# Ice Rink Resurfacing Efficiency Pilot (IRRE)
# Measurement & Verification (M&V) Result

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## Executive Summary

FortisBC Energy Inc. have partnered with ten ice rinks to conduct a measurement & verification (M&V) pilot study on an emerging technology, the vortex technology, to maintain the ice surface using low temperature water. The vortex system is intended to remove air bubbles and filaments from the resurfacing water through cavitation before it is applied to the ice surface. Air bubbles and filaments cause the ice surface to be uneven and thus unfavorable or even unusable for ice sports. Ordinarily, resurfacing water is heated up to approximately 130 degrees Fahrenheit to achieve the desired result.

Resurfacing through vortex technology generates thermal and electricity savings through a:

- reduction in thermal energy by significantly reducing the need to heat up resurfacing water; and
- reduction in electricity for the operation of the ice rink refrigeration plant as
  - Vortex generated resurfacing water creates a lower refrigeration load as low temperature water is applied to the ice surface for the ongoing resurfacing and initial ice build up; and
  - the ice rink slab temperature is raised to allow the vortex generated resurfacing water freeze at an appropriate rate.

| Fuel | Measured Savings | % Savings (vs Adjusted Baseline)[1] |
|---|---|---|
| Natural Gas | 330 GJ/year | 79% |
| Electricity | 22,400 kWh/year | 28% |
| **Total** | **410 eGJ/year** | **58%** |

Natural gas savings results represent the average measured at eight of the ten pilot sites. Out of ten participants only one site (Arena 4) was not successful in overcoming operational challenges during the commissioning process. The natural gas savings at Arena 2 could not be evaluated due to operational circumstances.

Fortis Electric participated in this pilot project and facilitated the data acquisition at three sites to evaluate the electricity savings on the refrigeration plants. The electricity savings shown in the table above are electricity savings related to reduced refrigeration load resulting from using low temperature resurfacing water.

[1] % Savings = Measured Savings over Adjusted Baseline Consumption

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## 1 About FortisBC Energy Efficiency & Conservation

FortisBC Energy Inc. ("FortisBC") has developed Energy Efficiency & Conservation (EEC) incentive programs that are designed to support customers in managing their energy costs and reducing their carbon footprint. These programs have been successful in promoting the efficient use of natural gas, encouraging the adoption of low carbon alternatives, reducing energy costs for customers, and supporting government policy by reducing greenhouse gas emissions.

## 2 Project Overview

The operation of an ice rink requires an ongoing maintenance of the ice surface as activities on the ice surface may cause damage to the ice. This regular and ongoing ice surface maintenance is referred to as resurfacing. In preparation for the resurfacing, air bubbles and filaments must be removed from the resurfacing water before it is applied to the ice surface. Air bubbles and filaments cause the ice surface to be uneven and thus unfavorable or even unusable for ice sports. Ordinarily, resurfacing water is heated up to approximately 130 degrees Fahrenheit to achieve the desired result.

The objective of this M&V project is to evaluate the energy savings potential of a technology which reduces the need thermal energy to remove of air bubbles and filaments. A survey was conducted to identify customer acceptance and operational challenges. This technology is referred to as vortex and the product specified (REALIce) for this pilot is produced by the manufacturer Watreco.

The pilot is technology-focused and vendor-agnostic. Nevertheless, the pilot relied on the following process for filtering-out products that do not meet British Columbia safety requirements:

1. Vendors had to identify which provincial safety requirements their products must meet in order to be deployed in British Columbia. The pilot team directed vendors to CSA International and various local consulting companies for support with this task.
2. Step 1 did not yield any dedicated safety requirements for mechanical de-aerators as these represent a novel product class.
3. Vendors were instructed to demonstrate how their products will be acceptable to local code and safety inspectors via either obtaining an opinion from specific inspectors or demonstrating satisfactory test results from an ISO 9001-certified lab on the following product characteristics: pressure tolerance, heat tolerance, as well as hygiene and sanitation impacts.
4. In addition to the requirements of Step 3, only products that require installation of a backflow preventer were admitted as eligible technologies for the pilot.
5. In order to maintain integrity of the pilot schedule, vendors had to demonstrate that they met Steps 3 and 4 by September 20, 2013.

# 3 Pilot Participants

Ten ice rinks, as shown in Table 3-1, participated in the Ice Rink Resurfacing Efficiency Pilot. All of the participants have only one sheet of ice except for:

- Arena 4 — One training rink in addition to the full size NHL rink
- Arena 6 — One Curling rink in addition to the full size NHL rink. Curling rinks do not require resurfacing

Table 3-1 – Participants IRRE

| Participant | Ice Season Start | Ice Season End |
|---|---|---|
| **Arena 1** | 15-Sep-13 | 18-Mar-14 |
| **Arena 2** | 1-Jan-13 | 31-Dec-13 |
| **Arena 3** | 1-Jan-13 | 31-Dec-13 |
| **Arena 4** | 1-Sep-13 | 7-Apr-14 |
| **Arena 5** | 10-Aug-13 | 20-Apr-14 |
| **Arena 6** | 15-Aug-13 | 1-Apr-14 |
| **Arena 7** | 26-Aug-13 | 31-Mar-14 |
| **Arena 8** | 1-Aug-13 | 30-Apr-14 |
| **Arena 9** | 9-Sep-13 | 1-Apr-14 |
| **Arena 10** | 23-Sep-13 | 10-Mar-14 |

## 4 Technology Description

Vortex technology is a compact piping system which removes  air bubbles and filaments from the resurfacing flood water through cavitation instead of thermal activation.  The resurfacing water is forced through guide vanes creating a pressure gradient to separates air bubbles and filaments from the potable water. As a result, vortex-treated water does not have to be heated to the high temperature as traditionally done before applying the water to the ice surface.  This generates thermal and electricity savings through:

- reduction in thermal energy by significantly reducing the need to heat up resurfacing water; and
- reduction in electricity for the operation of the ice rink refrigeration plant as:
  - vortex generated resurfacing water creates a lower refrigeration load since low temperature water is applied to the ice surface for ongoing resurfacing and the initial ice buildup; and
  - the ice rink slab temperature is raised to allow the vortex generated resurfacing water freeze at an appropriate rate.

## 5 Project Timeline

Table 5-1 below outlines the measurement & verification (M&V) timelines:

Table 5-1 – Project timeline and M&V period[2]

| Participant | Baseline Period | Reporting Period |
|---|---|---|
| **Arena 1** | 27-Nov-13 – 8-Jan-14 | 16-Jan-14 – 10-Mar-14 |
| **Arena 2** | 12-Dec-13 – 8-Jan-14 | 12-Jan-14 – 20-Mar-14 |
| **Arena 3** | 3-Dec-13 – 8-Jan-14 | 15-Jan-14 – 17-Mar-14 |
| **Arena 4** | 12-Dec-13 – 7-Jan-14 | N/A |
| **Arena 5** | 10-Dec-13 – 7-Jan-14 | 10-Jan-14 – 13-Mar-14 |
| **Arena 6** | 10-Dec-13 – 7-Jan-14 | 10-Jan-14 – 13-Mar-14 |
| **Arena 7** | 3-Dec-13 – 6-Jan-14 | 21-Jan-14 – 17-Mar-14 |
| **Arena 8** | 5-Dec-13 – 9-Jan-14 | 15-Jan-14 – 15-Mar-14 |
| **Arena 9** | 3-Dec-13 – 2-Jan-14 | 4-Feb-14 – 12-Mar-14 |
| **Arena 10** | 12-Dec-13 – 30-Dec-13 | 16-Jan-14 – 10-Mar-14 |

[2] time period between end of baseline period and beginning of the reporting period is the adjustment period during which operational changes were carried out

Site specific comments:

- Arena 1, Arena 7 and Arena 9: temperature and pressure sensors were installed by Fortis Electric in the holding tank of the Zamboni to log the duration of the resurfacing event and temperature of the resurfacing water when it was applied to the ice surface.
- Arena 7: city water temperature was assumed to be the average of the two closest rinks (Kelowna and Nelson) as the temperature sensor was installed downstream of a shut off valve which is an inadequate to measure the city water temperature.
- Arena 5 and Arena 8: city water temperature was assumed to be the average of all sites as the temperature sensor was in an inadequate location.
- Arena 2: Reporting Period analysis could not be performed as the vortex installation required a manual switch over for the snow wash down which was performed using high temperature water.
- Arena 4: Reporting Period analysis was not performed as the facility reverted back to using hot water for resurfacing by the end of the reporting period.

# 6 M&V Results

Table 6-1 shows summary of the M&V Results as an average across all participants.

Table 6-1 – Summary M&V Results

| | Baseline | Adjusted Baseline | Reporting Period |
|---|---|---|---|
| **Number of Operating Weeks Per Year (#/year)** | 35 | | |
| **Number of resurfacing per week (#/week)** | 64 | 63 | |
| **Volume of Water per Resurfacing (Gal)** | 141 | 148 | |
| **City Water Temperature (°F)** | 45.27 | | 42.5 |
| **Resurfacing Water Temperature (°F)** | 131.0 | | 60.3 |

| | Baseline | Adjusted Baseline | Reporting Period | Verified Saving | Percentage Savings |
|---|---|---|---|---|---|
| **Thermal Energy for Resurfacing (GJ/year)** | 400 | 418 | 87 | 330 | 79% |
| **Refrigeration Energy for Resurfacing (kWh/year)** | 75,380 | 78,815 | 56,357 | 22,500 | 29% |

Note, the following

- baseline was derived by averaging the results of all ten participating facilities;
- reporting period was derived by averaging the results of eight facilities as described in section 5;
- refrigeration electricity savings was evaluated for the three sites with sensors installed in the Zamboni holding tank; and
- constants and assumptions as shown in Table 6-2 were applied in the analysis

Table 6-2 – Constants and Assumptions

| Constants | Value | Unit |
|---|---|---|
| **Heat Capacity Water** | 4.183 | kJ/kg K |
| **Latent Heat Water to Ice** | 344 | kJ/kg |
| **Heat Capacity Ice** | 2.0715 | kJ/kg K |
| **Coefficient of Performance Refrigeration Plant**[3] | 2.5 | Ratio energy out / energy in |
| **Efficiency Hot Water System (Hot Water Tank)**[4] | 60 | % thermal efficiency |

Following feedback was received in regards to ice quality and ice temperature:

Table 6-3 – Operator Feedback

| Site | Baseline | | | Reporting Period | | |
|---|---|---|---|---|---|---|
| | Ice Quality | Slab Thickness (inch) | Ice Temperature (°F) | Ice Quality | Slab Thickness (inch) | Ice Temperature (°F) |
| **Arena 1** | 2 | 1.25 | 15.8 | 2 | 1 – 1.125 | 20.3 |
| **Arena 2** | 2 – 3 | 1.25 – 1.75 | 24 | 2 | 1.375 – 1.875 | 24 |
| **Arena 3** | 2 | 1.75 | 15 | 2 – 3 | 1.25 | 17 – 19 |
| **Arena 4** | 2 | 1.375 | 16 | 2 | 1.375 | 18 – 20 |
| **Arena 5** | 2 | 2 – 2.375 | 13 | 3 | 1.75 - 2.5 | 16.5 |
| **Arena 6** | 3 | 1.25 – 1.5 | 20 | 2 – 3 | 1.25 – 1.5 | 22.5 – 24 |
| **Arena 7** | 3 | 1 – 1.5 | 23 | 2 – 3 | 1.5 | 24.5 |
| **Arena 8** | 2 – 3 | 1.5 – 1.75 | 17.5 | 2 – 3 | 1.25 – 1.5 | 20.5 – 23.5 |
| **Arena 9** | 2 | 1 – 1.75 | 16.5 | 2 | 1.25 | 19 – 20 |
| **Arena 10** | 2 | 1.15 – 1.45 | 17.6 – 19.4 | 2 | 1.38 – 1.5 | 20.3 – 21.2 |

The table above shows a summary of the daily and weekly logs which Zamboni driver and ice operators were required to fill out during the M&V period. Following observations were made:

[3] Comparitive Study of Refrigeration Systems for Ice Rinks, NRCan CanmetENERGY, July 2013 ftp://ftp.nrcan.gc.ca/pub/outgoing/nrcan-rncan/2013-143_RP-FIN_e_(Ref-2013-132)-VFinale-2013-08-15.pdf

[4] Ministry of Energy and Mines, Gas Water Heater Reference Table http://www.empr.gov.bc.ca/EEC/Strategy/EEA/Documents/Gas%20lookup%20table.pdf

- Ice quality was evaluated to be acceptable (2) to excellent (3) in both cases (before and after the retrofit). None of the sites indicated a significant drop or increase in ice quality
- Generally the ice slab thickness was marginally reduced; and
- An increase in ice temperature was required at almost all sites.

Further savings, not verified through this M&V project, are realized by:

- raising the slab temperature as part of the commissioning process to allow for an appropriate rate of freezing. A raise of almost 3°F in slab temperature was reported as an average across all facilities:
  - Sask Power suggests 2% - 4% reduction in electricity usage on the refrigeration plant by raising the slab temperature by 1°F to 2°F[5].
  - Manitoba Hydro suggests that with each degree Fahrenheit that the slab temperature is raised the load on the ice plant is reduced by up to 2%[6].
- reducing the slab thickness which results in reduced load on the refrigeration plant as less mass of ice needs to be kept at operating temperature. Both cited sources use the same graph to illustrate the savings potential[1,2]; and
- ice surface build up using low temperature water results in reduced loads on the refrigeration plant when the ice is generated at the beginning of the season.
- space heating required for arena due to the reduced cooling on the refrigeration plant.

## 7 Conclusion

The measurement & verification (M&V) project demonstrated that natural gas and electricity savings were achieved by using the Vortex Technology. It allows the facilities to resurface their ice rinks with low temperature water instead of the conventional approach with high temperature water. Mixing of hot water with cold water was required in most cases to generate a blended water temperature of approximately 60 F which is significantly lower than the conventional average resurfacing water temperature of 130 F.

Nine out of ten sites were successful in implementing the change of operating parameters which are required when using Vortex treated water for resurfacing. Sites which experienced challenges during the switch over period and proactively worked with the manufacture to resolve these issues were all able to overcome their challenges. Appendix C summarizes the findings of the commissioning of the Vortex technology.

[5] Sask Power, Municipal Ice Rink Program http://www.ceop.ca/rinks/ice-rink-best-practices/refrigerationice-plant/refrigerationice-plantice-slab-temperature-optimization/

[6] Manitoba Hydro: http://www.everything-ice.com/media/Resources/BOI-Publication.pdf

## Appendix A – Original and Quantified TRC Calculation Input

Comparison of TRC Calculation inputs between the original business case and the quantified results in this M&V pilot:

| Input | Original Business Case | M&V |
|---|---|---|
| Energy Savings – Natural Gas (GJ/year) | 380 | 330 |
| Energy Savings – Electricity (kWh/year) | 24,680 | 22,500 |
| Measure Life | 10 | 10 |
| Incremental Cost | | |
| Equipment (Vortex) | $29,000 | $28,933 |
| Incentives ($/unit) | $29,000 | N/A |
| Participant Investment ($/unit) | $0 | N/A |

## Appendix B – M&V Plan

# Measurement & Verification Plan
# For
# Ice Rink Resurfacing Efficiency Pilot

**Prepared by:** Market Development-Technical Group Revision Date: 22 Aug 2013

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## 1. Background

This project investigates the energy savings associated with Ice Rink Resurfacing methodologies and technologies in recreational facilities. Specifically we are looking at the energy benefits of adding a mechanical de-aerator to the Zamboni fill water system to allow colder water to be used for resurfacing without compromising quality of the ice surface.

Ice resurfacing is typically performed multiple times per day. Typically, ice resurfacing involves heating the water to approximately 140 deg-F in order to drive air or other dissolved gasses out of the water, i.e. to de-aerate the water such that it freezes faster and offers better ice characteristics than regular tap water. This de-aerated water is then used to resurface the ice with a Zamboni or other driven vehicle. This project investigates the feasibility of using a mechanical de-aerator to remove dissolved gasses without the need of using hot water. It is also claimed that a mechanical de-aerator is able to provide better ice crystal characteristics which improve the ice surface conditions.

The energy saving premise is twofold. First, the mechanical de-aerator will eliminate the energy (natural gas) needed to heat the water up to 140 deg-F. Secondly, it will eliminate the energy (electric) required for the refrigeration compressors and associated system to cool the heated water from 140 deg-F to 32 deg-F and eventually to ice.

In most facilities the ice is built at the beginning of season to about an inch or more of depth and is quite often made with cold water. While there are claimed to be some savings from the de-aerator manufacturers for the initial ice build, we will not be looking at that aspect in this experiment. The opportunity to build ice in most cases is just once a year so the opportunity for baseline and reporting period is limited and difficult to align with the program deadlines.

Ice resurfacing can be described as shaving and then flooding the ice surface to remove imperfections so that the ice returns to a smooth flat surface. As the Zamboni is driven across the ice, it shaves the ice using a blade to remove high spots and frozen imperfection, and floods the ice using a water feed at the back of the unit to fill cracks and gouges.

The typical arrangement in an ice rink is for hot water to be available near where the Zamboni or other brand of ice resurfacing machine enters the ice surface. Typically the Zamboni will fill anywhere up to 200 US gallons of hot water into an on-board reservoir some time before it enters the ice for resurfacing.

The mechanical de-aerator, if used, would be installed at the existing Zamboni water filling station on the wall between the water supply and the hose used to fill the Zamboni reservoir.

## 2. Measurement & Verification (M&V) Plan-Scope of Work

The purpose of this pilot is to verify the thermal energy savings associated with avoiding the use of hot water for ice resurfacing and the refrigeration energy savings associated with the lowered temperature and volume of resurfacing water. If the energy savings are proven and there are no other detrimental effects of the system, then the intent would be to encourage the integration of mechanical de-aerators in ice rinks throughout our service territory.

## 2.1 Energy Conservation Measures (ECM) Intent

For thermal energy savings, our intent is to measure and record the volume of resurfacing water used and the temperature rise from incoming cold water temperature to leaving hot water temperature to ascertain the amount of energy used to heat the Zamboni water.

For refrigeration energy savings, our intent is to measure the temperature of the resurfacing water at the time of resurfacing. The hot water flow data from the thermal energy measurements along with the Zamboni resurfacing water temperature will allow us to determine the amount of heat that is added to the ice surface. This can then be used to estimate the amount of electricity (i.e. the amount consumed by the compressors) necessary to remove that heat from the ice surface. For instance, if 50 kilowatt-hour (kWh) of hot water is applied to the ice and the existing refrigeration Co-efficient of Performance (COP) is 2.5, then 20 kWh (i.e. 50/2.5) of electrical energy usage could have been avoided by the refrigeration system.

Note that measurements on the refrigeration energy will only be performed at three participant sites within the FortisBC Shared Service Territory (SST). The refrigeration energy savings for participant sites outside of the SST area will be calculated separately.

## 2.2 Selected IPMVP Option and Measurement Boundary

IPMVP Option A Retrofit Isolation: Key Parameter Measurement will be used. There are two key parameters to be measured: Thermal energy (natural gas) avoided to heat the hot water and refrigeration energy (electric) avoided to remove the heat from the ice surface.

For the thermal energy savings, we will measure the water volume for each resurfacing event and the difference in temperature between the water entering the water heater and the water leaving the water heater. The measurement boundary will be the hot water heater and water pipe or hose used to refill the Zamboni water reservoir.

For the refrigeration energy savings, we will measure the water volume for each resurfacing event and the temperature of the Zamboni water reservoir as it is driven across the ice surface during resurfacing. The measurement boundary will be the

Zamboni water reservoir.

## 2.3 Baseline: Period, Energy and Conditions

The baseline period will be three (3) weeks of monitoring the existing resurfacing system, follow by the installation of the mechanical de-aerator, three (3) weeks of adjustment period to fine tune the variables that will need to be manipulated, and finally a three (3) weeks monitoring period of the new mechanical de-aerator resurfacing system. The typical ice rink season opportunity for monitoring is usually from September to April with some facilities operating for more months' right up to some facilities that provide ice surfaces year round.

## 2.4 Reporting Period

The reporting period will include baseline, adjustment, and new measure and should persist for a minimum of nine (9) weeks.

## 2.5 Basis of Adjustment

The difference between ground water temperature and temperature at the inlet to the hot water tank will vary from one facility to another depending on the design and distance between the water heater and the inlet of the city water. As long as we capture the actual energy expended by looking at the water temperature as it enters and leaves the water heater, we will accurately capture the energy usage although it will vary from one facility to another. It will be important in the reporting phase to identify this anomaly.

Some facilities utilize heat recovery from the refrigeration plant to augment other mechanical systems in the facility. In such case, we will be measuring the water temperature prior to entering the heat recovery section instead of prior to entering the water heater. This will ensure the total temperature rise necessary for the water is captured and the overall thermal energy required for ice resurfacing can be determined. Note that a second data-logger might be required depending on the location of the water pipe entering the recovery section.

If the existing water heater is supplying hot water to more than the one usage point then we will need to track the amount of water entering the water heater and the amount of water entering the Zamboni filling station for the baseline. Furthermore, we will need to capture the new cold water flow to the Zamboni filling station during the monitoring period.

To estimate the potential avoided natural gas energy from the measured thermal energy, an assumed efficiency of the water heater will be used.

To calculate the refrigeration energy savings, we will need the hot water temperature inside the Zamboni and the amount of hot water used during the ice resurfacing. This is because during each ice resurfacing, it is not necessarily that all hot water in the Zamboni reservoir will be used, thus it will be inaccurate to use only the capacity of the Zamboni reservoir will not be sufficient. As such, we will use the hot water flow data, measured at the water pipe or hose used to refill the Zamboni, to determine how much hot water is used to refill the Zamboni. This should be equivalent to how much hot water is actually used during the last ice resurfacing. We will also use a combination of water level / temperature logger to monitor the temperature and the water level inside the Zamboni reservoir. If the data recorded by the combination water level / temperature logger shows a drop in water level, it indicates ice resurfacing is occurring, thus the water temperature at that time in the Zamboni and the amount of water recorded during the next refill are taken for refrigeration energy saving calculations.

To estimate the potential avoided electrical energy from the measured refrigeration energy, an assumed COP of the refrigeration system will be used.

The average amount of energy used during the baseline period to freeze the resurfacing water will be compared to the average amount of energy required to freeze the resurfacing water using the mechanical de-aerator (cold water) during the post-retrofit period.

## 2.6 Energy Units

All reporting will be in energy units of mega joule (MJ) with kilo Watt hours (kWh) shown in parenthesis. For example: 108 MJ (30 kWh). 1MJ = 0.277777778 kWh, 1 kWh = 3.6 MJ

Savings will also be quantified by energy per volume of water per temperature unit, MJ/liter/C degree with BTU/US Gallon/F degree in parenthesis.

## 2.7 Meter Specifications

For the thermal energy: Hobo data loggers with Hobo temperature sensors and an Omega flow sensor will be used for water temperature and flow. The sampling rate will be set at 5 minutes in order to have sufficient resolution for each ice resurfacing, typically takes about 10 to 15 min each. In some facilities depending on system configuration (e.g. distance between DHW heater and the refilling station is large and/or the use of heat recovery), we may need additional Hobo data loggers (i.e. two additional if both scenarios exist) with flow and/or temperature sensors to ensure the total temperature rise is captured

Output of the flow meter and temperature sensors will be collected by data logger. Data will be retrieved from the data logger at appropriate intervals and collected in a secure and backed up location.

For the refrigeration energy: the flow data from the gas energy measurement will be used along with a Madgetech Level1000 data logger with temperature and water level sensor that will be placed at the bottom of the resurface machine water reservoir tank. The data logger has a temperature range of -40F to 176F (+/- 1F) and a level range of 0 to 30ft (+/- 2.5") with data storage for 16,383 samples each. For consistency with the gas energy data loggers, the sample rate will be set of 5 minutes. This recording interval should be frequent enough to capture the change in tank level and temperature when the Zamboni tank is refilled and resurfacing occurs.

For both thermal and refrigeration energy measurements, one download will be performed after the baseline period (after the first three weeks), and one download will be performed after the monitoring period (after the ninth week). This will ensure no data will be deleted by the data-logger if the storage memory is full.

## 2.8 Monitoring Responsibilities

**FortisBC Gas:**

Thermal energy (natural gas) monitoring equipment and data loggers will be ordered, coordinated, packaged, and tested for readiness, and eventually removed and inventoried by the FortisBC Gas Technical Solutions Group ("hereafter FortisBC Gas"). For participants in the shared service territory, FortisBC Gas will coordinate with FortisBC Electric PowerSense Group ("hereafter FBC Electric") to select and train the appropriate contractor(s) for installing and removing both the gas and electrical monitoring equipment. For participants outside of the shared service territory, FortisBC

Gas will select and train the appropriate contractor(s) for installing and removing the gas monitoring equipment only.

For participants inside the shared service territory, FortisBC Electric will download the raw data from the natural gas data-logger and email to FortisBC Gas. For participants outside of the shared service territory, this will be completed by the selected contractor(s). FortisBC Gas will ensure both FortisBC Electric and the selected contractor(s) understands the procedure of downloading raw data.

FortisBC Gas will also aggregate, compile, and manipulate both the gas and electric data in order to align the two sets of data with comparable timestamps. The two sets of data must have comparable timestamps so that the energy (gas & electricity) savings can be analyzed. FortisBC Gas will provide the aggregated data to FortisBC Electric for all electricity analysis.

FortisBC Gas is responsible to analyze and report on the gas savings for all participants. For participants outside of the shared service territory, FortisBC Gas will determine the electricity savings using engineering calculations and assumptions.

**FortisBC Electric (applies to participants within the shared service territory only):**

Refrigeration energy (electrical) monitoring equipment and data logging equipment will be specified, ordered, coordinated and tested for readiness, and eventually removed and inventoried by the FortisBC Electric. FortisBC Electric will coordinate with FortisBC Gas to select and train the appropriate contractor for installing and removing both the gas and electrical monitoring equipment.

FortisBC Electric will download the raw data from both the gas and electrical monitoring equipment. FortisBC Electric will forward all raw data (gas and electric) to FortisBC Gas. FortisBC Gas will provide training to FortisBC Electric on downloading the raw data from the gas monitoring equipment.

FortisBC Electric to coordinate with FortisBC Gas for the monitoring equipment specifications, data intervals, and data format, method of data collection, collection period, and engineering formulas to be used for analysis such that the two sets of data are inline and comparable. FortisBC Electric is responsible to deliver the measurement data for electricity to FortisBC Gas in a manner and format that is acceptable to FortisBC Gas, e.g. the two sets of data are able to be aggregated and manipulated with comparable timestamps so that the energy (gas & electricity) savings can be analyzed. FortisBC Electric will report on electric savings only.

## 2.9 Budget

**FortisBC Gas:**

Costs for one data logger site:

- Budget $500/site for configuring and testing existing data logger/temperature sensors with new flow meter
- Budget $200 for data retrieval shuttle
- Budget $200/site for site visits to identify monitoring equipment locations etc.
- Budget $1500/site for installation of the monitoring equipment
- Budget $200/site for commissioning, and trouble shooting
- Budget $500/site for removal of the monitoring equipment
- Budget $300/site for contingencies
- *Total budget $3400/site*

For additional equipment requirements, additional costs to above:

- For 2nd data logger - Budget an additional $500 equipment, $1000 installation & commissioning, $300 removal
- *Total additional budget up to $1800/site*

Budgets do not include costs for file manipulation, data analysis, and reporting.

We will be re-purposing some measurement equipment that was available after completion of 0.80 water heater pilot. This re-purposed equipment includes: Hobo data logger and case, temperature sensors, and a power supply all wired up, commissioned and mounted to a board. The value of this is approximately $2500 for equipment and $500 for connections, mounting and commissioning, for a total value of $3000

**FortisBC Electric (Three Sites in the FortisBC Electric Service Area):**

Costs for one data logger site:

- Budget $800/site for new data loggers
- Budget $800/site for installation of the monitoring equipment
- Budget $200/site for commissioning and trouble shooting of communication and operational parameters throughout the baseline and reporting periods
- Budget $500/site for removal of the monitoring equipment
- Budget $300/site for contingencies
- *Total budget $2,600/site*

## 2.10 Report Format

The M&V Reports should be prepared and presented as defined in the M&V Plan. Complete M&V reports should include at least:

- Observed data of the reporting period: the measurement period start and end points in time, the energy data, and the values of the independent variables.
- Description and justification for any corrections made to observed data.
- Energy units in mega joules (MJ) with kilo Watt hours (kWh) in parenthesis.
- All details of any baseline non-routine adjustment performed. Details should include an explanation of the change in conditions since the baseline period; all observed facts and assumptions, and the engineering calculations leading to the adjustment.
- Computed savings in energy and monetary units.
- A final report upon completion of the evaluation period illustrating overall findings, observations, assumptions, variances and results should include a detailed explanation. This report will be submitted to the BC Utilities Commission as supporting evidence of the evaluation and as such should respect the privacy of the participants by aggregating the results.

M&V reports should be written to their reader's levels of understanding.

## 2.11 Quality Assurance

Specify quality-assurance procedures that will be used for savings reports and any interim steps in preparing the reports.

## Appendix C – Observation Report

*Sustainability*

*Beyond*

*Boundaries*


# FortisBC IRRE Pilot Metering Project

## Measurement Period Observation Report

21st March 2014

Building Energy Solutions Ltd.

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# PROJECT BACKGROUND

## Project Background

BES – Building Energy Solutions Ltd was engaged by FortisBC Energy Inc. ("FortisBC") to install, commission, re-commission, and remove monitoring equipment for the Ice Rink Resurfacing Efficiency (IRRE) Pilot. This pilot program sought to validate savings claims, assess customer acceptance behavior, and identify any technical issues associated with the installation and operation of vortex mechanical de-aerator products in British Columbia (BC) ice arenas.

Vortex mechanical de-aerators can be inserted as an add-on to an ice arena's resurfacing flood water system. Vortex products utilize the existing kinetic energy of the pressurized water flow along with proprietary design features to mechanically de-aerate the flood water, reducing the requirement for heating this water in order to de-aerate it.

The pilot had three main objectives:

- Engagement of ice arenas which were considering efficiency upgrades to their existing ice resurfacing equipment and enrolling them into a pilot during which FortisBC will financially incent them to install a vortex product.
- Monitoring the operation and energy performance of the participants' existing ice resurfacing equipment during a period of time ("Baseline Period") in order to establish a benchmark.
- Monitoring the operation and energy performance of participants' ice resurfacing equipment during a set period of time ("Test Period") after the installation of the vortex product and comparing the data gathered with the benchmark established during the Baseline Period.

This report has been produced upon completion of the "Monitoring Period" and is intended to provide FortisBC with customer feedback and observations for of the Vortex Equipment.

# PROJECT OBSERVATIONS

## General Observations

BES – Building Energy Solutions Ltd noted the following General Observations appertaining to all of the selected arenas:

- Ice Making has a long tradition of using hot water (>120$^0$F) to clean and re-surface the ice. The Vortex De-Aerator comprises of a mechanical system that allows blended water to be used (55$^0$F). This goes against everything the arena operators have been taught, and therefore requires an amount of re-education and open mindedness.
- A typical Arena also has several Zamboni operators and it became evident that some embraced the technology quicker than other.
- The Vortex has factory supplied plastic unions. These were a cause for concern at all arenas as they were pre-fixed by the manufacturer and 90% of them leak. Due to warranty concerns, most arena's chose not to tighten the unions and the one that did actually broke the fittings. It was replaced with a brass fitting and no more leaks were found. This is something the manufacturer should look into.
- The project began mid-way through the season, which was not ideal. This resulted in the ice arenas having to scrape the already laid ice back to the depth required by REALice and then re-surface the arenas before the next booking.
- Due to the time it takes to resurface the arenas, there was a concern of a loss of revenue as they had to cancel some booking/skate times.
- Where arenas use a blend of hot and cold water to produce the 55$^0$F water for the Zamboni fill (REALice requirement), it is recommended to install a mixing valve. Where this is achieved with lever valves, it was generally found that there was a differential in hot and cold pressures which resulted in a difficulty in keeping a balanced supply temperature. Check valves could be installed to eliminate this, which is what was done, however it is felt that a mixing valve is the preferred option.
- With the installation of any new technology, there were a few teething problems, however with a proactive approach from REALice and communication between the arenas, these were generally rectified quickly.
- Generally the feedback was good and with the exception of Arena 4, all of the arenas talked to are looking forward to using the Vortex next season.

## Specific Site Observations

More specifically the following was noted on a site by site basis:

### Arena 2

- Arena 2 has a sand floor and has ice year round. Having a sand floor, instead of concrete requires the arena to use a thicker than normal ice thickness. The ice thickness is approximately 3".
- Utilization of the Vortex generally resulted in more ice shavings and more Zamboni time between skate times. This ice arena is forbidden to leave the shavings outside and must dispose of them via a snow melt pit in the arena. They currently use Domestic hot water for this. Unfortunately it was noted that they were using the Zamboni (metered) hot water to do this, even though an un-metered hose was installed less than 1ft away. This has impaired the results of the measurement period.

### Arena 1

- Arena 1 had favourable feedback for the quality of ice, however did note there were significant more shavings to dispose of. They monitored the water temperature to the Zamboni to try and reduce it as much as possible.

Arena 3

- Arena 3 uses heat pump (Ice Kube) technology to freeze the ice and recover the heat from the refrigeration heat rejection to heat the building. One advantage of the Vortex is that the ice temperature can be raised 6-8$^0$F. As a result, the refrigeration heat rejection reduces and during peak heating times, the arena felt that there may not be enough heating to the building. With the diligence of the operators, over the course of the pilot, this has balanced itself out, but should be considered at other arenas.
- This arena had water temperature balancing issues as described in the general comments, which were rectified with the installation of check valves.

Arena 4

- This arena experienced difficulties in maintaining good ice quality using the Vortex. They did confirm speaking to REALice and raising the ice temperature, however it was evident from the measurement logging and speaking to one (of four or five) zamboni drivers that they are still using approximately 120$^0$F water. The water temperature was raised several times during the measurement period.

Arena 5

- Arena 5 had good feedback for the Vortex. They mentioned that they were cleaning the ice less, especially during extended periods when the arenas first team trained. It is not clear how much savings they will actually have due to the fact that only DHW is supplied to the zamboni tank. Domestic cold water was taken from an adjacent area for the purposes of this project.

Arena 6

- Arena 6 also had favourable feedback and managed to use only domestic cold water (no blend) to produce the ice. It must be noted that it does use Well water which is slightly wamer than city water in the region. Arena 6 also logged the compessor runtime and hydo data and initial feedback showed approximately 8% hydro savings, in addition to the gas savings.

Arena 7

- Arena 7 had good feedback and were extremely happy with the ice quality. They continually monitored the water temperature and reduced the supply temperature to near city water temperature.

Arena 9

- Arena 9 had good feedback and were extremely happy with the ice quality. They continually monitored the water temperature and reduced the supply temperature to near city water temperature.

Arena 10

- Arena 10 had good feedback for the Vortex and were extremely helpful assisting other arenas with teething problems. They also monitoring the compressor loads and found substantial energy savings in the region of 15-20%.

Arena 8

- Arena 8 has been using 16 F water to produce ice and therefore had a few teething problems switching to lower water temperature. There was constant communication between them and Arena 10 to solve these problems. (ice tempeatue was aised, and some hot floods continued – these were not measured as they used a different DHW service).

## Appendix D – Survey Results

In addition to gathering data via sensors installed at the pilot sites, the pilot project was privy to participant information via Expression of Interest forms submitted by applicants, log sheets completed by the participants throughout the full duration of the pilot, a survey administered after the end of the pilot monitoring period, and follow-up questions on the survey for specific pilot sites.

This appendix displays select information gathered from the survey responses. The survey was administered by the FortisBC Customer Programs & Research group and received answers from 14 responses across the ten pilot sites. 90 per cent of pilot participants indicate that they intend to keep their vortex product after completion of the pilot.

The survey information is broken down by pilot period (baseline, adjustment, reporting) and by whether the results pertain to impacts on facility operations or ice quality characteristics.

## 1. Baseline Period

**Operational Impacts**

Manufacturer guidelines for the tested vortex technology require certain changes to ice-making parameters and practices, such as adjustments to the brine temperature and the temperature of the resurfacing flood water.

The following survey responses highlight actions that the pilot sites took in order to familiarize their staff with the manufacturer guidelines:

**Aside from the kick-off teleconference conducted by FortisBC, did you convene a dedicated meeting in order to familiarize your Zamboni drivers and refrigeration plant operators with the vortex product and its operational guidelines?**

| Response | Percentage | Count |
|---|---|---|
| Yes | 64% | 7 |
| No | 36% | 4 |
| | Total Responses | 11 |

**How many of the following individuals were in the meeting:**

| Type | Individual Answers | | | | | | | Average |
|---|---|---|---|---|---|---|---|---|
| Zamboni drivers | 4 | 5 | 7 | 3 | 0 | 2 | 4 | 3.5 |
| Refrigeration plant operators | 4 | 2 | 7 | 1 | 1 | 2 | 2 | 2.8 |
| Company executives | 0 | 1 | 2 | 2 | 2 | 3 | | 1.7 |

**How many such meetings did you conduct?**

| | Individual Answers | | | | | | | Average |
|---|---|---|---|---|---|---|---|---|
| Incidence | 4 | 1 | 4 | 2 | 1 | 4 | 3 | 2.7 |

**How long did each meeting last on average?**

| | Individual Answers | | | | | | | Average |
|---|---|---|---|---|---|---|---|---|
| Minutes | 15 | 90 | 15 | 20 | 20 | 30 | 45 | 33.6 |

**Did you provide written instructions to your Zamboni drivers and refrigeration plant operators on the installation and operation of the vortex product?**

| Response | Percentage | Count |
|---|---|---|
| Yes | 64% | 7 |
| No | 36% | 4 |
| | Total Responses | 11 |

**Ice Quality Impacts**

Survey respondents provided qualitative answers to the following two questions:

1. What were the top five most common comments that you received from your Zamboni drivers and refrigeration plant operators?

   The most common responses indicate skepticism about whether the technology would work.

2. What were the top five most common comments that you received from your user groups regarding ice quality?

   The most common responses indicate customer satisfaction with the ice quality.

## 2. Adjustment Period

**Operational Impacts**

The following responses describe the ease of implementing operational changes during installation and the initial three weeks of using the vortex technology:

**Did you have to make any changes to the way that you operate the Zamboni in order to use the vortex product?**

| Response | Percentage | Count |
|---|---|---|
| Yes | 90% | 9 |
| No | 10% | 1 |
| | Total Responses | 10 |

**Were the above changes easy for everyone to understand and implement?**

| Response | Percentage | Count |
|---|---|---|
| Yes | 70% | 7 |
| No | 30% | 3 |
| | Total Responses | 10 |

**Were the changes in the brine temperature easy to understand and implement?**

| Response | Percentage | Count |
|---|---|---|
| Yes | 90% | 9 |
| No | 10% | 1 |
| | Total Responses | 10 |

**Has the frequency of ice re-surfacing changed since the installation of the vortex product?**

| Response | Percentage | Count |
|---|---|---|
| No | 80% | 8 |
| Increased: | 10% | 1 |
| Decreased: | 10% | 1 |
| | Total Responses | 10 |

The respondents also provided qualitative answers about specific difficulties and lessons learned:

1. Four facilities reported that they had to slow down the Zamboni during the resurfacing run.
2. Three facilities reported that they shaved more ice with each pass.
3. Two facilities reported that they had to use more wash water.
4. One facility reported that they had to overlap the resurfacing runs by 8”-10.
5. One facility reported that Zamboni blades get dull faster as ice is harder
6. One ice operator expressed concern about whether the vortex device provides sufficient flow for the first build of the ice surface at the beginning of the ice season.

**Ice Quality Impacts**

Survey respondents provided qualitative answers to the following two questions:

1. What were the top five most common comments that you received from your Zamboni drivers and refrigeration plant operators?

   The most common responses indicate that the flood water freezes quickly. Three facilities reported more snow on the ice.

2. What were the top five most common comments that you received from your user groups regarding ice quality?

   Two facilities reported user comments about gouges in the ice. Two facilities reported user comments about more snow on the ice.

## 3. Reporting Period

### Operational Impacts

**After the installation of the Vortex product, did you have to take any additional steps that were not necessary before when scheduling different user groups back to back (e.g. figure skating directly after hockey)?**

| Response | Percentage | Count |
|---|---|---|
| Yes | 20% | 2 |
| No | 80% | 8 |
| | Total Responses | 10 |

The two respondents who answered positively for the previous question provided qualitative follow-up statements. One respondent indicates that additional ice cleanings are required after heavy use. The other respondent suggests that their facility had to warm up the flood water somewhat or that the facility may have to schedule a double flood after hockey groups that play for 1.5 hours.

**How much time was required for a typical resurfacing run?**

| Period | Individual Responses (minutes) | | | | | | | | | | Average (minutes) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Baseline period | 10 | 8 | 12 | 10 | 15 | 8 | 10 | 11 | 8 | 10 | 10.2 |
| Adjustment period | 15 | 9 | 12 | 12 | 15 | 8 | 10 | 11 | 10 | 12 | 11.4 |
| Reporting period | 15 | 9 | 12 | 12 | 15 | 12 | 10 | 12 | 10 | 11 | 11.8 |

### Ice Quality Impacts

**Did all user groups express the same comments regardless of their activity on the ice (e.g. hockey, figure skating)?**

| Response | Chart | Percentage | Count |
|---|---|---|---|
| Yes | 60% | 60% | 6 |
| No | 40% | 40% | 4 |
| | Total Responses | | 10 |

The four respondents who answered positively for the previous questions provided qualitative follow-up statements. Two respondents indicate that figure skaters liked the ice or did not notice any changes from the baseline period. One respondent indicates that the ice was good for the kids and ladies groups but that the facility had more difficulty with the men's groups.
Survey respondents also provided qualitative answers to the following two questions:

1. Q: What were the top five most common comments that you received from your Zamboni drivers and refrigeration plant operators?

   A: The following table provides the responses received:

| |
|---|
| Can't get a good sheet of ice with cold water after heavy use. |
| 1. Could have used more time to continue making adjustments.<br>2. Ice was still freezing a little quickly by the end of the adjustment period, despite having increased brine temperature by 6 degrees Fahrenheit.<br>3. Ice was somewhat brittle, but this could have been addressed with a longer adjustment period. |
| The only questions after we adjusted ice temps have had to do with the Zamboni. We still have a few issues there as the making of the ice changes somewhat during the course of a single shift. |
| Less snow but still issue. We are using less energy. Maybe this product works? |
| the need to introduce a hot water clean after very use |
| This shows promise<br>Still may have to go back to hot water |
| -we some times have to do extra clean at end of night<br>-are we saving money<br>-ice looks good<br>-new system is more work<br>- it will be interesting start from scratch next season |
| 1. Ice seemed harder and more durable than old ice<br>2. Ice compressors ran approximately 25% less than when using hot water to make ice<br>3. Hot Water boilers ran approximately 50% less than when using hot water for making ice<br>4. Zamboni blades would dull quicker since using REALice<br>5. User groups had positive comments and seemed happy with REALice |
| can we do hose floods? |
| things seemed to be better after adjusting the hot water between 90 & 100* F |

2. Q: What were the top five most common comments that you received from your user groups regarding ice quality?

A: The following table provides the responses received:

| |
|---|
| Ice is not bumpy. |
| I have not heard any more complaints |
| the ice has been great and plenty of good comments from our customers. |
| Too much snow. Slower ice surface for skating as the snow built up. Comments from elite hockey teams. |
| no remarks |
| less snow buildup<br>does not fill in deep gouges as good |
| None. User groups were kept unaware of the pilot to guage actual issues without pre-conceived notions of the change. |
| -some said faster ice<br>-Jan. 23 public/ice users read newspaper article about system we installed-this is when public/users were informed<br>I think users have been happy , ice looks better because we are keeping thinner |
| 1. Ice seemed to have less snow than old ice after use<br>2. Ice quality was very good<br>3. No changes were noticed in ice quality<br>4. Ice seemed to be faster for hockey users<br>5. Ice seemed to get less ruts than old ice |
| have not heard negative comments |