BC hydro
powersmart

# Measurement & Verification Report

# Version #01

# British Columbia Institute of Technology

**BCIT Burnaby Campus – 3650 Willingdon Avenue, Burnaby, B.C. V5G 3G9**

**BCH 00114**

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Reviewed by: Aron Garrecht [AScT, PMP, CEM, CMVP]

Power Smart Measurement & Verification

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| Version | Description | Version Author | Revision Date |
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| #1 | M&V Final Report | Aron Garrecht / Jagdeep Sekhon | |
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# 1. Executive Summary

In 2013, an energy conservation project was completed at British Columbia Institute of Technology in Burnaby, B.C. This report is focused on presenting the energy savings after upgrading existing make up air units and exhaust fans with Variable Frequency Drive (VFD) controls.

An analysis has been performed to verify that the expected electrical savings from these retrofits are being achieved. The results from this analysis are shown below.

**Table 1.1 Energy Savings**

| ECM | Initial Review (IR) Annual Electricity Savings[1] | Site Inspection (SI) Annual Electricity Savings[1] | Verified (M&V) Annual Electricity Savings[1] |
|---|---|---|---|
| #1: Adjustable speed drive on fan | 603,000 kWh | 575,000 kWh | 683,000 kWh |
| **Totals:** | **603,000 kWh** | **575,000 kWh** | **683,000 kWh** |

[1]Rounded to nearest 1,000 kWh

# 2. Project Overview & Background

In 2013, the British Columbia Institute of Technology (BCIT) implemented an energy-efficient project at their facility in Burnaby, B.C. This project consisted of upgrading existing make up air units (MAUs) and exhaust fans with Variable Frequency Drive (VFD) controls.

Before the project implementation, the five (5) main make up air units at BCIT's NE08 (welding training building) were direct fired and each unit had an integrated constant volume exhaust fan with a stack that exhausts the air up. All MAU units were turned on via a timer located on the wall in the vicinity of the service areas. The fan system typically operated the entire duration (Monday to Friday, from 7 am to 10 pm and 8 am to 4 pm on Saturday).

This project consisted of the following Energy Conservation Measure (ECM):

- **Adjustable speed drive on fan:** This ECM involved replacing the existing five (5) make-up air units (MAUs) and their associated exhaust fans with new MAUs equipped with variable frequency drive (VFD) controls. This ECM also involved implementing DDC controls with differential pressure sensor to monitor the flow.

**Table 2.1 Equipment List**

| Equipment List | Equipment Size | Annual Hours of Operation [Baseline] | Control Type [Proposed] |
|---|---|---|---|
| Exhaust Fan #1 | 40 hp | 4,200 | VFD |
| Exhaust Fan #2a | 25 hp | 4,200 | VFD |
| Exhaust Fan #2b | 25 hp | 4,200 | VFD |
| Exhaust Fan #3 | 40 hp | 4,200 | VFD |
| Exhaust Fan #4 | 25 hp | 4,200 | VFD |
| Exhaust Fan #5 | 20 hp | 4,200 | VFD |
| Exhaust Fan #6 | 10 hp | 4,200 | VFD |
| Exhaust Fan #7 | 5 hp | 4,200 | VFD |
| DC #1 | 15 hp | 4,200 | VFD |
| DC #2 | 15 hp | 4,200 | VFD |
| Supply Fan #1 (MUA) | 25 hp | 4,200 | VFD |
| Supply Fan #2 (MUA) | 25 hp | 4,200 | VFD |
| Supply Fan #3 (MUA) | 25 hp | 4,200 | VFD |
| Supply Fan #4 (MUA) | 25 hp | 4,200 | VFD |
| Supply Fan #5 (MUA) | 30 hp | 4,200 | VFD |

# 3. M&V Methodology

As defined by BC Hydro and referred to in the BC Hydro Power Smart Incentive Agreement, the BC Hydro Project completion date enables the start of the Measurement & Verification (M&V) period. The M&V consists of at least one year of post project operations plus additional time to perform other related activities.

A detailed utility bill analysis was performed to measure the electricity savings resulting from this project. The guidelines used to perform these measurements were taken from the International Performance Measurement & Verification Protocol (IPMVP), and the Federal Energy Management Program (FEMP). Both of these guidelines recommend that an "M&V Option C" methodology be used to monitor savings in a project with a project scope such as this. The Option C usually involves collecting historical whole facility baseline energy use data, and the continuous measuring of whole facility energy use after ECM installation.

# 4. Analysis

The electricity savings for these measures were calculated by taking the most current one year period before implementation as a representative year of typical electricity consumption [baseline]. That electricity consumption was then used to create a model to estimate or simulate what the electricity consumption would have been for the first year following the retrofit *(May, 2014 to April, 2015)* had the retrofit not occurred. This data was then compared to the current actual electricity consumption correcting for any variables that may affect consumption outside the scope of the project, and the difference is the savings.

**Table 4.1 Project Model Timelines**

| Model | From | To | Duration |
|---|---|---|---|
| Base Year | February, 2012 | January, 2013 | 1 year |
| Performance Year | May, 2014 | April, 2015 | 1 year |

The table-4.2 and graphs in Figure-4.1 and 4.2 illustrate:

- A graphical savings chart showcasing the monthly baseline consumption trend compared against the current year consumption trend
- A chart summarizing the savings resulting from the installed measures on a month by month basis.

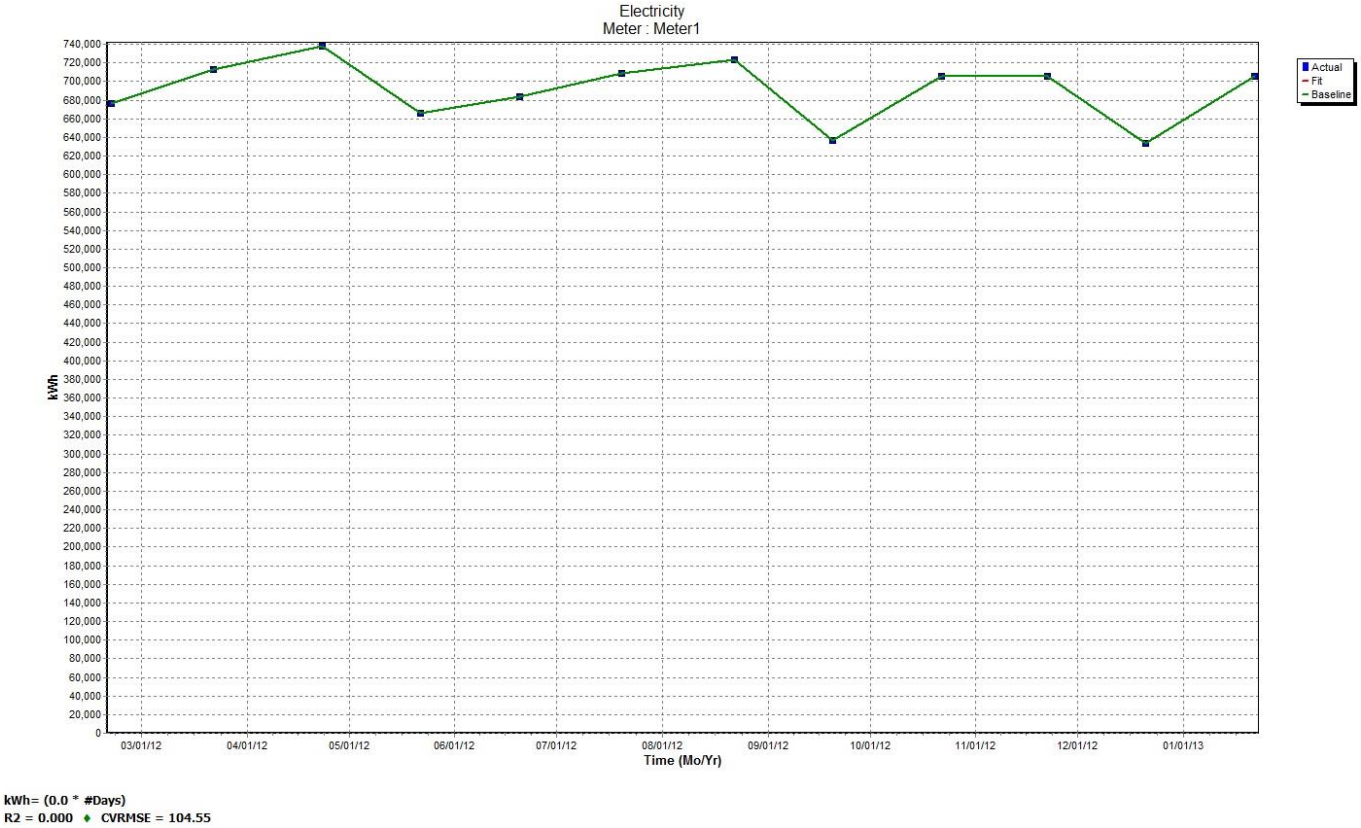


**Figure 4.1 Baseline Model**

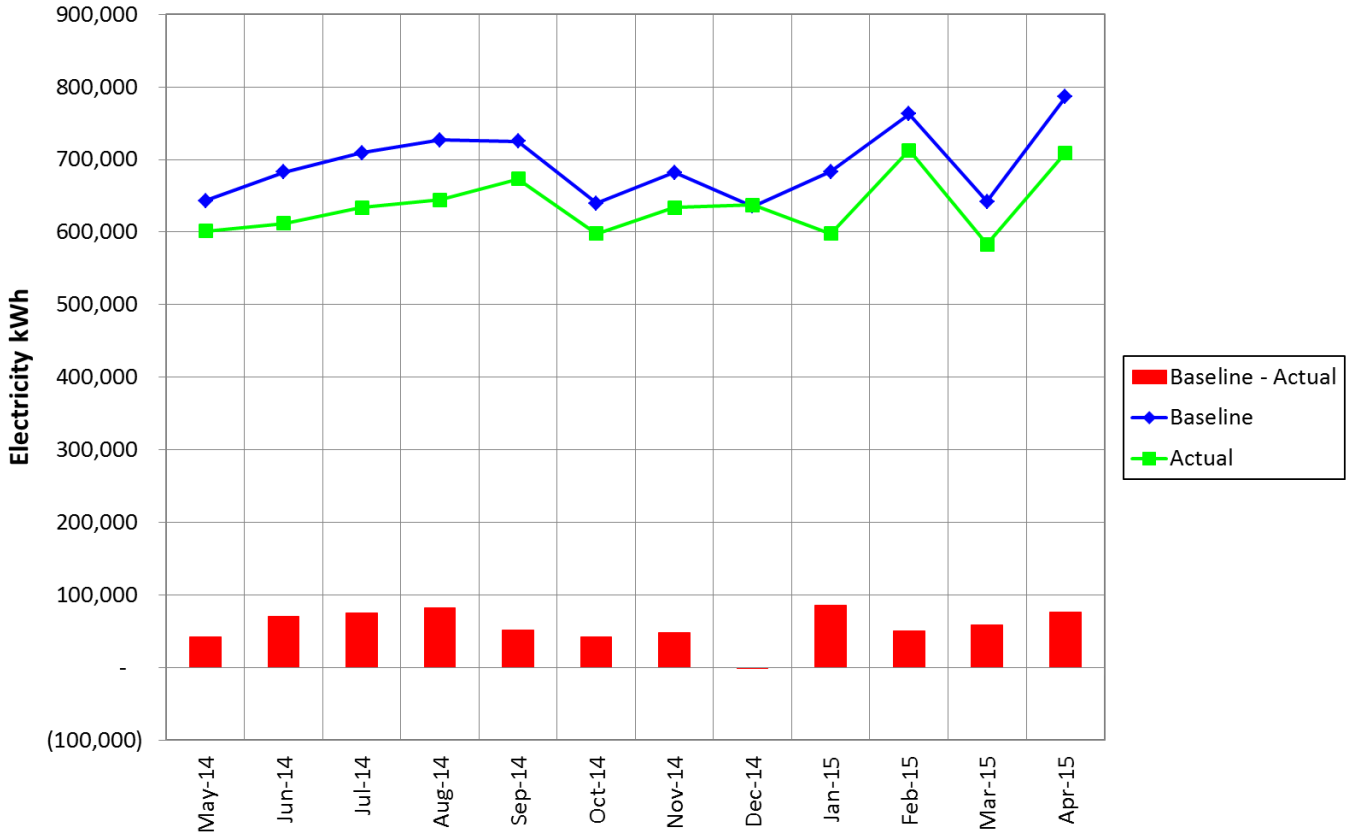


**Figure 4.2 Actual Savings Resulting from All Measures**

**Table 4.2 Baseline Energy, Adjusted and Savings**

| Month & Year | Baseline Energy (kWh) | Performance Period Energy (kWh) | Savings: Baseline - Performance (kWh) |
|---|---|---|---|
| May, 2014 | 643,132 | 601,200 | 41,932 |
| June, 2014 | 682,759 | 612,000 | 70,759 |
| July, 2014 | 709,093 | 633,600 | 75,493 |
| August, 2014 | 727,025 | 644,400 | 82,625 |
| September, 2014 | 725,155 | 673,200 | 51,955 |
| October, 2014 | 639,450 | 597,600 | 41,850 |
| November, 2014 | 682,127 | 633,600 | 48,527 |
| December, 2014 | 635,426 | 637,200 | (1,774) |
| January, 2015 | 683,147 | 597,600 | 85,547 |
| February, 2015 | 762,826 | 712,800 | 50,026 |
| March, 2015 | 641,917 | 583,200 | 58,717 |
| April, 2015 | 786,218 | 709,200 | 77,017 |
| **Totals:** | **8,318,273** | **7,635,600** | **682,673** |

# 5. Forensic Review

Upon initial review of the savings for this project, it was determined that this project is in fact performing better than anticipated. The original savings for all measures within the scope of this project were estimated to be 603,000 kWh per year. Based on the results of the analysis using billing data, and the baseline model shown in Figure-4.1, actual savings for this project are measured to be 682,673 kWh per year as indicated in the chart (*Figure-4.2: Actual Savings Resulting from All Measures*) and Table-4.2 (*Baseline Energy, Adjusted and Savings*) in section 4 (Analysis).

# 6. References

1) **Energy Study Report** [J:\CC&C\PS Projects\Commercial\BCH-XXX\BCH Projects\BCH-0XXXX\BCH-00114 INC BCIT\BCH- 00114 BCIT- INC\1-Application]

2) **Initial Review (IR)** [J:\CC&C\PS Projects\Commercial\BCH-XXX\BCH Projects\BCH-0XXXX\BCH-00114 INC BCIT\BCH- 00114 BCIT- INC\2-PSE IR]

3) **Measurement and Verification Plan** [J:\CC&C\M&V Shared\Projects\BCH 00114 - BCIT\MV Plan]

4) **Schedule B Document** [J:\CC&C\PS Projects\Commercial\BCH-XXX\BCH Projects\BCH-0XXXX\BCH-00114 INC BCIT\BCH- 00114 BCIT- INC\6-Install Docs]

5) **M&V Data Analysis** [J:\CC&C\M&V Shared\Projects\BCH 00114 - BCIT\M&V Analysis]

# Appendix A Measurement & Verification Plan

**BCIT Welding Shop**
**BCH 00114**

## 1. Customer M&V Responsibilities

### 1.1. Project Completion Documents

When the project has been installed and commissioned, BC Hydro will require the installation documents to be submitted which include:

- Schedule B: Installation Completion Document
- Schedule C: Invoice Reconciliation, Permits
- Schedule E: Customer Evaluation (for Demonstration Projects Only)

### 1.2. Site Inspection

BC Hydro may perform a site inspection to confirm the installation of the project Energy Conservation Measures (ECMs) as per the Power Smart Incentive Agreement (Schedule A). If a Site Inspection is required, the customer will be required to:

- Provide site access
- Provide site personnel to accompany the inspector if necessary

The site inspection may include (but is not limited to):

- Investigating performance issues with a particular piece of equipment
- Reviewing other factors which may impact savings that the customer may not be aware of
- Ensuring that the ECMs are installed and performing as intended.

### 1.3. Forensic Investigation

BC Hydro may perform a Forensic Investigation if the Option C billing analysis shows that the project is not performing as anticipated. If a forensic investigation is required, the customer will be required to:

- Provide site access to the investigator
- Provide site technical personnel to accompany the investigator if necessary
- Provide site specific data such as occupancy data, production data, operating data as applicable
- Advise any projects implemented during the pre-retrofit and post retrofit periods that may have an affect on the facility energy consumption

The above information is important as it allows BC Hydro to perform baseline adjustments which can dramatically impact the final savings figure.

## 2. Project Characteristics

**Site:**

| | | | |
|---|---|---|---|
| *Technical Contact:* | Alexander Hebert | *Phone Number:* | 604-451-7011 |
| *Facility address:* | 3650 Willingdon | *Location:* | Burnaby |
| *Facility type:* | College | *Annual consumption:* | 23.8 GWh |

**Power Smart:**

| | | | |
|---|---|---|---|
| *Technical Reviewer:* | Stan Ma | *BC Hydro Rep:* | Ron Mastromonaco |
| *M&V Author:* | Aron Garrecht | *M&V Author Phone* | 604-453-6273 |
| *M&V Plan Issue Date:* | 5/16/13 | *M&V Post Metering* | 1 Year |
| *Pre-metering:* | None | *M&V Revision Author:* | |

## 3. Project Savings

| ECM Description | Expected Annual Savings | IPMVP Option |
|---|---|---|
| 1. Adjustable speed drive on fan | 603,000 kWh | C |
| **Total expected annual savings:** | **603,000 kWh** | **C** |

# 4. Project Background

BCIT's NE08 Welding Training building contains a variety of welding equipment and associated processing equipment. There are five (5) main make up air units serving the building. These units are direct fired, constant volume 100% outdoor air units. Each unit has an integrated constant volume exhaust fan with a stack that exhausts the air up.

The arc welding booths are served by MAU-1, MAU-2 and MAU-3. The supply air is provided to the space at the west end of the rows of booths.

The material handling area is located at the south end of the building and is served by MAU-4.

The entry, foyer and oxy-acetylene welding areas are served by MAU-5.

This project involves replacing the five existing MAUs and their associated exhaust fans with new MAUs with variable flow capabilities, and implementing DDC controls with differential pressure sensor to monitor flow.

# 5. Measure Specific Implementation Details

## 5.1. General M&V Approach:

The determination of actual energy savings for this project will generally follow Option C, as defined in IPMVP Volume I, EVO 10000 - 1:2010

Option C: Whole Facility

This option is based on:

- Performing complex billing analysis using specialized accounting software on utility, sub-meter or whole-facility metering data. Option C typically requires 24 months of pre-retrofit billing data and 12 months of post retrofit billing data.

### 5.1.1. Analysis Method

IPMVP Option Used: C

### 5.1.2. Data Requirements

- Electrical billing for 24 months prior to retrofit. This information will be provided by BCIT for the welding building only as the meter data for the entire campus cannot be used due to the significantly higher consumption.

- Electric billing for 12 months post retrofit. This information will be provided by BCIT for the welding building only as the meter data for the entire campus cannot be used due to the significantly higher consumption.

- Degree-day data (if applicable)

### 5.1.3. Stipulated values supporting data

- None

### 5.1.4. Energy use calculation

The following calculation is the standard form of a multivariate regression model for a weather-dependent measure. The form will be adjusted to suit the specific project.

$$\text{KWh Usage}_t = B_1 + (B_2\ (T_i - T_1)) + (B_3 * HDD_i) + (B_4 * CDD_i) + (B_5 * X_1) + (B_6 * X_2) + (B_7 * X_3)$$

### 5.1.5. Metering and monitoring

- None (use utility data).

### 5.1.6. Baseline determination

- Derived from utility data.

### 5.1.7. Savings adjustments

- Savings will be adjusted for weather (as per the HDD/CDD in the regression model) and/or number of days in a billing period.

## 6. Date of M&V Report

- Final report 15 months after completion Date. This may be delayed due to forensic review complexity, and availability of information.

## 7. Disclaimer

The actual Measurement & Verification (M&V) methodology may vary from the M&V plan. BC Hydro reserves the right, in consultation with the customer, to determine and implement the M&V necessary to determine the electrical energy savings.