# 370 DOMINION AVENUE

# Heating Investigation & Report

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## 1.0 INTRODUCTION:

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## 2.0. PURPOSE

The purpose of this study is to evaluate the existing heating systems used in the building to determine the viability of converting from all electric to all gas heating. The report includes review of the building make up air system, existing 2-pipe chilled water fan coil system, and existing controls. An energy modeling analysis was performed to determine the heating requirements during the winter months and compared to electricity bills. The report includes a construction cost estimate and simple payback analysis. In addition, the garage ventilation system was also reviewed for proposed CO monitoring system.

## 3.0. EXISTING SYSTEMS

### .1 Residential Systems

The 14 story residential building, located at 370 Dominion Avenue, Ottawa, Ontario, was constructed in 1975 and contains approximately 100 suites. The penthouse floor contains a mechanical room and two (2) executive suites. The building contains an attached two (2) story parking garage and a pool building located on the west face.

Building ventilation air is provided to the corridors and main lobby via a single make-up air unit (MAU) consisting of a Q-Dot heat recovery section, chilled water coil, and electric reheat. The unit is located within the penthouse mechanical room. The unit is designed to deliver 10,200 CFM of air at 78 $^{o}$F in the winter and 65 $^{o}$F in the summer.

The design incorporates a total of 7,280 CFM of dryer exhaust, which is collected from residential suites. The exhaust passes through the heat recovery section of the Q-Dot unit to temper the air entering the MAU.

Independent washroom exhaust is vented to the outside of the building in each of the suites.

The ventilation air is designed to enter the suites from hallways under the door entrance. The suites contain operable windows allowing occupants to increase ventilation when required.

The penthouse mechanical room also contains two (2) A.O. Smith gas fired domestic hot water boilers, complete with pressure reducing valves (PRV), to reduce the gas pressure from 5 psi to 7" w.c. The boilers are piped to existing electric hot water storage tanks.

## 3.0. **EXISTING SYSTEMS** (CONT'D)

### .1 **Residential Systems** (Cont'd)

Residential suites are air conditioned using chilled water fan coil units ducted to supply grilles in the living room, kitchen, and bedrooms. Each residential suite contains one (1) or two (2) chilled water fan coil units; three (3) bedroom units contain two (2) fancoil units; two (2) bedroom units contain one (1) fancoil unit. There are approximately 24 suites with two (2) fan coils and approximately 76 suites with a single fan coil unit. Additional fan coils are located in storage rooms and offices on the ground floor.

Chilled water is supplied via a refrigeration chiller located in the penthouse mechanical room and is pumped throughout the building by a base-mounted 7.5 HP pump. A second base-mounted 3 HP pump circulates chilled water through the make-up air unit cooling coil. The chiller has a nominal capacity of 220 tons and rejects its heat to a matching roof-mounted cooling tower.

Suite air conditioning is controlled using a mercury-filled cooling-only thermostat mounted in the corridor of each suite. The thermostat is connected to a two-position chilled water control valve which opens on cooling demand and closes when the cooling demand is satisfied. The thermostat is accompanied by a stand-alone three-speed line voltage manual fan speed controller. This enables the occupant to manually control fan speed between off, low, medium, and high speeds.

Heating to the suites is provided by electric baseboard heaters located along the perimeter. The baseboards are controlled by wall mounted thermostats located in each perimeter room.

The pool building is conditioned by a Dectron pool dehumidifier unit which also heats the pool water.

### .2 **Parking Garage**

The parking garage consists of two (2) levels of parking with automated garage doors and entrances to the ground and second floor of the complex. The garage contains a water filled sprinkler system and is heated by a series of electric force-flow heaters. Ventilation is provided by a single exhaust fan operating at high speed during the day and low speed at night. To achieve this, the exhaust fan is connected to a variable frequency drive (VFD) and time clock.

Multiple adjacent areas, such as storage rooms and vestibules, are vented to the parking garage using wall mounted exhaust fans with integral back draft damper. (Refer to OBC Review).

The parking garage also contains an emergency power generator running on natural gas.

## 3.0. EXISTING SYSTEMS (CONT'D)

### .3 Natural Gas Supply

The natural gas meter and regulator are located at the north east corner of the building. The natural gas is supplied at a pressure of 5 psi through the meter having a capacity of two (2) million BTU/h. An existing 1"Ø natural gas line is installed on the north exterior face of the building from the meter to the penthouse. In addition, a 1 ¼"Ø gas line is piped from the meter to the generator room.

## 4.0. PROPOSED ENERGY COST SAVING MEASURES

The energy cost savings measures which have been considered are as follows:

Introduce gas fired heating system with hot water distribution during the winter months utilizing the existing chilled water distribution system. Replace existing electric heating elements in the MAU with a new glycol heating coil.

CO monitoring and exhaust control system for parking garage.

### .1 Measure 1 – Introduce natural gas heating system

#### .1 Penthouse

In this measure, two (2) new boilers will need to be installed in the penthouse mechanical room and be connected to the existing chilled water infrastructure to provide heating water in the winter months. A two (2) boiler configuration would provide redundancy in the event of one boiler requiring maintenance. The boilers can be sized for 100% redundancy or as low as 50% load each. The existing electric heating element in the MAU will be replaced with a new glycol heating coil. The coil will operate via a new glycol loop which will draw heat from the system through a heat exchanger. The existing chilled water coil in the MAU will remain.

Space in the mechanical room is limited. One (1) of the two (2) existing electric DHW storage tanks may need to be removed to accommodate new boilers and piping.

Existing electric heating elements will be removed from the MAU and replaced with a glycol filled heating coil. The glycol will provide freeze protection during the winter. A new glycol loop, complete with pump and heat exchanger, will be installed in the penthouse mechanical room to serve the new coil. This will involve installation of new coil, piping, pump, heat exchanger and controls.

#### .2 Natural Gas Supply

The existing piping will need to be upsized to accommodate the increased demand of the new boilers. A new pressure regulator will be required on the roof as well as new piping to the boilers.

## 4.0. PROPOSED ENERGY COST SAVING MEASURES (CONT'D)

### .1 Measure 1 – Introduce Natural Gas Heating System (Cont'd)

#### .3 Fan Coil Control

Existing thermostats controlling each fan coil in the suites will need to be removed and replaced with new heat-cool thermostats. The new thermostats will have a manual switch to change operating mode from cooling to heating.

The existing fan speed controllers will remain separate from temperature control. This will maintain the option of selecting the different fan speed by occupants.

### .2 Measure 2 – CO Monitoring and exhaust control system for parking garage

#### .1 Ontario Building Code (OBC) Review

The OBC has been reviewed to determine the viability of installing a new CO monitoring system and exhaust control within the parking garage. The relevant sections from the OBC are as follows:

Section 6.2.3.8 clause (6) of the 2006 OBC states:

'Exhaust systems are permitted to exhaust into a *storage garage*, provided,
(a) They serve rooms that area accessible only from the *storage garage*,
(b) The exhaust contains no contaminants that would adversely affect the air quality in the *storage garage*, and
(c) They are designed in accordance with Sentence 6.2.3.9.(3)'

Section 6.2.3.9 clause (3) of the 2006 OBC states:

'Exhaust ducts referred to in Sentence 6.2.3.8 (6) may exhaust through an enclosed *storage garage* prior to exhausting to the outdoors provided,
(a) The storage garage exhaust system runs continuously,
(b) The capacity of the storage garage exhaust system is equal to or exceeds the volume of the exhaust entering the garage, and
(c) A leakage rate 1 smoke/fire damper rated in accordance with CAN/ULC-S112.1-M, "Leakage Rated Dampers for Use in Smoke Control Systems", is provided near the duct outlet location in the *storage garage* to prevent air from the *storage garage* from entering the exhaust ductwork system in the event the building's exhaust fan is shut down.'

## 4.0. PROPOSED ENERGY COST SAVING MEASURES (CONT'D)

### .2 Measure 2 – CO Monitoring and exhaust control system for parking garage (Cont'd)

#### .1 Ontario Building Code (OBC) Review (Cont'd)

Based on the above, the proposed installation of the CO monitoring system in the garage is not permitted under the current version OBC due to existing rooms with separate entrances being exhausted in to the parking garage. The existing exhausts from storage rooms and vestibules will need to be collected and routed to the exterior of the building prior to the CO monitoring system being implemented. Additional heating will be required for the garage as a result of these modifications and will negatively impact the amount of energy required to heat this area. Also, the vestibules between the building and garage will need to be properly pressurized. Any cost savings resulting from savings in electricity used to run the exhaust fan will be offset by the construction costs.

## 5.0. HEATING ENERGY ANALYSIS

Energy modeling was performed on the residential portion of the complex. The analysis was broken up in three (3) sections. Suites on 3rd to 13th floors (typical floors), suites on ground and 2nd floors, and the make-up air unit.

The following assumptions were used in the modeling:

1) Average of two (2) person occupancy between 5 pm and 6 am.
2) Average lighting and electrical loads of 400 Watts per suite between 5 pm and 10 pm, as well as between 6 am and 8 am.
3) Infiltration losses of 0.05 CFM/sq.ft.
4) No open windows.

## 5.0. HEATING ENERGY ANALYSIS (CONT'D)

### .1 Suites on 3rd to 13th Floors (Typical Floors)

The building contains a total of eleven (11) typical floors from 3rd to 13th floor.

Monthly heating loads for a typical floor are as follows:

| **Month** | Heating (kBTU) | Heating (kWh) |
|---|---|---|
| January | 67,200 | 19,700 |
| February | 46,900 | 13,700 |
| March | 25,700 | 7,500 |
| April | 11,900 | 3,500 |
| May | 0 | 0 |
| June | 0 | 0 |
| July | 0 | 0 |
| August | 0 | 0 |
| September | 0 | 0 |
| October | 13,500 | 4,000 |
| November | 31,500 | 9,200 |
| December | 57,000 | 16,700 |
| **Total** | 253,700 | 74,300 |

The total heating requirement for the eleven (11) typical floors is:

253,700 kBTU x 11 = 2,790,700 kBTU or 818,400 kWh

## 5.0. **HEATING ENERGY ANALYSIS** (CONT'D)

### .2 **Suites on the Ground and 2nd Floors**

Monthly heating loads for the Ground and 2nd floors are as follows:

| **Month** | Heating (kBTU) | Heating (kWh) |
|---|---|---|
| January | 57,200 | 16,800 |
| February | 42,700 | 12,500 |
| March | 26,300 | 7,700 |
| April | 12,700 | 3,700 |
| May | 0 | 0 |
| June | 0 | 0 |
| July | 0 | 0 |
| August | 0 | 0 |
| September | 0 | 0 |
| October | 13,300 | 3,900 |
| November | 28,100 | 8,200 |
| December | 48,900 | 14,300 |
| **Total** | 229,200 | 67,100 |

The total heating requirement for the Ground and 2nd floors (excluding parking garage) is:

229,200 kBTU x 2 = 458,400 kBTU or 134,400 kWh

## 5.0. HEATING ENERGY ANALYSIS (CONT'D)

### .3 Make-Up Air Unit

Monthly heating loads for the make-up air unit are:

| **Month** | Heating (kBTU) | Heating (kWh) |
|---|---|---|
| January | 211,700 | 62,100 |
| February | 179,800 | 52,700 |
| March | 157,000 | 46,000 |
| April | 108,800 | 31,900 |
| May | 0 | 0 |
| June | 0 | 0 |
| July | 0 | 0 |
| August | 0 | 0 |
| September | 0 | 0 |
| October | 102,000 | 29,900 |
| November | 133,400 | 39,100 |
| December | 187,800 | 55,000 |
| **Total** | 1,080,500 | 316,700 |

### .4 Yearly Heating Load Summary

The following is a summary of the heating loads for the residential tower:

| | Heating (kBTU) | Heating (kWh) |
|---|---|---|
| 3rd to 11th floor suites | 2,790,700 | 818,400 |
| Ground and 2nd floors | 458,400 | 134,400 |
| Make-up air unit | 1,080,500 | 316,700 |
| **Total** | 4,329,600 | 1,269,500 |

## 5.0. HEATING ENERGY ANALYSIS (CONT'D)

### .5 Comparison of Modeled Heating Energy to Actual Yearly Consumption

The building has consumed a total of 2,139,951 kWh from January 4, 2009 to January 4, 2010. For estimating purposes, it is assumed that negligible heating or cooling equipment was operating between September 8, 2009 and October 6, 2009 as it was the lowest electricity consumption of any of the months thus it was assumed to be zero. Therefore, the electricity consumption for this period will be used as a building base load and subtracted from the consumption for both the winter and summer months accordingly. The electricity used during the summer months was also removed from the calculation.

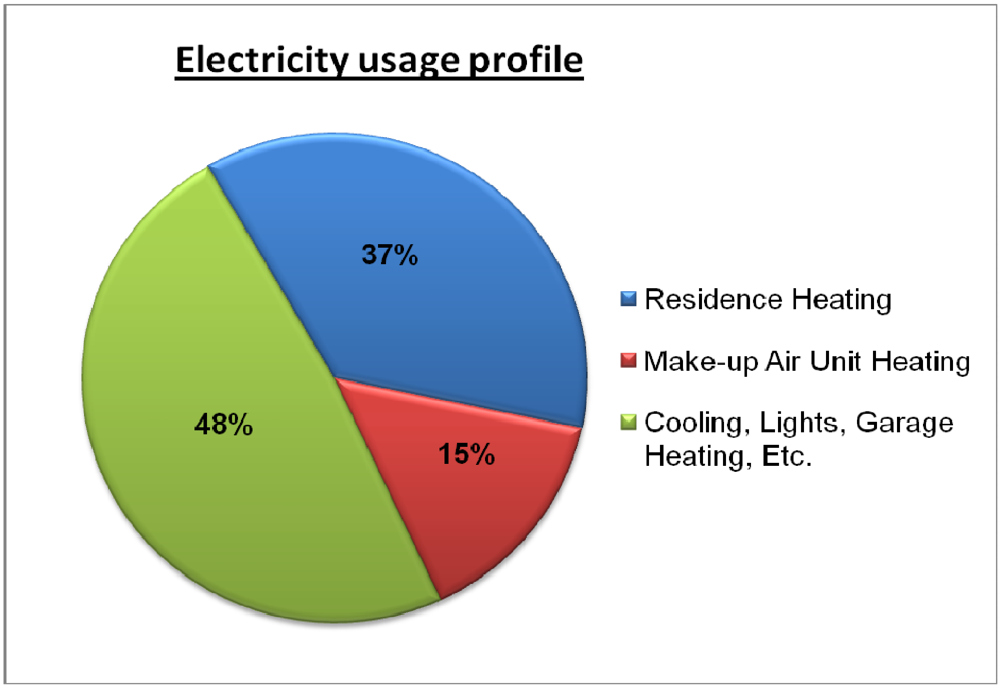
| Date | Actual kWh Consumed | Estimated Heating kWh |
|---|---|---|
| February 4, 2010 | 322,560 | 263,578 |
| January 5, 2010 | 348,364 | 289,382 |
| December 3, 2009 | 184,320 | 125,338 |
| November 4, 2009 | 158,515 | 99,533 |
| October 6, 2009 | 58,982 | 0 |
| September 8, 2009 | 136,396 | 0 |
| August 6, 2009 | 90,316 | 0 |
| July 7, 2009 | 103,219 | 0 |
| June 2, 2009 | 105,062 | 0 |
| May 4, 2009 | 101,376 | 0 |
| April 6, 2009 | 221,184 | 162,202 |
| March 5, 2009 | 309,657 | 250,675 |
| **Total** | 2,139,951 | 1,190,708 |

By subtracting the base load from the winter months, the resulting total yearly heating energy is estimated at 1,190,708 kWh. This value is within 6% of the estimated heating loads generated by the energy modeling software (1,269,500 kWh). Annual garage heating has been estimated at 90,000 kWh and will be subtracted from energy savings calculations resulting in approximately 1,100,000 kWh of energy which can potentially be converted from electric heat to gas.

## 5.0. HEATING ENERGY ANALYSIS (CONT'D)

### .6 Electricity Usage Profile

The following is the electricity usage profile for the building based on electrical billing data and energy modeling:




Residential heating accounts for 37% of the total electrical energy consumed. MAU heating accounts for 15% of the total electrical energy used by the building. Total electrical demands can be significantly reduced by switching these two (2) systems to natural gas.

## 6.0. ENERGY COST SAVINGS AND CONSTRUCTION ESTIMATES

### 1. Measure #1

#### .1 Energy Cost Savings

The following is an analysis of simple annual heating energy cost savings using current electricity and natural gas rates excluding delivery, transmission, demand charges, taxes, and miscellaneous fees. The effective delivered electricity rate based on available billing data during the 2010/2011 winter is approximately $0.09/kWh from Hydro Ottawa. The effective delivered natural gas rate based on available billing data is 0.27 $/m^3$. Natural gas energy cost calculations assume an average heating value of 35,000 BTU/$m^3$ and boiler efficiency of 97%.

The analysis assumes no electric baseboard heating will be used in the residential suites during the winter months.

## 6.0. ENERGY COST SAVINGS AND CONSTRUCTION ESTIMATES (CONT'D)

### 1. Measure #1 (Cont'd)

#### .1 Energy Cost Savings (Cont'd)

| | | |
|---|---|---|
| Electrical Energy Cost | = | kWh x cost/kWh |
| | = | 1,100,000 kWh x $0.09/kWh |
| | = | $99,000.00 |
| Natural Gas Energy Cost | = | kWh x m$^3$/kWh x cost/m$^3$ x 1/eff. |
| | = | 1,100,000 kWh x 0.0966 m$^3$/kWh x 0.27 $/m$^3$ x 1/0.97 |
| | = | $29,600.00 |
| Circulation Pump (Main) | = | 7.5 HP x 0.75 kW/HP x 24h x 180 days x $0.09/kWh |
| | = | $2,200.00 |
| Circulation Pump (MAU) | = | 3 HP x 0.75 kW/HP x 24h x 180 days x $0.09/kWh |
| | = | $900.00 |
| Fan Coil Units (fans) | = | 0.25 HP x 0.75 kW/HP x 100 fans x 24h x 180 days x $0.09/kWh |
| | = | $7,300 |
| Energy Cost Savings | = | Electrical Energy Cost - Natural Gas Energy Cost - Circulation Pump |
| | = | $99,000.00 - $29,600.00 - $2,200 - $7,300 - $900 |
| | = | **$ 59,000.00** |

#### .2 Construction Estimate

The following is an estimate of the construction cost to implement Measure #1:

Construction Cost Estimate

| | |
|---|---|
| Two (2) Boilers | $ 100,000.00 |
| Installation | $ 20,000.00 |
| Natural Gas piping + Regulator | $ 10,000.00 |
| Penthouse piping / pumps | $ 20,000.00 |
| Heating coil + Heat Exchanger | $ 10,000.00 |
| Electrical | $ 8,000.00 |
| Controls | $ 30,000.00 |
| Sub-total | $ 198,000.00 |
| Consulting (15%) | $ 30,000.00 |
| Contingency | $ 30,000.00 |
| Total Cost | $ 258,000.00 |

The above estimated costs exclude taxes.

## 7.0. PAYBACK ANALYSIS

The energy savings have been estimated at $59,000.00 per year. The construction cost has been estimated at $258,000.00.

The simple payback is about 4.5 years, assuming that the electric baseboard heaters in each residence is not operating during the heating season and that the gas heated hot water system supplies 100% of the space heating in the residences.

## 8.0 CONCLUSION

A review of the conversion from all electric heating to natural gas has been performed. The annual savings have been estimated at $59,000.00 provided no electric heating is used in the residential suites. Construction cost has been estimated at $258,000.00 to implement the new gas heating system. The resultant simple payback for this modification is 4.5 years.

The option of addition CO monitoring to the parking garage was reviewed. Adjacent storage rooms and vestibules are being exhausted into the parking garage. This practice does not satisfy the latest version of the Ontario Building Code. To implement CO monitoring and provide new ability to turn off the exhaust fan during off-hours, new ductwork infrastructure will need to be installed to collect the exhausts and duct them to the exterior.

Any cost savings resulting from savings in electricity used to run the exhaust fan will be offset by the construction costs.

## 9.0 RECOMMENDATIONS

.1 Implement cost savings measure #1 (Introduce natural gas heating system). Natural gas heating offers significant savings vs. electric baseboards. Utilizing natural gas heating vs. electric baseboards offers potential annual savings of $59,000.00.

.2 Do not implement cost savings measure #2 (CO monitoring for parking garage). Installation of new exhaust ductwork will be required in the parking garage prior to implementation of CO monitoring system. Additional heating will be required for the area as a result of this modification.

.3 Additional cost savings could be achieved by replacing the existing 84% efficiency domestic hot water boilers with fully condensing boilers. This option should be considered when the boilers are approaching the end of their service life.