# CampusEnergy2021

## BRIDGE TO THE FUTURE

Feb. 16-18 | CONNECTING VIRTUALLY

**WORKSHOPS** | Thermal Distribution: March 2 | Microgrid: March 16

# ***Adaption in action:***
# *Leveraging existing with new technology and process improvement*

Jelena Vulovic Basic – Senior Manager, Building Mechanical Services,
**University of Toronto**

Andrew Pratt – Executive Vice-President, Mechanical,
**Crossey Engineering Ltd**

# Q&A Will Not Be Answered Live

**Please submit questions in the Q&A box.**
**The presenters will respond to questions off-line.**

# ***Adaption in action:***

## *Leveraging existing with new technology and process improvement*

- The building systems and infrastructure industry is buzzing with words such as smart buildings, intelligent buildings, sustainable equipment and infrastructure.

- Vendors are soliciting frequently and offering integrated solutions to make our buildings smarter and more energy efficient.

- The expectation is that the facility operation and maintenance is data driven and automated, flexible enough to accept changes in institutional programs and new technologies.

- With this presentation we will walk you through the **processes and strategies** presently taken at University of Toronto for improved operation of the new buildings / major retrofits / building mechanical infrastructure upgrades.

University of Toronto

# St. George Campus

Facilities & Services
**Facts**

Every day, about **100,000 people** (students, faculty, staff and visitors) count on the **800 Facilities and Services team members** to make sure the St. George campus is a safe, clean, comfortable, attractive and sustainable environment.

## INDOOR SPACE OPERATIONS

Ensure buildings are kept in a good operational state, are safe, comfortable and efficient including property management, heating/cooling, ventilation, electrical systems, design of new buildings, renovations, mechanical equipment, general and specialized cleaning, elevators, hazardous waste removal, lab equipment installation, trades —electrical, locksmith, carpentry, machine, sheet metal, plumbing, steam fitting.

**$5.5**
BILLION IN PHYSICAL ASSETS
Buildings and grounds at the St. George Campus.

**130**
BUILDINGS
over
**14**
MILLION SQUARE FEET

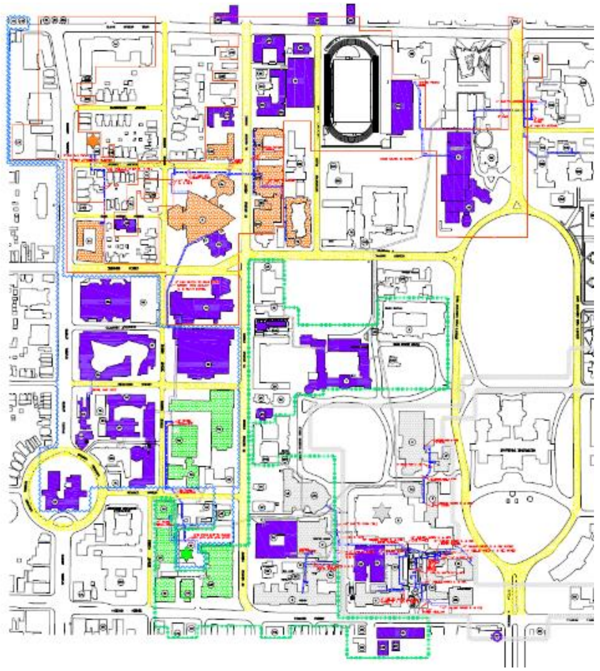
**150**
BUILDINGS SERVED BY EXTENSIVE DISTRICT ENERGY SYSTEM
Energy efficient network of pipes that heat and cool.

**80%**
OF HEATING
and
**25%**
ELECTRICITY NEEDS
are produced at St. George Campus.

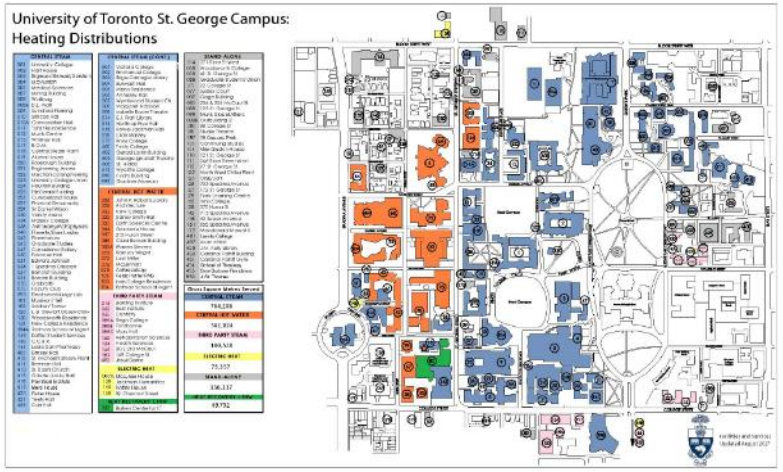
**$19**
MILLION SAVINGS
in utility costs since 2011.

# University of Toronto – St.George Campus **District Energy**

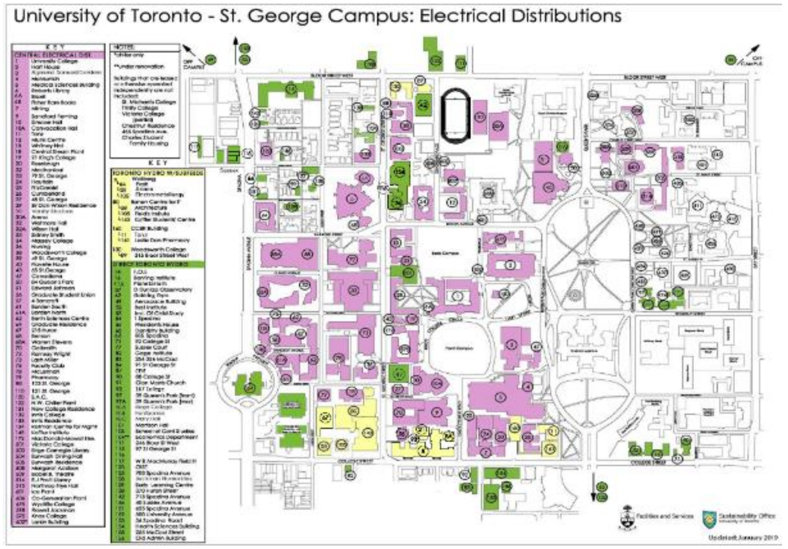
- **Heating**
  - Annual consumption : 331,990 MWh
  - Peak demand: 107 MW
- **Central steam plant**: 205 MW **installed capacity**
- **Central flue gas heat recovery system** (**Sofame**): 20 MW installed capacity
- **Cooling**
  - Annual consumption: 98,350 MWh
  - Peak demand: 65 MW
  - Plants: 3 main plants of 4000, 5000 and 11,000 tons
- **Electrical**
  - Annual consumption: 217,000 MWh
  - Peak demand: 46 MW
  - Electrical Purchase: 192,000 MWh
- **Cogen Generation:** 45,000 MWh



chilled water distribution

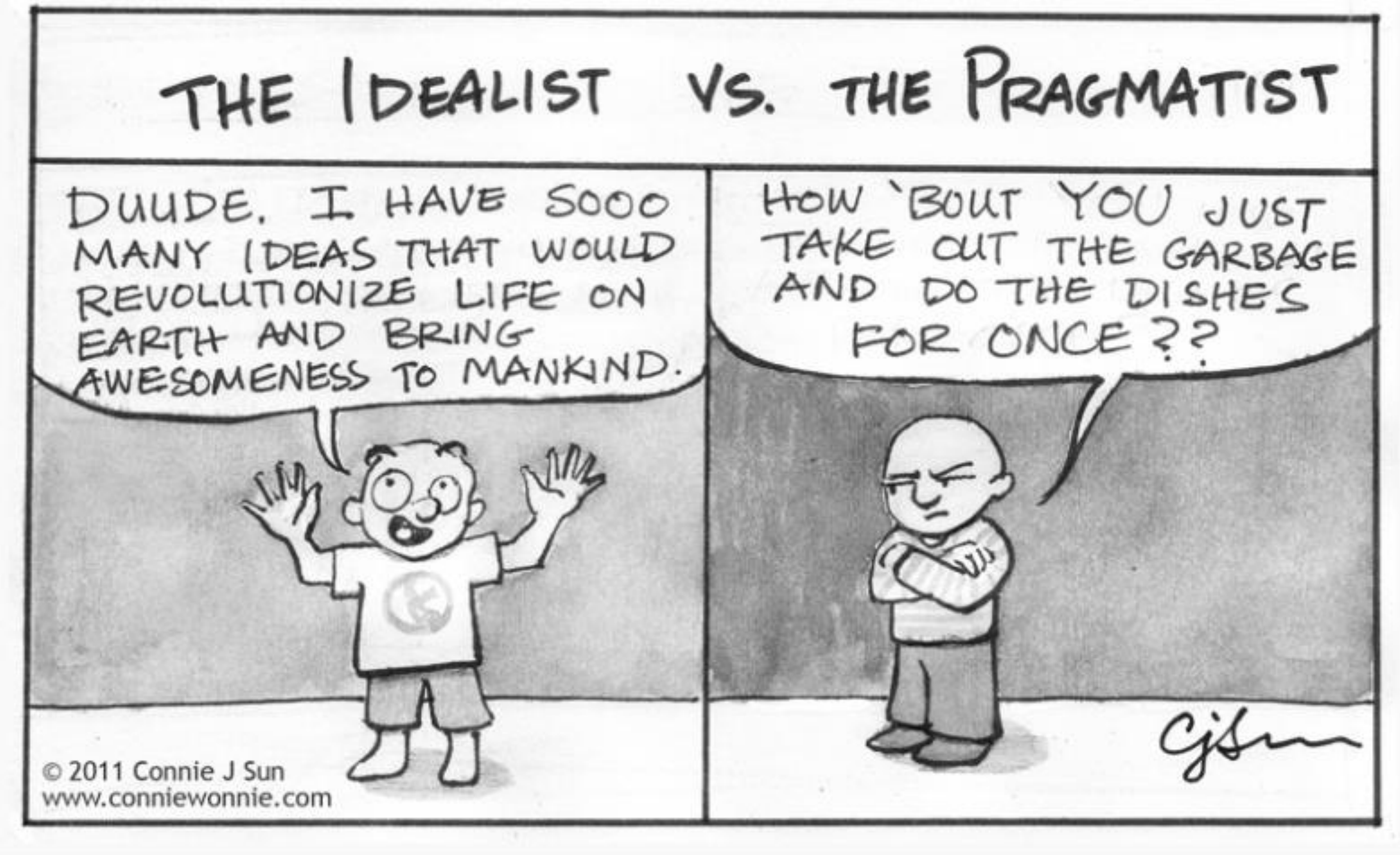



heating distribution




electrical distribution

# UofT Process in a nutshell




- How do you eat an elephant ? " one bite at a time"

# UofT Process in a nutshell

**Set the Goals** : Create a road map of where you want to be and choose metrics to evaluate your progress.

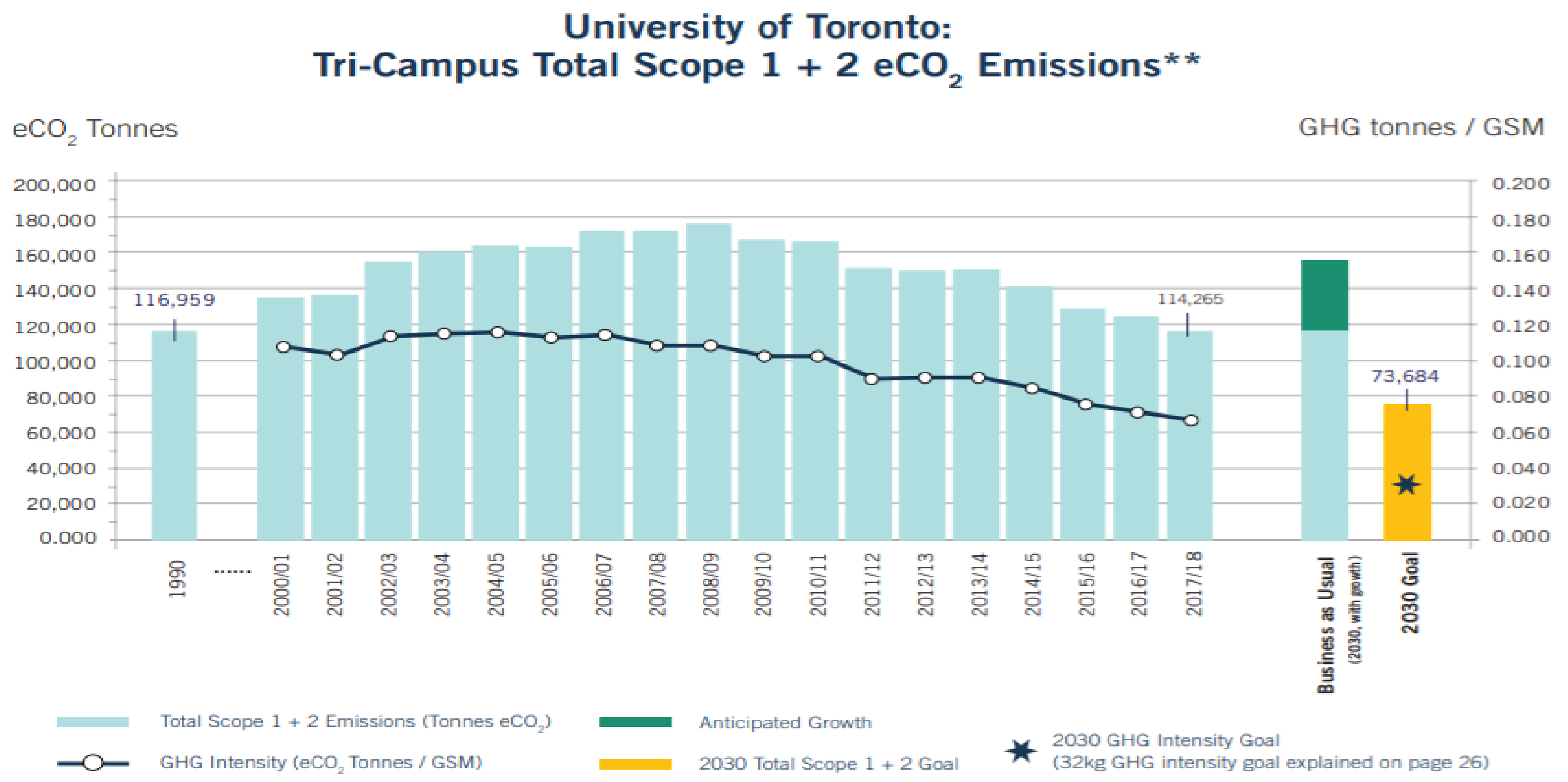
**Gain commitment**: Make it strategic

**Set the foundations right** : Understand what you have and how to communicate the expectations

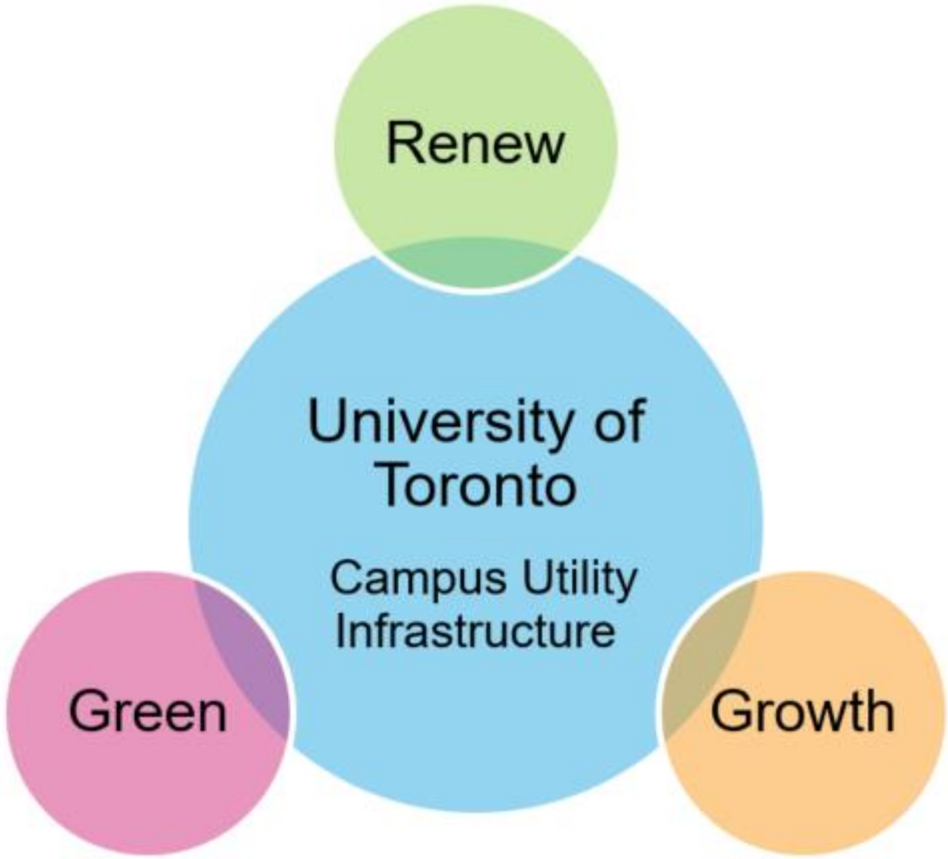
# UofT 2019 Low Carbon Action Plan

"The University of Toronto has set a goal to advance towards a 37% reduction in Greenhouse Gas Emissions by 2030, from a 1990 level baseline."

Scott Mabury Vice-President, Operations and Real Estate Partnerships



# UTILITY INFRASTRUCTURE MASTER PLAN OBJECTIVES




Existing campus utility infrastructure is aged and requires renewal to support the university campus in its pursuit of academic and research excellence

Significant new campus growth will require expansion of the campus utility infrastructure in terms of:

- reliability
- redundancy
- resiliency

Commitment to reduce Green House Gas emission (by 37% below 1990's emission by the year 2030) will require transformational changes of the campus utility infrastructure

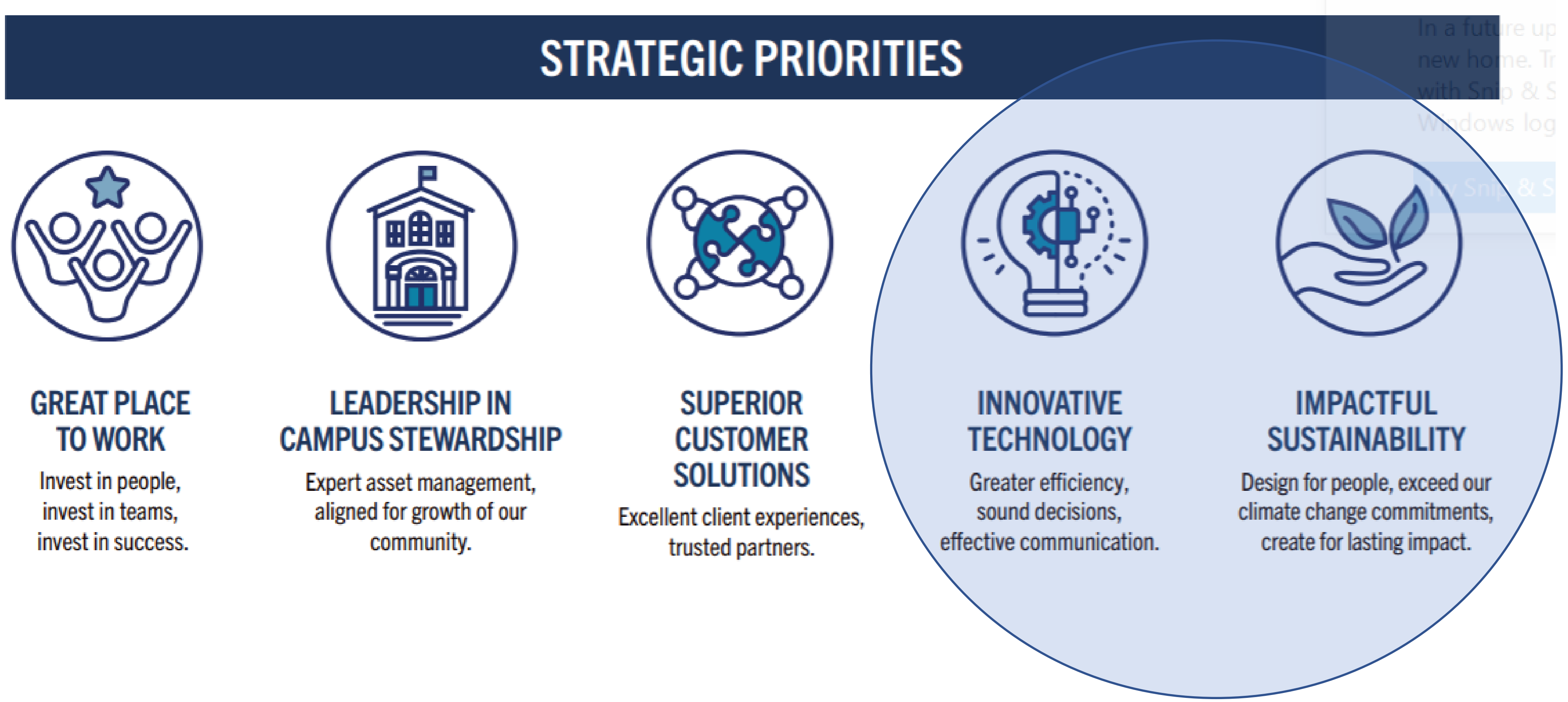
# Metrics To Determine Progress:

- Improved ability to maintain **thermal comfort and air quality**
- Improved **reliability and resiliency** of the mechanical services
- **Greater visibility** of System Operation
- **Have central document** repository
- **Reduced operating** costs
- **Reduced utilities** costs
- **Reduced Carbon Footprint** by transitioning systems from natural gas to low carbon sources of energy.

# UofT St. George Campus F&S Strategic Plan

" The F&S strategic  plan is our road map to guide not only what we'll focus on over the next 5 years but also how we'll do it" –

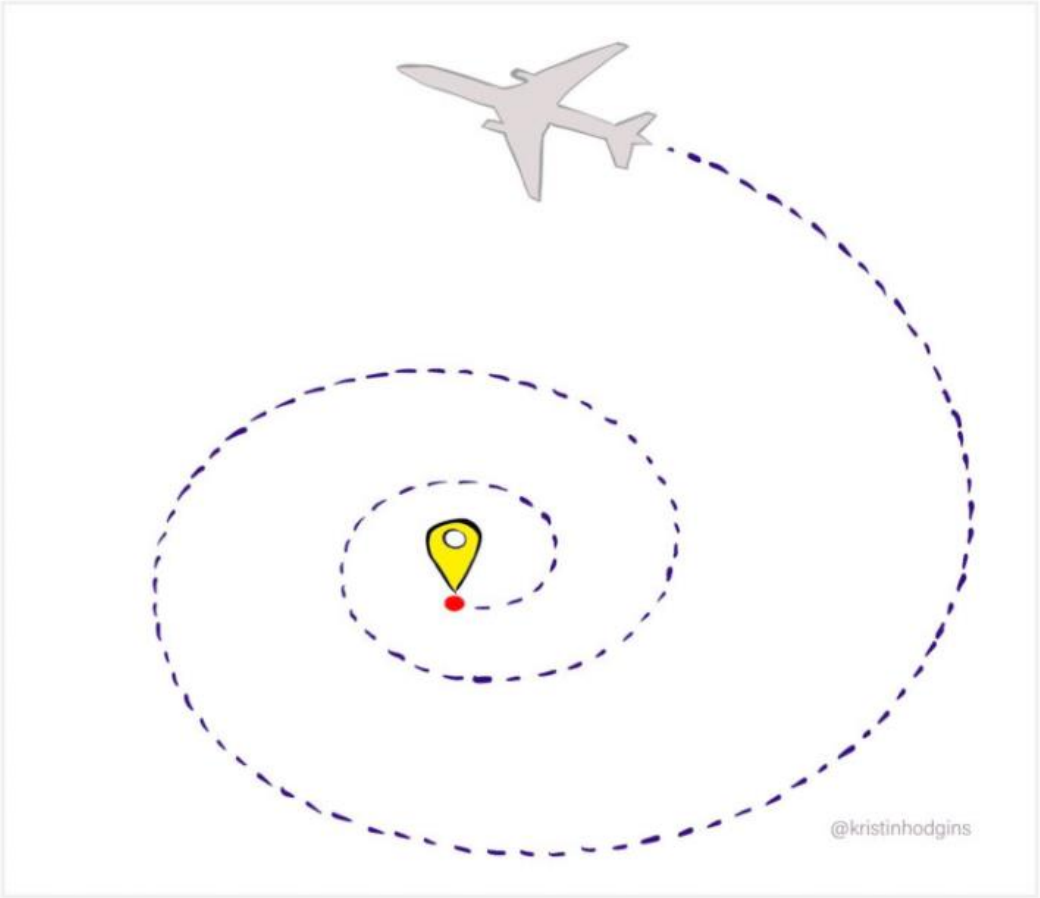
Ron Saporta, Chief Operating Officer, Property Services & Sustainability



# We have the goals, what is next?

- Have a process for **consistent** conveyance of Building User & Operations Requirements
- **Consistently** challenge the status quo
- **Consistently** push the envelope

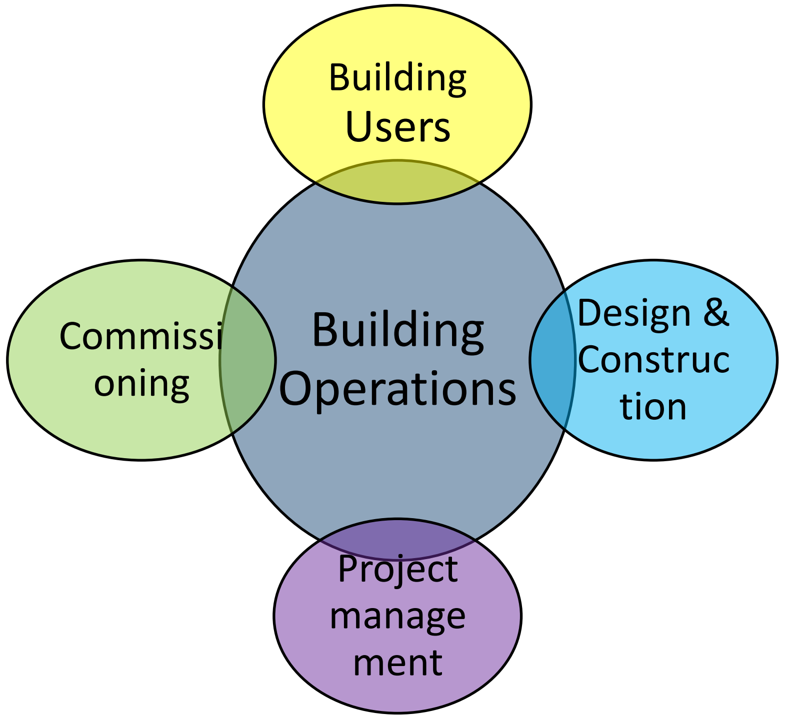
.... And **communicate and collaborate**



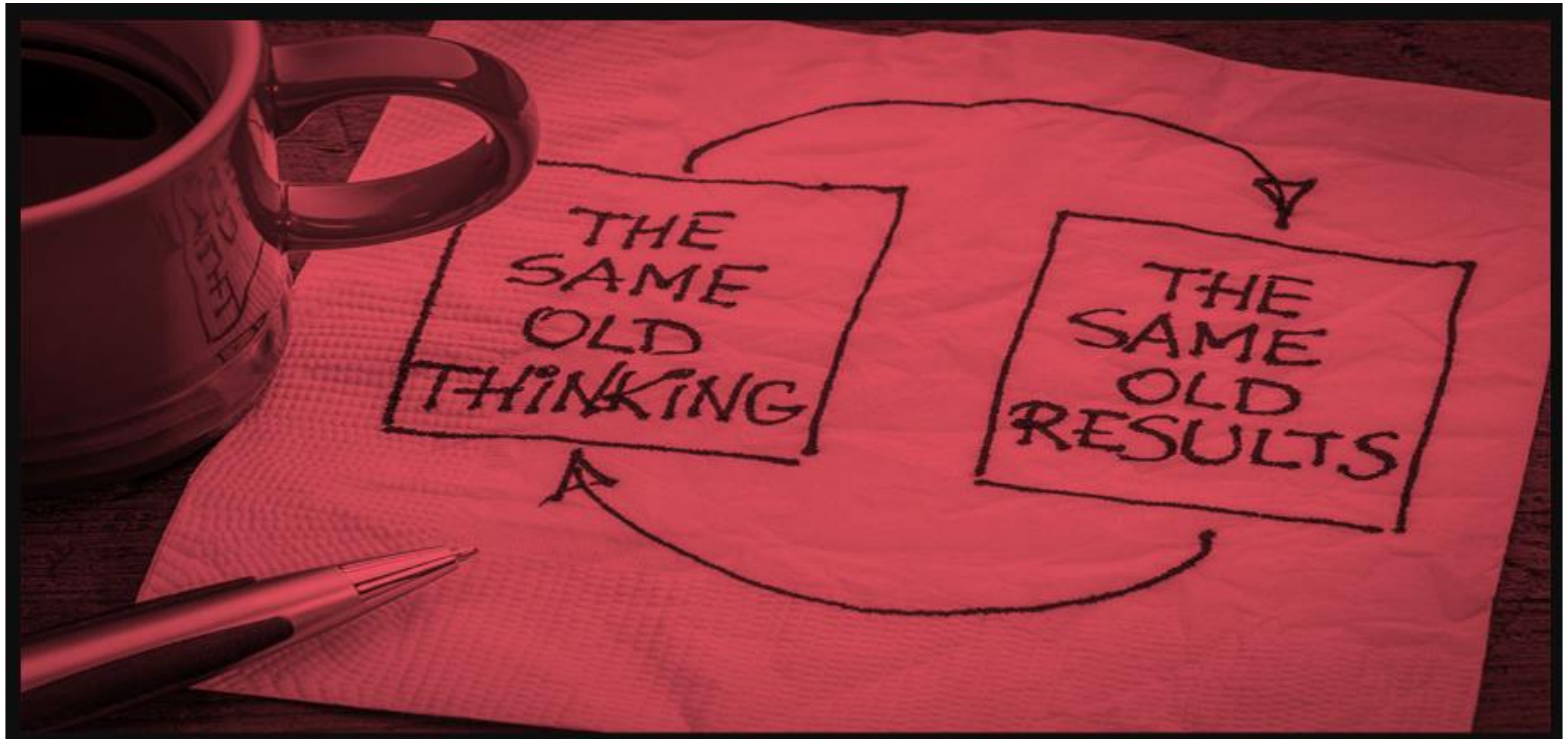

Taken from Kristin Hodgins Blog – chaos pilot

# Conveying Building User & Operation Requirements

- Project Planning Requirements
- UofT Standards
- Tools for project managers : check lists, outlining design review processes, Cx



# Challenging the status quo



# Twist in Commissioning Roles

Commissioning agent responsible for creation of the system narrative:

| | |
|---|---|
| | the system. |
| System Description with narrative | A detailed description of the design philosophy, design intent, and design criteria for each system. Includes details of system type, composition, location of areas served in the building, and function of major components. |
| System | A system focused composite document that includes the design and |

| | |
|---|---|
| Operating Instruction for Emergency Work | A detailed narrative providing, in building operators' layman language, the specific instructions for start-up, shut down and seasonal changeover of the systems/components. This shall be provided including all relevant details such as: exact type and specific location of each device and interlocks; list of conditions to be fulfilled prior to attempting the equipment start up (correct valve positioning, etc) |

| Task | Proj. Mgr. | Facilities Rep. | Designer | Contractor | Operations (Control Tech./Building Eng.) | Commissioning Authority |
|---|---|---|---|---|---|---|
| Owner Project Requirement (OPR) update | * | * | * | * | * | R |
| Basis of Design (BoD) | P | P | R | | | P |
| Design | P | P | R | | | P |
| Commissioning Procedures | | | | | | |
| 1. System Description Narrative | P | P | P | | | R |
| 2. Verify OPR to BoD | P | P | P | | | R |
| 3. Confirm Design matches BoD including design standards | P | O | P | | | R |
| 4. Prepare Commissioning Reports (100% SD, 100% DD, 100%CD) | P | O | P | | | R |
| 5. Verify equipment matches spec (IQ) | P | | | P | | R |
| 6. Verify operating parameters (OQ) | P | | | P | | R |
| 7. Verify overall performance (PQ) | P | | | P | | R |
| 8. Operating Instruction for Emergency Work | P | O | P | P | O | R |

# Communication & Collaboration

- Consistent communication of requirements through standards
- Standards are made through collaborative process



### 1.11.13 BAS Sequence of Operations – Context and Format

It is the responsibility of the Project Consultant to ensure that the project design specifications include the requirements below:

**1.11.13.1 PURPOSE**

Purpose of this standard is to convey minimum University of Toronto, Facilities and Services expectations in terms of the context and format of the Sequence of Operation for Building Automation System (BAS) for the Project Consultant to include in the Design Specification It is the responsibility of the Project Consultant to ensure that the project design specifications include the following requirements:

**1.11.13.2 INTENT**

Clear, detailed control sequence of operation is necessary to provide proper operation of the building. It shall sufficiently describe in simple and understandable language how the control system and associated building systems and equipment shall operate. Energy consumption, savings and demand as well as system performance troubleshooting are also part of the building operation and BAS.

The sequence of operation shall provide a story of the design intent for the building operation with set values to what the building shall be operated to (set points). It shall clearly state what parameters shall be adjusted / determined during initial start-up, balancing, commissioning and what are user adjustable. It shall provide information on safety features (hardwired / soft points), integration with life safety systems (fire alarm, smoke exhaust, stair pressurization, and similar). It shall describe system operation during power failure, scheduled start / stop and integration with any other building systems / equipment.

BAS vendor is a controls integrator so the BAS shop drawings and sequence of operation have to have all required details to allow the UofT Facilities and Services to operate and maintain the buildings, which means that all relevant info associated with packaged units and lab controls has to be included in and/or clearly referenced & affixed as appendices with this document. These mandatory requirements are applicable to all the projects listed in the section 1.2 of this document.

**1.11.13.3 APPLICATION**

This Standard is applicable for BAS controls and any other control systems that may be provided by the separate control vendors / equipment packages for integration with / through BAS system. Examples are Lab control, Fume Hood control, VRF systems, packaged AHUs, chillers, boilers, VRF systems, etc.

# Engineering Agreement to the rescue

Define expectations upfront:

Use Item 9.4 :

“ ... to address the operational issues **identified** during commissioning or start up, **or** within **first two years** of operation associated with not being able to operate as per design / commissioned parameters, or not meeting energy performance / green house reduction of the building “

ASSOCIATION OF CONSULTING ENGINEERING COMPANIES | CANADA

ASSOCIATION OF CONSULTING ENGINEERING COMPANIES–CANADA

DOCUMENT NO. 31 - 2010

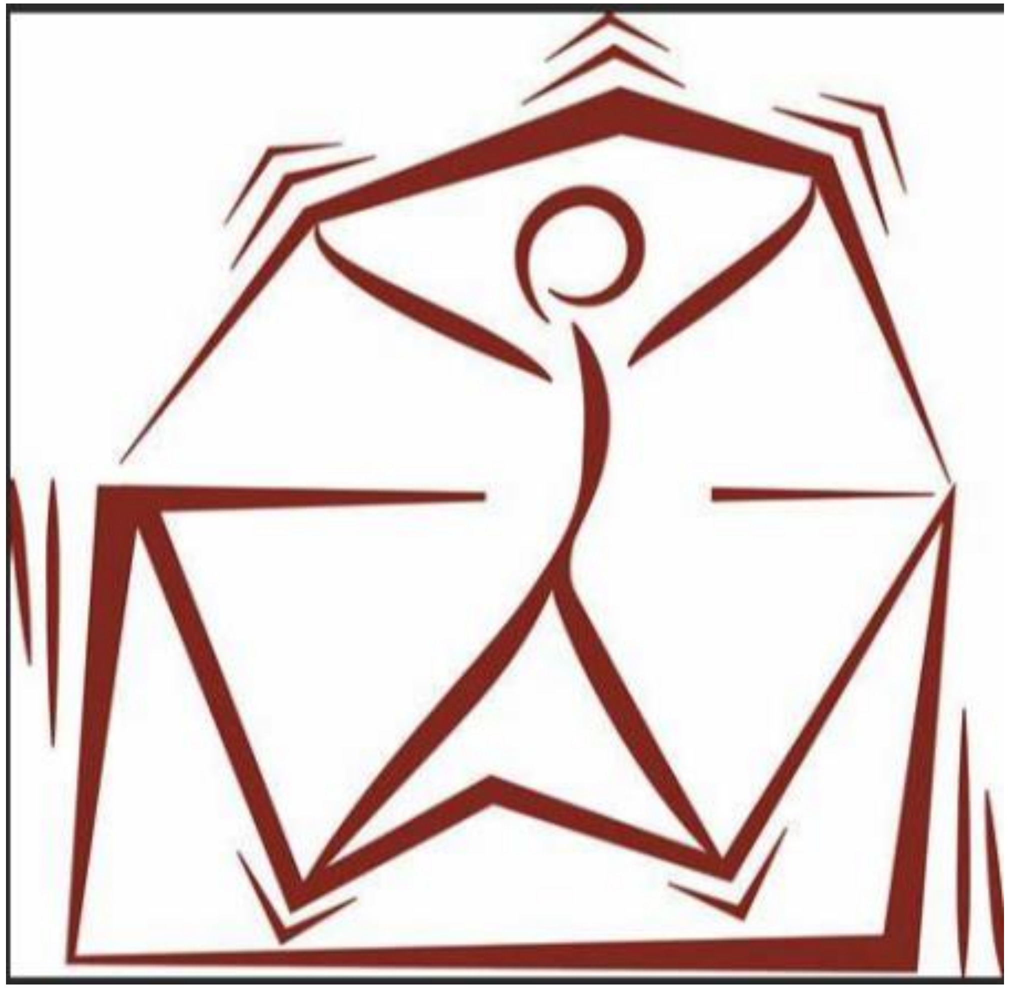
ENGINEERING AGREEMENT BETWEEN CLIENT AND ENGINEER

ACEC Document 31 – 2010 A-11

**A-9 Post Construction Engineering Services**

| | Description of Services | Yes | No |
|---|---|---|---|
| If Post Construction Services WILL NOT BE PROVIDED, check this box: | | | ☐ |
| If Post Construction Services WILL BE PROVIDED, identify them by completing the following: | | | |
| Post Construction Engineering Services comprising the following: | | | |
| 9.1 | Provision of commissioning and start-up assistance. | ☒ | ☐ |
| 9.2 | Collection and organization of operating and maintenance manuals. | ☒ | ☐ |
| 9.3 | Identification of deficiencies during the warranty period at the *Client's* request. | ☒ | ☐ |
| 9.4 | Assistance in facility management or operations after commissioning and start-up. | | |
| 9.5 | Preparation of record documents in accordance with GC 7.13 of PART 7 CONSTRUCTION ADMINISTRATION. | ☒ | ☐ |

# Pushing the envelope



# Our take on: "What is a smart building"?

- Whole facility operation and maintenance is data driven and automated
- Flexible enough to accept changes in institutional programs and new technologies
- Building that can report when it is operating outside or normal parameters
- Building that can troubleshoot itself and adjust its operation based on the data and/or send a work order for maintenance work


Taken from "BuiltWorlds @ 2017"

# PID Programming During Construction

- BAS systems are becoming more complicated.
- The number of Control Technician's that understand PID loops and loop tuning is decreasing.  This task is often left for the Control Vendor’s Service Department to set up once the building is turned over.
- Improperly tuned Control Systems will hunt and not perform as intended resulting in uncomfortable users and higher energy costs than intended.
- To ensure proper operation of systems require that the Control Vendors demonstrate stable operation for all systems via trend data prior to project turnover.

# Fault Detection & Diagnostic via BAS

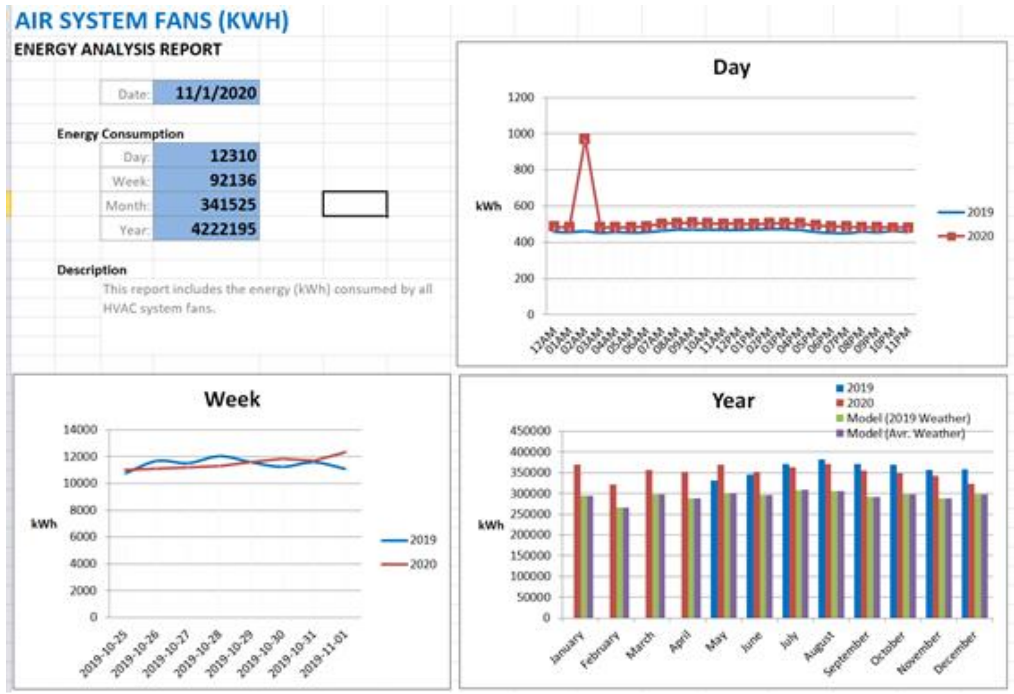
- Provide additional sensors to allow for faster troubleshooting , integral BAS Fault Detection and Diagnostic (FDD) or future integration with external FDD system

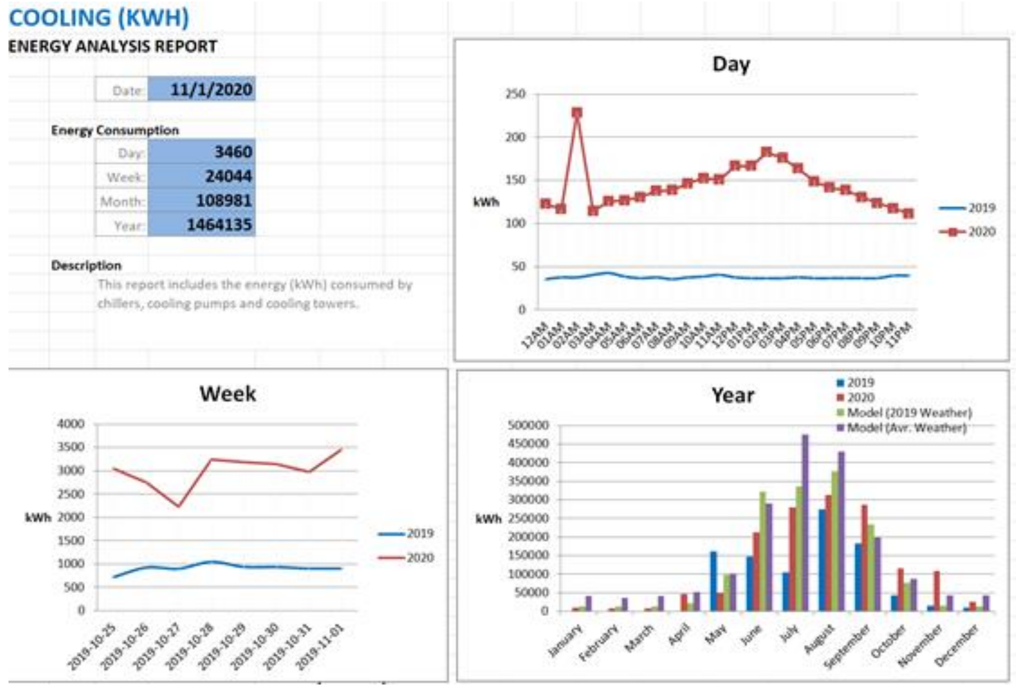
- Put alarms in place to notify the Operator when systems are not operating as intended.  Not just equipment failure.

- Provide system dashboards for comparison of energy use.

# Energy Dashboard via BAS

- System
  - Displays energy utilized by each system on a daily, weekly and yearly basis.
  - Compares current years energy usage against last years and the energy model (if available).
- Benefits
  - Allows Building Operators to see when something has changed resulting In higher energy use.
  - Provides a means of showing how modifications to systems are impacting facility energy use.

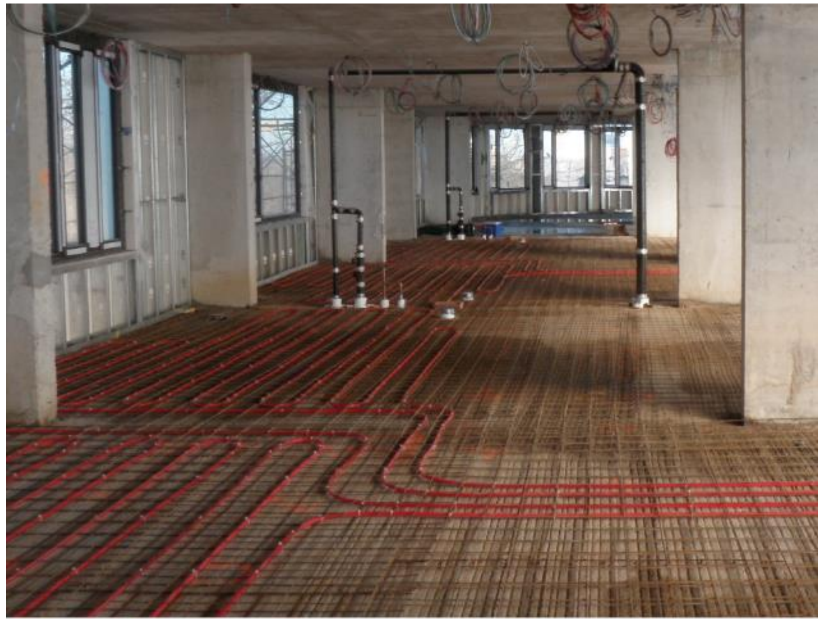


# Trending technology

- Equipment
  - **GeoExchange**
  - **Heat Pumps**
    - **Water source**
    - Air Source
  - **Heat reclaim chillers**
  - Dedicated Outside Air Systems (DOAS)
  - Exhaust air heat recovery utilizing heat pumps
  - Enthalpy wheels
  - Radiant floor heating and cooling
  - Photovoltaic
- Design Tools
  - Computational  Fluid Dynamic (CFD)
  - **Building Information Modeling (BIM)**
- Building Automation
  - **DDC Building Automation System with Fault Detection & Diagnostic**
  - **Internet of Things (IOT)**
  - Artificial Intelligence (AI)

GeoExchange Wells UofT Kings College Circle



Radiant Heating/Cooling

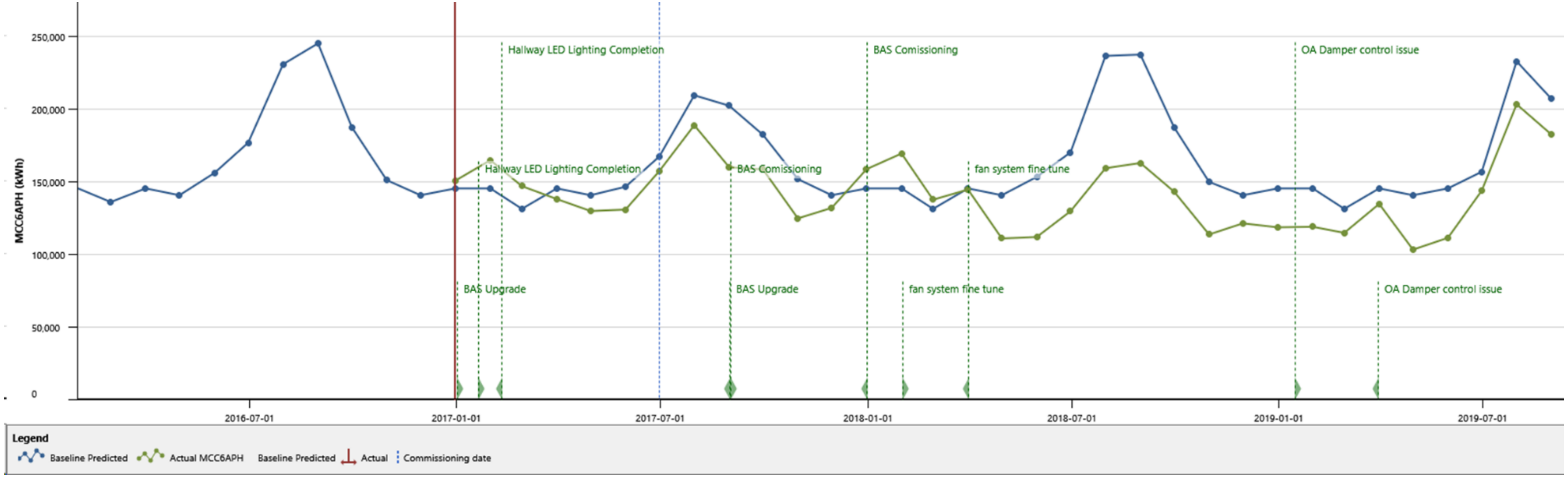
# Adapting sustainable technologies to suit unique requirements of each facility and the campus:

- Age and heritage of the buildings / campus
- Geographical location - Urban setting
- Existing heating systems utilize steam or high temperature hot water at 71.1 C (160 F) or higher which makes the use of heat pumps and heat reclaim chillers more complicated
- Limited space within existing facilities to add new equipment
- Existing documentation is not up to date
- Energy (reduction, recovery, renewable)
- UofT strategic documents – utilities master plan


Simcoe Hall 1907 – photo taken from UofT DM 2019 report

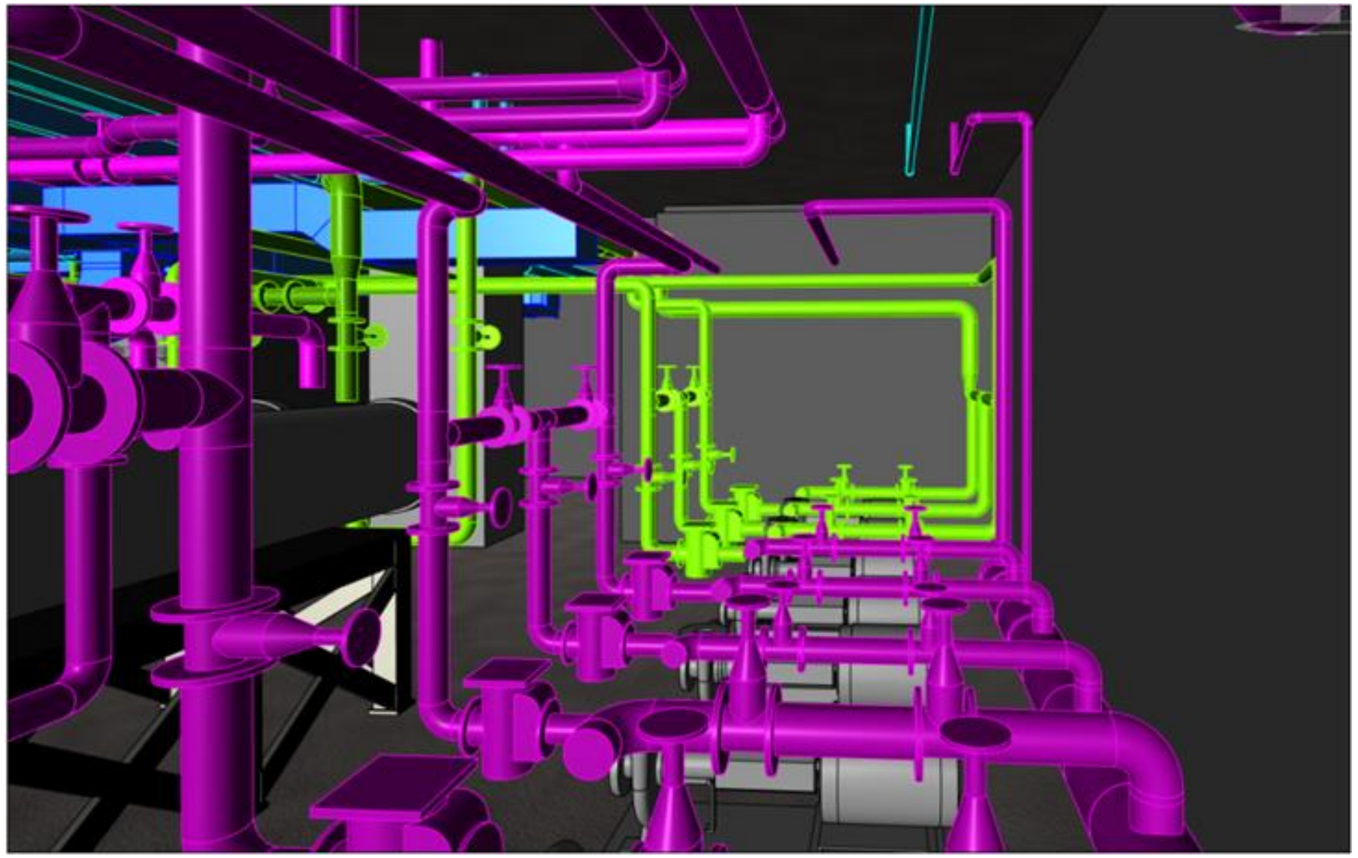
# Bahen center for Informatioin Techonology -BAS upgrade project

- 2001; admin, classrooms and computer labs; 500,000 sqft; Underfloor HVAC with VAV box;
- Conversion of pneumatic to DDC controls
- No changes to sequence of operation



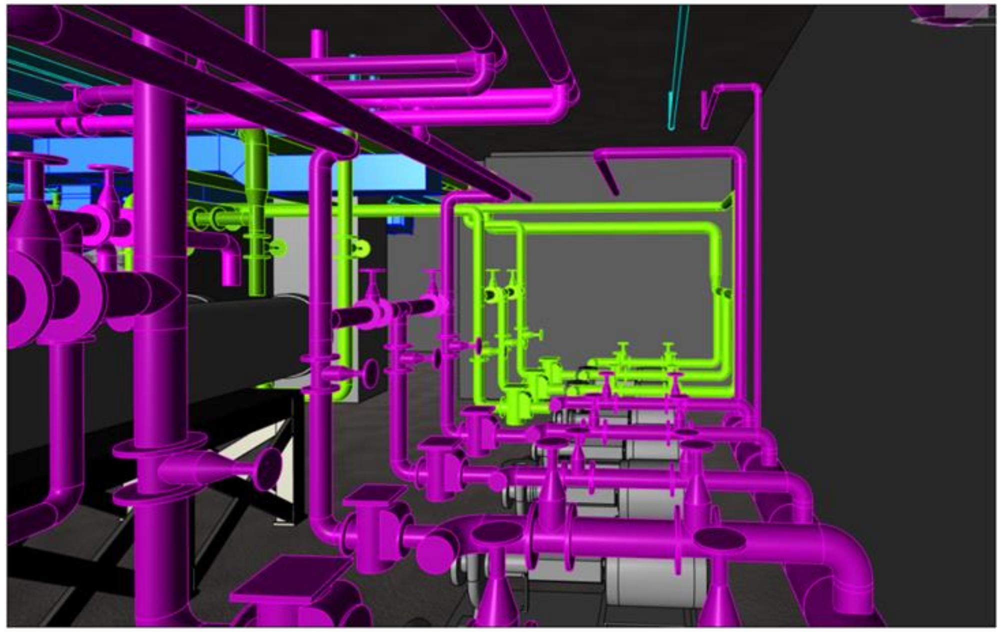
# McLennan Building Chiller Replacement

# McLennan Building Chiller Replacement



# McLennan Building Chiller Replacement

- Laser Scan
  - Existing building systems were laser scanned to ensure that the design drawings matched the existing conditions.
- Revit was utilized to provide the following:
  - Provide greater visualization to User Groups during the design process and allow Designers to coordinate As Built Conditions from their desktop.
  - Improve Coordination between Design Professionals
  - Provides a Database which includes the design data for of all systems within the model.



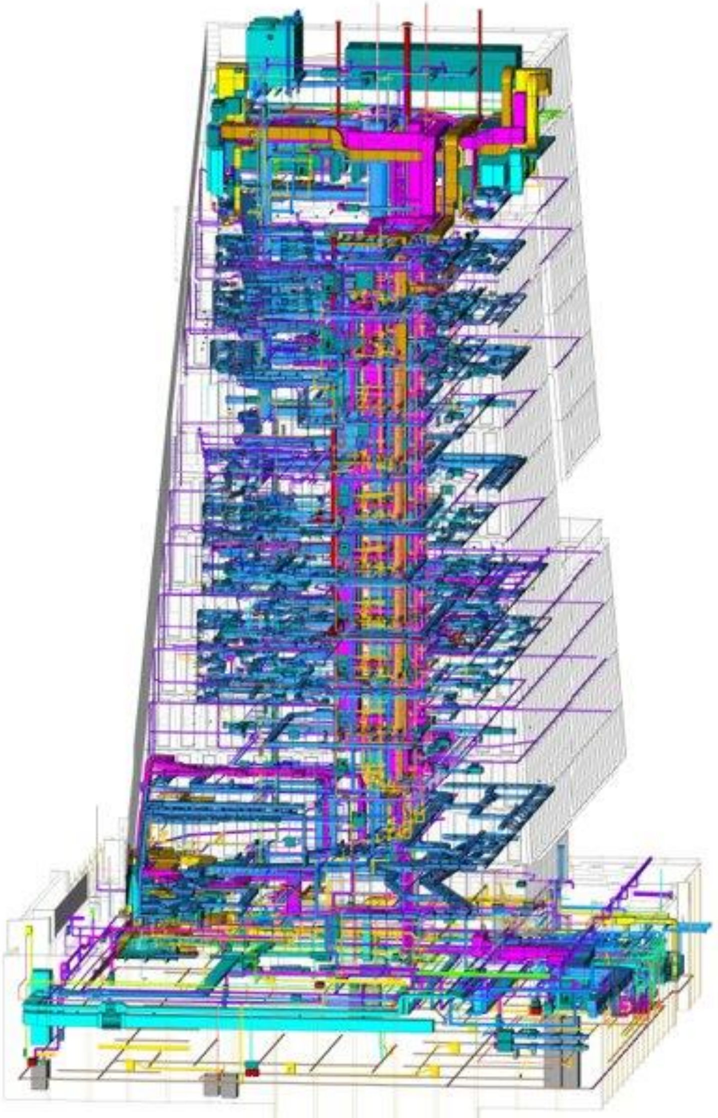
# Benefits of BIM and Future Considerations

Benefits of BIM

- Improved Quality Control
- Significantly reduces the risk of change orders due to clashes with existing systems or systems not being where they were anticipated to be.
- Provides an accurate as built drawing which can be utilized for future work

Future considerations:

- BIM model in data depository
- Assist with maintaining and setting up F & S maintenance data bases

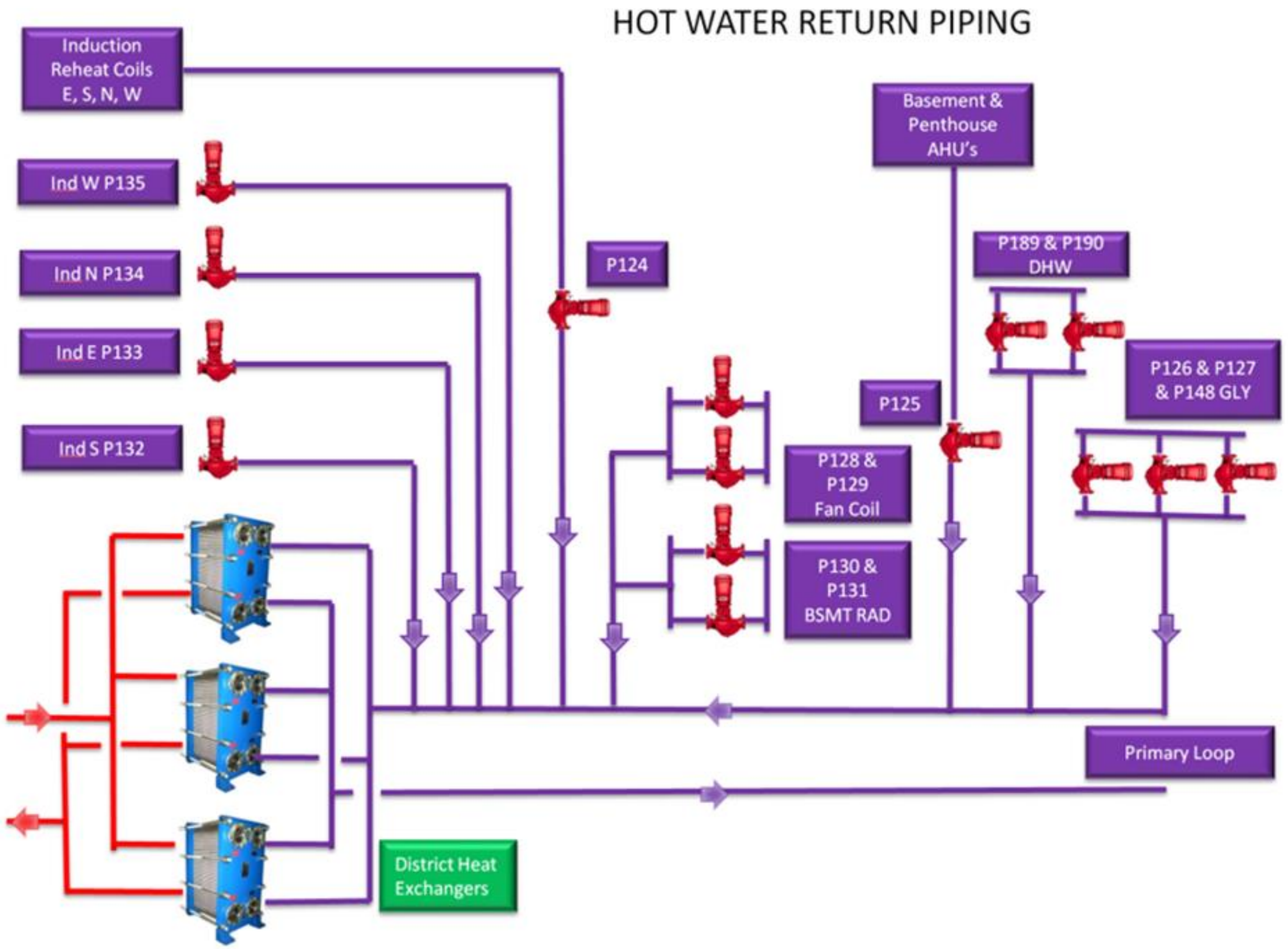


U of T Schwartz Reisman Innovation Centre

# McLennan Building Chiller Replacement

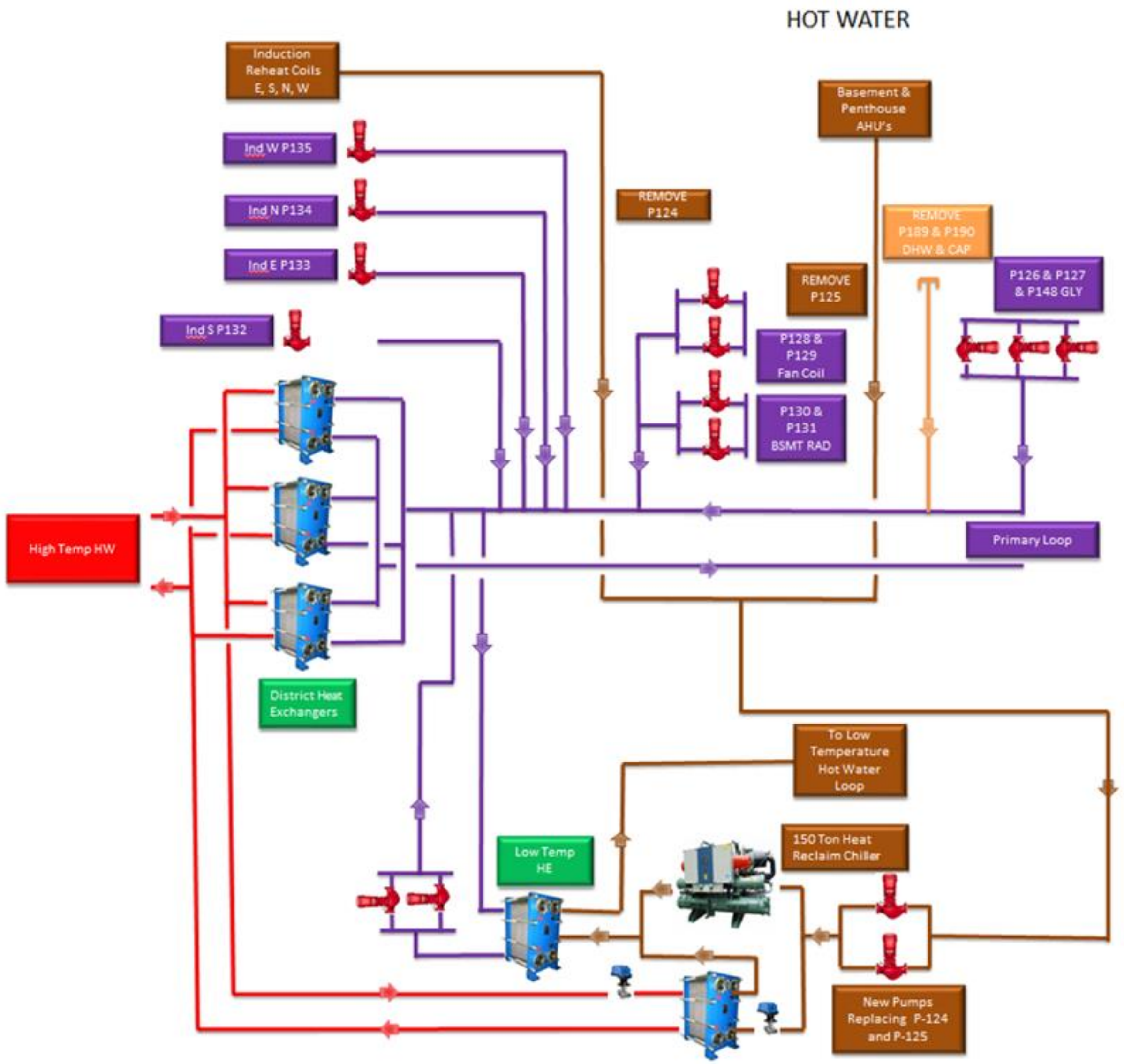
Existing Systems

- Building is served by a District High Temperature Hot Water System 198 C (388 F)
- High Temperature Hot Water is utilized to transfer heat to a Medium Temperature Hot Water system 82.2 C (180 F) through heat exchangers
- Multiple zoned distribution pumps on the return branch lines.
- Two data centres are located in the building and each data centre utilizes 100 tons of cooling year round. (200 tons total)



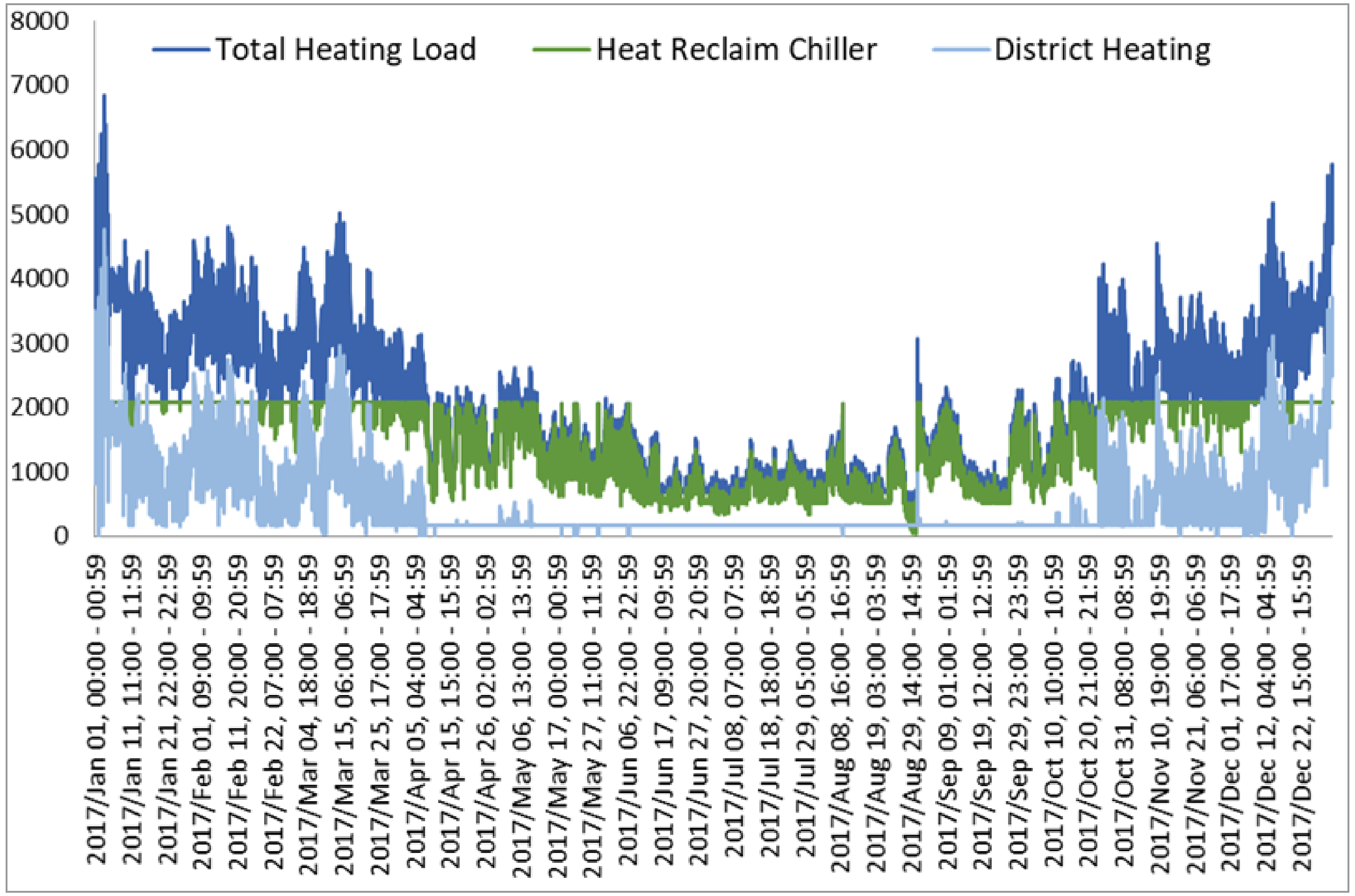
# McLennan Building Chiller Replacement

- New Systems
  - New heat reclaim chiller takes heat generated by cooling the data rooms and utilizes it to heat the building.
  - Air Handling Unit heating loop was decoupled from the Medium Temperature System
  - AHU Coils were replaced with low temperature hot water coils 51.7 C (125 F) to allow the heat reclaim chiller to meet the heating loads.
  - Low Temperature Hot Water System backfeeds the medium temperature system when outdoor air conditions permit.



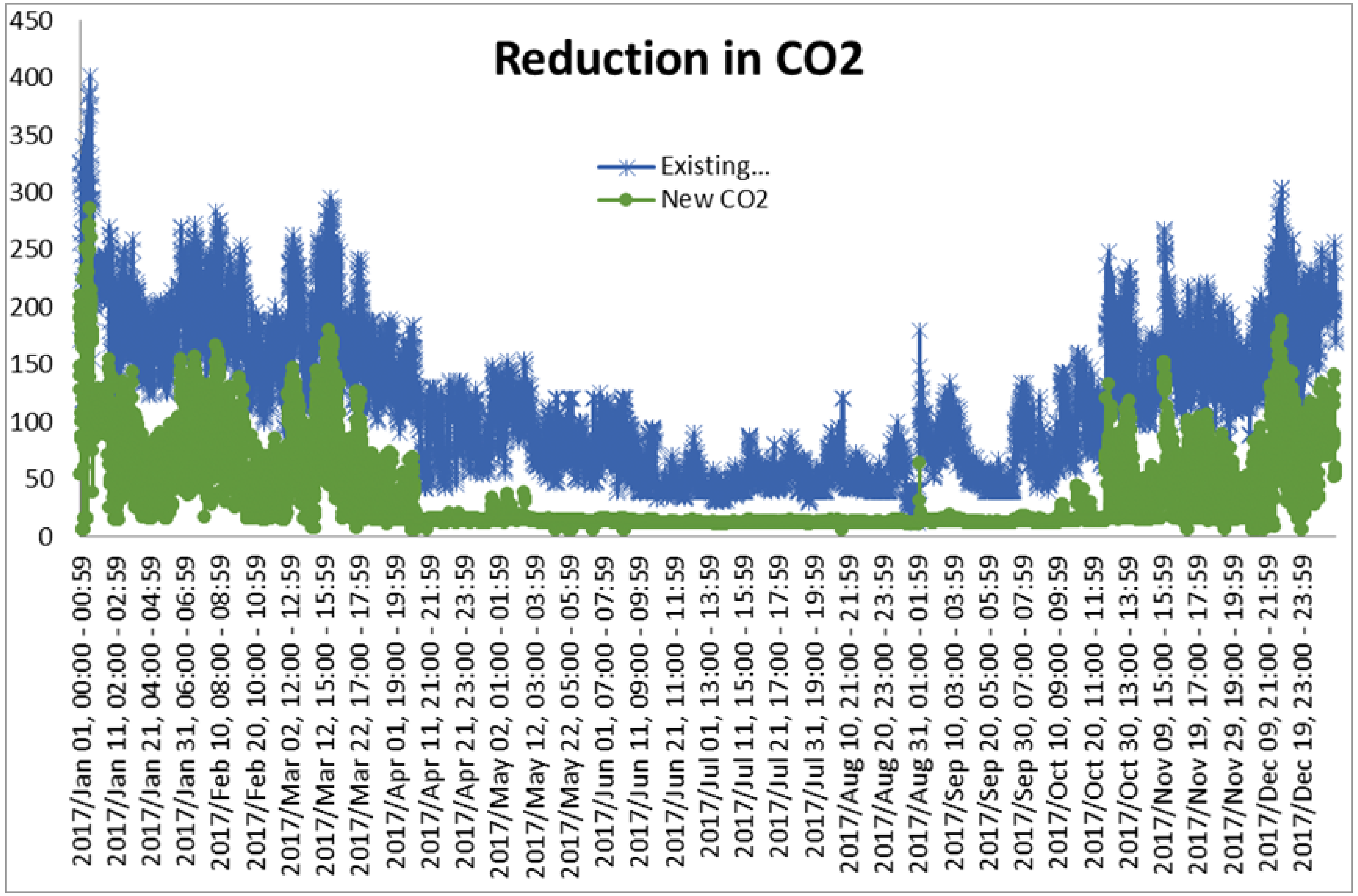
# McLennan Building Chiller Replacement

- Significant shift of energy use from Natural Gas to Electricity
- Electrical load increased by 103,782 kw hr / yr ($13,683)
- Natural gas load decreased by 12,965,680 MBH per year ($113,655)



# McLennan Building Chiller Replacement

- 727 eton reduction in $CO_2$

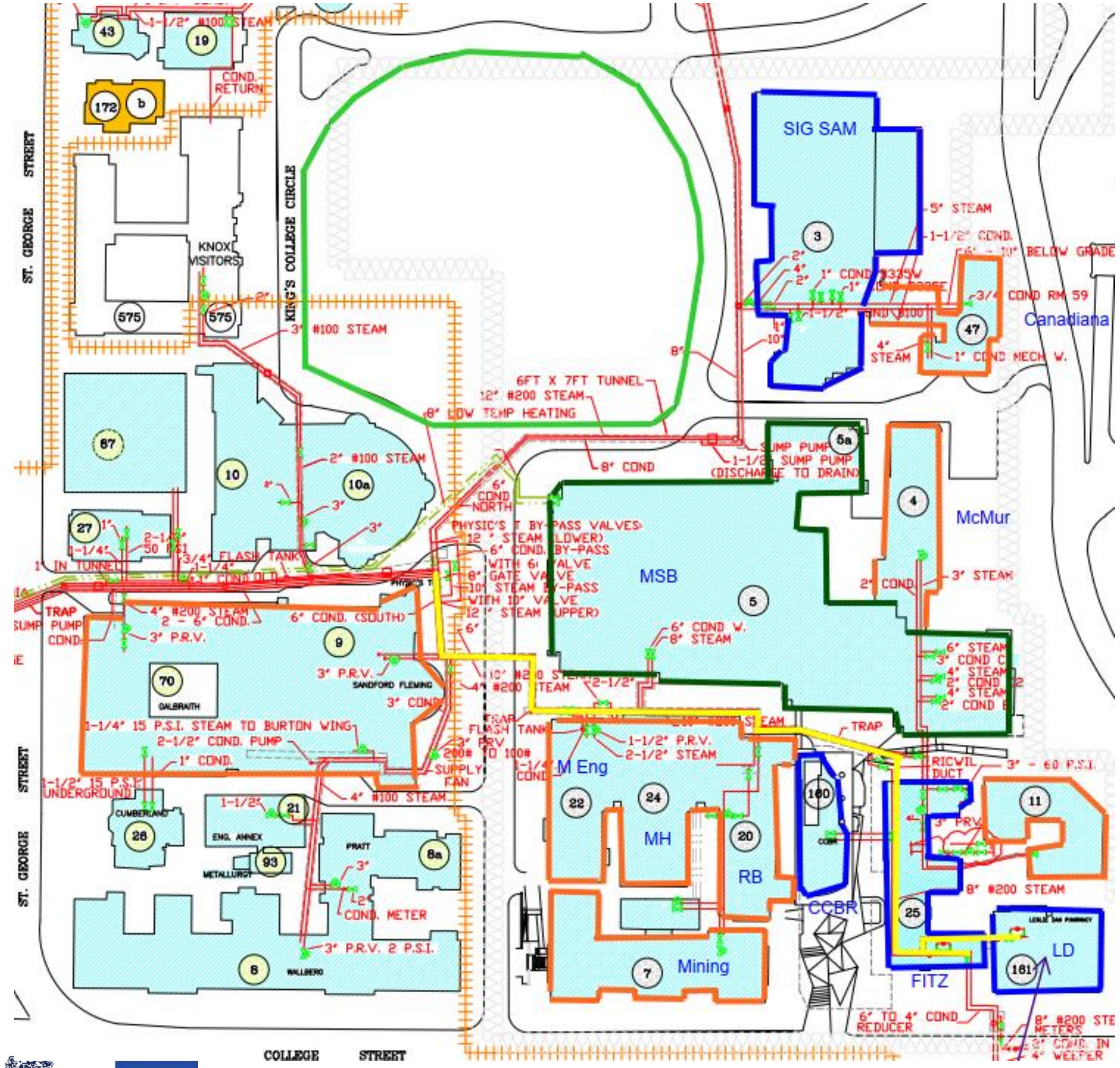


# Kings College Circle Geo-Exchange Field

- 374 boreholes at 244 metres. One of Largest Geo-Exchange systems in Canda.

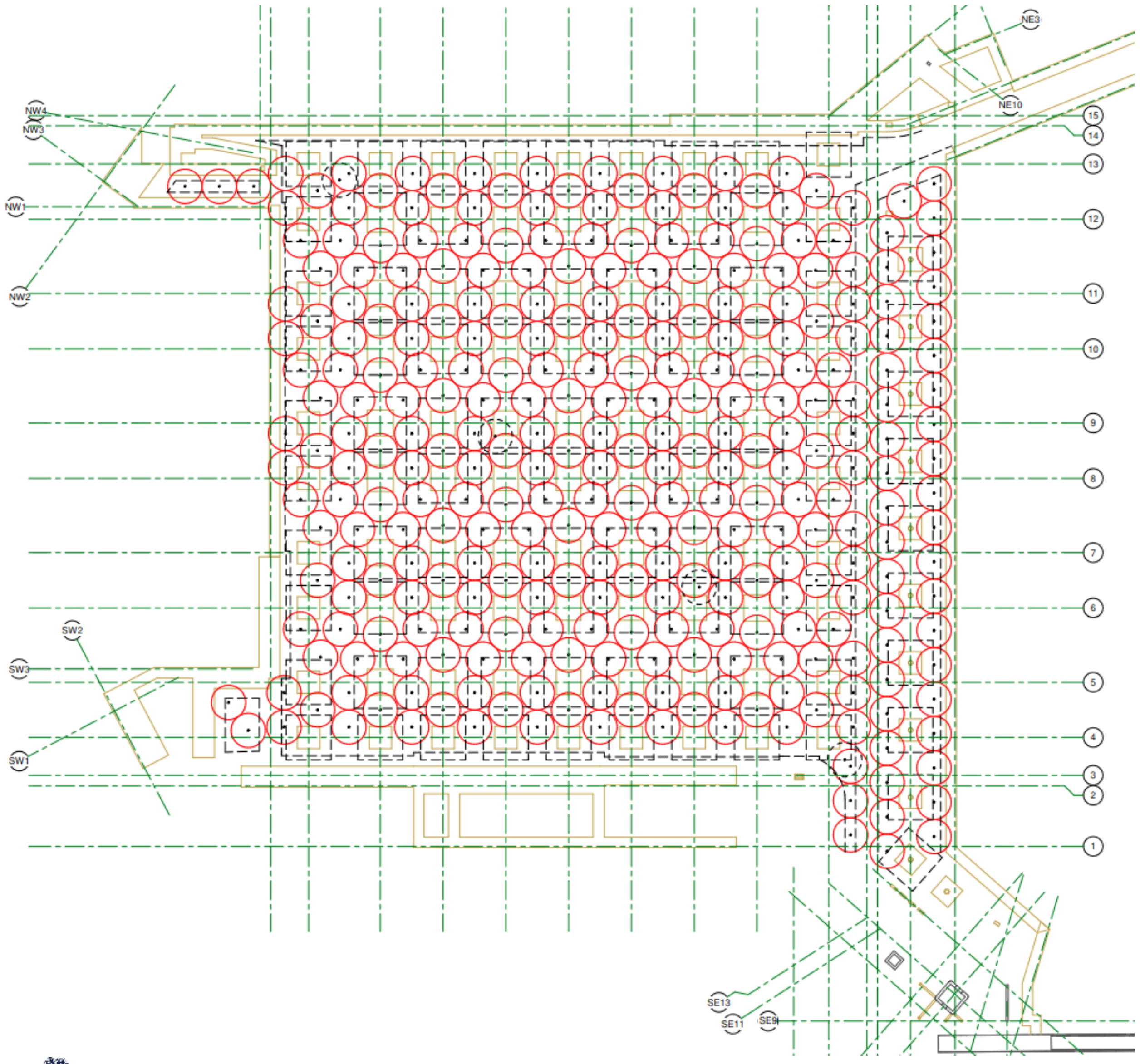
- Initial Use
  - Stores heat recovered from the Central Plant Diesel Generators and Boilers by the U of T Sofame system during the summer and shoulder seasons for future use and improves the Delta T of the Sofame System increasing useable capacity.

- Future Use
  - Will be charged by heat generated by the MSB chilled water plant during the summer for use during the winter / shoulder seasons.



# Kings College Circle Geoexchange Field

- New Low Temperature Hot Water Loop will serve the following:
  - Existing MSB building which currently utlizes Sofame
  - New buildings that are being  built on the Southeast side of the campus (ie Fitzgerald)
  - Existing buildings converted from steam to low temperature hot water.



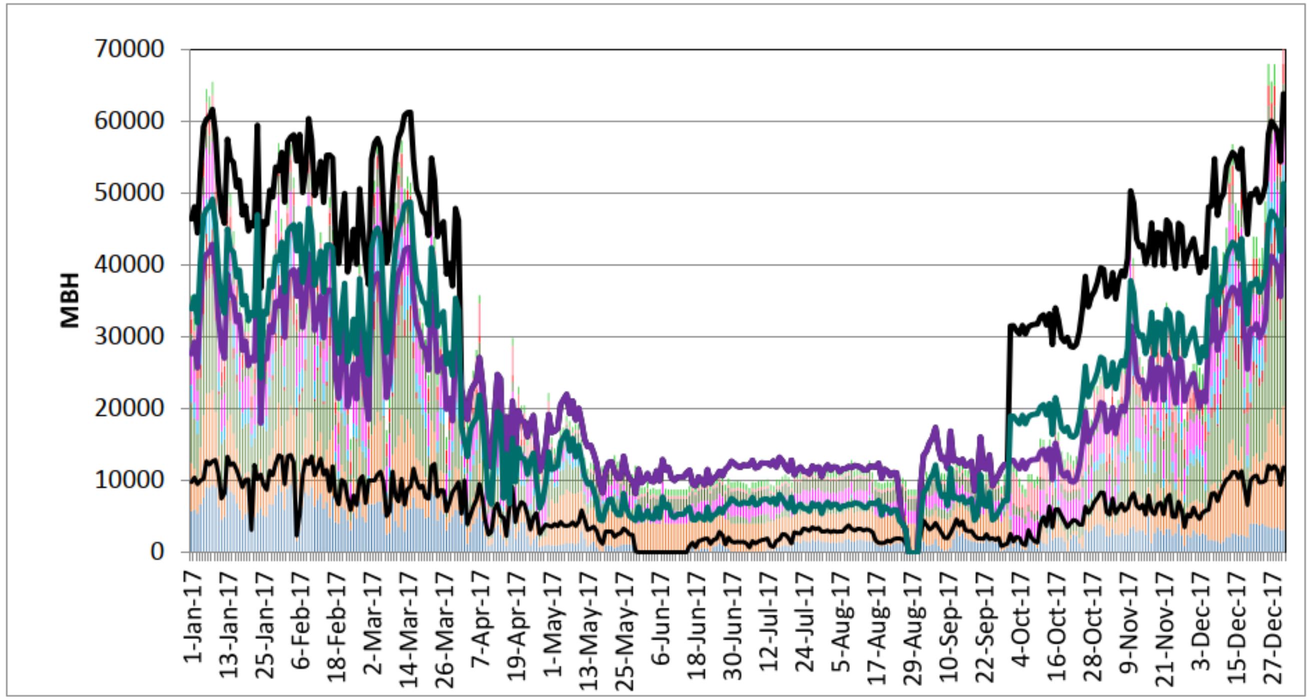
# Kings College Circle GeoExchange  Field

- Objective is to significantly increase the performance of the Sofame system by increasing the Temperature Differential Between Supply and Return so that it can absorb more heat.

- Store heat generated by the Sofame system and MSB chillers  in the summer and shoulder seasons for utilization during the winter.

- Anticipated $CO_2$ Reduction once system is fully implemented
  - 15,000 etons / year.

Graph 2: Impact of All Renovations on Total Steam Consumption




| Legend | Description |
|---|---|
| Bottom Black Line | Existing Sofame Consumption |
| Middle Teal Line | Day 1 Predicted Capacity (Sofame & Geothermal) |
| Middle Purple Line | Available Sofame Capacity based on Steam Production at ΔT=50°F |
| Top Block Line | Full-Fit Out Predicted Capacity (Sofame & Geothermal) |
| Bar Graph | Extended Study Building Load Predictions on Low Temperature Hot Water |

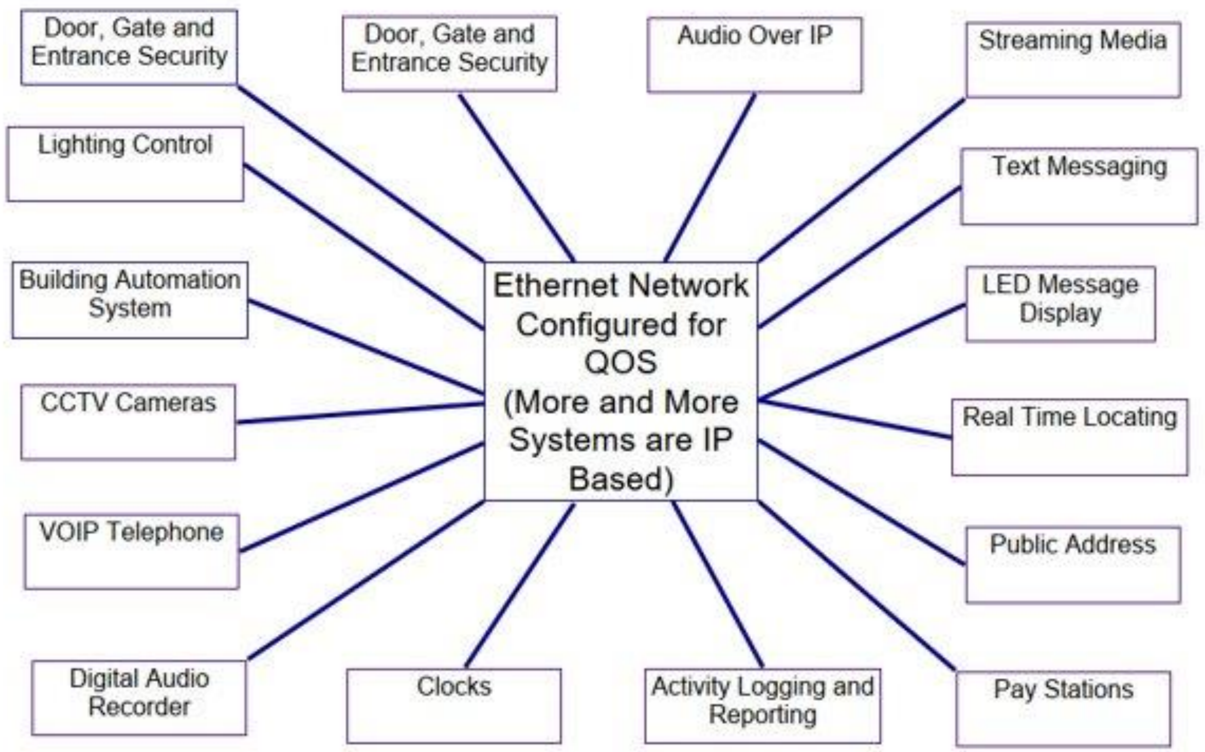
# Where we want to be – Internet of Things (IOT)

- The IOT is blurring the line between Building Automation, Lighting, Process, Security and Fire Alarm Controls.

- Total systems interconnectivity: one of the aspects of the SMART Building

- Internet of Things (IOT) Challenges to address:

➢ Requirement for clear delineation of scope and commissioning
➢ The construction schedule



# Where we want to be – AI for building operations?

Artificial intelligence in building operations will:

- Allow systems to adjust its operation proactively
- Temporary compensate for deficiencies in mechanical systems
- ???

Questions to be addressed:

- Security of the system
- Requires takeover of the conventional controls by third party
- Responsibility for the design of the mechanical systems

*An important step to AI adoption is to quantify connected assets. Identify how many and what types of HVAC controls, sensors, relays, and communications devices are available and in use.*

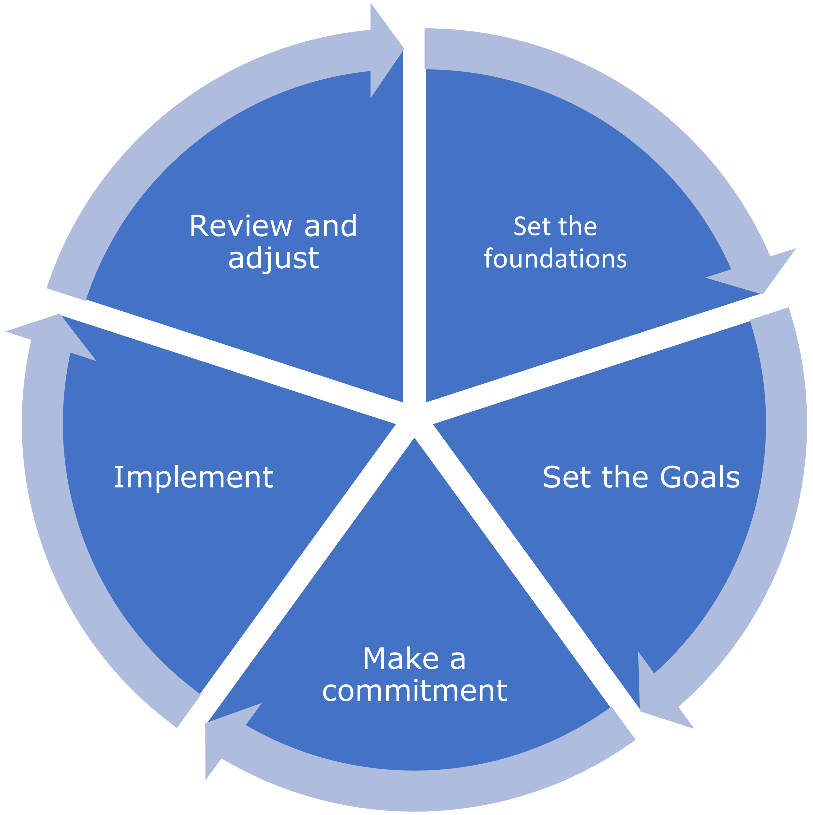
**Taken from: Facility Executive : AI Gains Traction In Commercial Buildings**
*Facility management increasingly sees the benefits of artificial intelligence implementation throughout building operations.*
December 21, 2020 By Neil Strother

# Pragmatic and Visionary

Keep an Open Mind to stay agile and flexible


By Frank Zappa

Have a Process



# Thank You!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