Optimizing buildings for energy efficiency during a pandemic

BOMA BC – June 16, 2020

Introductions

Prism ENGINEERING

saving you energy

Prism Engineering provides consulting services to address technical, behavioural and organizational aspects of Energy Management

We design and implement cost effective approaches to address comfort, efficiency and reliability.

Introduction to your Prism Facilitator

Sam Thomas, BSc, CEM, Principal, Branch Manager

Sam's background includes a broad spectrum of energy studies and audits, electrical and mechanical concept design, field review, and engineering and construction project management. He has conducted numerous energy and building automation system optimization studies on commercial, industrial, and institutional facilities.

Today's Agenda

1. **Best practices** related to ventilation and filtration during COVID-19 and how to prepare for a second wave

2. **Measuring the energy impact** of COVID-19 on our buildings

3. Concepts for **finding and implementing energy efficiency measures** in a building impacted by COVID-19

Webinar themes

Philosophy:

1. **We want to operate buildings safely, first and foremost**
2. **We also want to operate buildings as energy efficiently as possible, while adhering to best practices around safety.**

Relevance:

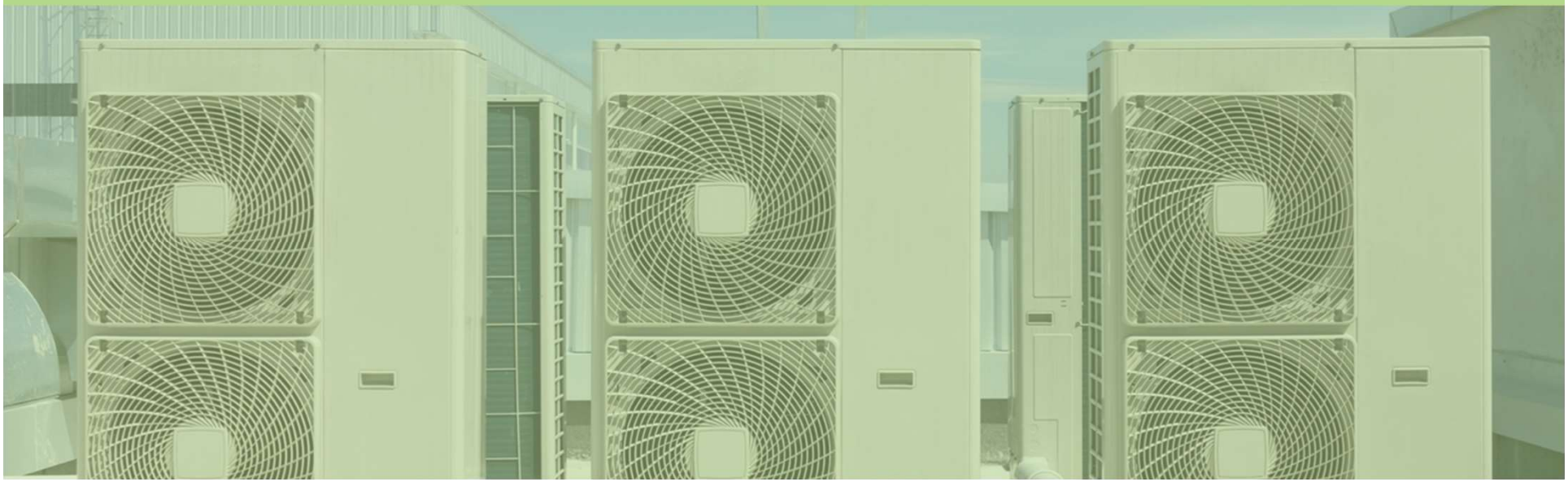
- **Now:**
  - Relevant now while buildings may be in 'rest' mode
- **Future:**
  - As we bring buildings back 'online'
  - Partly occupied, or lower occupant density may become a new 'normal'
  - In preparation for a second wave or future pandemics.

1

Operating Buildings during COVID-19

Considerations and best practices

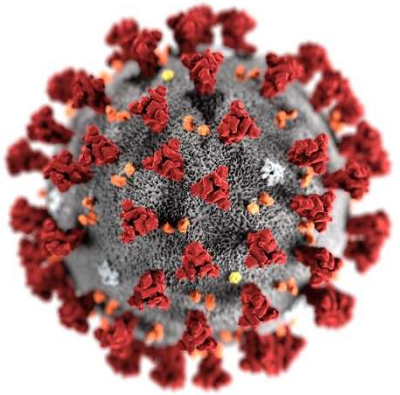
HVAC



Infectious aerosols

- Still undetermined whether COVID-19 is a smaller infectious aerosol, or a larger emitted droplet. Research is rapidly evolving.

- Evidence points towards predominantly large droplet at short range transmission (WHO, CDC).



ASHRAE position

ASHRAE Position Document on Infectious Aerosols – April 14, 2020

"Transmission of SARS-CoV-2 through the air is **sufficiently likely** that airborne exposure to the virus should be controlled."

"**Ventilation and filtration** provided by HVAC systems **can reduce the airborne concentration** of SARS-CoV-2 and thus the risk of transmission through the air."

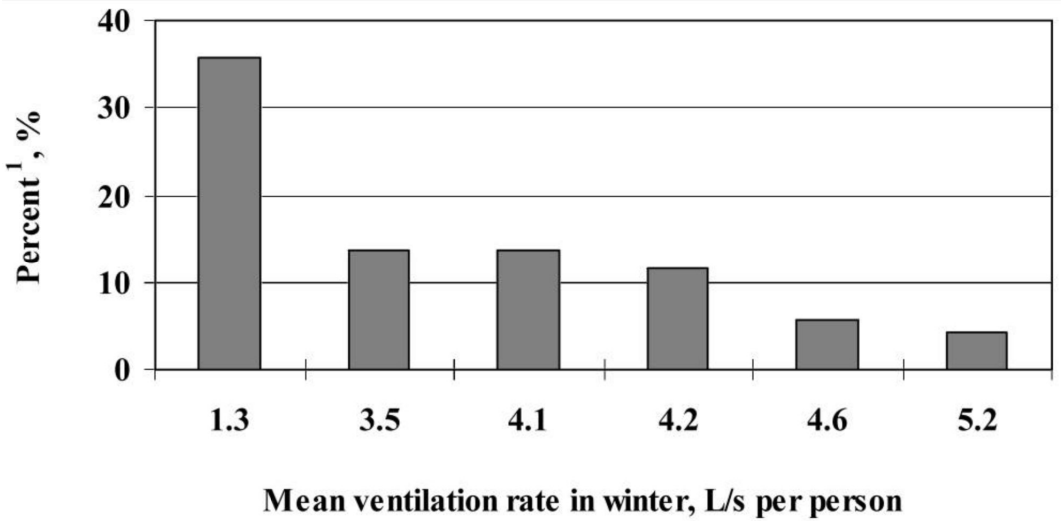
"However, even the most robust HVAC system **cannot control all airflows and completely prevent** dissemination of an infectious aerosol or disease transmission by droplets or aerosols."

https://www.ashrae.org/file%20library/about/position%20documents/filtration-and-air-cleaning-pd.pdf

Approaches

Approaches that have shown to be effective related to HVAC:

1. Ventilation
2. Filtration
3. Sterilization (UV-C)
4. Temperature & Humidity



1 L/s = 2.12 cfm

Associations between common cold infection rates and mean ventilation rate in winter in buildings constructed after year 1993. [1] *Proportion of occupants with ≥6 common colds in the previous 12 months.*
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3217956/

Ventilation

- Best practices for **occupied** buildings:
  - In general, more ventilation is considered better during the pandemic.
  - ASHRAE currently recommends 100% outdoor air when possible in occupied spaces.
  - US DOE recommends increasing by 1.5x
  - As a minimum requirement, any outside air dampers should operate at no less than their minimum position required to meet ventilation rates defined by ASHRAE standard 62.1 during occupied periods.

Ventilation

In **occupied** buildings (cont'd):

- Demand controlled ventilation (DCV)
  - For HVAC systems that use DCV sequences (CO_2 or occupancy based ventilation), ASHRAE recommends disabling this feature for the duration of the pandemic
- Ensure dampers, filter, and economizers seals and frames are intact and clean, are functional and are responding to control signals.
- Use operable windows when possible.

Ventilation

Best practices for **re-occupancy**:

- Flush prior to occupancy - Where possible, open outside air intake dampers to their maximum, 100% preferred, 4 hours minimum, before any reoccupation.
- In buildings with operable windows, if the outside air temperature and humidity are moderate, open all windows for two hours minimum before any reoccupation.
- Parkade exhaust, if any, should run two hours before re-occupancy.

https://www.ashrae.org/technical-resources/frequently-asked-questions-faq

Exhaust Fans

- For **partially occupied** buildings:
  - Consider which exhaust fans can be turned off based on occupied zoning.
  - For washroom exhaust fans (during pandemic):
    - Toilets can be a risk of generating airborne droplets and droplet residues that could contribute to transmission of pathogens.
    - **Operate continuously during occupied periods**
    - Operate for 2hrs before and after occupancy
  - For elevator ventilation fans (during pandemic)
    - **Operate continuously during occupied periods**

https://www.ashrae.org/technical-resources/filtration-disinfection

Filtration

- Highly efficient particle filtration in centralized HVAC systems reduces the airborne load of infectious particles

- Not a 'silver bullet' for eliminating all risk of transmission of airborne particulates, but is proven to make a difference

Filtration

MERV rating (Minimum Efficiency Reporting Value)

MERV Std 52.2	Intended Dust Spot Efficiency Std 52.1 (1)	Average Arrestance	Particle Size Ranges	Typical Applications	Typical Filter Type
1 - 4	<20%	60 to 80%	> 10.0 µm	Residential/Minimum Light Commercial/ Minimum Minimum Equipment Protection	Permanent / Self Charging (passive) Washable / Metal, Foam / Synthetics Disposable Panels Fiberglass / Synthetics
5 - 8	<20 to 60%	80 to 95%	3.0-10.0 µm	Industrial Workplaces Commercial Better / Residential Paint Booth / Finishing	Pleated Filters Extended Surface Filters Media Panel Filters
9 - 12	40 to 85%	>90 to 98%	1.0-3.0 µm	Superior/Residential Better/Industrial Workplaces Better/Commercial Buildings	Non-Supported / Pocket Filter / Rigid Box Rigid Cell / Cartridge V-Cells
13 - 16	70 - 98%	>95 to 99%	0.30-1.0 µm	Smoke Removal General Surgery Hospitals & Health Care Superior/ Commercial Buildings	Rigid Cell / Cartridge Rigid Box / Non-Supported / Pocket Filter V-Cells

Note: This table is intended to be a general guide to filter use and does not address specific applications or individual filter performance in a given application. Refer to manufacturer test results for additional information.
(1) ANSI/ASHRAE 52.1 ranges are provided for reference only. The ANSI/ASHRAE 52.1 Standard was discontinued as of January 2009.

Source: National Air Filtration Association

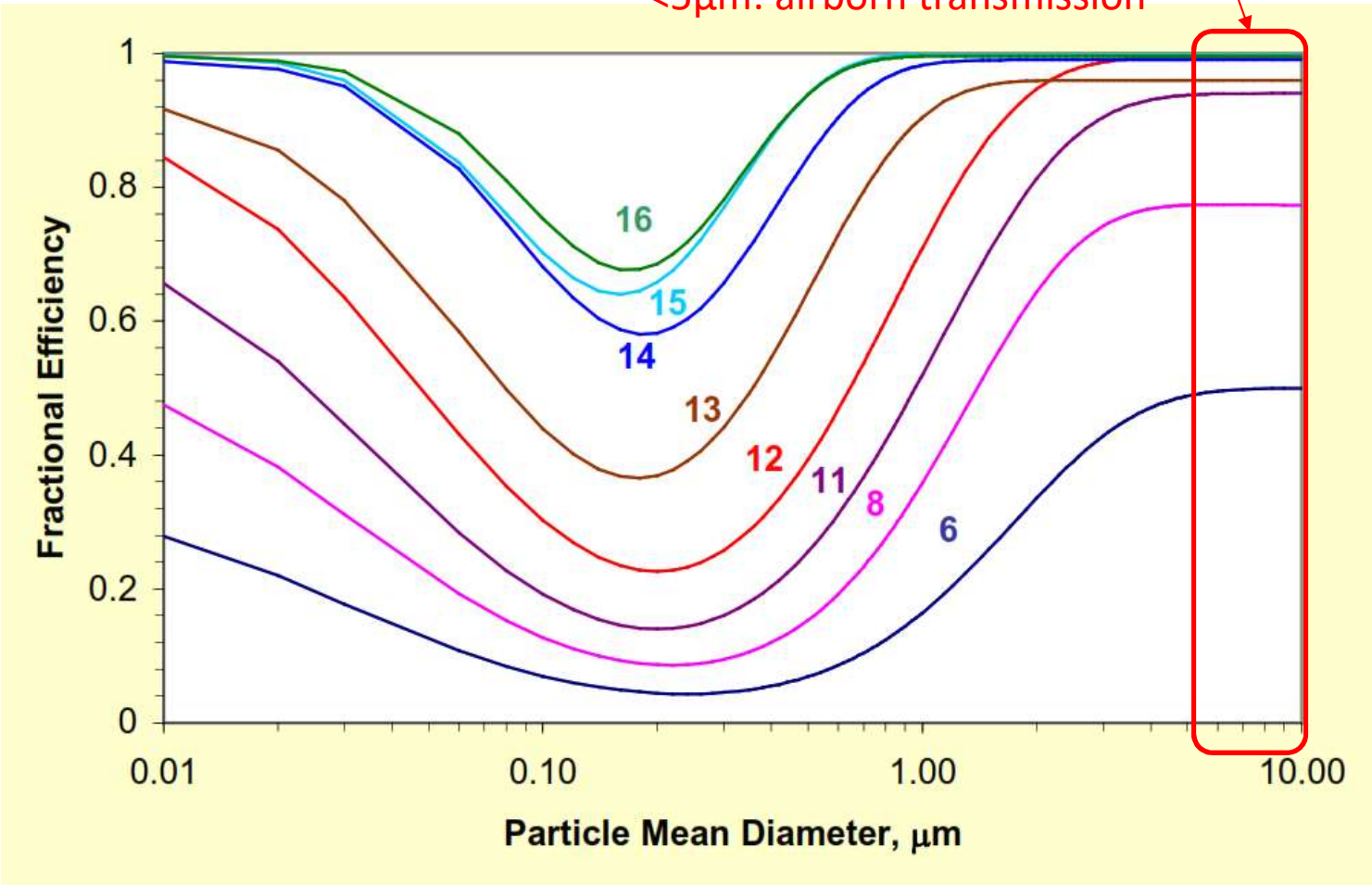
Filtration Best Practices

- **ASHRAE recommends no less than MERV 13 for capturing airborne viruses**, or the highest compatible with the filter rack
- Seal edges of the filter to limit bypass
- Make sure the air handling systems and fans can overcome the **additional pressure drop** of the new filters. Engage consultant/engineer to review if necessary
- High efficiency particulate air (HEPA) filters are more efficient than MERV 16 filters

Filtration

5-10µm: respiratory droplets*

<5µm: airborn transmission



Representative MERV filter performance (Kowalski and Bahnfleth 2002, via DOE)

*https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations

UV Sterilization

- May start to become more common in our building HVAC systems.
- The ultraviolet (UV) spectrum can kill or inactivate microorganisms, but UV-C energy (200 to 280 nm) provides the most germicidal effect, with 265 nm being the optimum wavelength
- Energy consumption impact needs to be considered.

https://www.ashrae.org/file%20library/about/position%20documents/filtration-and-air-cleaning-pd.pdf

UV Sterilization

UV-C In-Duct Air Disinfection

- Requires high UV doses to inactivate microorganisms on-the-fly as they pass through the irradiated zone
- limited exposure time (approx 0.25 sec)
- Still need to be coupled with mechanical filtration

https://www.ashrae.org/file%20library/about/position%20documents/filtration-and-air-cleaning-pd.pdf

Temperature

- Most literature points towards temperatures of greater than 30°C to reduce the survival of airborne influenza viruses.
- Maintaining >30°C is not practical
- Research still underway on COVID-19 and effects based on temperature.

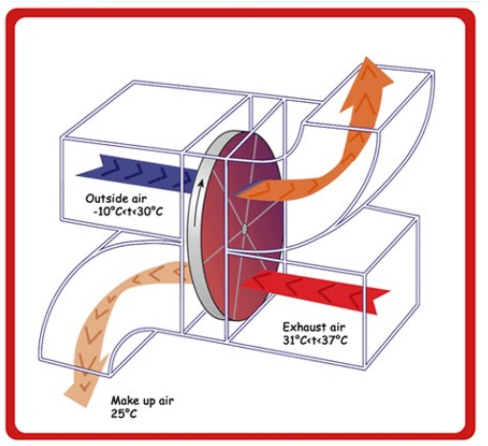
General recommendation is to maintain typical standard space temperature setpoints during the pandemic.

Heating

- For **occupied** buildings:
  - In general, maintain standard occupied temperature setpoints (19-21°C)
  - If possible, only heat zones that are occupied.
  - Consider an over-ride button for occupants if coming in sporadically
  - Ensure weekly schedules are optimized
  - VERIFY setbacks and schedules are working

Heat Recovery Systems

- Heat wheels, reverse flow
  - Check the status of the systems for leakage and cross-contamination.
  - Disable during summer (during pandemic)
  - These systems can continue operation if the unit serves only one space.



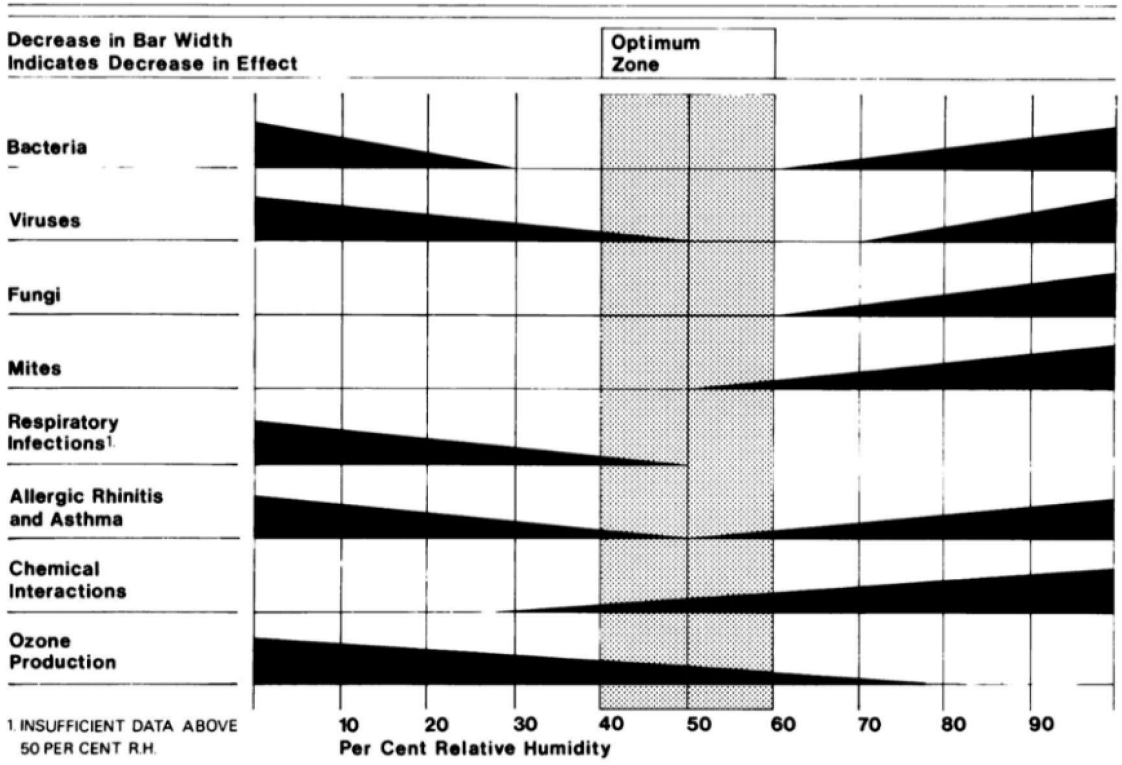
A diagram of a rotary heat exchanger, or "heat wheel" (From Uptime Technology BV)

- Run-around coils, heat pipe, plate HX's
  - Other heat recovery devices that decouple the intake and exhaust air steams can continue to operate.

Humidity

- ASHRAE Research Project CO-RP-03 reports that scientific literature generally reflects the most unfavorable survival for micro-organisms when the RH is between **40%-60%.**

Arundel AV, Sterling EM et al. *Indirect Health Effects of Relative Humidity in Indoor Environments*, Environmental Health Perspectives Vol 65, 351-61, 1986.



Optimum relative humidity range for minimizing adverse health effects.

https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-d-co-rp3.pdf

Controls

General / Maintenance

- Ensure remote access to DDC is operable. Consider establishing this if not available yet.

- Zone and air temperature, humidity and CO_2 system sensors, as applicable, are calibrated and accurately reporting to the DDC or local controllers.

‘Pandemic’ Mode

- Consider an update to programming that would incorporate HVAC strategies to reduce virus transmission prior to future events.
- Automate control sequences applied as “Pandemic Mode” override operation that can be manually selected by the operator with one click.

Plumbing

"If you don't use it, nature takes it back!"

Domestic Hot Water

- Best practices:
  - Temperature
    - Keep water above 50°C (min) to 60°C (ideal)
    - If shutting down, system should be drained
  - Circulation
    - Maintain DHW circulation if building still occupied
    - If system is shut down, circulate once every 2 weeks for 2hrs at 60°C

https://www.ashrae.org/technical-resources/frequently-asked-questions-faq

Space Consolidation

Space Consolidation

- For partially occupied buildings consider where occupants can be consolidated, whilst maintaining social distancing guidelines.
- Consider HVAC zoning when reallocating spaces.
- Example:
  - Vancouver International Airport

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Energy impact of COVID-19 on buildings

What impacts energy?

Energy impacts during the pandemic

- Think about how the pandemic will impact energy performance of your operations.
- Energy increases
  - Increased ventilation, fan energy
  - Increased humidification
- Energy decreases
  - Reduced plug loads – PC's, kitchens, etc
  - Reduced lighting loads
  - Reduced heating setpoints

How to measure & estimate savings

Tools and approaches

Approaches

- Calculation, modelling
- Measurement
- Simulation

Measurement & Verification

M&V Key Components

- Identification & treatment of critical factors that affect energy consumption
- Complete baseline definition
  - Equipment, operating hours and delivered conditions such as comfort, light levels etc.
- Definition of analysis and confidence required in savings calculation to determine:
  - Detail, length and accuracy of data collection & analysis
- Definition of a cost effective level of accuracy (uncertainty)

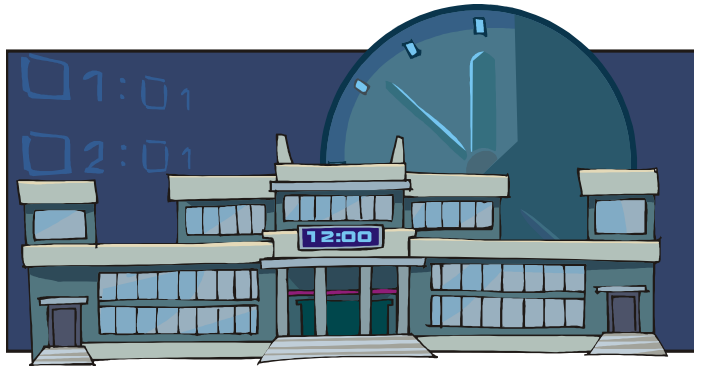
IPMVP Verification Methods

A. Partially measured retrofit isolation
   - With assumption/stipulations

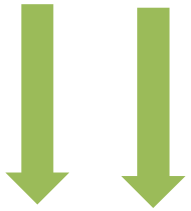
B. Retrofit isolation
   - Fully measured

C. Whole facility
   - Or sub-metered part

D. Calibrated simulation
   - With software



Selecting an Option

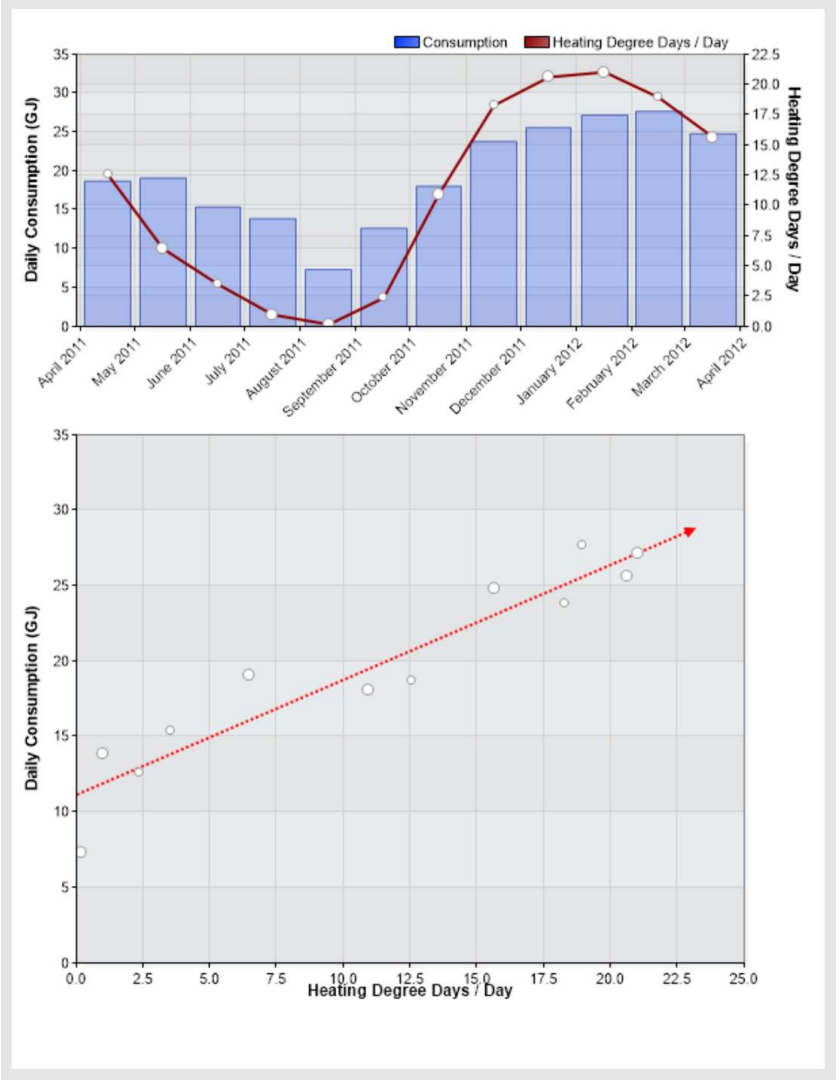


ECM Project Characteristic	Suggested Option			
	A	B	C	D
Need to assess ECMs individually	X	X		X
Need to assess only total facility performance			X	X
Expected savings less than 10% of utility meter	X	X		X
Multiple ECMs	X		X	X
Significance of some energy driving variables is unclear		X	X	X
Interactive effects of ECM are significant or immeasurable			X	X
Many future changes expected within measurement boundary	X			X
Long term performance assessment needed	X		X	
Baseline data not available				X

Adapted from*: IPMVP Concepts and Options for Determining Energy and Water Savings vol. 1, 2012, p. 34*

Option C: Whole Facility

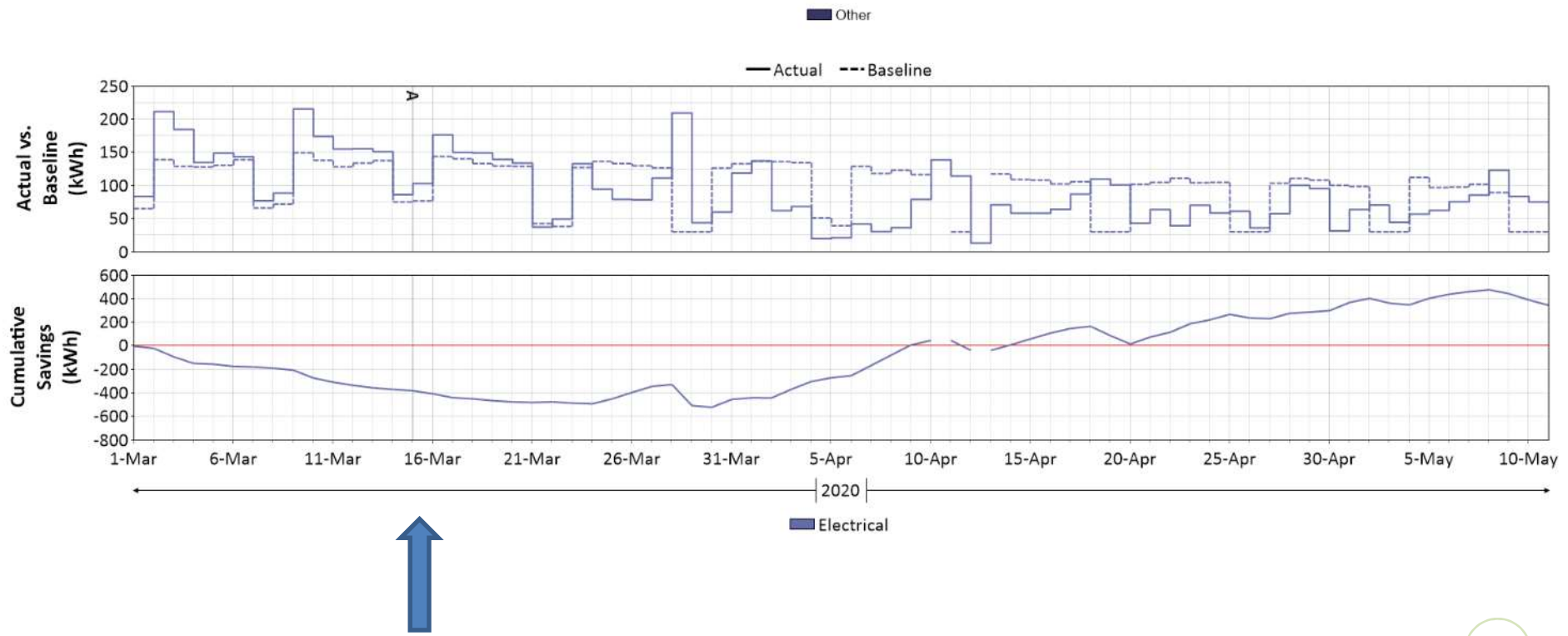
- Gas and electricity modelled by correlation with degree days
- Savings calculated under post-retrofit conditions as "avoided costs"
- Compare pre and post to estimate energy impacts.
- Generate CUSUM



Option C: Whole Facility

Master Report By Meter By Reading

Project: **PUMA Demo, Daily Data (DEMO-DLY)**
Site: **PRISM-DLY Prism Offices**
Meter: **Heat-Pumps (VM3605GILMOREHC-1)**



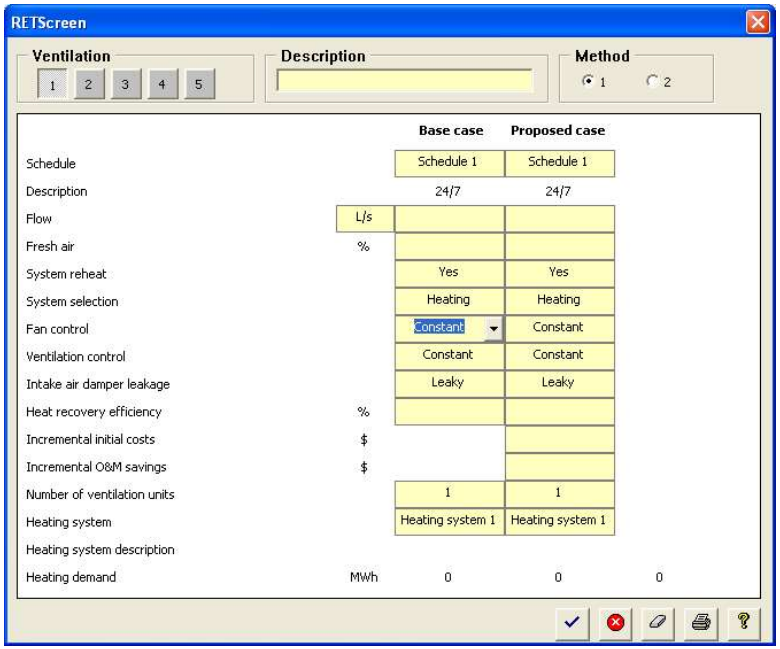
COVID office restrictions begin

Savings Calculations

RETScreen Ventilation Model

- cfm x ΔT x 1.08 or l/s x ΔT x 1.2
  - no latent load

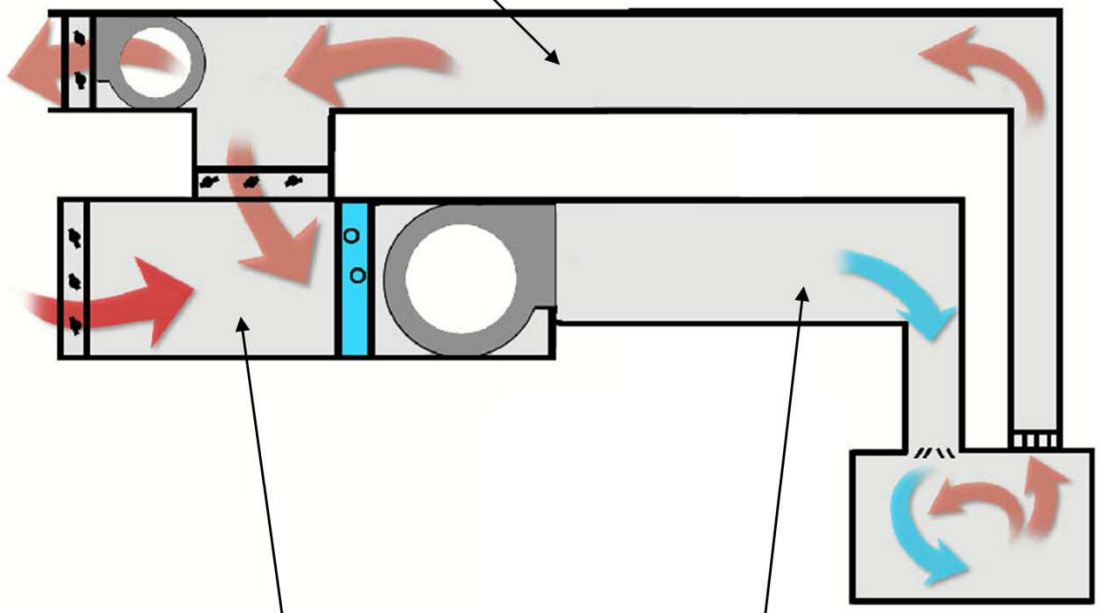
- **Method 2: Detailed**
  - Schedule
  - Total air flow
  - % fresh air
  - Reheat (Y/N)
  - HV, VAC or HVAC
  - Damper leakage
  - Heat recovery



- **Method 1: Simple**
  - Schedule
  - Flow
  - HV, VAC or HVAC
  - Heat recovery

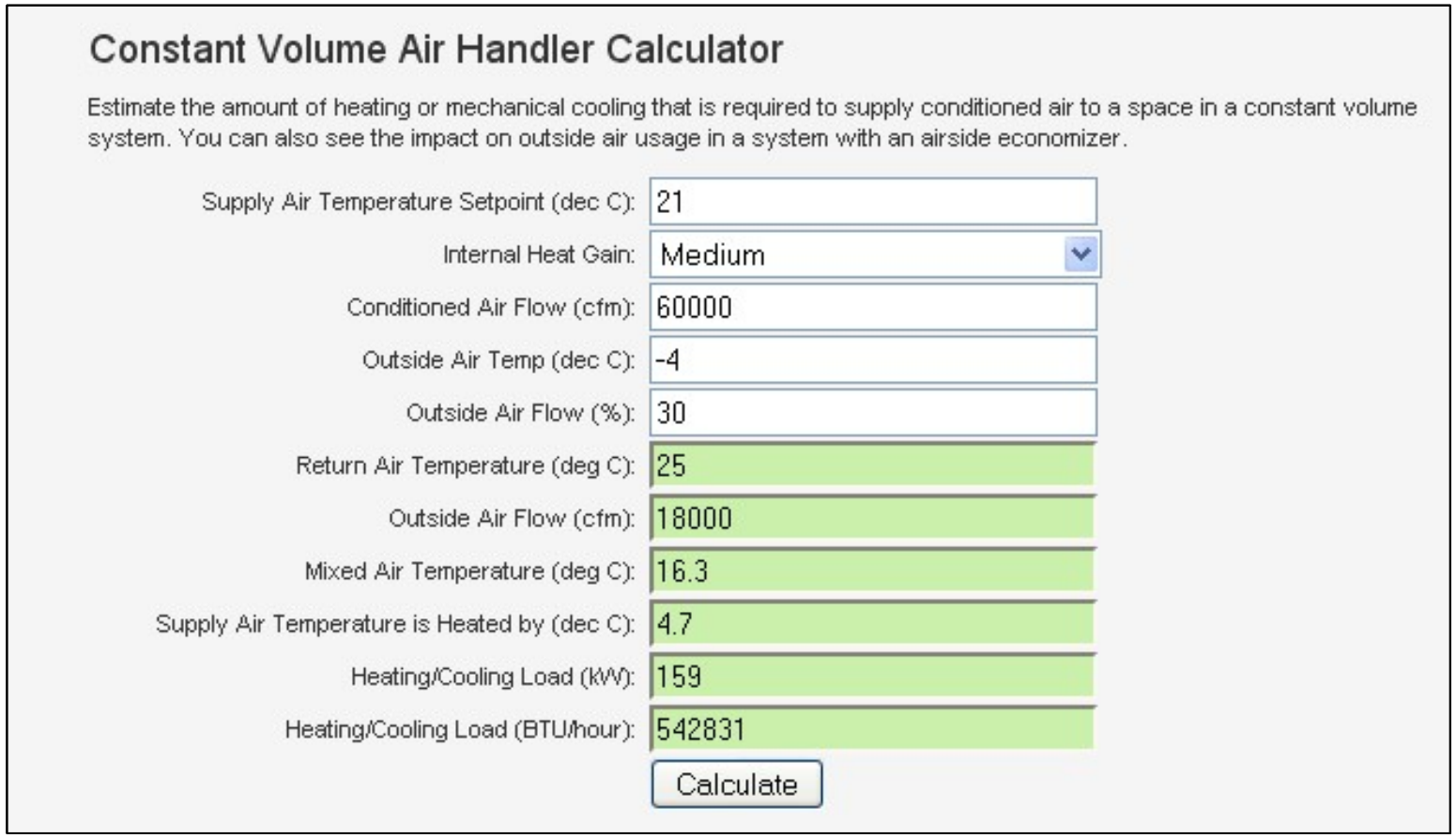
A Common System Simulation

Constant Volume System Simulation



Supply Air Temperature is Heated by	4.7	deg C requiring:	159 kW	=	542,831 BTU/Hr

Ventilation Energy Load Calculations - Tools



Constant Volume Air Handler Calculator

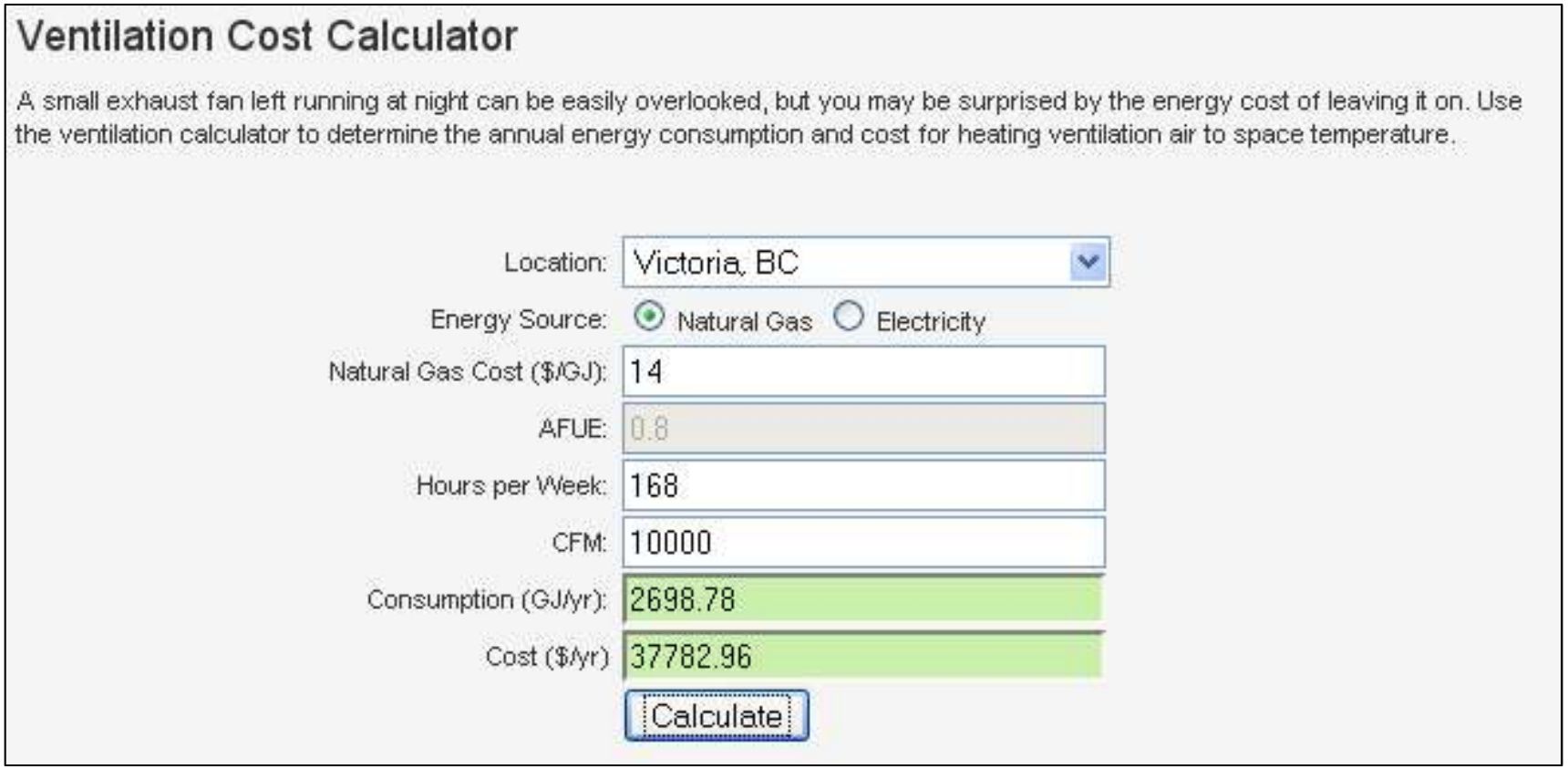
Estimate the amount of heating or mechanical cooling that is required to supply conditioned air to a space in a constant volume system. You can also see the impact on outside air usage in a system with an airside economizer.

Supply Air Temperature Setpoint (dec C):	21
Internal Heat Gain:	Medium
Conditioned Air Flow (cfm):	60000
Outside Air Temp (dec C):	-4
Outside Air Flow (%):	30
Return Air Temperature (deg C):	25
Outside Air Flow (cfm):	18000
Mixed Air Temperature (deg C):	16.3
Supply Air Temperature is Heated by (dec C):	4.7
Heating/Cooling Load (kW):	159
Heating/Cooling Load (BTU/hour):	542831

Calculate

http://prismengineering.com/resources/calculators

Ventilation Energy Calculations - Tools



http://prismengineering.com/resources/calculators

3

Finding Opportunities in Empty Buildings

Auditing

Energy Audits

Empty buildings

- Challenge – do not get a sense of 'normal' operation
- Opportunity – easy to navigate while empty

Different levels

- Opportunity Scan – Basic
- ASHRAE Level 1 – Walk through
- ASHRAE Level 2 – Detailed
- ASHRAE Level 3 – Advanced

7 Steps to Energy Auditing

1. From the point of Purchase

2. To the point of End-Use

Understand Present Usage

1. Understand Costs
2. Compare Yourself
3. Understand When
4. Understand Where

Find the Savings Opportunities

5. Eliminate Waste
6. Maximize Efficiency
7. Optimize Supply

3. And, back to the point of Purchase (or supply)

FortisBC - Custom Efficiency Program

- **Energy Study Incentive –** Up to 50% of energy study costs for a detailed engineering study.

- **Implementation Incentive –** Eligible cost-effective energy efficiency projects can receive incentives up to a maximum of $500,000.

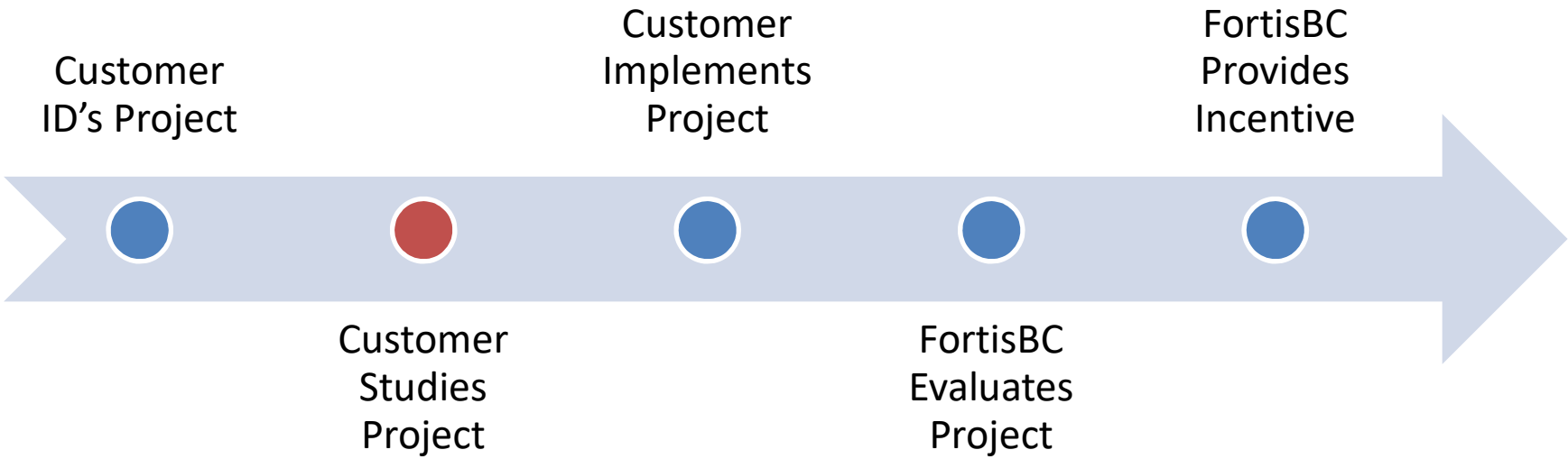
  Additional incentives available from CleanBC!

- **Implementation Bonus –** Remaining 50% of energy study costs if customer implements one or more eligible measures funded by FortisBC.

Energy at work FORTIS BC™

FortisBC - Custom Efficiency Program (Commercial)

- Customized incentives for comprehensive or complex natural gas energy efficiency retrofits
- **Eligibility:** Project has the potential to save 1200 GJ of natural gas



Energy at work FORTIS BC™

Recommissioning (RCx) and functional testing

Overview

- Recommissioning (RCx) – building 'tune up'.
- Functional testing – process used to physically test operation of control systems. Can be done remotely.

Empty or partially occupied buildings present a great opportunity to undertake functional testing as part of the RCx process.

End-to-End Functional Tests

- Involves manipulating a control variable to see whether the expected result at the end device occurs.
  - Example: Manipulate a heating valve to fully close. Observe the sensor reading downstream of the coil and compare to expected results.

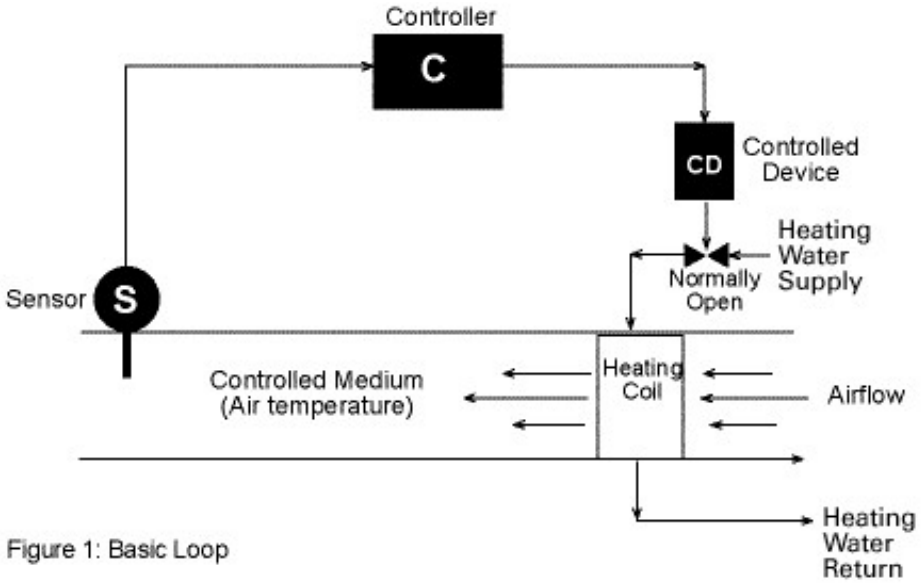
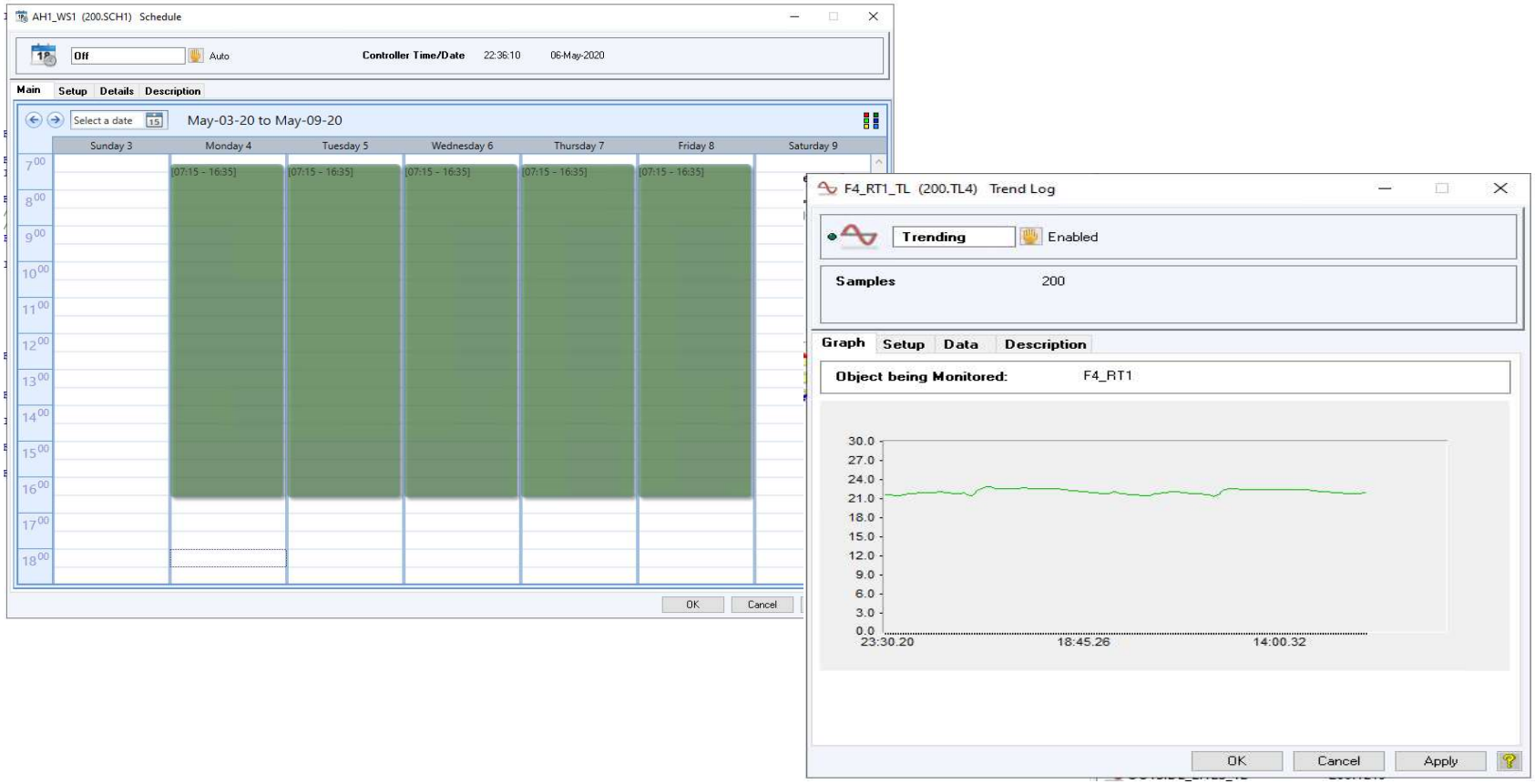


Figure 1: Basic Loop

Schedules

- Check that all schedules are in auto (as appropriate) and confirm that the schedules are active through review of trend logs, or through functional testing.

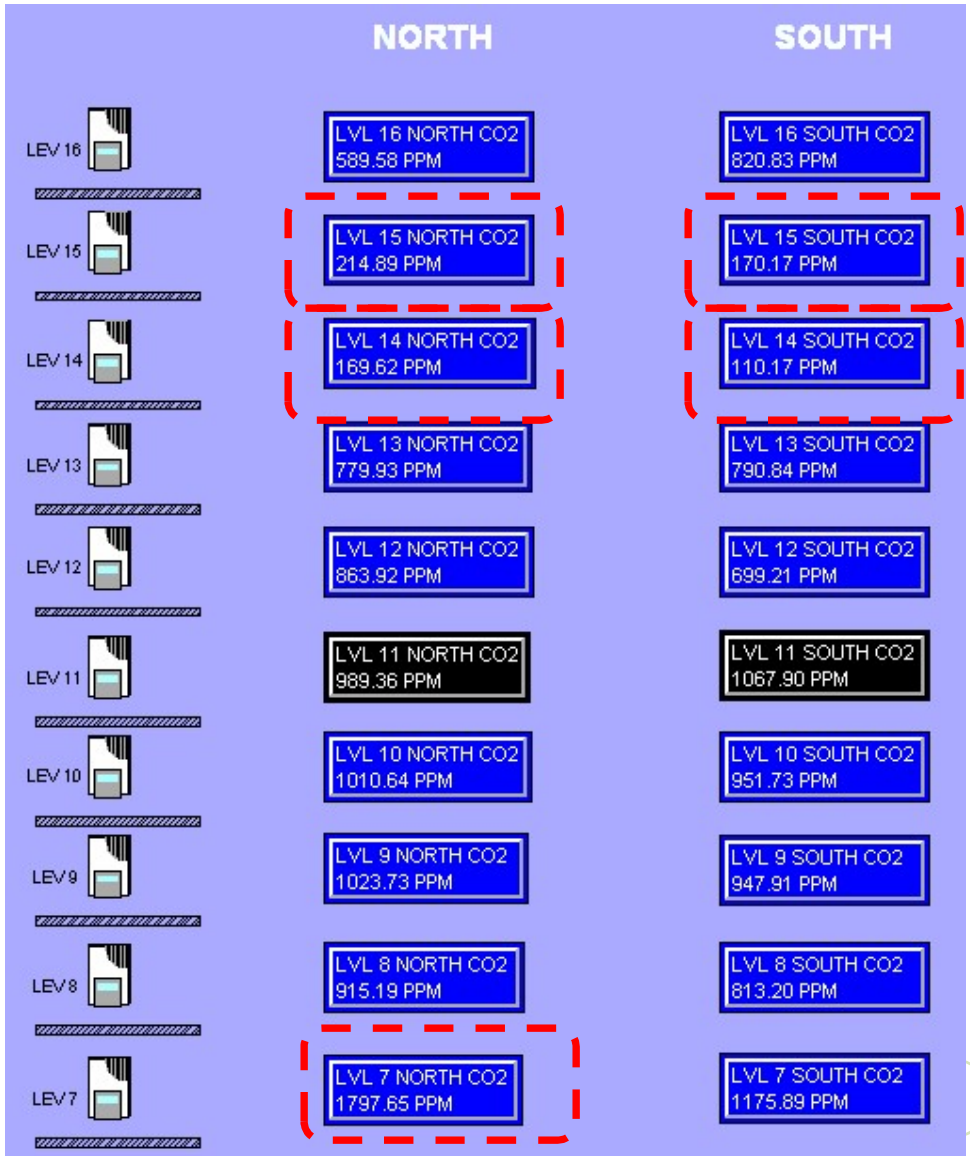


Sensors

- Ensure all **temperature sensors** are
  - checked that are operating in tolerant ranges and in auto
- Ensure that all **outside ambient lock outs** have correct set points
- Ensure that **outside air sensors** are calibrated and reading correctly.
  - An outside air temperature sensor is used various programs for scheduling
- Check **supply air sensors**
  - confirm they are calibrated
  - verify that there are no heating or cooling valves leaking

CO_2 Sensor Calibration

- CO_2 sensors can be damaged during renovations (excessive dust), putting them out of calibration
- Important to check CO_2 sensors, or you may end up over or under ventilating a space
- Expect between 400-1000 ppm typically



Air balancing

- Testing and adjusting air systems to deliver the right amount of air to each space
- Right amount of air is defined by design, in accordance to standards and codes
- Optimizing air flows also optimizes energy efficiency (and **health and safety**)
- Requires access to all spaces, therefore easier to do while spaces are unoccupied

Continuous Optimization Program

- Joint program between BC Hydro, FortisBC Energy Inc and FortisBC. Inc.
- For commercial customers with buildings >50,000 sf with a DDC or BMS system
- Can chose consultant of choice as pre-approved for Recommissioning Services with the BC Hydro Alliance of Energy Professionals
- Three Offers:

UPDATED OFFER!

  - **Recommissioning**: Up to $0.15/sf for a qualified consultant to conduct a recommissioning assessment
  - **Refresh**: Up to $0.025 for a contractor to revisit a past recommissioning study and re-tune building
  - **Real Time Energy Monitoring**: Incentives to implement building energy monitoring

Energy at work FORTIS BC™

Envelope testing

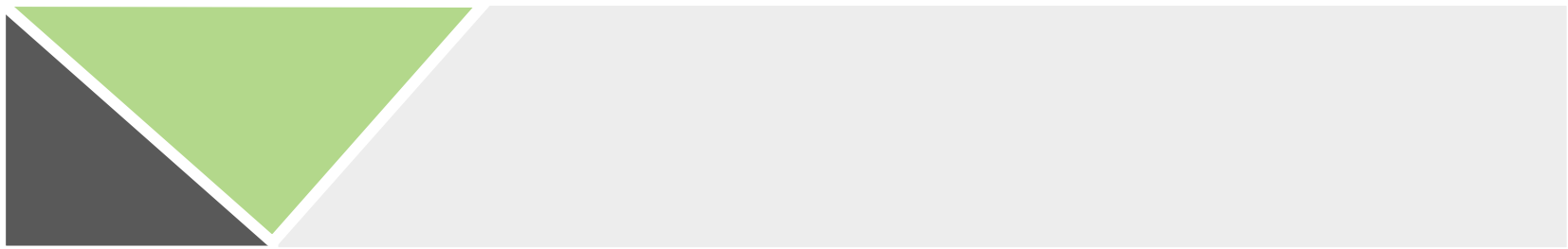
Blower door testing

Example: **University of the Fraser Valley**

- Building D - "Whole Building Airtightness Test"
- ASTM E779-10 "Standard test method for determining air leakage rate by fan pressurization".
- 60,000 ft2 of floor area
- 4 fans distributed across the building enclosure via two testing stations.
- all mechanical vents and intentional openings were sealed/masked prior to testing.

Blower door testing

WRAP UP



Resources

- ASHRAE
  - FAQ: https://www.ashrae.org/technical-resources/frequently-asked-questions-faq
  - ASHRAE Position Document on Infectious Aerosols: https://www.ashrae.org/file%20library/about/position%20documents/pd_infectiousaerosols_2020.pdf
  - COVID resources: https://www.ashrae.org/technical-resources/resources
- BOMA
  - http://bomacanada.ca/coronavirus/
- FortisBC
  - https://www.fortisbc.com/rebates-and-energy-savings/rebates-and-offers/rebates-business

Q & A

Thank you!

Sam Thomas, BSc, CEM, CPEnMS

sam@prismengineering.com

Ian Mitchell

Ian.Mitchell@fortisbc.com

@Prism_Eng

www.prismengineering.com

saving you energy