Role of Demand Response Baselines
In Estimating Participant Impacts

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Introduction

Demand Response in Wholesale Electricity Markets

This presentation addresses changes in demand response wholesale market measurement and verification, and baseline rules in various jurisdictions.

- The purpose is to anticipate possible rule changes and to frame future program designs.
- It also tracks changes in market rules in other organized markets.
- The three East Coast ISOs/RTOs are of particular interest because they have the most developed capacity and energy markets in which demand response plays a significant role.
- The Federal Energy Regulatory Administration’s rules governing wholesale baselines are modeled in part on manuals at ISO New England and PJM Interconnection.
What is the Challenge?

A baseline calculation is a counter-factual, or pure theoretical, mathematical estimate of what a customer *would have done* during a DR event.

*So the question is, what is the best baseline?*

Baseline calculations that are accurate and unbiased are among the most challenging aspects of DR programs, as they can only estimate the counterfactual.

**Well designed baseline**
- Results in accurate load impact estimates.
- Properly compensates customers for load reductions.

**Poorly designed baseline**
- Can deprive customers of just and reasonable compensation, resulting in dissatisfaction and loss of participation.
- Can reduce the benefits of DR resources and devalue the overall cost effectiveness of programs.
Role of Baselines

Baseline Basics

DR performance depends on the baseline calculations which means that the methodology needs to be as accurate as possible.

- Two techniques for calculating baselines are day matching and regression analysis. Day matching is the most commonly used and is the subject of this discussion.

- Day matching involves constructing a baseline day that most accurately matches the actual DR event day.

- The ideal baseline will balance accuracy, simplicity and integrity.

- Baselines designed exclusively for accuracy (regressions) can be too complex and vulnerable to manipulation.

- Ultimately, the baseline will serve as the primary tool for measurement that forms the basis for settlement payments to the customer who provided the resource.
Baseline Basics

DR programs offer customers who are able to curtail load the opportunity earn financial incentives for reducing electric consumption in response to a signal from the ISO/RTO.

- Customers respond to DR events called by the ISO/RTO. An event is the time period during which demand resources are expected to perform.

- Measurement of customer load reductions during DR events requires two key pieces of information – the baseline and actual metered use.

Load Reduction = Baseline – Actual Use

<table>
<thead>
<tr>
<th>Load Reduction</th>
<th>Baseline</th>
<th>Actual Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>The mathematical difference between the baseline and actual electricity use.</td>
<td>The amount of energy the customer would have consumed absent a signal to reduce.</td>
<td>This is the amount of energy the customer actually consumed during the DR event period.</td>
</tr>
</tbody>
</table>
Role of Baselines

**Baseline Basics**

A baseline is an estimate of the electricity that would have been consumed by a demand resource in the absence of a demand response event.

- The baseline is compared to the actual metered electricity consumption during the demand response event to determine the demand reduction value.

- DR providers are incentivized by ISOs/RTOs based on the extent to which they can demonstrate load reductions.

- This analysis is confined to baseline rules for dispatchable DR programs in these markets.

Source: NAESB
Role of Baselines

Baseline Uses

As DR plays an increasing role in organized markets baselines are becoming a more important element in determining the magnitude of curtailment and settlement values. Baselines and M&V can have implications for grid operations, financial settlement between parties and ISO/RTO planning.

Grid Operations
Magnitude of demand savings that a DR resource will deliver to the electric grid.

Financial Settlement
Magnitude of curtailment by customer, as estimated by the baseline, determines financial settlement.

ISO/RTO Planning
Amount of DR expected from enrolled resources. Includes comparison with alternate grid resources.
Context

Curtailment Service Providers

End-use retail customers have access to wholesale electricity market through agents known as curtailment service providers (CSPs) or aggregators.

- Curtailment service providers, also known as DR aggregators, are a key intermediary between the customer providing a demand resource and the ISO/RTO.

- DR aggregation firms vary in size and focus. They can include load-serving entities, firms whose primary focus is profiting from DR payments, and vendors who profit from the sale of proprietary energy management or enabling technologies.

- DR aggregators have differing relationships to customers and to enabling technologies. One of the most important advantages of engaging aggregators is leveraging their marketing expertise.

- They can bundle several program options under one brand and funnel participants into the appropriate program in a manner that is seamless and invisible to the customer.

- Few customers are in the business of curtailing electric load. Customers use CSPs because they streamline the logistical process of participation.

- All of the ISO/RTO baseline programs studied permit aggregation.
FERC is the regulatory authority for organized electricity markets, and is responsible for establishing DR baseline rules. Individual ISOs/RTOs have somewhat different baseline rules that comply with their specific FERC tariffs. This study considered East and West Coast ISOs/RTOs.
Development of M&V Rules

Federal Energy Regulatory Commission

FERC requested that the North American Energy Standards Board develop M&V standards for DR in organized markets.

- The purpose was to develop a common standards framework for transparency, accountability and consistency across regional electricity markets.

- The NAESB collaborative stakeholder process was an attempt by FERC to bring together diverse stakeholders. This was a departure from previous FERC actions that were not well coordinated with states.

- Standards are developed through a formal process in which NAESB working groups prepare draft documents. These move up through the NAESB organization for review and revision. Final NAESB standards are submitted to FERC as recommendations for its consideration.
Development of M&V Rules

**Federal Energy Regulatory Commission**

**Phase 1**
- NAESB completed phase 1 M&V standards and they were approved by FERC in 2010.
- ISOs/RTOs updated their tariffs to comply.

**Phase 2**
- Phase 2 was initiated by FERC to provide additional specificity and regional uniformity.
- NAESB submitted draft standards to FERC in May 2011 and stakeholder comments were filed with FERC in July 2012. Utilities and ISOs/RTOs generally supported the draft standards, while numerous other parties had objections to certain elements of the NAESB recommendations.
- A FERC decision is anticipated by year end.

NAESB phase 2 standards provided additional specificity on:
- **Baselines**
- **Telemetry (pre- and post-event)**
- **Meter data reporting**
- **Advanced notification**
- **Technical issues**
The most active participants in the NAESB wholesale DR working group developing M&V and baseline rules have been:

**ISOs/RTOs**
- ISO New England
- PJM
- ERCOT
- Midwest ISO

**Utilities**
- Southern California Edison
- Southern Company
- BGE
- DTE Energy
- Northeast Utilities
- Duke Energy

**DR Aggregators**
- EnerNOC
- Comverge
- ECS
- North America Power Partners LLC

**Miscellaneous**
- ACES Power Marketing
- NEP
- TVA
Industry Rulemaking

Other M&V Protocols

FERC is not the only organization that has put forth industry M&V protocols. Many protocols have been developed over the years starting in the 1990s with the first generation of utility demand-side management programs and federal contracting procedures for efficiency upgrades in government buildings.

Interest in national standards for M&V has accelerated following the National Action Plan for Energy Efficiency in 2005. A new period of rapid growth is underway with developing markets for DR and EE, as well as smart grid build-out.

Many of these documents have been updated since their initial release dates shown here.

DR Event Day Chronology

DEMAND RESPONSE EVENT

DEPLOYMENT PERIOD
- ADVANCE NOTIFICATION(S)
- DEPLOYMENT
- REDUCTION DEADLINE

RAMP PERIOD
- Time at which a demand resource begins reducing usage.

SUSTAINED RESPONSE PERIOD
- Time at which a demand resource meets its demand reduction value obligation.

RECOVERY PERIOD
- Time at which the System Operator specifies the deployment period is ending.
- RELEASE/RECALL
- NORMAL OPERATIONS
- Time at which a demand resource returns load usage to normal levels.

Source: NAESB
Performance Methodologies

**Baseline Types**

The elements of a good baseline are accuracy, integrity and simplicity. Baselines use historical interval meter data, and may include other variables such as weather or conditions in the facility in the hours prior to the DR event.

FERC specifies five performance methodologies that may be used to estimate savings from DR resources. **Baseline type 1 is the most prominent in DR programs today and the subject of this analysis.**

- **Baseline Type-I**
- **Baseline Type-II**

**Non-baseline performance evaluation methods:**

- Maximum Base Load
- Meter Before / Meter After
- Metering Generator Output
Baseline Types

Baseline Type 1

Baseline type 1 is the most commonly used baseline method for performance measurement of demand resources in ISO/RTO markets.

- Type 1 baseline is based on historical interval meter data for each demand resource.
- It may also include other variables such as weather and calendar data on the day of the event.
- Statistical sampling of sites is not permitted.
- Day-of DR event adjustment to minimize baseline error.

Prepared by EnerNoc and presented to NAESB, October 8, 2009
Baseline Types

**Baseline Type 2**

Baseline type 2 is a performance evaluation methodology that uses statistical sampling to estimate electricity consumption of an aggregated demand resource that was dispatched by the ISO/RTO.

- Type 2 is used in cases where interval meter data is not available for individual sites. The need for type 2 baselines will diminish as interval meters become more commonplace.

- Statistical sampling techniques are used to generate a baseline for a portfolio of customers.

- This can be used when a group of sites (especially residential) are homogenous with similar load behavior. A few sites can be metered in order to develop an average load estimate per site, and then use this to allocate load from the aggregated baseline.
Non-Baseline Performance Evaluation

**Maximum Base Load (non-baseline)**

Maximum base load is a performance evaluation methodology based solely on the ability of a demand resource to reduce to a specified level of electricity demand.

- MBL is sometimes referred to as the *Drop To* method. It is superior for highly variable loads that do are not appropriate for baseline style programs.

- This method should use coincident peak hours to capture approximate load reductions during DR events.

- This is not a baseline estimation method.

Source: NAESB
Non-Baseline Performance Evaluation

Meter Before/Meter After (non-baseline)

Meter Before/Meter After is a performance evaluation methodology in which electricity demand over a prescribed period of time prior to DR deployment is compared to similar readings during a sustained response period.

- The load shape for this performance metric is static.
- Meter data from individual sites is utilized.
- It relies on a small interval of historical meter data.
- This is not a baseline estimation methodology.

Source: NAESB

Customer reduced load by ~40 kW during Sustained Response Period
Baseline Characteristics

X of Y Baselines

The most commonly used DR baselines are in the “X of Y” family. These baselines are used to help calculate how much load customers actually reduced during DR events.

- X of Y baselines are a performance evaluation methodology based on historical interval meter data for a demand resource. They use data for the Y most recent days preceding a DR event. A high X of Y baseline uses meter data from a specified X number of days with the highest load within the set of Y days.

- These baselines are popular for program settlement because they are intuitive and less costly than the alternative baseline approach using regression analysis.

<table>
<thead>
<tr>
<th>Y Value</th>
<th>The specified Y value includes a specified number of days prior to a DR event, often between 5 and 10. This one element of the set used to construct a customer baseline.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X Value</td>
<td>The Y group of days may be narrowed down to a subset of X days for a better representation of the DR event day. For example, a high 4 of 5 baseline would evaluate the previous five days (excluding weekends, etc.) and select the four with the highest load. An average 10 of 10 would include the last 10 qualifying days.</td>
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Baseline Characteristics

**X of Y Baselines**

X of Y baselines are continually refreshed with recent meter data to reflect normal operations specific resources. Baseline will reflect an average or highest load day over a specified number of days prior to the event.

- **Averaging**: This considers all of the days in the look back window and averages usage for each hour. A 10 of 10 baseline is an example of this method.

- **Highest**: This identifies the highest usage days over a specified period prior to an event. A high 4 of 5 baseline would use the 4 highest load days over the past 5 days.

Source: CAISO

Baseline using average of most recent 5 weekdays *(5 of 5 baseline)*
Baseline Characteristics

X of Y Baselines

A variation on the X of Y baselines described above is ISO New England’s ten day rolling average baseline.

ISO-New England 10 Day Rolling Average

Actual Usage

Adjusted Baseline

Baseline (Average of 10 prior non-event business days)

Source: ISO-NE
Loads Unsuitable for Baseline Analysis

**Highly Variable Loads (HLV)**

DR resources that have highly variable load patterns pose a problem for baseline analysis because historic meter data can be an unreliable indicator of event day usage.

- Baseline errors from HLV customers are problematic because they carry over into load impact estimates of performance and create settlement errors.

- In a study performed for the California PUC, HLV customers were defined as those whose average variability around their mean use in the event window is 30% or more. One quarter of DR customers were found to fit this definition, with substantial variation by program and industry type.

- Customers with irregular baselines are most common in agriculture, construction, other utilities, schools and sometimes manufacturing. A preferred DR performance methodology for these customers would be the Guaranteed Load Drop.

> **PJM Interconnection market rules handle this problem by requiring that customers be screened for HVL to participate in a baseline program.**
Baseline Adjustments

Day of DR Event Adjustments

Baseline measurement accuracy can normally be improved with adjustments that capture circumstances on the day of the DR event.

- A study by Lawrence Berkeley National Laboratory concluded that applying a morning adjustment factor significantly reduces bias and improves accuracy of baseline load profiles. Numerous other studies, including those performed for the PJM, ISO-NE and the California ISO have corroborated this finding.

- Such adjustments use actual load data in the hours prior to the event to adjust the X of Y baseline. Adjustments may reflect weather conditions, changes at a facility or other information.

- Adjustments may be capped or uncapped. Capped adjustments limit the magnitude of a baseline adjustment.

- Customers with highly variable loads typically have the most irregular load profiles and require the largest adjustments. The better option is for such customers to transition to a non-baseline style program.

- Adjustments are capped at many ISOs/RTOs, including CAISO, ISO-NE and NYISO. PJM does not cap adjustments but pre-screens customers for highly variable loads to limit the need for large adjustments.
Baseline Adjustments

Event Day Adjusted and Unadjusted Baselines

Source: CAISO
Baseline Adjustments

**Pre-event hours**

Baseline rules specify the pre-event timeframe, typically between two and four hours preceding a DR event, used to calculate baseline adjustments.

- Pre-event hours should not overlap with the ramp period because this could penalize customers for early curtailment.
- Pre-event hours normally exclude the hour or half hour prior to the DR event.
- The pre-event timeframe refers to the day of a DR event, whereas a look back window refers to the number of days prior to the event used to construct the X of Y baseline.

*For example, ISO-NE and New York ISO and the California ISO all specify a two hour pre-event window. PJM Interconnection market rules specify a four hour pre-event period. All of these ISOS/RTOs specify a period of time immediately prior to the DR event (ramp period) that is not included in this computation.*
Baseline Adjustments

**Symmetric versus Asymmetric Adjustments**

Baseline adjustments on the day of a DR event may be either symmetric (baseline adjusted up or down) or asymmetric (baseline adjusted up only).

Symmetric: Considers that day of event conditions can impact baseline kW in either direction. This permits downward adjustment that can be damaging to customers at settlement but is generally more accurate.

Asymmetric: Asymmetric baseline adjustments are one directional. They are simpler and more friendly to customers who do not want to be penalized for taking early actions to curtail load on event days.

*For example, the three East Coast ISOs/RTOs and California ISO all use symmetric baseline adjustments.*
Baseline adjustments based on day-of event conditions may be either multiplicative or additive.

### Multiplicative (X×Y)
Multiplicative adjustments are based on a percentage comparison. If load in the designated hours prior to the event is 20% higher than the baseline, then each baseline interval is multiplied by 120%.

### Additive (X-Y)
Additive adjustments are based on the actual difference between the baseline and the adjustment. If load in the designated hours is 20kW above the baseline, then 20kW is added to each interval in the baseline.

For example, the New York ISO and California ISO market rules specify multiplicative adjustments, whereas PJM Interconnection and ISO-NE specify additive adjustments.
M&V Settlement

Teasing Settlement Payments from Profiles

The elements of baselines are brought together in this illustration of a DR event day. In this case the adjusted baseline captures circumstances on the day of the event and better reflects the actual resource provided than the unadjusted baseline would have captured.

Prepared by EnerNoc and presented to NAESB, October 8, 2009
Thank you!

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