4 Simplified M&V Guidelines for Constant Load Motor Measures

4.1 Overview

This measurement and verification (M&V) method is appropriate for projects involving existing motors serving a constant load being replaced with higher efficiency motors of equal or lesser capacity (horsepower). The rated efficiency of the new motor must exceed the minimum efficiency standard defined in the Table of Standard Motor Efficiencies in Appendix B to be eligible for the program. Potential retrofit equipment includes:

- Constant load chilled water, hot water, or condenser water pumps
- Constant speed exhaust, return, and supply fans without dampers or pressure controls
- Single-speed cooling tower fans
- Constant load industrial processes
- Similar capacity, constant speed, energy efficiency motors
- Smaller, constant speed, energy efficiency motors when the existing motor is oversized

These M&V procedures are not appropriate for motor change outs that are accompanied by:

- Changes in operating schedule
- Changes in operating hours
- Changes in flow rate
- Changes in motor controls (except VSDs)

If the proposed retrofit does not meet the constant load requirements, or involves scheduling or operational changes, refer to the *Full M&V Guidelines for Generic Variable Loads* in Chapter 7 for appropriate M&V techniques.

In the C&I Standard Offer Program, the calculation of demand and energy savings for motor replacements is based on the baseline and post-installation kW, the difference in efficiency of the baseline and new motors, and the motor operating hours. The operating hours are assumed the same for existing and new motors. The baseline motor efficiency is based on the minimum efficiency rating defined by the Table for Standard Motor Efficiencies in Appendix B. The Table of Standard Motor Efficiencies is categorized by motor size and rotation speed. No incentive payments are made for replacement motors with efficiencies equal to or less than the baseline efficiency. In addition to having a higher efficiency than baseline motors, all new motors should meet minimum equipment standards as defined by state and federal law.

The recommended M&V approach for motors includes some or all of the following data collection activities:

- Compiling inventories for existing and new motors
- Short-term metering of existing motors to verify constant loading (if warranted)

- Spot metering of all existing and new motors
- Short-term metering of a sample of the new motors to determine operating hours

4.2 Determination of Baseline Operating Characteristics

The M&V steps that characterize the existing motors are:

1. Pre-installation equipment survey (to be conducted by the Sponsor)

- Spot measurement of demand (kW), and short-term metering of existing motors, where needed (to be conducted by the Sponsor)
- Pre-installation inspection (to be conducted by CenterPoint Energy or its contractor)

4.2.1 Pre-Installation Equipment Survey

The Sponsor should conduct a pre-installation survey to inventory the equipment to be replaced and record data about each motor in the Motor and VFD Inventory Form. Motor location and corresponding facility mechanical plans should be included with the survey submittal as part of the Final Application. At a minimum, the surveys should include the following for each existing motor:

- Motor name
- Load served
- Motor location
- Operating schedule
- Equipment manufacturer
- Nameplate data including model, horsepower, and speed

The baseline motor efficiency should be determined from the Table of Standard Motor Efficiencies based on the existing motor data provided in the Final Application.

Any M&V activities that need to be conducted prior to the demolition of existing equipment (i.e., short-term measurements) should take place at this time. **Demolition of existing equipment and/or installation of new equipment cannot begin until baseline M&V activities are completed, the pre-installation inspection is completed, and CenterPoint Energy has approved the Final Application and issued a Project Authorization.**

4.2.2 Spot and Short-term Measurement of Existing Motors

To establish the baseline kW, the Sponsor must conduct spot measurements of the power draw of the existing motors. If the constant load criterion cannot be verified by visual inspection, then short-term metering of the power draw or current (amperes) of the existing motors may also be required.

The verification of constant motor loading by short-term metering is warranted in situations where the effect of piping, valves, controls, or processes on motor load is uncertain. A motor load is considered to be constant if **90%** of all non-zero observations are within **±10%** of the running average kW. If short-term metering demonstrates that the proposed retrofit does not meet the constant load definition, then the Sponsor should refer to the *Full M&V Guidelines for Generic Variable Loads* in Chapter 7 for appropriate M&V techniques.

To compensate for the variations in spot measurements that occur even in constant-load motors, the Sponsor may need to develop normalization factors for groups of like motors serving similar loads. A normalization factor is the ratio of a motor's average current (from short-term metering) to its spot measured current. CenterPoint Energy may require the use of a normalization factor for projects with a group or groups of identical motors.

The minimum efficiency standard for the existing motor type is listed in the Table of Standard Motor Efficiencies. If the efficiency of the existing motor is greater than or equal to the minimum efficiency standard, then the baseline demand is equal to the spot measured value. If not, then the baseline demand is calculated according to Equation 4.1.

Equation 4.1:

$$\text{Baseline Demand [kW]} = \frac{\text{Existing Motor Efficiency}}{\text{Standard Minimum Efficiency}} * \text{Spot Measured Existing Motor Demand [kW]}$$

4.2.3 Pre-Installation Inspection

CenterPoint Energy will conduct a pre-installation inspection to verify that the existing condition is as reported in the pre-installation equipment survey in the Final Application. CenterPoint Energy will require the Sponsor to make any necessary corrections to the Final Application based upon the results of the inspection.

Demolition of existing equipment and/or installation of new equipment cannot begin until the pre-installation inspection is completed and CenterPoint Energy has approved the Final Application and issued a Project Authorization.

4.3 Document Post-Retrofit Operating Characteristics

The M&V steps that characterize the new motors are:

1. Post-installation equipment survey (to be conducted by the Sponsor)

- Spot measurements of the power draw (one-hour average values) of all the new motors (to be conducted by the Sponsor)
- Post-installation inspection (to be conducted by CenterPoint Energy or its contractor)
- Short-term metering of operating hours for a sample of existing motors (to be conducted by the Sponsor)

4.3.1 Post-Installation Equipment Survey

The Sponsor shall conduct a post-installation equipment survey and record data about each motor in the Motor and VFD Inventory Form. The survey shall reflect the actual, as-built conditions of the project. The post-installation survey will be included in the Installation Report.

4.3.2 Spot Measurements of Motor Demand

The Sponsor must conduct spot measurements of the power draw (one-hour average values) of each new, high-efficiency motor in order to establish the post-installation demand. The Sponsor will report the measured kW as part of the Installation Report.

4.3.3 Post-Installation Inspection

Once CenterPoint Energy receives the Installation Report for the motor project, CenterPoint Energy or its contractor will conduct a post-installation inspection to verify that the equipment specifications are correctly reported in the Installation Report. CenterPoint Energy will require the Sponsor to make any necessary corrections to the Installation Report based upon the results of the inspection.

4.3.4 Short-Term Metering of Motor Operating Hours

Baseline motor operating hours are assumed to be the same as post-installation operating hours, and should be determined after new motor installation. Short-term metering is used to determine both pre- and post-installation operating hours.

After CenterPoint Energy approves the Installation Report, the Sponsor should begin short-term metering of motor operating hours. The metering must be conducted for a minimum period of one week, or a sufficient amount of time to capture the full range of operation. The motor annual operating hours are calculated from the metering data according to Equation 4.2.

Equation 4.2:

$$\text{Annual Operating Hours [hrs/yr]} = \frac{\text{Motor On-time during Metering Period [hrs]}}{\text{Length of Metering Period [hrs]}} * \text{8,760 [hrs/yr]}$$

For projects in which a large number of equal-sized motors with the same application and operating schedule will be replaced, metering may be conducted on a sample of the motors and the results extrapolated to the applicable population. If this approach is adopted, CenterPoint Energy will assist the Sponsor in selecting the motors to be metered.

The Sponsor should include electronic copies of the unprocessed data files as part of the Savings Report.

4.4 Calculation of Peak Demand and Energy Savings

Demand savings are calculated for equipment that operates during the summer peak period, which is defined as weekdays between the hours of 1 p.m. and 7 p.m. from May 1 through September 30. The peak demand savings and energy savings are calculated according to Equation 4.3 and Equation 4.4, respectively.

Equation 4.3:

$$\text{Peak Demand Savings [kW]} = \text{Baseline Demand [kW]} - \text{Spot Measured New Motor Demand [kW]}$$

Equation 4.4:

$$\text{Energy Savings [kWh]} = \text{Peak demand savings [kW]} * \text{Annual Operating Hours [hrs]}$$

The Sponsor reports the peak demand and energy savings to CenterPoint Energy in the project Savings Report.

Example

A constant-speed process motor at an agricultural processing plant will be replaced with a smaller, high-efficiency motor. As indicated on its nameplate, the existing motor is a 200 hp, 1800 RPM enclosed motor with a nominal efficiency of 0.91. This motor will be down-sized to a 150 hp motor with a nominal efficiency of 0.96.

As the first step in the M&V, a spot measurement of the existing motor was made and indicated a power draw of 165.3 kW.

The minimum efficiency standard for the existing motor is 0.95 (as given in the Minimum Standard Motor Table) which is greater than the efficiency of the existing motor; therefore, the baseline demand is calculated according to Equation 4.1.

(a) Baseline motor demand = (0.91/0.95) * 165.3 **= 158.3 kW**

Following installation of the new motor, a spot measurement was made, and indicated an average, one hour, power draw of 117.9 kW.

Post-installation metering of operating hours was then conducted for a one-week period. The metering results show that the motor was operating for 81 hours out of the 168 hours in the metering period. The annual operating hours were calculated using Equation 4.2, as shown below.

(b) Annual operating hours = (81/168)*8760 **= 4224 hrs**

The peak demand savings and energy savings were then calculated using Equations 4.3 and 4.4, respectively, as shown below.

(c) Peak demand savings = 158.3 - 117.9 **= 40.4 kW**

(d) Annual energy savings = 40.4 * 4224 **= 170,650 kWh**

4.5 Variable Speed Drives on Constant Baseline Motors

Installing variable-speed drive (VSD) controllers on motors that serve a constant baseline load requires a modified motor M&V procedure. In order to qualify for the CenterPoint Energy 2004 C&I Standard Offer Program, VSDs must be installed in conjunction with other energy efficiency measures that deliver demand as well as energy savings. Potential retrofit projects that might include VSDs include:

- Converting constant air volume (CAV) systems to variable air volume (VAV)
- Retrofitting central chiller plants
- Replacing standard efficiency electric motors with high efficiency models

Motors that are scheduled for the installation of VSDs follow the same **Determination of Baseline Operating Characteristics** described earlier in this chapter. If the efficiency of the existing motor is greater than or equal to the minimum listed in the Table of Standard Motor Efficiencies, then the baseline demand is equal to the spot measured value; if not, then it is calculated according to Equation 4.1.

After the VSD and associated project retrofit has been installed, the Sponsor will again **Document Post-Retrofit Operating Characteristics**. The **Post-installation equipment survey** and the **Post-installation inspection** procedures are the same as described earlier in this chapter.

After CenterPoint Energy has conducted a post-installation inspection and approved the project Installation Report, the Sponsor should begin short-term metering[1] of the power draw (kW) of the motors. The data must be recorded at intervals of 15 minutes or less. However,

[1] Long-term monitoring may be required for motors with non-uniform or unpredictable load patterns.

averaged one-hour values are used in the calculation of demand and energy savings. For calculating peak demand, the metering must occur during the summer peak period.

The duration of the metering period must be sufficient to capture the full range of motor operation. If the motor load varies only on a daily basis and not seasonally, then a metering period of one week is generally sufficient. If the motor load or operating hours vary with weather or other seasonal parameters (e.g., production schedules, school calendars), then at least two weeks of metering during each operating period is generally necessary. For example, if the motor serves cooling equipment, then the metering should occur for at least two weeks during the winter months and two weeks during the summer months.

The metering data are used to determine three values:

2. **Peak summer period demand (kW):** Equal to the maximum-recorded peak summer period demand (one hour average values, where the summer peak period is defined as weekdays, between the hours of 1 PM and 7 PM, from May 1 through September 30).

3. **Average demand (kW):** Equal to the average recorded demand. For motors with seasonal load patterns, the average demand should be weighted according to the relative length of each seasonal period (see VSD example).

4. **Annual operating hours:** Calculated from the metering data according to Equation 4.5. For motors with seasonal load patterns, the annual operating hours should be weighted according to the relative length of each seasonal period.

Equation 4.5:

$$\text{VSD Annual Operating Hours [hrs/yr]} = \frac{\text{Motor On-time during Metering Period [hrs]}}{\text{Length of Metering Period [hrs]}} * 8{,}760 \text{ [hrs/yr]}$$

For projects in which a large number of equal-sized motors with the same application and operating schedule will be replaced, M&V may be conducted on a sample of the motors and the results extrapolated to the applicable population. If this approach is adopted, the utility Program Manager will select the motors to be metered.

The peak demand savings and energy savings are calculated according to Equation 4.6 and Equation 4.7, respectively.

Equation 4.6:

$$\text{VSD Peak Demand Savings [kW]} = \text{Baseline Demand [kW]} - \text{Peak Summer Period Demand [kW]}$$

Equation 4.7:

$$\text{VSD Energy Savings [kWh]} = (\text{Baseline Demand [kW]} - \text{Average Demand [kW]}) * \text{Annual Operating Hours [hrs]}$$

VSD Example

The constant air volume ventilation system at a commercial office building will be converted to a variable air volume (VAV) system. The conversion involves retrofitting four 50 hp supply fan motors with variable speed drives (VSDs). Additionally, the existing motors will be replaced with premium efficiency motors. The M&V procedures for a single motor are illustrated below. In general, the same procedure would be followed for all four motors.

A spot measurement of the power draw of the existing motor was made and gave a reading of 42.3 kW. The nameplate on the existing motor indicates that it is an 1800 RPM, enclosed motor with a nominal efficiency of 0.92. From Appendix B, the mininum efficiency standard for this type of motor is 0.93; therefore, the baseline demand is calculated according to Equation (a)

(a) Baseline demand = (0.92/0.93)*42.3 = 41.8 kW

Because the motor load is weather dependent, short-term post-installation metering must be conducted during both summer and winter months. Thus, after the new motor and VSD are installed, short-term metering of the motor's power draw (kW) is conducted for two weeks in January (winter) and two weeks in July (summer).

The metering data indicates that the peak (one hour) summer period demand was 37.6 kW. The average demand during the January metering period was 5.3 kW, and the average demand during the July metering period was 19.8 kW. The summer and winter periods are assumed to account for equal portions of the year; therefore, the metering results are weighted evenly for the two periods. Thus, the average demand is 12.6 kW.

The metering data indicates that motor was operating for 88 hours during the 336-hour January metering period, and for 110 hours during the 336-hour July metering period. As discussed above, the results from the two metering periods are weighted evenly; thus, the annual operating hours are calculated as shown in Equation (b).

(b) Annual operating hours = [(88/336+110/336)/2]*8760 = 2581 hours

The peak demand savings and energy savings for this motor are calculated according Equations (c) and (d), respectively.

(c) Peak demand savings = 41.8-37.6 = 4.2 kW

(d) Energy savings = (41.8-12.6)*2581 = 73,365 kWh