TAF The Atmospheric Fund

Robert Cooke Co-Op Case Study

A TOWERWISE RETROFIT PROJECT

TAF The Atmospheric Fund

ACKNOWLEDGMENTS

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About The Atmospheric Fund (TAF)

Founded in 1991, The Atmospheric Fund (TAF) invests in urban low-carbon solutions in the Greater Toronto and Hamilton Area to reduce carbon emissions and air pollution. TAF is supported by dedicated endowment funds provided by the City of Toronto (1991) and the Province of Ontario (2016) and has invested more than $50 million to date.

Visit **www.taf.ca** for more information or message message us at **info@taf.ca**

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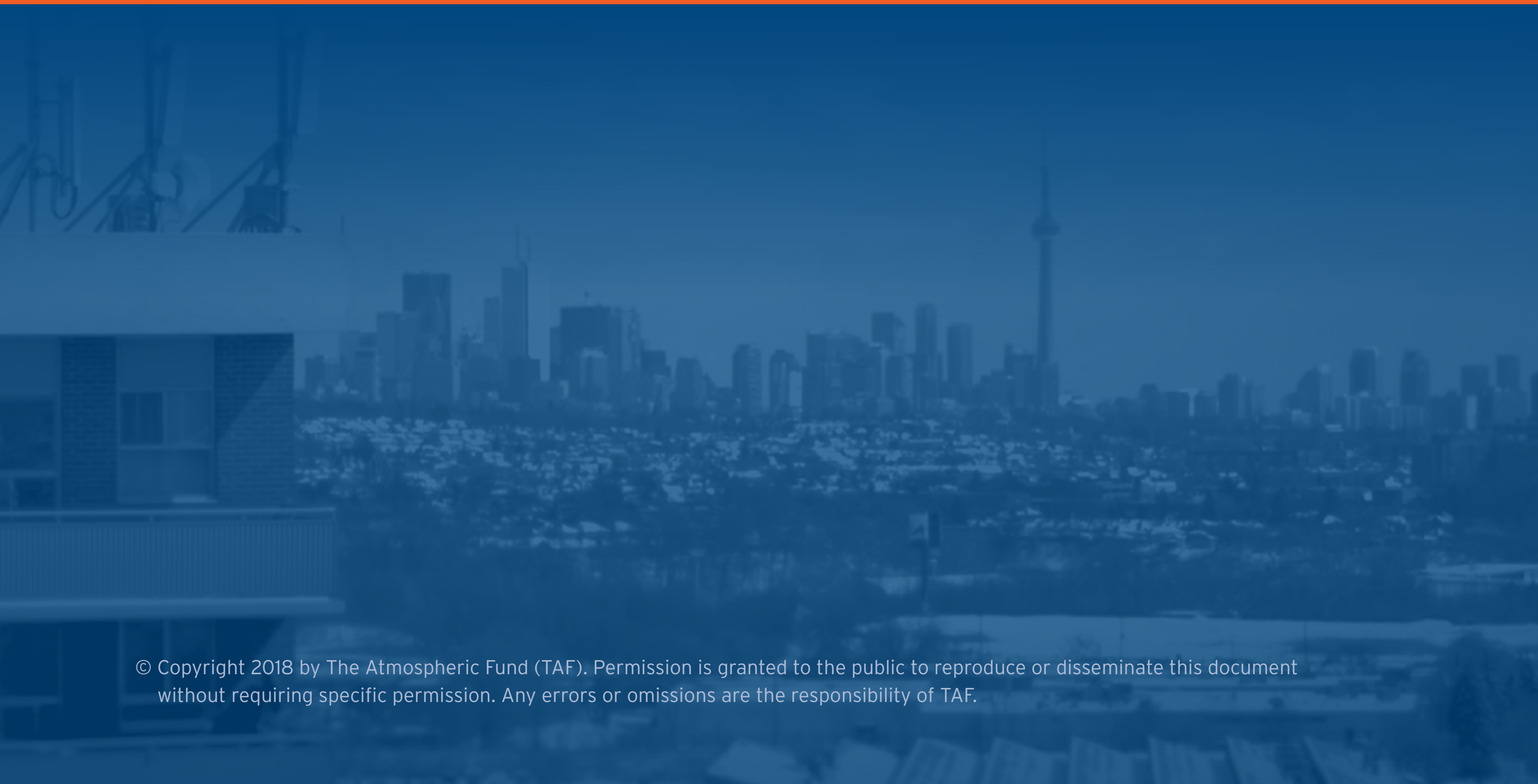


Executive Summary

Buildings are a major source of carbon emissions in the Greater Toronto and Hamilton Area (GTHA) accounting for 44 per cent of total carbon emissions. Reducing those carbon emissions is critical for reaching our climate targets. However, some carbon emissions-reducing resource conservation measures require significant up-front investments for building owners, posing a major barrier to implementation. Additionally, there is very little experience in the region with deep retrofits, with most conservation programs and projects targeting ‘low-hanging fruit’ measures or quick paybacks.

To address this challenge, The Atmospheric Fund (TAF) launched the TowerWise program in 2007 with the aim of accelerating deep energy and GHG emission retrofits across the multi-unit residential building sector. To support this initiative and make it easier for building owners to access capital for resource conservation measures, TAF created an innovative tool called an Energy Savings Performance Agreement (ESPA™). In 2012, the TAF-led retrofit of Robert Cooke Co-op in Toronto was one of the first projects financed through an ESPA™. Using this performance savings agreement, TAF paid 100 per cent of the capital costs in exchange for a share of the verified energy savings over a 10 year term. After ten years, Robert Cooke Co-op retains 100 per cent of the savings and retrofit equipment. With this type of performance agreement, a third party insures the energy savings, reducing the risk for the retrofit partners.

TAF aimed to achieve 20 to 30 per cent carbon emission reductions at the Robert Cooke Co-op, a residential complex constructed in 1992 with 28 townhomes and a 123-unit tower. The project team reached this goal through a comprehensive retrofit that reduced carbon emissions by 30 per cent, or an average of 209 tonnes of carbon dioxide per year. The retrofit project achieved nearly $93,000 in annual cost savings representing a 20 per cent reduction in total utility costs, far exceeding the initial goal of $65,000 in annual utility savings.

TAF implemented the following retrofit measures at the Robert Cooke Co-op:

REDUCED/REPLACED

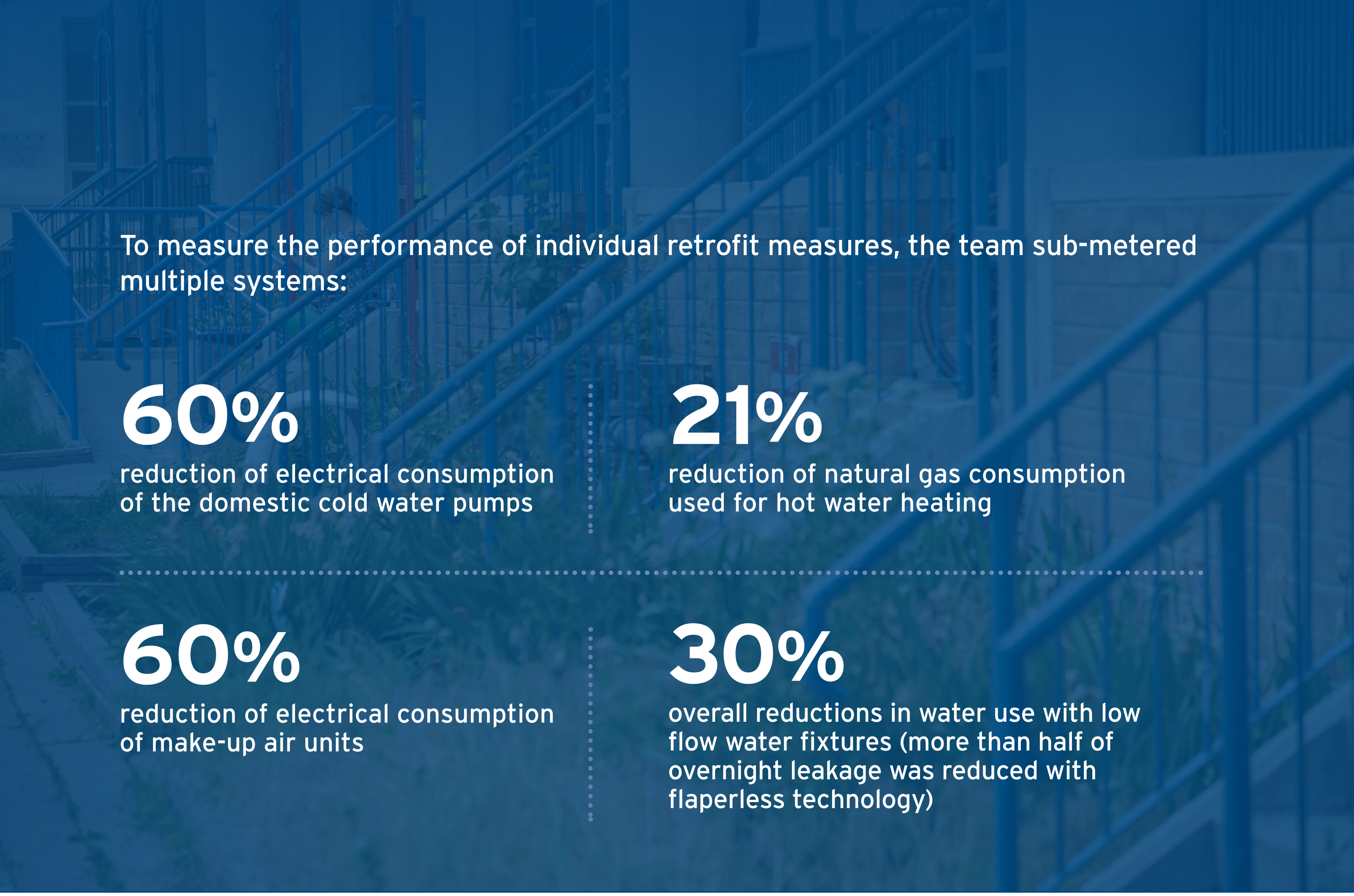
- Reduced water consumption through low flow showerheads, faucet aerators, and 3L water closets.
- Replaced existing boilers with two high efficiency boilers for domestic hot water and one condensing boiler for space heating. This was done after separating the domestic hot water and heating systems.
- Replaced domestic cold water booster pumps with variable frequency drive equipped models.
- Lowered electricity consumption from appliances by replacing original fridges and stoves with high-efficiency models.
- Installed corridor lighting with lower wattage T8 fluorescent tubes and added motion sensors in some common spaces.

INCREASED

- Increased the efficiency of the two make up air units (MAUs) by installing motors with variable speed drives.

WEATHERSTRIP

- Weatherstripped exterior doors to reduce drafts.



To measure the performance of individual retrofit measures, the team sub-metered multiple systems:

60%
reduction of electrical consumption of the domestic cold water pumps

21%
reduction of natural gas consumption used for hot water heating

60%
reduction of electrical consumption of make-up air units

30%
overall reductions in water use with low flow water fixtures (more than half of overnight leakage was reduced with flaperless technology)

Annual savings in 2015 exceeded projections by 169 per cent for water, 93 per cent for natural gas, and 82 per cent for electricity. This difference resulted from a combination of conservative performance estimations (mostly due to the leaking flappers which had not been accounted for in the estimate) and conservative estimates of future utility cost increases. A key learning is that while it is important to retain a certain degree of conservatism in estimating the savings, overly conservative estimates can result in underinvestment in the retrofit project.

The Robert Cooke Co-op retrofit was a success for all parties, meeting its 30 per cent reduction in carbon emissions and significantly exceeding estimated annual utility cost savings. This comprehensive retrofit also demonstrates the power of innovative financing such as an ESPA as a win-win tool: it helps building owners achieve significant cost savings while at the same time enabling the GTHA to reduce its carbon emissions

Robert Cooke Co-op | BENEFICIARY OF ESPA™

20%
Annual cost savings

$93,000
Annual cost savings (first 10 years):

30%
Reduction in carbon emissions

CO-BENEFITS:

☑ Lowered the building's operating costs

☑ Addressed deferred maintenance priorities

☑ Improved indoor environment for residents

TAF | PROVIDER OF ESPA™

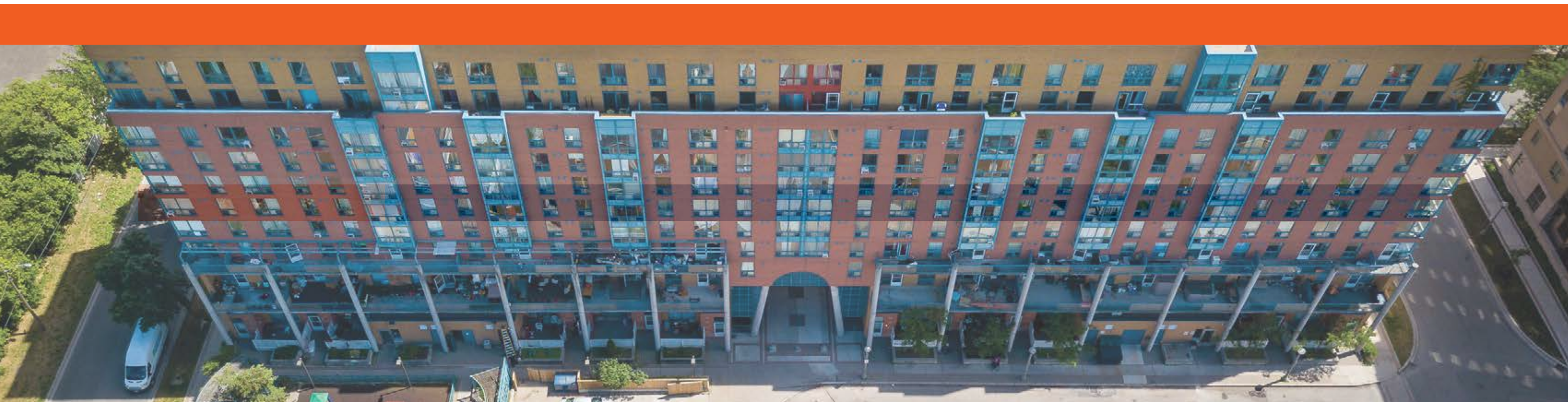
218%
Return on Investment

16%
Internal Rate of Return

$352,000
Net Present Value

5 years
Simple payback

Content



Robert Cooke
Case study

Built in 1992, the Robert Cooke residential complex includes a thirteen-storey tower with a gross floor area of approximately 14,000 m^2. By 2012, many of the building's fresh air and heating systems were close to the end of their service life and in significant need of renewal. The building also had a variety of other energy and water savings opportunities which were not being realized due to capital constrants.

To finance the critical repairs and other conservation measures, TAF's Energy Savings Performance Agreement (ESPA™) was implemented. Through this financing platform, TAF paid 100 per cent of the retrofit costs in exchange for a share of the varified energy savings over a 10-year term. After the end of the term, 100 per cent of the savings and retrofit equipment will be retained by Robert Cooke.

The measures implemented included replacing the existing boilers with two high efficiency models for the domestic hot water and one condensing boiler for space heating, incorporating variable speed drives in the make-up air units, installing low flow aerators and toilets, replacing appliances, replacing domestic cold water booster pumps, and air sealing exterior doors, and conducting an indoor lighting retrofit.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$93k
Annual cost savings

30%
Annual carbon emission reductions

5 years
Simple payback

16%
Internal rate of return

$352k
Net present value

218%
Return on investment

Imagery © 2018 Google, Map data

PROJECT DESCRIPTION

In 2012 Robert Cooke Co-op, located at 20 Garnett Janes Road, Toronto, was one of the first projects financed through The Atmospheric Fund's Energy Savings Performance Agreement for the implementation of resource conservation measures.

An ESPA™ is a non-debt agreement where guaranteed energy savings are used to cover the capital retrofit costs. Appendix A illustrates the structure of the ESPA™. This approach allows building owners to implement energy saving measures in their buildings without amassing any upfront costs. Using the ESPA™ platform, TAF finances the design, construction, and equipment costs, while sharing the savings with building owners over a 10 year term. At the end of the contract, the building owners keep all of the energy savings. Since the savings are insured by a third party, building owners are not penalized if the savings fall short of the original targets over the contract term. Ultimately, the ESPA™ agreement provides a project platform where all parties have a vested interest in ensuring a project reaches its utility cost, energy, and carbon emission reduction goals.

The retrofit measures aimed to maximize energy savings and address renewal problems with the building mechanical systems. Along with reductions in utility consumption and carbon emissions, TAF recognized an opportunity to monitor the performance of key energy consuming equipment such as domestic hot water and heating boilers. This case study will detail the process, results, and insights garnered from this project.

Goals

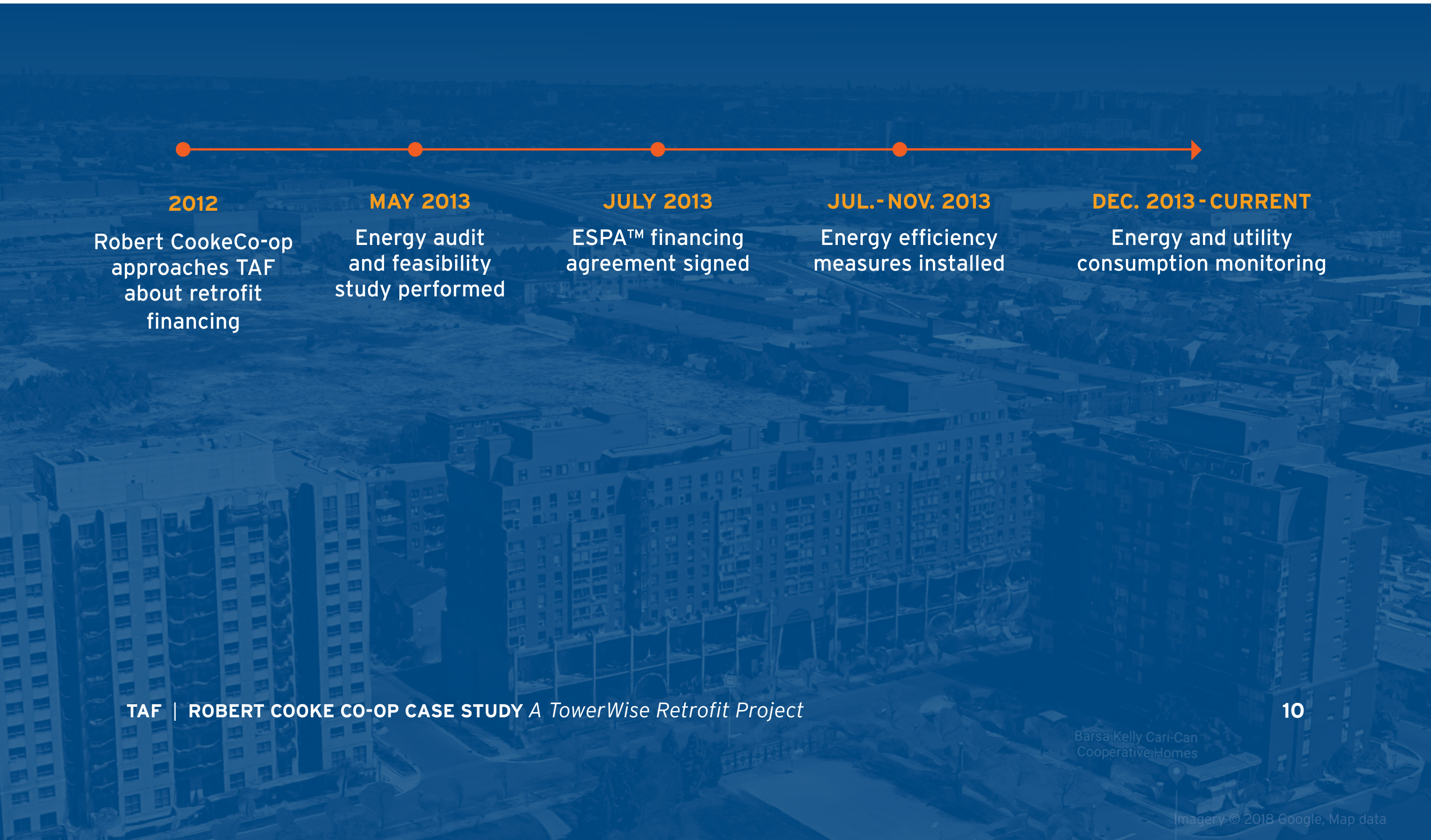
TAF aimed to achieve at least 30 per cent carbon emission reductions and $65,000 in annual utility savings, as well as address deferred maintenance priorities and improve the indoor environment for residents. As part of the in-depth monitoring program of the mechanical systems, TAF also aimed to measure the actual operating performance of the new boilers and quantify the differences in performance between condensing and non-condensing boilers.

Project Timeline

In 2012, the Robert Cooke Co-op expressed interest in TAF's ESPA™ as a financing platform for investment in building energy retrofits. Based on the Level II and Level III ASHRAE audits completed in 2011 and 2013, respectively, TAF provided a series of retrofit recommendations to Robert Cooke.

In 2013, the ESPA™ was signed between TAF and Robert Cooke. In addition, an engineering service provider, Finn Projects, was hired to implement the retrofit on a design-build basis and develop a measurement and verification plan. Through an insurance product available from Energi Insurance, the engineering service provider guaranteed 90 per cent of the expected utility cost savings.

Between July 2013 and November 2013, the retrofit measures were implemented at Robert Cooke and adjustments were made through the commissioning process. Over a 10 year agreement between TAF and Robert Cooke, which started in December 2013, the majority of the energy savings are transferred to TAF and the remaining are retained by the Co-op. The annual utility savings are measured and verified against a reference baseline year that is weather normalized. At the end of the 10 year agreement, 100 per cent of the ongoing savings will be retained by Robert Cooke Co-Op.



2012	MAY 2013	JULY 2013	JUL.-NOV. 2013	DEC. 2013-CURRENT
Robert CookeCo-op approaches TAF about retrofit financing	Energy audit and feasibility study performed	ESPA™ financing agreement signed	Energy efficiency measures installed	Energy and utility consumption monitoring

Energy and Water Conservation Measures

Robert Cooke Co-op is a residential complex with 28 townhomes and a 123 unit tower constructed in 1992. The tower is thirteen storeys tall with a gross area of approximately 14,000 m^2 and has two levels of underground parking. The building is centrally heated and ventilated. Some residents have installed personal window-mounted air conditioning units and there is a separate rooftop unit air conditioner in the offices. There is also an activity room and common laundry facilities. Detailed building information can be found in Appendix B.

In 2013, TAF, Finn Projects, and the Robert Cooke Co-op worked collaboratively to determine the energy and water conservation measures (or resource conservation measures, RCMs) that would most effectively meet the project goals. The team prioritized measures which would address the fresh air and heating systems that were either not functioning properly or nearing the end of their service life. Of particular concern was one malfunctioning make-up air unit, which was causing the building to receive only half of the intended fresh air supply. The resource conservation measures implemented are summarized below; detailed information can be found in Appendix C.

1. Separate the domestic hot water and heating systems;
2. Remove the existing boilers and install two high efficiency boilers for domestic hot water and one condensing boiler for space heating;
3. Replace the motors on the two make-up air units with models incorporating variable speed drives;
4. Replace the domestic cold water booster pumps with variable speed drive equipped models;
5. Replace corridor lighting with lower wattage T8 fluorescent tubes and install motion sensors in some common spaces;
6. Convert existing showerheads, faucet aerators, and toilets to low-flow;
7. Replace original fridges and stoves with high efficiency models;
8. Weatherstrip exterior doors.

A few additional RCMs that were considered but ultimately not installed are tabulated below.

TABLE 1: List of RCMs Not Installed

RCM	Rationale for Not Implementing
Solar hot water preheating/PV	Requires significant amount of equipment on roof and roof area was insufficient.
Direct digital control system	Building does not have sufficient equipment to warrant installation.
High efficiency motors	Motors were not near the end of their service life and replacement was not planned at this time. Run time too low for high efficiency motors to be cost effective.
Replace thermostats with programmable models	Low projected gas savings. Low gas rates and no cooling during the summer resulted in programmable thermostats not being financially attractive.

A summary of the actual construction costs and projected utility savings are provided below. Based on the outlined RCMs, the projected annual carbon emission reductions were 133 tCO2eq, representing a 23 per cent reduction.

TABLE 2: Projected Costs and Utility Savings

Project Performance	Value
Total Project Cost[1]	$658,477
Total Incentives[1]	$185,151
Net Cost	$468,326
Projected Utility Cost Savings	$66,650

[1] The actual project costs and incentives vary from Appendix C1. The values contained in Appendix C1 are feasibility study *estimates* prior to the start of construction.

Building Monitoring and Installation

Table 3 summarizes the building sub-metering points, while Appendix D provides the equipment and monitoring details. Data was collected at multiple intervals starting on August 1, 2013, and later collected consistently at one minute intervals since January 1, 2014. This report primarily focuses on the analysis from January 1, 2014 onwards.

TABLE 3: Metering Parameters

Metering Point	Resource Metered
Whole building	Natural gas, electricity, water flow
Parking garage	Electricity
Domestic cold water booster pumps	Electricity
Condensing boiler	Natural gas
East make-up air unit	Natural gas, electricity
West make-up air unit	Natural gas, electricity
Gas dryers (laundry)	Natural gas
Supply & return water for condensing boiler	Temperature
Return water for condensing boiler	Water flow
Supply & return water for high efficiency boilers	Temperature
Return water for high efficiency boilers	Water flow
High efficiency boilers	Energy production

To determine the pre-retrofit baseline, the 2010 calendarized building utility consumption was plotted against the number of exterior heating degree days. The weather dependent variables used for the regression analysis were natural gas consumption and garage electricity, which includes ramp heating in the winter. Adjustments were made to the baseline to account for a make-up air unit that was brought into operation and elevator room cooling which was added during the retrofit process. The RCM savings were then calculated based on the difference between the forecast baseline consumption and the billed consumption for each month in 2014 and 2015.

Left: two high efficiency boilers for domestic hot water; Right: low flow toilets awaiting installation.

A summary of the RCM installations is provided in Table 4. Given the sequencing of installations, there was an opportunity to determine impacts of individual RCM measures. These impacts are discussed in the next section.

TABLE 4: RCM Installation Sequencing

Measure	Start Date	Completion Date
Replace existing heating/domestic hot water boilers with high efficiency and condensing boilers	Jul. 29, 2013	Sept. 12, 2013
Provide variable speed drives for the make-up air units	Jul. 24, 2013	Oct. 15, 2013
Replace the domestic cold water booster pump motors and install variable speed drives	Aug. 6, 2013	Oct. 8, 2013
Replace corridor lighting	Oct. 31, 2013	Dec. 31, 2013
Install low-flow aerators, toilets and showerheads	Aug. 6, 2013	Sept. 12, 2013
Replace fridges and stoves with new high efficiency models	Aug. 20, 2013	Aug. 20, 2013
Weatherstrip exterior doors	Nov. 27, 2013	Dec. 4, 2013

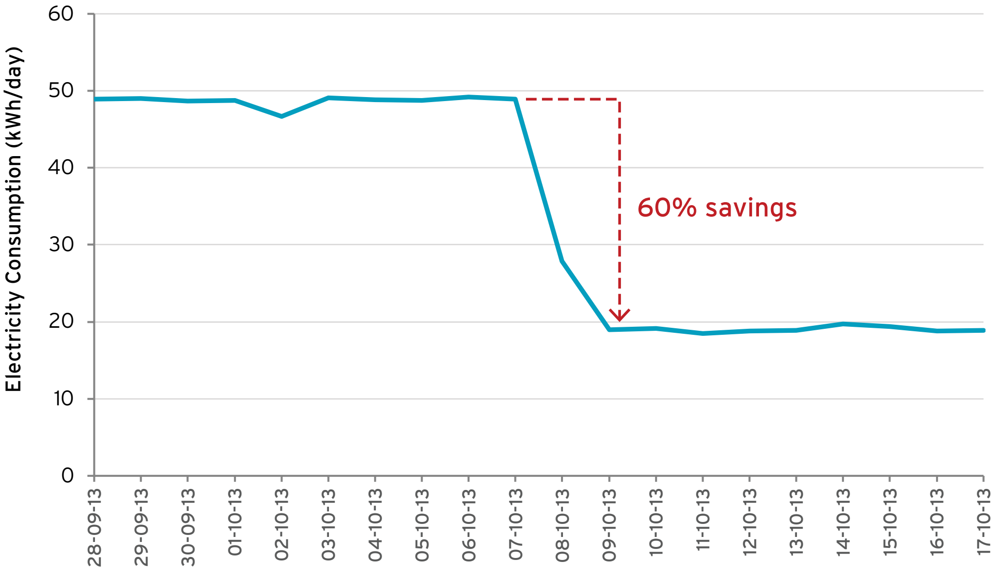
Energy and Carbon Emissions Performance

This section presents the 2014 and 2015 energy and carbon emissions performance of the RCM impacts. Given the timing of the installations, it was possible to evaluate the individual performance of the domestic cold water pump, make-up air units, and low flow fixtures. In addition, the boiler performance and operating efficiencies are also evaluated separately and described in this section.

Domestic Cold Water Pump

After the two new domestic cold water pumps controlled by variable speed drives were installed, Figure 1 shows an immediate reduction in the electrical consumption beginning on October 7, 2013. The consumption was reduced by approximately 60 per cent, from 50 kWh/day to 20 kWh/day. This RCM resulted in a total of 10,950 kWh savings per year, corresponding well with the feasibility study's estimate of 9,600 kWh savings per year (see Appendix C2).

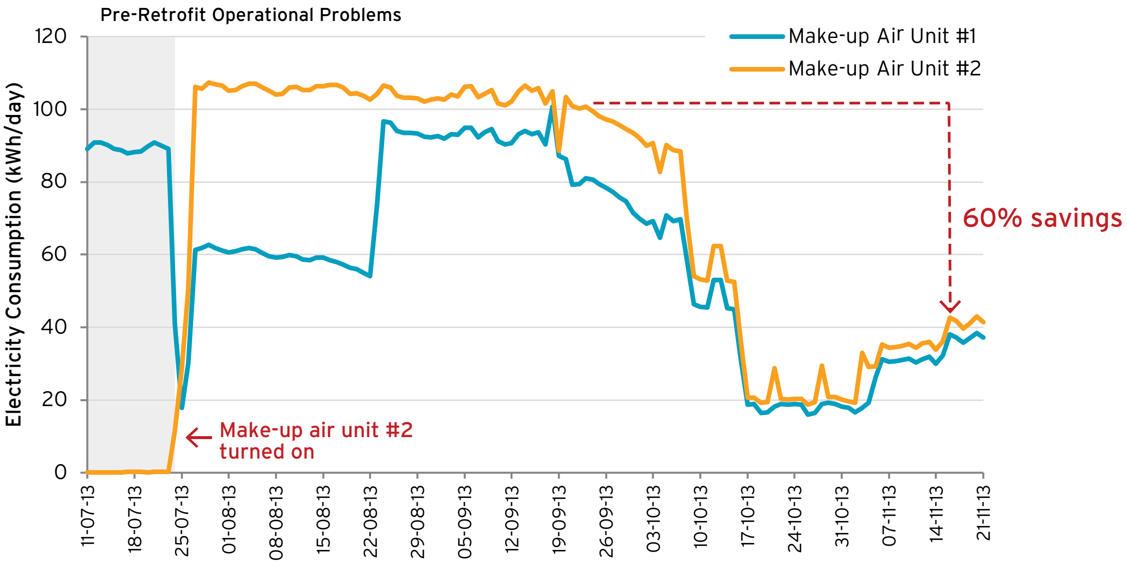
Figure 1: Daily booster pump electrical consumption



Make-Up Air Units

Variable speed drives and new fan motors were added to the make-up air units (MAUs) in order to match the amount of fresh air supplied with the building needs. Figure 2 shows the electrical consumption of the two make-up air units starting in July 2013. Make-up air unit #2, which was not previously working due to pre-retrofit operational problems, began operation on July 24, 2013. Since MAU #2 was not working for the majority of 2013, an adjustment of approximately 29,000 kWh/year was added to the baseline consumption to represent what the building would have used if both MAUs were operating properly. After this adjustment, the total baseline consumption was 58,000 kWh/year.

Figure 2: Daily make-up air unit electrical consumption



Between September 19, 2013 and November 21, 2013 the graph shows declining electricity consumption for each make-up air unit from approximately 100 kWh/day to 40 kWh/day[2]. This resulted in savings of approximately 60% when compared to the pre-retrofit operation. The total savings associated with the make-up air unit retrofits, calculated as the difference between the adjusted baseline consumption and the actual 2014 consumption, were approximately 38,000 kWh/year[3]. The gas consumption of the make-up air units was not analyzed since they were retrofitted during the summer (when the air does not need to be preheated).

TAF fixed a number of operational issues with the existing make-up air units and installed variable speed drives to achieve 60 per cent electricity savings.

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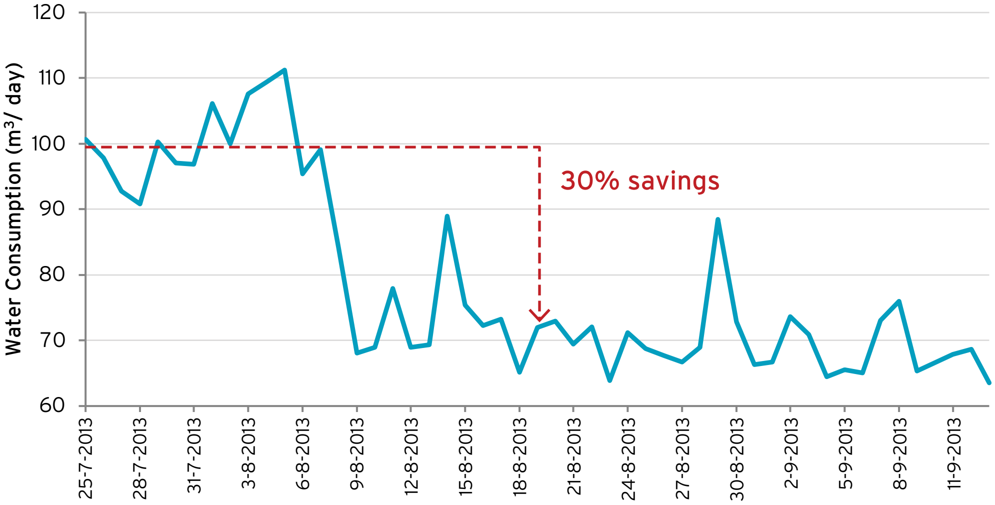
[2] The increase that occurred between October 2013 and November 2013 (20 kWh/day to 40 kWh/day) was likely due to modifying the MAU settings as the heating season began. To be conservative, the percentage of savings was calculated based on the 40 kWh/day consumption.

[3] The actual utility savings that the Robert Cooke sees are 9,000 kWh/year, calculated as the total savings minus the adjustment associated with MAU#2.

Low-flow Water Fixtures

The low flow water fixture retrofit consisted of installing 3 L toilets, 1.5 gpm low flow showerheads, 1.0 gpm aerators in the bathrooms and 1.5 gpm aerators in the kitchens. A few days after the RCM construction began on August 6, 2013, a reduction in water consumption from approximately 100 m^3/day to 70 m^3/day is shown in Figure 3. Annual water savings were 12,057 m^3 in 2014 and 11,629 m^3 in 2015 – more than double the 5,270 m^3 in estimated savings from the feasibility study (see Appendix C2).

Figure 3: Daily water consumption



The projected savings associated with the toilet replacement only took into account savings when flushing the 3 L low flow toilets. Any savings stemming from reducing toilet leakage through the flapper valves were not taken into account. These savings likely account for a large portion of the difference between the actual savings achieved and the projected savings.

The hourly water consumption during the night was analyzed since water savings at that time are largely due to flapper leakage reduction rather than a reduction associated with the flushes. This analysis revealed that the water consumption decreased by 50 to 60 per cent during the night in many cases. These significant savings were not taken into account at the feasibility stage, demonstrating that overly conservative estimates can result in significantly underestimating the savings that can be realized. This can potentially lead to underinvestment in energy and water efficiency retrofit projects.

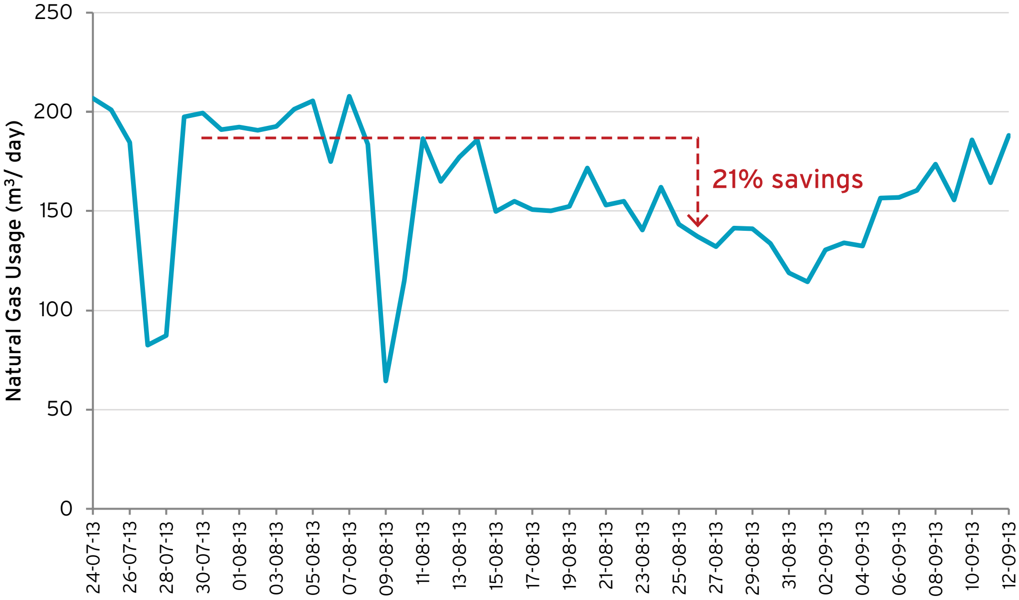
Through low flow fixtures and toilets, TAF reduced water consumption by an average of 30 per cent.

Boilers

The existing oversized boilers were replaced with one 1,100 MBTU/h condensing unit serving the heating system and two 1,100 MBTU/h high efficiency boilers serving the domestic hot water load. Figure 4 shows two sharp declines in natural gas consumption on July 27–July 28, 2013 and August 9, 2013 – likely when the existing boilers were taken offline and replaced. Prior to August 9, 2013, the average daily natural gas consumption was 187 m^3 (excluding the drops). Post retrofit, the average consumption was reduced to 147 m^3, equivalent to a savings of approximately 21 per cent. It is important to note that these savings are only due to improved efficiencies of the domestic hot water system, since the space heating was not turned on at this time. Gas savings stemming from the make-up air units improvements, as well as a comparison between the condensing and high efficiency boilers, is provided in the next section.

By replacing oversized boilers with new condensing equipment TAF lowered natural gas consumption for hot water by 21 per cent.

Figure 4: Daily natural gas consumption



Savings

Figure 5 shows the total utility savings resulting from all of the implemented RCMs. The actual savings achieved in 2015 were nearly double compared to the estimated savings from the feasibilty study, largely because of the water savings. These higher than anticipated water savings are likely the result of reduced water leakage from replacing the old flapper valves.

Figure 5: Utility Savings – gas and electricity (left), water (right)

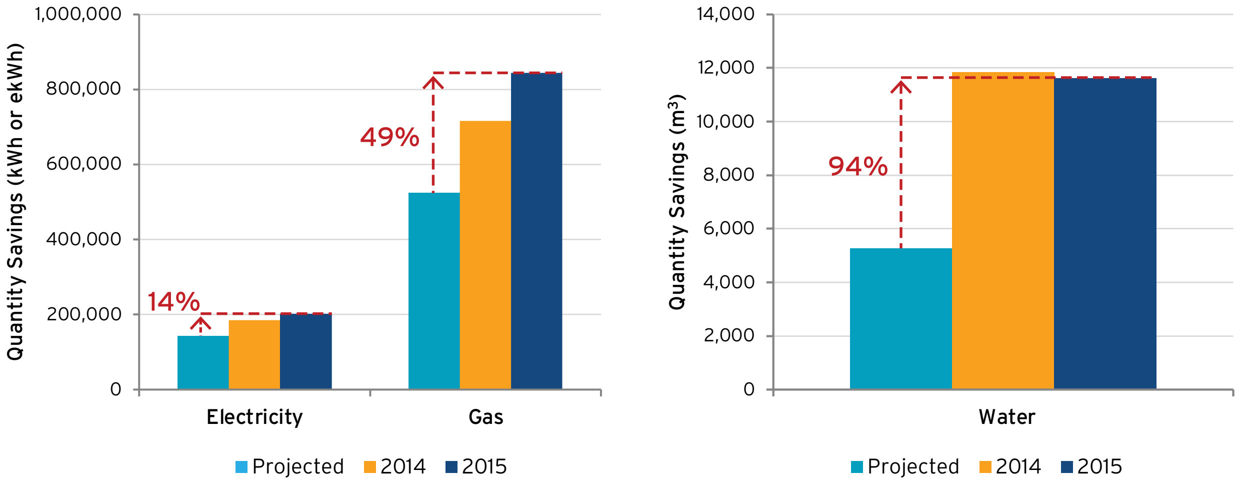


Table 5 summarizes the carbon emissions and utility cost savings, per year, for each utility type. These savings are based on the difference between the actual consumption and the adjusted baseline. Appendix E has a full table of these parameters, including the carbon emission factors used. While gas savings represented the majority of carbon emission savings, they resulted in the smallest cost savings due to their low utility cost. In comparison, the water measures had the largest cost savings, but contributed minimally to the carbon emission savings. Overall, the total utility cost savings averaged between the two years was 20 per cent.

TABLE 5: Summary of GHG emissions and Cost Savings

Year	Resource	GHG emissions (tCO$_2$eq)	Cost Savings ($)
2014	Electricity	66.1	$27,391
	Gas	130.6	$21,194
	Water	N/A	$36,860
	TOTAL	**196.7**	**$85,445**
2015	Electricity	67.3	$33,330
	Gas	154.1	$28,440
	Water	N/A	$38,561
	TOTAL	**221.5**	**$100,331**

Boiler Efficiency and Analysis

The existing boiler configuration included three 1,467 MBTU/h (input) Raypack boilers that served the heating and domestic hot water systems, with estimated operating efficiencies lower than 70 per cent. Prior to the retrofit, one of these boilers had failed and another was in very poor condition. The domestic hot water tank was heated via a heat exchanger on a secondary loop.

Boiler sizing analysis was performed, which indicated that the boilers could be adequately replaced with 1,100 MBTU/h boilers. However, there were concerns over providing sufficient heating in extended cold winter periods and a desire to enable redundancy in case of boiler failure. Thus, the resulting two domestic hot water boilers bought were sized at 1,500 MBTU/h (input) and the condensing boiler for heating sized at 1,050 MBTU/h (input). The rated efficiencies for the condensing and non-condensing boilers were 94 per cent and 85 per cent respectively. A three-way valve was installed to connect the domestic hot water loop to the heating loop via a heat exchanger in case additional heating is needed in the future. All three boilers have a turndown ratio of 5:1, alleviating some concerns over potential inefficiencies associated with installing oversized boilers which have no modulation capabilities.

Overall Efficiency

Table 6 summarizes the average boiler efficiency of the two domestic hot water high efficiency boilers and the condensing space heating boiler. The efficiency presented for the domestic hot water boilers is averaged between the two units. The range is based on the use of two different data sets were to evaluate the efficiency. One was supplied by Finn Projects through quarterly measurement and verification plans, while the second is from the building sub-metering points.

TABLE 6: Summary of Average Boiler Efficiency[4]

High Efficiency Boilers[5]	Condensing Boiler
73.4% - 78.0%	87.6% - 89.2%

Differences between the two data sets can be attributed to different time periods, where one is based on data available between March 2014 and February 2015 while the second is based on data between May 2014 and October 2015. The gas meter output was also modified in February 2015[6] which can also contribute to some of the differences found in Table 6.

Condensing boiler operated at a considerably higher efficiency than the non-condensing boilers, even when the temperature is outside the condensing range.

Condensing Range

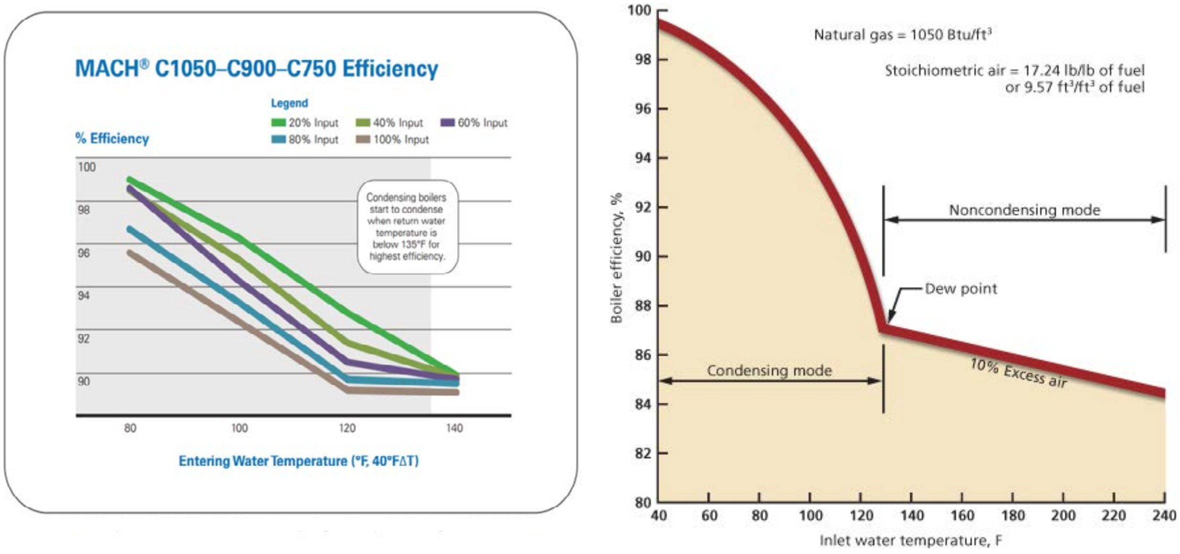
A common claim is that condensing boilers may not have any efficiency gains over non-condensing boilers when these systems operate outside the condensing temperature range. The condensing range is typically accepted as having the return water temperature equal to 130°F (54.4°C) or lower.

[4] Range is based on the use of two data sets to evaluate boiler efficiency.

[5] Gas consumption of the high efficiency boilers was not sub-metered, it was calculated as the total gas minus all of the other submetering gas points. In addition, the hot water flow rate of the high efficiency boilers was spot metered and assumed to be consistent when the boilers were on. The outcome of both of these modifications may lead to less accurate data used in the high efficiency boiler analysis.

[6] The gas meter was initially configured to send a pulse reading every time 10 ft^3 of gas was used. The pulse readings were then collected in 15 minute intervals. Since the supply and return temperatures changed very frequently, the resolution and intrval were changed to 1 ft3 and 1 minute, respectively, in February 2015.

Figure 6: Efficiency Diagram for Condensing Boiler Installed (Left) and Boiler Inlet Temperature vs. Boiler Efficiency from ASHRAE 2008 Handbook (Right)



Data collected in 2015 were analyzed to determine the condensing boiler efficiency above and below the 130°F (54.4°C) threshold. This particular monitoring year was chosen because performance data at 1-minute intervals was collected for the largest amount of time without any erroneous readings. A direct comparison is not possible since the two types of boilers are servicing different mechanical systems and the non-condensing boilers almost never enter the condensing temperature range. However, it is still useful to examine the differences in performance.

Table 7[7] shows the condensing boiler efficiency based on the temperature of the return water. As expected, the condensing boiler performance is better within the condensing range, i.e. lower than 130°F (54.4°C).

TABLE 7: Efficiency Based on Return Temperature for Condensing Boiler

Return Temperature	Condensing Boiler Efficiency
≥ 130°F (54.4°C)	90.8%
< 130°F (54.4°C)	91.1%

Additional analysis specifically looked at the correlation between cycling, efficiency, and return water temperature. This analysis is based on data from February 20, 2015 to March 29, 2015, which was the longest uninterrupted interval where reasonable data were available.

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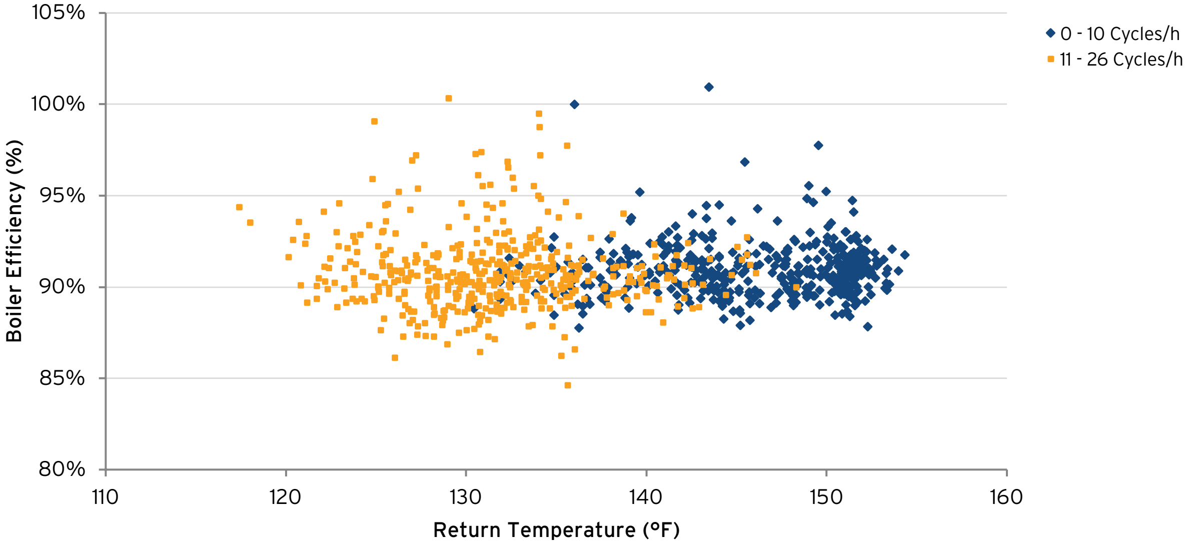
[7] The efficiencies shown in Table 7 are slightly higher than those in Table 6 due to the shorter time frame of the analysis. The analysis in Table 7 is based on data collected between February 20, 2015 and March 29, 2015.

Figure 7 shows the average hourly condensing boiler efficiency plotted against the average hourly return temperature[8]. Blue points represent instances when the boiler cycled ≤10 times per hour, while the orange points represent instances when the boiler cycled >10 times per hour. A full cycled occurred when the boiler down time was one minute long. The sensitivity of the boiler down time was explored revealing that the condensing boiler infrequently turned off for more than one minute and very rarely turned off for more than two minutes.

Figure 7: Average Hourly Efficiency vs. Average Hourly Return Temperature



The graph shows that time periods with more frequent condensing boiler cycles coincided with lower return water temperatures and vice versa. This was the expected result since a lower return temperature would generally indicate less demand for heating and result in more occurrences when the boiler turns off. However, there was no appreciable difference in the average efficiency between the two thresholds of cycling. Although higher efficiencies might be expected at lower return water temperatures, the modulation rate at those times is unknown and the increased amount of cycling could offset those efficiency gains. Further research into how cycling, modulation and return water temperatures affect condensing boiler efficiency should be undertaken in order to better understand the relationship between these parameters.

More cycling coincided with lower return temperatures.

No significant efficiency differences were seen between the two thresholds of cycling.

[8] Four of the points plotted had an operating efficiency over 100%. These points represented 0.4% of the data and were deemed to be outliers.

Financial Performance

Actual savings achieved have outperformed projections for 2014 and 2015[9]. This is because of the greater than expected water savings from the fixture and toilet replacements. Figure 8 shows the cost savings breakdown by utility. The second largest factor in helping achieve the high savings was the larger than expected gas savings.

Figure 8: Cost Savings Breakdown by Utility

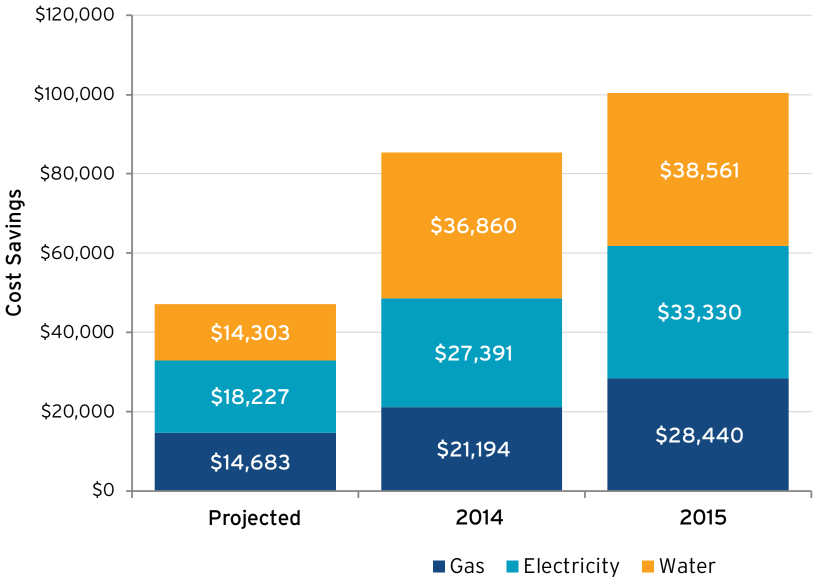


Figure 8 also shows that the 2015 savings were even greater than 2014 savings. An analysis was performed to determine whether the costs savings increase was due to a quantity increase (thus achieving higher savings) or due to a utility rate increase. The summary of this analysis is shown in Figure 9. For gas and electricity, the additional savings are almost equally split between the two factors. For water, there were fewer saving realized due to a quantity increase in 2015 compared to 2014. However, the increase in the water utility rates between these two years more than offset this difference and generated a significant increase in cost savings.

Actual utility savings exceeded projected savings across all utility types, especially when it came to water reductions.

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[9] The Projected Cost Savings in Figure 8 ($47,212) are different than the original Feasibility Study projections of $66,650 shown in Table 2 and Appendix C1. This is because the in-suite lighting measure was ultimately not implemented. The projected savings were therefore updated to reflect this change.

Figure 9: Change in Cost Savings between 2014 and 2015

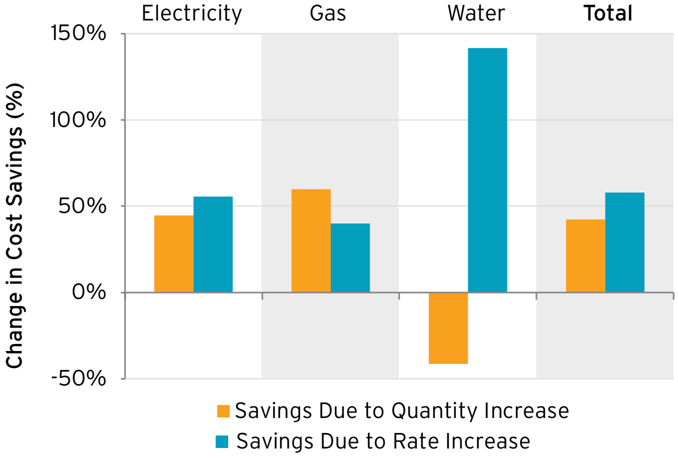


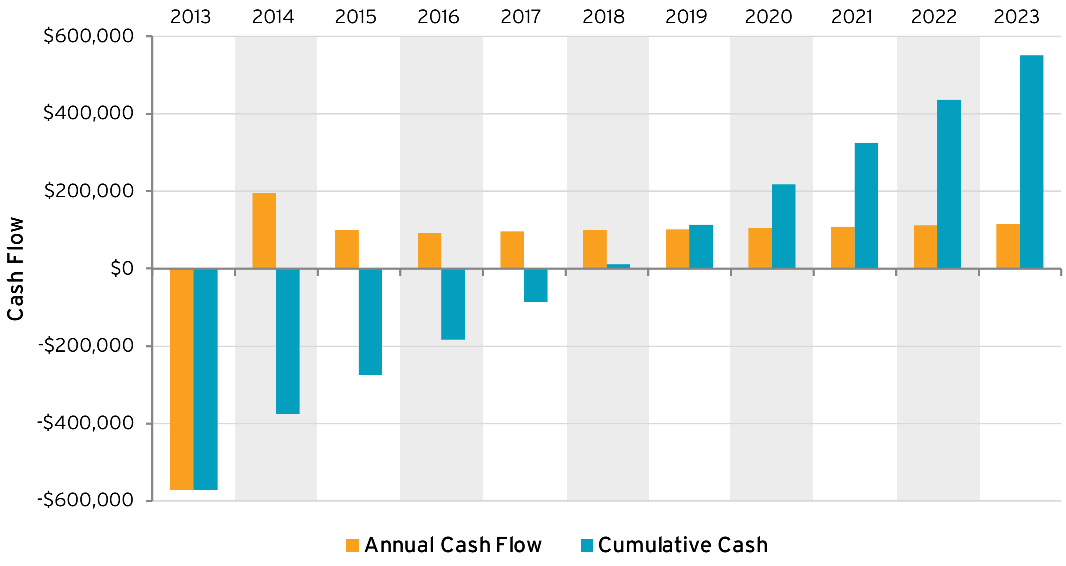
TABLE 8: Summary of Financial Parameters

Financial Summary	
Simple Payback	5 years
Internal Rate of Return (IRR)	16.6%
Net Present value (NPV) (at a 4% rate)	$352,328
Return On Investment (ROI)	218%

Table 8 summarizes the resulting internal rate of return (IRR), return on investment (ROI), net present value (NPV)[10] and simple payback. Based on these parameters, the project has fared well financially.

Figure 10 shows the annual cash flow and cumulative savings extrapolated over a 10 year period. The actual savings achieved were significantly higher than the projections. This difference is due to a combination of conservative estimations of measure performance (namely the water savings) as well as conservative estimates of future utility cost increases. While a certain degree of conservativeness is warranted, overly conservative savings estimations can be detrimental long term. Energy retrofit projects should carefully estimate the savings at the feasibility stage to avoid reducing the potential investment of future work.

Figure 10: Annual Cash Flow from 2013 to 2023 (includes receipt of incentive rebates)



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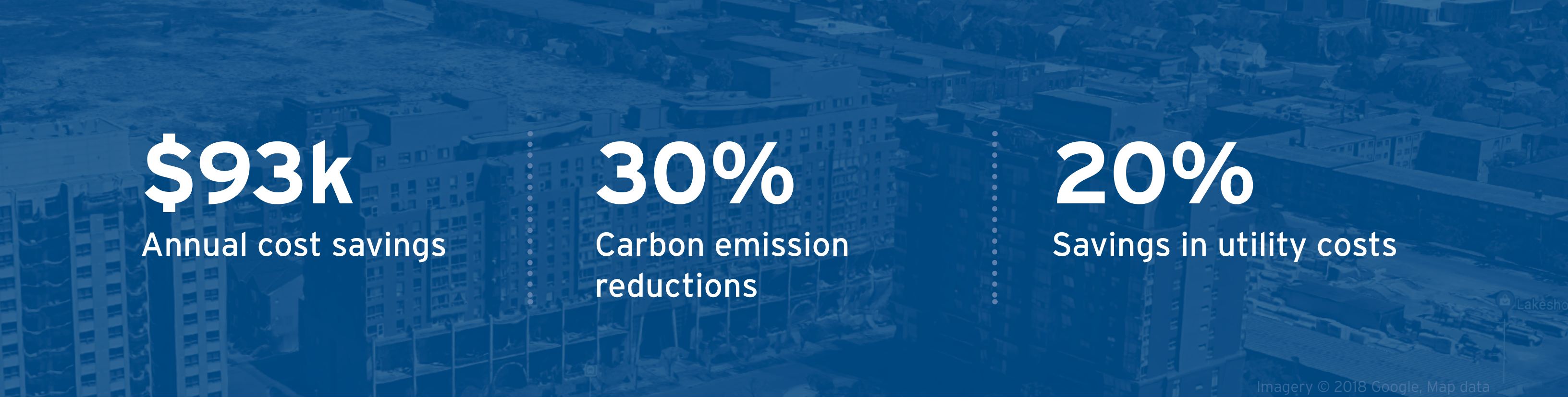
[10] The 2014 and 2015 cost savings that are extrapolated over a 10 year period.

Conclusion

A number of resource conservation measures have been implemented at Robert Cooke to reduce utility consumption, energy, and carbon emissions. Through these retrofits, there was also an opportunity to renew mechanical systems which were either malfunctioning or near the end of their service life. All measures were funded through the ESPA™ platform, where all project parties have a vested interest in ensuring the project goals are met.

Annual savings in 2015 exceeded the projections by 169 per cent for water, 93 per cent for natural gas, and 82 per cent for electricity. Higher than expected savings were largely due to large water savings associated with the toilet leakage which was not included in the savings projections. Overall, this project achieved 30 per cent carbon emission reductions and 20 per cent savings in utility costs.



$93k
Annual cost savings

30%
Carbon emission reductions

20%
Savings in utility costs

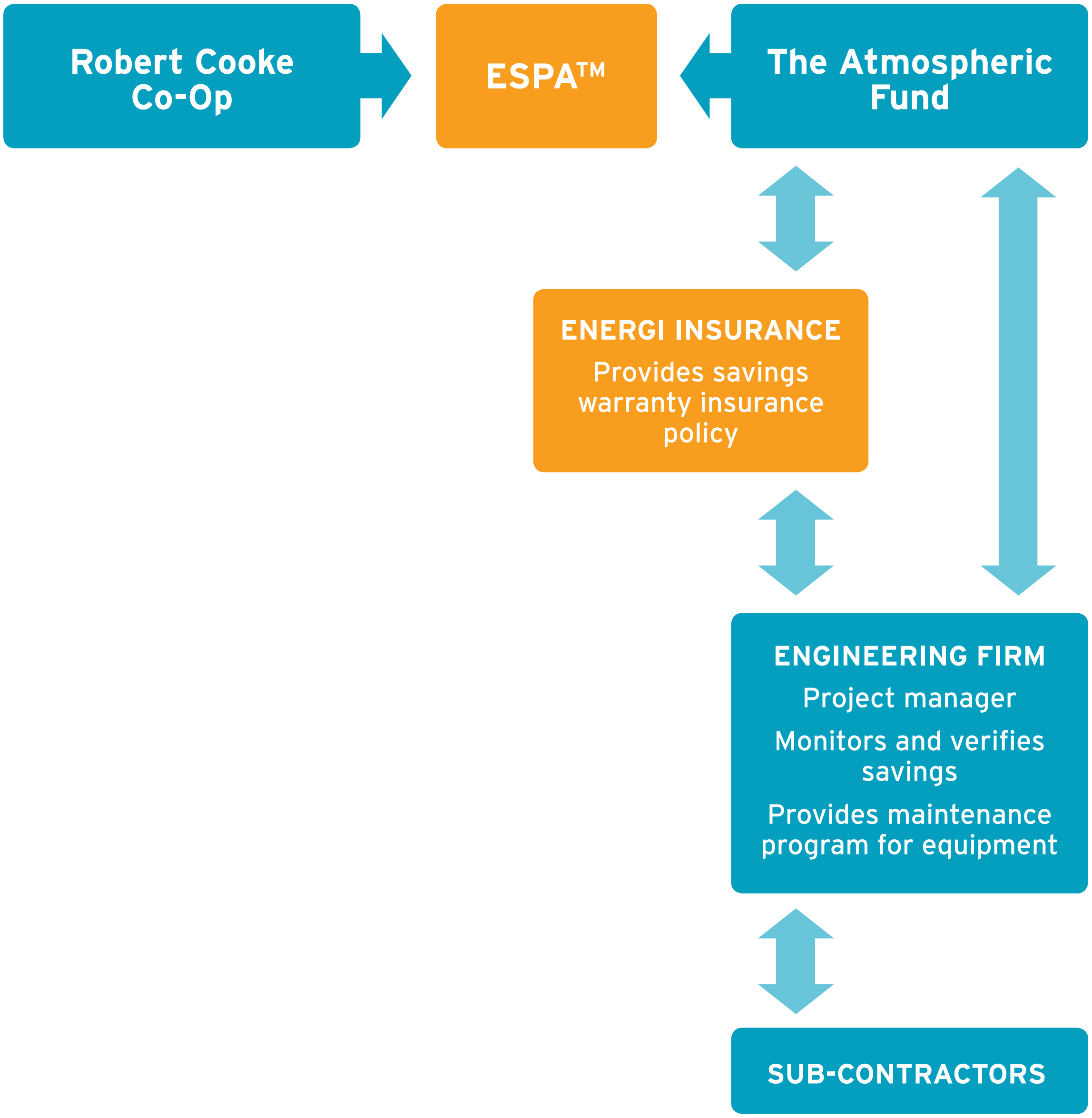
Imagery © 2018 Google, Map data

BEST PRACTICE GUIDELINES

From our experience in retrofit implementation and detailed monitoring of the boilers, here are some best practice guidelines that can be applied to future projects:

- Residents at the building were opposed to an in-suite lighting retrofit using compact fluorescent lights (CFLs), forgoing significant electrical savings. Future projects should involve residents early in the design process about in-suite retrofit measures, so there is an opportunity to address concerns and educate residents on the benefits of particular measures.
- The boiler analysis relied on spot metering the non-condensing boiler flow during the monitoring period. Given that these parameters can vary during operation, flow rates should be directly monitored. In addition, future projects must carefully align the individual sensor accuracy and logging capabilities with the level of accuracy required.
- A common industry belief is that condensing boilers may not have any efficiency gains over non-condensing boilers when operating conditions are outside the condensing temperature range (i.e. above 130°F, 54.4°C). This case study has shown that efficiency gains with condensing boilers are possible even when the water temperatures are outside the ideal condensing conditions. Future projects should consider installing condensing boilers over high efficiency units, even if the return water temperatures are expected to fall outside the ideal condensing range for a portion of the time.
- The condensing space heating boiler was found to cycle more when the return water temperature was lower, since the building had a lower heating demand during this time period. Although higher condensing boiler efficiencies are expected at lower return temperatures, the increased amount of cycling could partly offset those efficiency gains. To reduce cycling times and maximize the operating efficiency, oversized heating and domestic hot water boilers by a significant margin should be avoided.
- A combination of conservative savings estimates and assumptions about future utility rate increases resulted in substantially underestimating the long-term savings potential of this project. While a certain degree of conservativism in estimating utility cost savings is warranted, overly conservative estimates can result in underinvestment in energy and water efficiency retrofit projects. Conducting a detailed pre-retrofit investigation (e.g. checking for toilet leakage) can result in better savings projections which will ultimately increase the likelihood of retrofit projects being completed.
- This case study used a multi-measure retrofit approach that implemented both water saving measures that can result in large utility cost savings, as well as gas saving measures that provide significant carbon emission reductions. Simultaneously implementing a variety of measures targeting water, gas, and electricity consumption can help retrofit projects achieve significant carbon emissions and cost savings reductions. Financing platforms like TAF's ESPA™ are needed to encourage and incentivize building owners to take advantage of energy and water saving opportunities across the multi-residential sector.

APPENDIX A – ENERGY SAVINGS PERFORMANCE AGREEMENT STRUCTURE



Robert Cooke Co-Op

ESPA™

The Atmospheric Fund

ENERGI INSURANCE

Provides savings warranty insurance policy

ENGINEERING FIRM

Project manager

Monitors and verifies savings

Provides maintenance program for equipment

SUB-CONTRACTORS

APPENDIX B – PRE-RETROFIT BUILDING INFORMATION

Building Type	Co-operative
Name & Address	Robert Cooke Co-Operative Homes Inc. 20 Garnett Janes Road Toronto, ON M8V 3Z1
Year of Construction	1992
Major Renovations	N/A
Number of Floors	13
Parking Levels	2 (underground)
Number of Suites	123 (1-3 bedroom)
Gross Area	~14,000 m^2
Heating	4,400 MBTU/hr provided by three atmospheric boilers serving both heating and hot water. Building has a 750 gallon hot water tank. Primary loop is used for heating, secondary loop for domestic hot water. Residences heated by two-pipe fancoils. Common areas heated by fancoils and electric unit heaters.
Cooling	No central cooling, window units estimated at 150 tonnes combined. 5 ton rooftop unit serves offices; 2 ton unit serves community room at 13th floor.
Domestic Hot Water	Combined with space heating.
Ventilation	Two make-up air units rated at 8,000 CFM and 750 MBTU/h each. Common areas ventilated by fractional HP exhaust fans, garage ventilated by four 2-HP exhaust fans. Resident kitchen and sanitary exhaust fans discharge through wall-boxes.
Miscellaneous Equipment/Facilities	Activity room and common laundry facilities.

APPENDIX C1 – PROJECTED RESOURCE CONSERVATION MEASURE COSTS

Resource Conservation Measures	Gross Cost[11]	Incentives	Net Cost	Annual Savings	Asset Lifetime[12]	Net Present Value
Replace the three existing boilers with condensing and high efficiency boilers. Separate hot water and heating systems.	$270,000	$40,750	$229,250	$6,400	20	($140,987)
Install variable speed drives on make-up air units.	$23,200	$16,150	$7,050	$7,750	15	$68,667
Replace domestic cold water booster pump with booster pump equipped with a variable speed drive.	$23,300	$11,550	$11,750	$1,250	15	$21,183
Replace existing T12 and T8 fixtures with reduced wattage T8 fixtures and electronic ballasts. Replace existing in-suite incandescent lamps with compact fluorescent lamps.	$47,700	$17,000	$30,700	$16,300	10	$114,048
Install low-flow aerators and toilets.	$72,800	$1,250	$71,550	$16,350	15	$198,843
Replace remaining original fridges and stoves with high efficiency models.	$192,100	$95,300	$96,800	$11,250	10	$150,725
Replace weatherstripping of entry/exit doors.	$4,000	$400	$3,600	$550	10	$6,290
Monitoring, training and education.	$25,000	$5,000	$20,000	$6,800	10	$54,428
TOTAL	**$658,100**	**$187,400**	**$470,700**	**$66,650**	**-**	**$473,197**

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[11] Excludes engineering and design fees.

[12] Lifetime of asset is estimated by Finn Projects.

APPENDIX C2 – PROJECTED RESOURCE CONSERVATION MEASURE SAVINGS

RESOURCE CONSERVATION MEASURES	PROJECTED ANNUAL SAVINGS			
	Electricity (kWh)	Natural Gas (m^3)	Water (m^3)	GHG Emissions (tCO_2e)
Replace the three existing boilers with condensing and high efficiency boilers. Separate hot water and heating systems.	-	22,090	-	41.8
Install variable speed drives on make-up air units.	8,750	22,910	-	44.3
Replace domestic cold water booster pump with booster pump equipped with a VSD.	9,600	-	-	1.1
Replace existing T12 and T8 fixtures with reduced wattage T8 fixtures and electronic ballasts. Replace existing in-suite incandescent lamps with compact fluorescent lamps.	127,350	-	-	14.0
Install low-flow aerators and toilets.	7,750	3,680	5,270	7.8
Replace remaining original fridges and stoves with high efficiency models.	88,050	-	-	9.7
Replace weatherstripping of entry/exit doors.	-	1,950	-	3.7
Monitoring, training, and education[13].	28,700	4,140	710	11.0
TOTAL	**270,200**	**54,770**	**5,980**	**133.3**

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[13] Annual utility savings are achieved through several measures. A web-based real time monitoring system displaying the building utility consumption was installed in the common area so residents can see the real-time savings. In addition, Finn Projects has delivered a resident awareness program regarding resource conservation. Lastly, operator training was conducted to ensure the new mechanical systems are operating as intended. These savings are not included in the baseline savings.

APPENDIX D1 – EQUIPMENT DETAILS

Equipment	Manufacturer	Quantity	Description
Boilers	PK Mach PK Thermific Model	1 2	1.05 MBTU (condensing) 1.5 MBTU
Motors	Century	2	Outdoor and indoor make-up air unit supply fan motors
Appliances	Frigidaire Whirlpool	140 148 11	Range Fridge Fridge
Toilets	Proficiency	147 20	3 L – in units 3 L – accessible, in common areas
Showerheads	AM Conservation Group	135	1.5 gpm
Faucet aerators	AM Conservation Group	99 140	1.0 gpm – bathrooms 1.5 gpm – kitchens
Lighting	Various	~258 fixtures with ~413 lamps	48" T8-25W Elec. Ballast, 36" T8-25W Elec. Ballast, 24" T8-17W Elec. Ballast, LED 11W, LED 37W Outdoor

APPENDIX D2 – MONITORING DETAILS

Monitoring Equipment	Manufacturer	Model	Quantity
Facility Explorer web-based supervisory controller, sensors, boiler interface card, network controller and expansion module	Johnson Controls	FX-PCG2611-0, FX-PCX3711-0, LP-FX2021N-1, AFP-Version6	1
Data Industrial BTU System to measure flow through the boiler and temperatures and interface with the control system	Badger Meter	Series 380 Impeller BTU Meter	1
Diaphragm gas meters with volume pulse for real-time metering	CM Co.	3.5M-285-MTCI gas meter c/w RVP-F1 pulser, ACM630TC 25 PSI gas meter c/w RVP-F1 pulser	3

APPENDIX E - SAVINGS TABLES

UTILITY	CONSUMPTION		SAVINGS		COST SAVINGS		% SAVINGS	UTILITY RATE
	Baseline	Actual	Projected (Updated)	Actual	Projected (Updated)[1]	Actual		
2014								
Electricity (kWh)	1,707,464	1,521,657	142,400	185,807	$18,227.20	$27,390.81	10.9%	$0.15
Gas (m^3)	273,993	204,913	50,630	69,080	$14,682.70	$21,194.29	25.2%	$0.31
Water (m^3)	36,527	24,686	5,270	11,841	$14,302.78	$36,860.01	32.4%	$3.11
TOTAL					**$47,213**	**$85,445**	**19.0%**	**–**
2015								
Electricity (kWh)	1,705,390	1,503,552	142,400	201,838	$18,227.20	$33,329.62	11.8%	$0.17
Gas (m^3)	260,771	179,257	50,630	81,514	$14,682.70	$28,439.67	31.3%	$0.35
Water (m^3)	35,753	24,125	5,270	11,628	$14,302.78	$38,561.48	32.5%	$3.32
TOTAL					**$47,213**	**$100,331**	**20.4%**	**–**
2014 & 2015 AVERAGE					**–**	**$92,888**	**19.7%**	**–**

Utility	Baseline GHG Emission Factors	Adjusted Baseline GHG Emissions (tCO_2e)	Current GHG Emission Factors	Post-Retrofit GHG Emissions (tCO_2e)	GHG Emission Reductions (tCO_2e)	GHG Emission Reductions (%)
2014						
Electricity (kWh)	0.00011	187.8	0.00008	121.7	66.1	35.19%
Gas (m^3)	0.00189	518.1	0.00189	387.5	130.6	25.21%
Water (m^3)	–	–	–	–	N/A	–
TOTAL		**705.9**	**–**	**509.2**	**196.7**	**27.9%**
2015						
Electricity (kWh)	0.00011	187.6	0.00008	120.3	67.3	35.88%
Gas (m^3)	0.00189	493.1	0.00189	339.0	154.1	31.26%
Water (m^3)	N/A	N/A	N/A	N/A	N/A	N/A
TOTAL		**680.7**	–	**459.3**	**221.5**	**32.5%**
2014 & 2015 AVERAGE		**–**	**–**	**484.2**	**209.1**	**30.2%**

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[1] The Projected Cost Savings provided in this appendix ($47,212) are different than the original Feasibility Study projections of $66,650. This is because the in-suite lighting measure was ultimately not implemented. The projected savings were therefore updated to reflect this change.