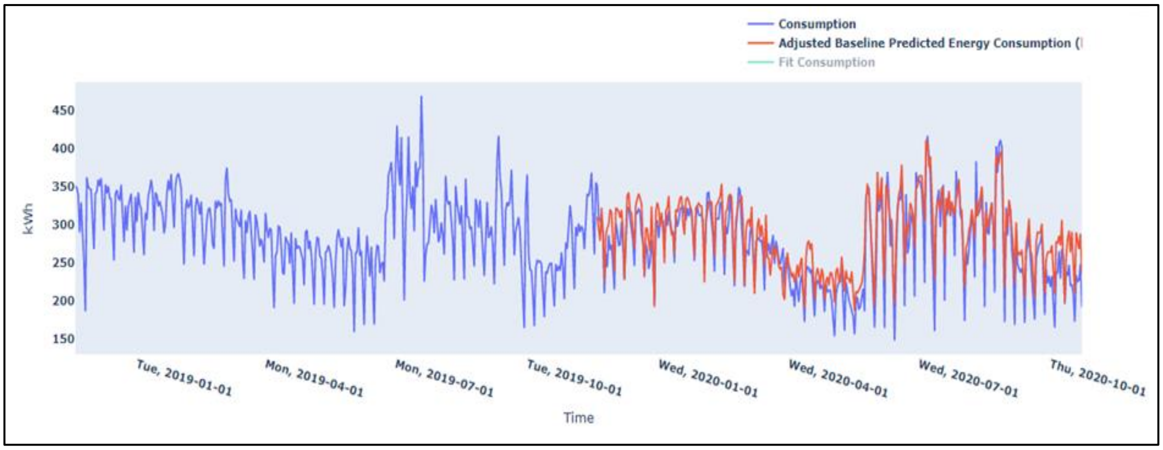

Figure A- 8: Actual Energy Consumption and Adjusted Energy Baseline Energy including NRA during COVID

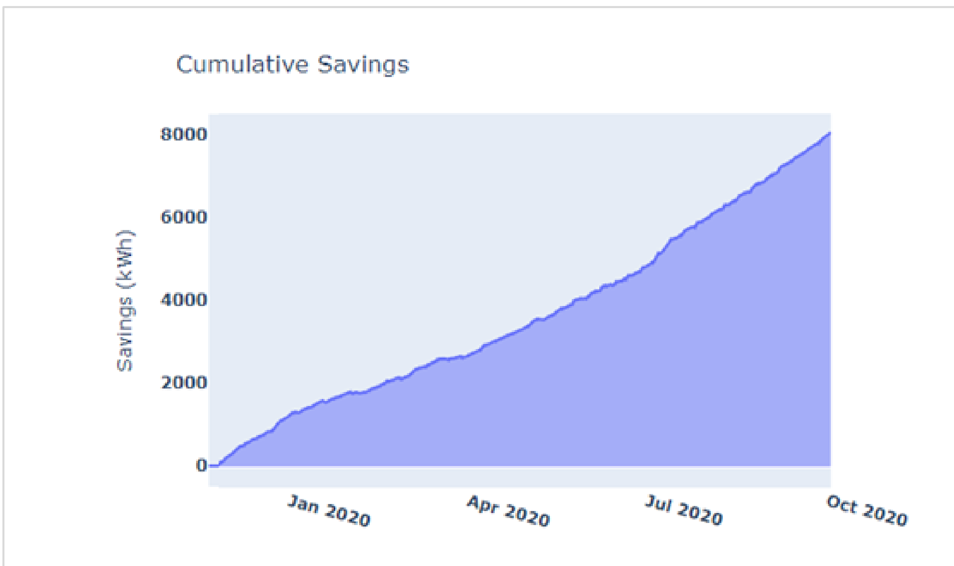

Figure A- 9: CUSUM of Savings after NRA is Applied

After adjusting for the NRE, the site's CV(RMSE) decreased to 0.15, the R^2 increased to 0.74, and the savings uncertainty increased slightly to 14%. The pre-post model's metrics over time are shown Table A- 3, and remained within acceptable ranges. The fact that the statistical metrics of the model did not change but the savings reverted closer to the estimate substantiates the need to monitor for NREs.

Appendix 5 EXAMPLE ADJUSTMENT FOR COVID USING A CUSTOM COVID INDEX*

*****The method used in this example does not adhere to IPMVP since a COVID index is not directly tied to site specific energy use (i.e., is an unvalidated proxy variable).

This example[22] is for an office building planning a major upgrade to the heating and cooling system. The baseline energy data for the facility was available in hourly increments, but only since the end of 2019 due to a utility meter upgrade. Unfortunately, this was just four months prior to COVID impacting the site's energy use. The site planned to use an advanced regression-based model based on daily electrical consumption (kWh), so this was the only baseline energy data available. A baseline energy model was developed that included both pre-COVID data and COVID-impacted data.

The actual daily energy use for the baseline period is shown in Figure A- 10 in black, predicted energy use in blue, and the model residuals in green and red. shown. Data prior to mid-March is at typical pre-pandemic levels, then following the COVID impact actual daily energy use reduced drastically for several weeks followed by slow climb up to a somewhat steady but still reduced 'new normal' in following months.

Note that although the statistic shown in Table A- 4 may appear (marginally) acceptable, the accuracy of the model is obviously diminished by including these different operating modes. The model fails to track the COVID-related changes and as such overestimates post-pandemic use levels. These over-predictions would likely carry over into the project savings calculations, resulting in an apparently "failed" energy savings project.

Twenty appropriate peer facilities ('buddy buildings') were identified using energy use data and other site-specific details within the portfolio of EMIS projects managed to develop a custom COVID index for this office building. Advanced regression-based energy models were constructed for each of the selected buddy buildings using only pre-COVID data.

Predictions for the post-COVID period using actual weather conditions are computed and compared to actual post-COVID energy use to determine the site's change in energy consumption (i.e., COVID-impacts). The ratio of actual energy to baseline energy for each data point (e.g., day) is determined and the results from the selected buildings are averaged for each timestamp. This percent of normal metric is the 'Custom COVID index' for the project. The COVID index was added as new variable in the baseline model and proved to be statistically significant per NRA Method #3, and improved model fit statistics as shown in Table A- 4.

Table A- 4: Statistical Metrics for Original and Adjusted Baseline Energy Models

Statistical Metric	Original Model	Adjusted Model
Cv (RMSE)	23%	9.5%
R^2	43%	90%
RMSE	1,007	415

[22] Example provided by Greg Anderson and Mark Shahinian from Gridium.

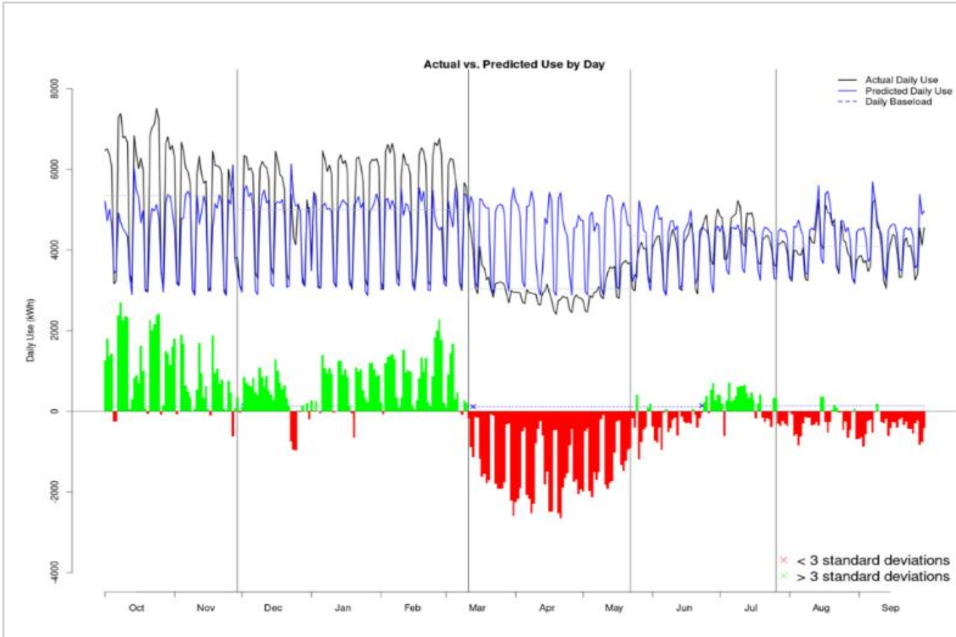

Figure A- 10: Energy Consumption and Predicted Baseline Energy Before Accounting for COVID

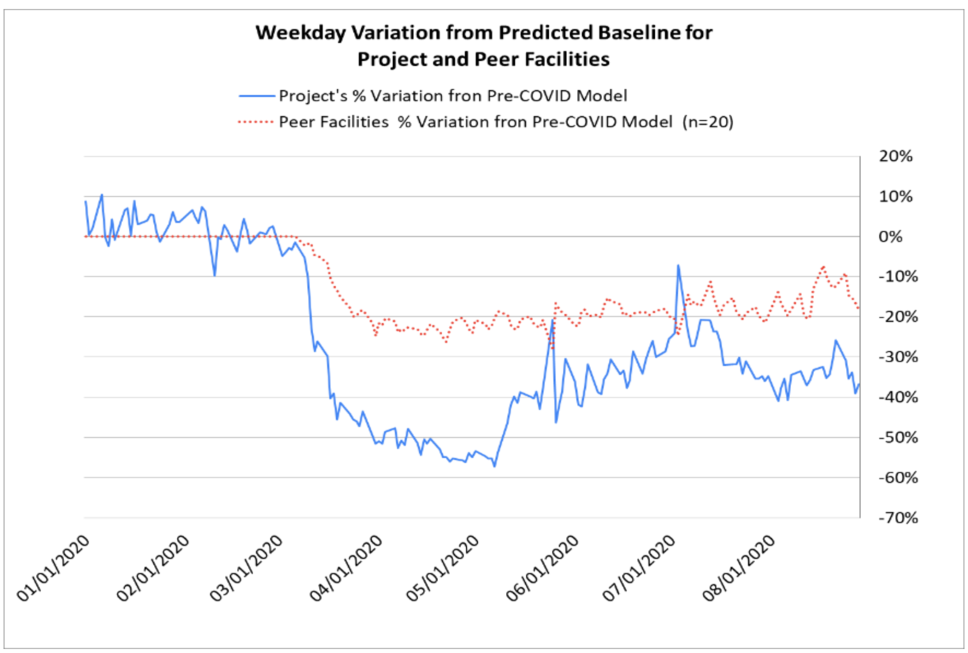

Figure A- 11: Custom Index Based on Average Deviation in Peer Facilities' Energy Use from Adjusted Baseline Models

Figure A- 12 below shows the actual daily energy use (grey lines) and the updated adjusted baseline energy (blue lines) in kWh for this specific office facility project. Using the index as a variable significantly improved the baseline energy model's statistics shown in Table A- 4, and the improvement is evident during the periods with dramatic COVID impacts.

The Custom Covid Index for this facility will be maintained over the course of the M&V effort. This includes:

- Maintaining energy models by monitoring and validating any NREs (e.g., EEMs implemented) for the project site and the selected buddy buildings.
- Periodically verifying the continued statistical significance of the COVID index as a variable in a reporting period model using recent data.

This method works well in this instance because the selected 'buddy buildings' are all participating in ongoing energy management efforts that use regression-based energy models and include regular communications and site level access.

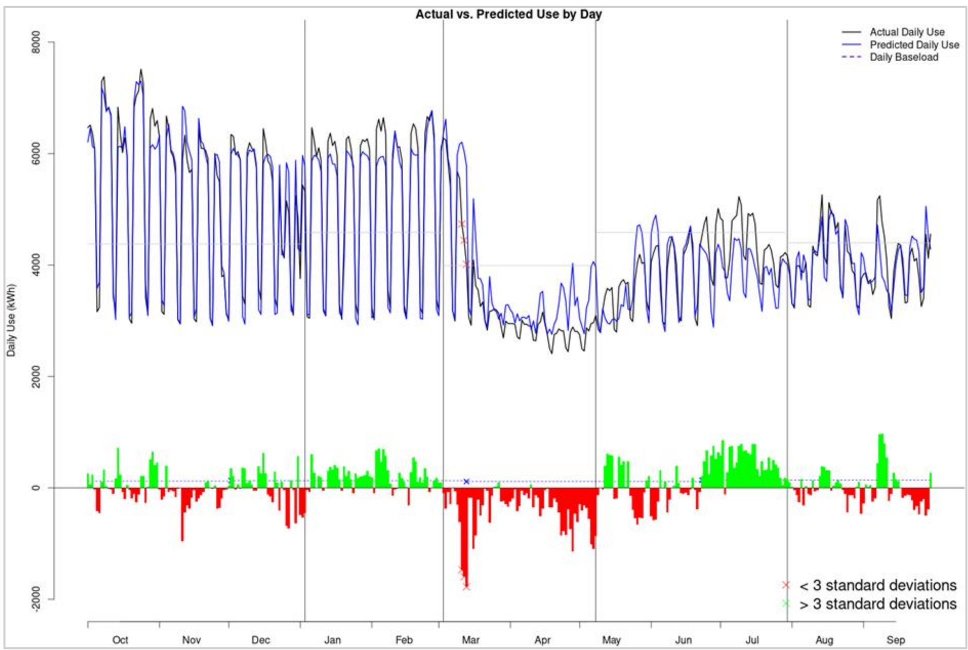

Figure A- 12: Actual Energy Consumption and Adjusted Baseline Energy after Accounting for COVID

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