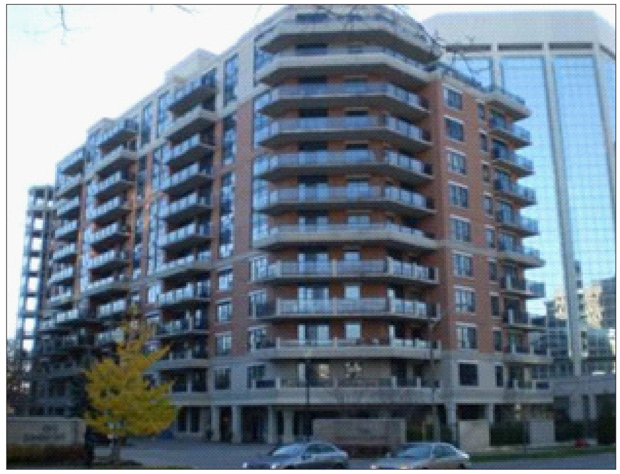
TORONTO Atmospheric Fund

TowerWise

Case Study:

2 Aberfoyle Crescent



1. Executive Summary

In 2004, a condo board member set out to see what solar energy options might be suitable for his then four–year-old building. What he discovered was that despite being a relatively new structure, there were many opportunities to improve the building's energy performance that it made more economic sense to tackle before embarking on the addition of solar.

Working with an energy management firm, the board of Two Aberfoyle drafted a three-year energy retrofit plan. A key element of the plan was staging the retrofit in such a way that quicker payback items would be completed first, freeing up funds to tackle bigger ticket longer-payback items.

The plan also emphasized a strategic approach to re-deploying the building's relatively new boilers. Instead of wholesale replacement, they chose to add a new high efficiency boiler to act as the "lead" boiler while retaining a number of the original units to act as "lag" boilers. This blended approach of having the high efficiency boiler take on most of the work, but supplementing when necessary with the older boilers, made the payback on the boiler system upgrade much more appealing.

Overall, Two Aberfoyle achieved savings of about 20% in natural gas consumption and 15% in electricity consumption for a total decrease in annual greenhouse gas emissions of about 164 Tonnes of CO_2e.

Despite equipment that had been in use for just four years, this condo realized that it could reap significant savings by upgrading to more efficient lighting, motors, and boilers. As an almost new building, Aberfoyle had to rely on retained surpluses rather than reserve funds for much of the work, but found it could carry the cost without turning to outside financing. In fact, with a blended payback of just 2.3 years and utility cost savings of roughly $35,000 per year, the project made great economic sense despite the age of the building.

Annual Cost Savings	$35,800
Blended Payback	2.3 years
Net Present Value	$270,000
Annual GHG Emission Reduction	164 Tonnes CO_2e

2. Project Description and Rationale

First occupied in 2001, Two Aberfoyle is a 12 storey condominium building with 116 suites and extensive common areas including two levels of underground parking, a party room, billiard room, exercise room, washrooms, change rooms and an indoor pool.

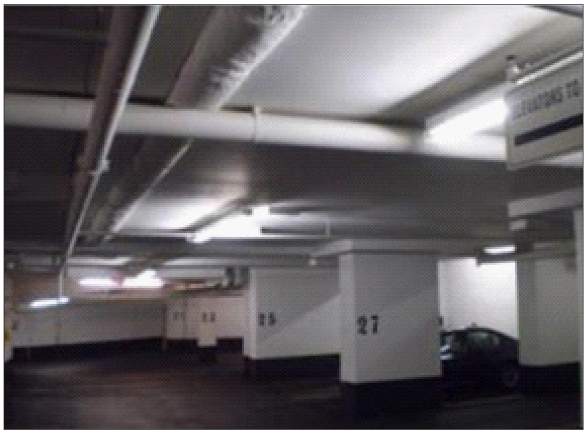
Jim Book, a condo board director in 2004, decided to look into the possibility of a solar energy installation for the building. During his investigation, he found that there were many energy efficiency measures that could be undertaken to reduce utility costs before installation of a solar energy system was appropriate. In 2004 the board of directors for the condominium struck an energy savings committee to investigate these alternatives. Using resources like the Canada Mortgage and Housing Corporation website and the Better Buildings Partnership listing of energy management firms, the energy savings committee developed a list of energy savings measures and approached three companies for quotes. From the proposals that followed, the board learned about building-specific approaches to energy savings and the Enbridge natural gas savings incentives available to them.

To reduce electricity use, a supplier of carbon monoxide (CO) monitors indicated that use of such monitors could reduce the operating time of the parking garage exhaust fan to just a few hours a day, resulting in an estimated 90% electricity use reduction for the fans.

Analysis of the make-up air unit (MAU) operation showed that airflow to the suites during peak periods could be reduced by about 25% and even more during off-peak hours, while still providing adequate ventilation. This reduced and more variable air flow could be achieved by installing a variable frequency drive (VFD) on the MAU. To further maximise energy savings, the winter set point temperature could be decreased slightly while the summer set point temperature could be increased. When combined, these measures would save fan motor electricity as well as natural gas and electricity associated with heating and cooling the incoming air.

The board was also presented with a lead-lag strategy for the boiler operation, whereby a new high efficiency boiler provides half the heating capacity and the older atmospheric boilers act as back up for periods when the lead boiler cannot supply the entire load. Piping changes were also suggested to reduce unnecessary air and water flow when the boilers are not operating, thereby reducing standby losses.

From this information the condo board developed a three-year retrofit plan with the following components (listed in the order in which they were undertaken):



Top left: Parking garage lighting; top right: DHW boilers; above: CO monitor

1. Replacement of T12 parking garage lighting with T8 lighting and electronic ballasts
2. Installation of CO monitors in the parking garage to ensure that fans switch on only when fresh air is needed
3. Replacement of one of two atmospheric domestic hot water (DHW) boilers with a high efficiency condensing boiler and new controls
4. Installation of a variable frequency drive on the make-up air unit
5. Replacement of one of four atmospheric fan coil boilers with a high efficiency condensing boiler (providing half the total capacity) and new controls
6. Replacement of one of two atmospheric domestic prime boilers (for heating the common areas, pool and slab) with a high efficiency condensing boiler and new controls

Once the project strategy was determined, the board introduced the plan to the suite owners at a "town hall" meeting. The suite owners were in favour of funding the four lowest cost projects from the surplus fund and then using the savings from these projects to fund the remaining two items. During the three year retrofit program, the project spending did not exceed 10% of the annual operating budget. Notice of work was communicated to the residents through newsletters posted in the building and resulting savings was presented at each AGM.

The project was managed by Jim Book and the property manager at the time, who together dealt directly with each of the suppliers.

3. Project Performance

There are a number of underlying operational issues that affected the natural gas and electricity savings over the years that were analyzed. The indoor pool was shut down for a significant portion of 2006 and the winter of 2007 during which time 50m^3 of natural gas was saved daily by reducing the space heating requirements of the pool area and change rooms. Electricity consumption was affected by a sensor issue with the ramp heater that kept the heater on for part of 2008 and 2009. Replacement of incandescent light bulbs with compact fluorescent ones and adjustment of the MAU airflow would also have affected electricity use during this period.

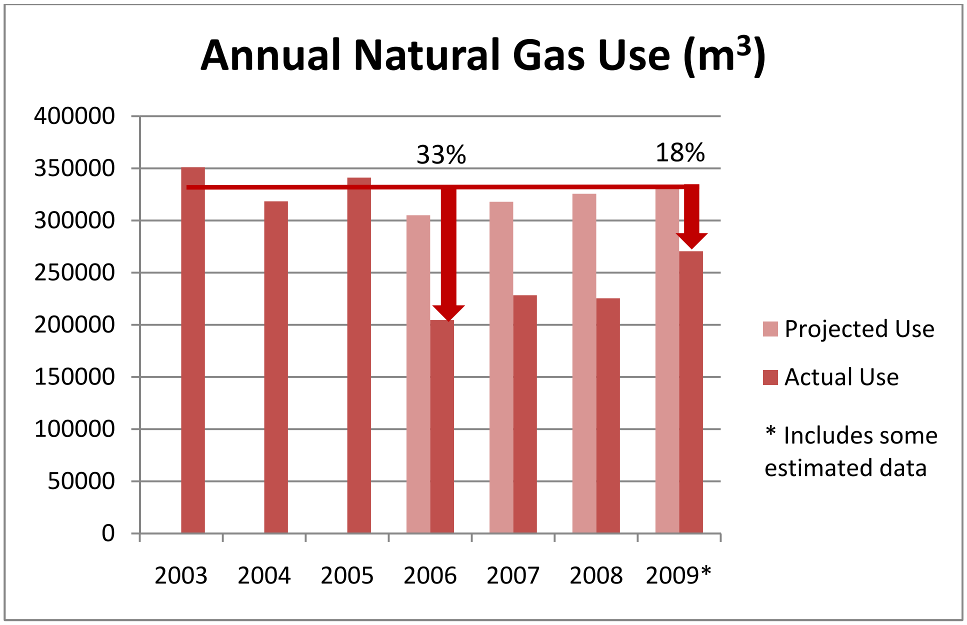
Gas savings of about 20,000m^3 were due to efficiency gains from the DHW boiler replacement in 2005. An additional 35,000m^3 reduction was secured in 2007 by the replacement of the fan coil and prime boilers. The remainder of the gas use savings can be attributed to a reduction in airflow, and therefore a reduction in air heating requirements, associated with installation of the VFD as well as the pool shutdown. Given the estimated annual natural gas usage rate from Enbridge of 8m^3 of gas per cubic foot per minute (cfm) of airflow and the pre- and post-retrofit airflow of 16,500 cfm and 11,300 cfm, respectively, the estimated contribution of the VFD to natural gas savings is about 40,000m^3 out of a total savings of 100,000m^3 during the first year.

However, the savings from the installation of the VFD have been eroded by operational problems with the MAU. When first installed, the VFD allowed the MAU to reduce airflows to 60% of capacity during peak and 50% during off-peak hours. This was in accordance with the minimum setting recommended by the MAU manufacturer, but, after a few years of operation, the frequent on/off cycling during periods of moderate outside temperatures created maintenance issues for the equipment. The system is currently being operated at 80% of its capacity in order to reduce on/off cycling; however this may negatively affect energy savings. See Section 6 for a more complete explanation of the issue and how it is being dealt with.

Fortunately, as shown in Section 5, the savings achieved in the first few years of operation were enough to cover the cost of the investment.

The CO monitors appear to be delivering the savings promised by controlling the garage exhaust fan operations. However, the CO monitors have a lifespan of only about five years and must be recalibrated annually, which can result in a significant maintenance cost.

Figure 1: Annual Natural Gas Use



As all of the electricity-saving projects were implemented at the end of 2005, it is difficult to separate out the exact contribution to savings of each individual measure. The initial reduction in electricity use due to the lighting retrofit and CO monitor installation in the parking garage as well as the VFD installation was about 17%, which also includes some savings from the pool shutdown. The higher 2008 consumption includes the period when the ramp heater was on as a result of the sensor problem, but there was still a 12% reduction from the baseline as shown in Figure 2.

Overall the natural gas savings resulted in a reduction of about 117 Tonnes of CO_2e annually, responsible for about 70% of the contribution to emission reductions as shown in Figure 3, while the electricity savings resulted in an annual reduction in CO_2e of about 47 Tonnes.

4. Project Costs

The board began by undertaking the lowest cost projects first, which included the VFD, parking garage lighting retrofit and installation of CO monitors to control the parking garage fans. Their aim was to start slowly, demonstrate savings and build credibility in order to build support for moving forward with the more expensive projects.

Given the age of the building, the Condominium Act would not allow reserve funds be used for the proposed work. However, surplus funds in the current account in 2002 and 2003 meant that there were sufficient funds to avoid the need for outside financing.

Figure 2: Annual Electricity Use

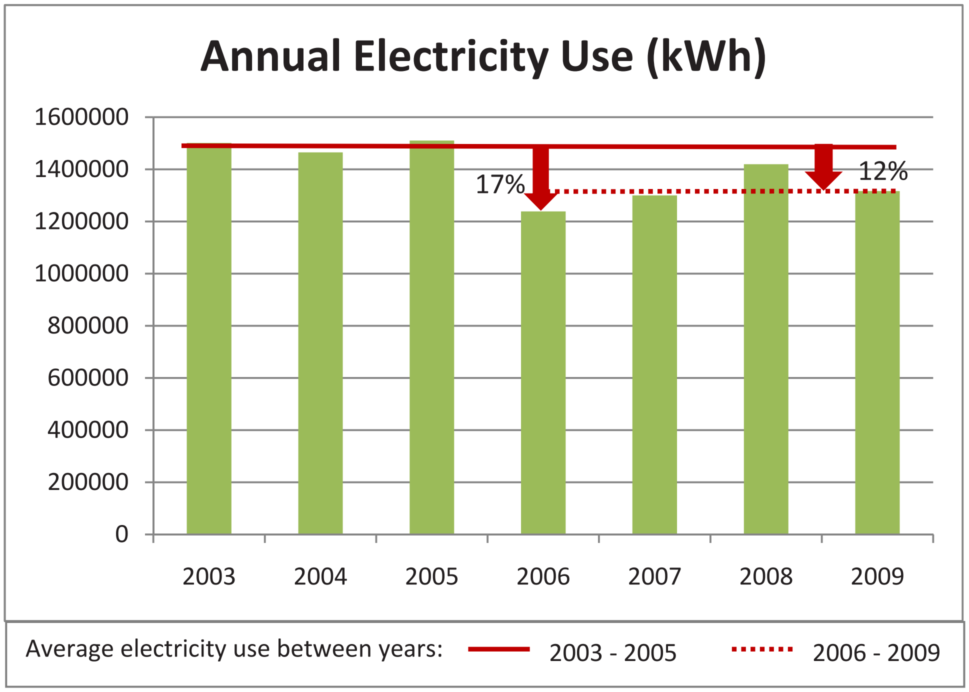


Figure 3: Impact of Resource Saving Measures on CO_2 emissions

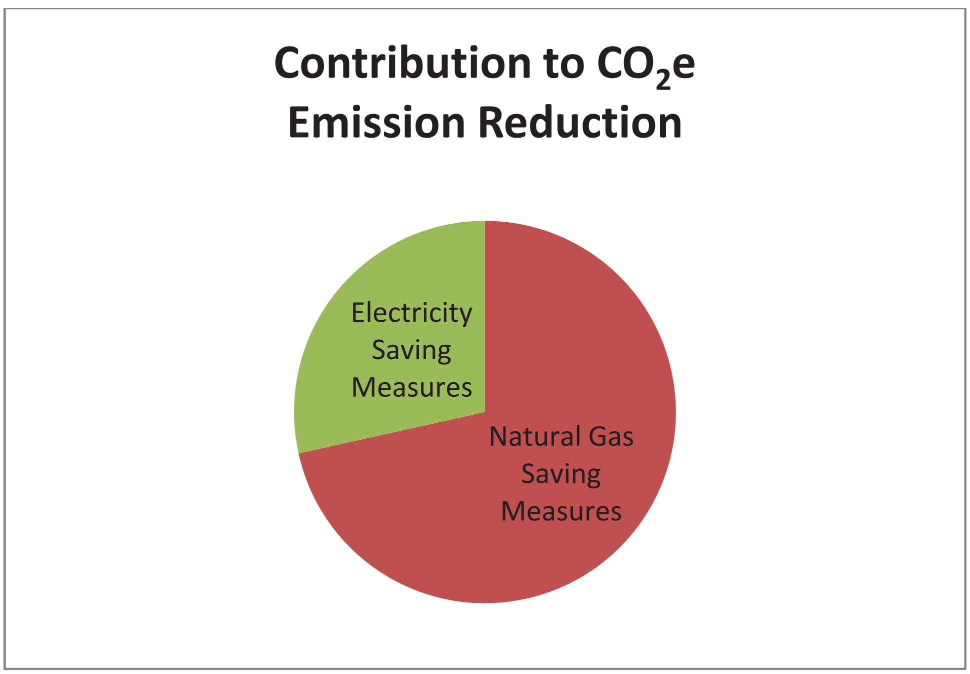


Table 1: Details of Retrofit Project Costs

Retrofit Measure	Month Completed	Cost
T8 lighting and electronic ballasts in parking garage	September 2005	$11,000
CO sensors in parking garage	September 2005	$10,050
DHW Boiler replacement	September 2005	$43,740
Installation of VFD on MAU	October 2005	$10,395
Replacement of one atmospheric fan coil boiler	October 2006	$51,675
Replacement of one atmospheric prime boiler	October 2007	$36,775
Enbridge Incentive		**-$18,000**
Total Project		**$145,635**

There was no budgeted amount for contingency because all prices were fixed-price contracts provided by suppliers. The actual projects costs are shown below in Table 1.

The boiler retrofits qualified for a total of $18,000 in incentives from Enbridge Gas, which helped to offset the capital cost of the work. The board considered other incentives such as ecoENERGY but felt the application process was too lengthy.

5. Financial Analysis

In order to examine the simple payback, return on investment (ROI), internal rate of return (IRR) and net present value (NPV) of the retrofits, a cash flow diagram is presented in Figure 4 showing capital expenditure as negative cash flows and annual cost savings as positive cash flows.

Natural gas cost savings are generated from the difference between actual consumption and projected consumption, while costs were derived from historical natural gas prices. Projected consumption was derived using two pre-retrofit baseline years, 2003 and 2004, and then, through a process of weather-normalization, adjusting that baseline usage according to the heating degree days (HDDs) of the subsequent years to determine how much energy would have been used had there been no retrofit.

The HDDs and electricity consumption for 2010 and beyond are assumed to be the same as 2009. Likewise utility rates beyond 2010 are assumed to be equal to 2010 rates. As the natural gas rates are relatively low compared to historical rates, the positive cash flow projections beyond 2010 may be underestimated. Also Two Aberfoyle's electricity rates were generally higher than the electricity rates used for the financial analysis which were sourced from the Ontario Energy Board, making the electricity-related positive cash flow estimates conservative as well.

Figure 4: Project Cash Flows

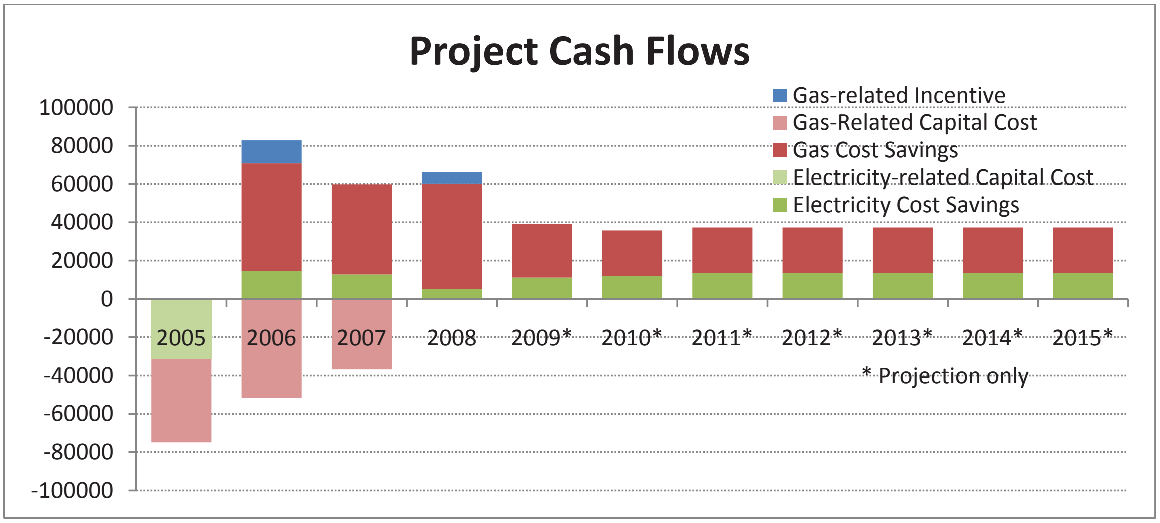


Table 2 shows the simple payback, return on investment (ROI) and internal rate of return (IRR) for the first ten years following each retrofit. Note that the 10-year period for all utilities is from 2006-2015 which will make the financial analysis measure conservative as there were gas-related capital costs incurred in 2006 and 2007. The table also includes the net present value (NPV) of each investment using 2010 as the present year and assuming ten years of cost savings following completion of the retrofit.

The VFD installation on the MAU affects both natural gas and electricity consumption due to the reduction in fan speed and chiller use. Without electricity sub-metering on this piece of equipment and given the variable operating speeds it is not possible, however, to determine the exact contribution of electricity savings attributed to the VFD for the fan motor and chiller respectively. For the purposes of this financial analysis, the capital cost of the VFD has been allocated to electricity use.

Even with the current difficulties surrounding the VFD, the project returns are impressive. The entire project cost was recouped from energy savings within three years.

6. Challenges

The greatest challenge with this retrofit has been the unintended consequences of the installation of the VFD on the MAU. Unfortunately it was not realized at the time of planning that partially closed dampers had already reduced airflow to the building by about 20%, which resulted in less savings than projected. Also, as the rated capacity of the MAU was oversized for the size of the building, the VFD caused the MAU to cycle on and off more frequently. This has resulted in increased maintenance costs. As a temporary solution, the VFD has been set to operate at 80% of the MAU capacity, reducing the

Table 2: Financial Analysis Measures

Utility Affected (Project duration)	Project	Simple Payback	10 year ROI (Est.)	IRR over 10 years (Est.)	Net Present Value in 2010
Natural Gas (2005-2007)	Boiler replacements	2.5 years (See Note 1)	495%	55%	$194,000
Electricity (2005)	Parking garage lighting retrofit	2.8 years	293%	37%	$76,000
	Parking garage CO monitors				
	VFD installation on MAU				
Total Project		2.3 years	410%	48%	$270,000
NOTE 1: As gas-related expenditures occurred over 3 years, all expenses were brought to 2005 to determine the simple payback.					

maintenance issues but also reducing some of the annual natural gas and electricity cost savings. The board is currently investigating the potential of retrofitting the MAU with a hydronic coil to take advantage of excess fan coil and chiller capacity to heat and cool the incoming fresh air.

Before embarking on this type of retrofit, it is important to consult the MAU manufacturer to see if a VFD is suitable and then to determine what fan speed reductions can be tolerated by the equipment. If installation of a VFD is not appropriate, it is important to determine if it is more advantageous to continue using the MAU until its operational end-of-life or incur the cost of replacing it with an appropriately-size MAU to reap the energy saving benefits.

Ongoing adjustments to the building system may also be required following a retrofit. For example, the first winter after the installation of the VFD, the corridor temperature was about 17°C which was deemed too cold. Sometimes these temperatures are difficult to control due to thermostat location. At this building the temperature controls were on the MAU rather than via a thermostat in the hallways.

Variable Frequency Drive

7. Project Risks

At the project outset, residents faced expiration of their natural gas contract which meant a potential price increase estimated at over $0.40 per cubic metre. They were also anticipating an increase in electricity rates to about $0.12 per kilowatt-hour. Both of the assumptions were quite reasonable considering historical trends but, at the time of writing, utility prices are actually slightly lower than the projected rates.

During the planning process, the condo board was concerned with the reliability of the utility cost savings estimates. To reduce the risk of overstating projected savings to the residents, they reduced the projections by 10-25% depending on the perceived reliability of the individual estimate. For example, projected savings from the lighting retrofit, which appeared to be straightforward, were reduced by 10%, whereas projected savings from the MAU and boiler retrofit, which was a bit more uncertain, were reduced by 25%.

Of particular concern was the fact that all of this equipment was being replaced after only four years in operation. However given the predicted operational energy savings, the investment was deemed worthwhile. The board attempted to sell the no-longer-needed boilers to offset some of the capital costs, but were unsuccessful so instead the heat exchangers were retained to be used as spare parts for the remaining boilers.

Any retrofit investment has an element of risk, but using historical utility cost trends, energy performance estimates and conservative assumptions where possible, it becomes a carefully calculated risk.

8. Testimonial from Condo Board Member

"Though use of solar energy sources can be a way to lower utility costs, it is important to first reduce the energy demand of your existing systems. By researching energy savings measures and consulting with experts to understand the existing conditions of the building, we were able to design a retrofit program that took advantage of the unique energy savings opportunities in our building. Then by staging the project over three years we were able to avoid borrowing costs. Of course there are lessons to be learned from our experience with the variable frequency drive, but overall the project has been a success as we have recouped our costs and continue to accrue energy cost savings."

9. Conclusions

Two Aberfoyle realized significant annual energy cost savings thanks to the willingness of its board and energy committee to dig into the operations of a relatively new building. By developing a good understanding of how building operations could be improved, the energy committee played a vital role in improving the value of the building and reducing its environmental impact.

This multi-faceted project combined both high capital cost projects with lower cost ones, to generate an acceptable overall payback period with impressive returns. By sequencing the retrofits so that quicker payback items were undertaken first, cash flow was freed up to cover the cost of longer payback items.

Use of a lead-lag boiler strategy has resulted in new high efficiency equipment meeting the majority of the heating needs of the building without requiring the replacement of the entire boiler fleet at once. And installation of a CO monitor allows existing exhaust fans to remain in place while simply reducing their operating time.

Installing a VFD drive on the make-up air unit initially looked to be a big money saver. However, problems resulted from the VFD not being properly matched to the MAU. This is a potentially lucrative retrofit for many buildings, but it is important to do your homework to ensure a good equipment match, proper calibration and post-installation monitoring to ensure that savings are being realized and equipment is operating within tolerances.

Fortunately for the residents of Two Aberfoyle, careful monitoring revealed both the problem with the MAU and the defective parking garage ramp sensor that was keeping ramp heaters operating in warm weather. Knowledge can be a money saver, as Two Aberfoyle also illustrates, because it is sometimes possible to change operations rather than equipment to save money.

The age of this building makes it a unique retrofit example because these types of strategies are typically applied to older buildings where equipment is reaching the end of its useful life. But Two Aberfoyle makes a compelling case for the wisdom of even new buildings carefully assessing their energy efficiency potential as well.

Acknowledgements

Research and writing by Marianne Touchie. Special thanks to Jim Book and Nathania Norrie for their assistance with the development of this case study. Most of the background information in the preceding report was based on a document written by Jim Book (*A Successful Energy Savings Program at Two Aberfoyle*) to provide information to other condominiums about the benefits of energy savings measures.

Glossary

Equivalent Carbon Dioxide (CO_2e) – A measure used to compare the emissions from various greenhouse gases based upon their global warming potential. For example, the global warming potential for methane over 100 years is 21. This means that emissions of one metric ton of methane are equivalent to emissions of 21 metric tons of carbon dioxide. (Source: Organisation for Economic Co-operation and Development)

Heating Degree Day (HDD) – Represents the amount of heating energy required during the heating season. It is measured by the difference between the base temperature of 18°C and the mean temperature for a particular day. (Source: Natural Resources Canada)

Heat Exchanger – A device used to transfer heat from one fluid to another across a barrier which does not allow the two fluids to come into direct contact. (Source: The Renewable Energy Resource Centre)

Internal Rate of Return (IRR) – The discount rate at which the net present value of all cash flows from a particular project is equal to zero. The IRR can be used to compare several projects under consideration. If all other factors are equal among the various projects, the project with the highest IRR would likely be selected first. (Source: Investopedia)

Net Present Value (NPV) – The difference between the present value of the cash inflows and the present value of the cash outflows which can be used to analyze the profitability of a project. (Source: Investopedia)

Return on Investment (ROI) – The benefit of an investment, or gain from investment minus cost of investment, is divided by the cost of the investment. This ratio or percentage is used to show the efficiency of the investment. (Source: Investopedia)

Simple Payback – The length of time in years required to cover the cost of a project. It is calculated by dividing the cost of the project by the annual cash inflows. (Source: Investopedia)

Sub-metering – The individual metering of utilities at the unit level in a multi-unit residential building. Each household can then be responsible for their own energy costs as opposed to splitting the energy bill for the entire building equally among all occupants. (Source: New York City Department of Housing Preservation and Development)

Weather Normalization – A mathematical process that adjusts actual energy usage so that it represents energy typically used in an average year for the same location. This accounts for weather differences from year to year that may result in abnormally high or low energy consumption. (Source: ENERGY STAR)

TORONTO Atmospheric Fund

The Toronto Atmospheric Fund (TAF) has been sparking action on climate, air pollution and energy use in Toronto for 20 years. Internationally recognized for its innovative and effective programs, TAF has helped the City save millions on energy costs and helped citizens to live greener lives in healthier communities. TAF relies exclusively on income from its own endowment and investments from program partners for its operations. For more information, visit www.toronto.ca/taf

www.TowerWise.ca

TAF's TowerWise program works with high-rise owners and managers to reduce energy use and emissions from apartment towers and condominiums. TowerWise provides unbiased advice and assistance to help high-rise owners to make their buildings more comfortable and less polluting. To get involved with the TowerWise program, contact Lyle Jones at ljones@tafund.org, 416-393-6370