SUMMARY GUIDE:

Engineering Calculations with Verification Protocol

BONNEVILLE POWER ADMINISTRATION

OVERVIEW

Bonneville Power Administration's (BPA) *Engineering Calculations with Verification Protocol* (ECwV) uses engineering algorithms to estimate baseline and post-installation energy use of equipment, systems, or buildings. Savings are the difference in estimated electricity consumption between the baseline and post-installation scenarios.

Engineering calculations:

- Are either developed in spreadsheets (e.g., Excel) or in energy simulation modeling software (e.g., eQUEST)
- Are based on the physics of systems
- Do not require measured energy use
- Require field verification and true up of calculations
- Accuracy of savings estimates can vary and depend on data and assumptions used
- Are intended for use on smaller projects

WHEN TO USE

- Measures saving less than 400,000 kwh/yr
- New construction / major renovations
- Retrofit or replacement of existing equipment
- Equipment and system operations are well understood
  - Values of key operating parameters
  - The relationship of important variables to other driving variables
- The measure's impacts on the system are well understood
- Knowledge of the system to which the measure applies
- Knowledge of the physics underpinning how the measure saves energy
- Equipment-level energy measurements are not feasible

WHEN NOT TO USE

- Physics of system performance are not clearly defined
- Operational details of system or equipment are not documented

PROCEDURE

Collect Data

Step 1: Describe the process and energy efficiency measure:

- Baseline conditions
- Post-installation conditions

Gather project related data:

- Existing and new system design and specifications
- Operational data

Pre-Installation

Step 2: Establish baseline annual energy use (kWh / year)

- Use existing or code conditions

Step 3: Estimate post-installation annual energy use (kWh/year)

Step 4: Calculate energy savings (kWh/year)

Post-Installation

Step 5: Measure verification

- Inspections, measurements, functional testing, trend logs

Step 6: Adjust estimated energy savings

- True up assumptions

REPORTING REQUIREMENTS

- Detailed descriptions of the project and efficiency measures. The description(s) should contain:
  - Sufficient detail to clearly understand the processes involved
  - The proposed savings measure details
  - How the measure will achieve the stated savings
- Detailed energy savings calculations should include:
  - Step by step descriptions
  - Details of the data used
  - Input and output details from software simulations
- Documentation may include pictures, field notes, equipment specifications, vendor quotes, calculation files, and written reports

TIPS

- Use accepted algorithms or well known software
- Annotate assumptions and equations used
- Conduct spot measurements or use available trend data
- Use equipment specifications (e.g., pump & fan curves, manufacturer specifications)
- Double check work!

TOOLS & RESOURCES

- **Weather Data:** NREL's TMY3 Weather Data
- **Software Tools:** Energy Plus, EQuest, ECAM, DOE software tools
- **Guidelines:** IPMVP, state building energy codes (OR, WA), ASHRAE, AHRI

APPLICATION SPECIFIC CONSIDERATIONS

Within the ECwV Protocol there are two calculation approaches considered:spreadsheet based engineering calculations and simulation models. Each approach has some specific requirements and considerations summarized below.

	SPREADSHEET CALCULATIONS	SIMULATION MODELS
Overview	Engineering estimates of system or equipment energy use are developed for the baseline and post-installation scenarios.	Software models of a system or whole building are developed to estimate energy use for the baseline and post-installation scenarios.
Analysis	Calculations made in spreadsheets (e.g., Excel) based on hourly analyses or annual temperature bins (8,760 hours).	Software simulating a whole-building (e.g., EnergyPlus, DOE-2 / eQUEST) or of system-level (e.g., pump tool) is used.
Use Cases	• Use for equipment or system-level retrofit or replacement projects in existing facilities • Correlations in site-specific operations and independent variables can be developed • Savings originate from a single piece of equipment or system • Savings are largely from controls changes • Method and data to calculate savings is available	• Use for new construction or major renovation projects • Correlations to real data cannot be developed • Measures affecting envelope loads or with other complex interactions • A simulation model already exists • Zone loads need to be estimated
Approach	Equipment level estimates of energy use based on known engineering relationships (e.g., air flow vs. fan speed, efficiency vs load) and site specific system data.	Building or system-level estimates of loads and energy use based on engineering relationships (e.g., air flow vs. fan speed, efficiency vs load) are used with site specific system data.
Savings	Savings are the difference in estimated electricity consumption between baseline and post-installation scenarios.	One simulation model is developed (e.g., baseline) and then modified to represent the change in conditions (e.g., post-installation).

EXAMPLES OF ENGINEERING CALCULATIONS

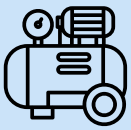
The ECwV Protocol includes four examples of how the protocol is applied to different types of energy savings projects.

Example 1

Scope:
New air compressor and dryer with increased capacity

M&V Approach:
Engineering Calculations using a publicly available software tool

Reference:
ECwV pg. 53



Example 2

Scope:
New windows and HVAC system at an elementary school.

M&V Approach:
Simulation Approach for an Existing Building using eQuest

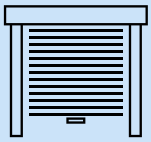
Reference:
ECwV pg. 58

Example 3

Scope:
Installation of high speed rollup doors.

M&V Approach:
Engineering Calculations using a vendor supplied software tool

Reference:
ECwV pg. 61

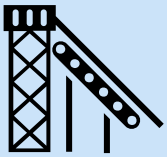


Example 4

Scope:
More efficient configuration of conveyor systems

M&V Approach:
Engineering Calculations using a custom spreadsheet

Reference:
ECwV pg. 70



BPA RESOURCES

BPA Measurement and Verification Resource Library

Engineering Calculations with Verification Protocol

M&V Protocol Selection Guide and Example M&V Plan