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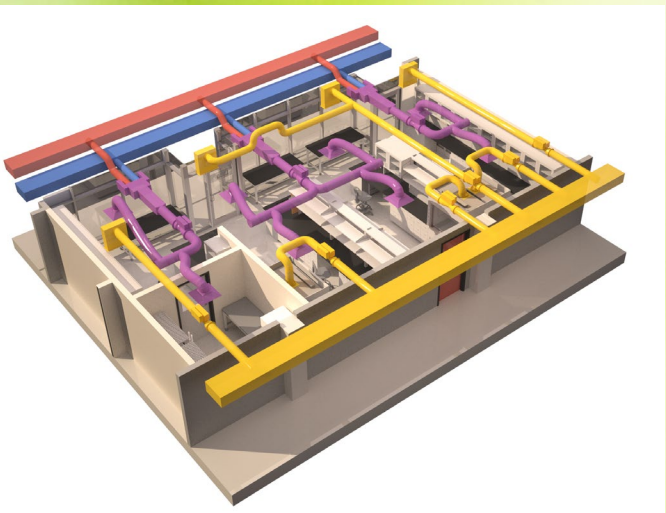

Canada Centre for Inland Waters Administration and Laboratory Building Laboratory Modernization Plan (LMP)

2015-08-08

PWGSC Project R.072688.001

Environment Canada

Burlington, Ontario

RS 2.1.2

Design Concept - Appendix A

Life Cycle Cost Analysis Report

Public Works and Government Services Canada

Travaux publics et Services gouvernementaux Canada

Environment Canada

Environnement Canada

Canada

EXECUTIVE SUMMARY

As part of the Lab Modernization Process (LMP) at the Canada Centre for Inland Waters (CCIW) DIALOG has performed energy modeling analysis and a Life Cycle Costing Analysis (LCCA).

Lifecycle Costing Analysis (LCCA) allows for the evaluation of multiple contemplated design options over the decision making life of a project. By completing the LCCA it is possible to evaluate not only initial capital costs but the total cost of ownership including utilities, operations, and maintenance. Calculating the total cost of ownership allows the project team to choose the best project alternative, inclusive of initial costs and ongoing annual or non-annual costs.

To allow for comparison between costs incurred today and costs incurred in the future, the 'time value of money' is considered by applying a discount factor to all future costs. Financial inputs were derived from the PWGSC website and confirmed with the Client team.

In addition to cost savings and positive financial returns, building retrofits can provide many other benefits including better air quality, better acoustics, increased natural light, improved thermal comfort, better morale, and increased productivity. The benefits in the workforce might generate returns that are far greater than those created by lower energy bills. Building owners will frequently prioritize projects that result in an improved work environment to enjoy a return on their investment through a more productive work force.

A list of Energy Conservation Measures (ECMs) were selected for analysis based on their potential for saving energy consumption, operating costs and Greenhouse Gas emissions (GHGs). The ECM's were simulated using the IES Virtual Environment VE 2014 software to predict the impact that each project would have on the building performance. ECM's analyzed in the project included:

1. **Central Exhaust System Upgrade:** Installation of central exhaust ducts for the North and South side of the building, carrying laboratory exhaust through a Variable Air Volume (VAV) system.

2. **Add Heat Recovery System:** Addition of a glycol heat recovery loop to capture waste heat from the exhaust air stream.

3. **Upgrade Lighting to High Efficiency LEDs:** Lighting design on floors 4-7 will be revised to include high-efficiency LED fixtures and achieve lower installed Lighting Power Density (LPD).

4. **Add lighting controls for occupancy and daylight:** Add daylight sensors for all perimeter spaces to automatically turn down light fixtures when natural light is available. Incorporate occupancy sensors for all offices, labs, washrooms and storage areas to automatically turn off lights when there is no activity in the space.

5. **Replace the existing windows:** Remove the existing windows and frames and replace with a new thermally broken framing system and double pane, high performance glazing with warm-edge spaces, argon fill and two low-e coatings.

6. **Add wall insulation:** A 1" layer of continuous insulation will be added to improve the thermal performance for exterior walls.

7. **Add VIEW dynamic glazing:** Replace the high performance glass described in item # 7 with the VIEW dynamic glazing, which is electro-chromatically controlled to provide automatic shading and glare control.

8. **Add air sampling system for Demand Control Ventilation in labs:** Incorporate a dynamic air sampling system to monitor air quality and pollutant levels in labs. When air quality is high, baseline air change rates can be reduced to save on fan energy and heating costs.

Life cycle cost calculations were carried out using the US Department of Energy 'Building Life Cycle Cost' software BLCC 5.3. The program is developed by the National Institute of Standards and Technology (NIST) specifically to help federal government project teams assess the long term cost implications of contemplated capital projects.

Each proposed system was inputted into the software as a separate iteration to evaluate the impact on initial cost, operating costs and develop a comparative total life cycle cost. The total LCC for each option can be compared to determine whether it represents a cost effective alternative with favourable returns.

Based on the above rationale we are recommending a bundle of options including the Central Exhaust System upgrade, installation of the Heat Recovery System, high efficiency LED lighting, replacement of the windows with a new high performance glazing system and installation of an air sampling system for reduced ventilation volume in labs.

The recommended upgrades have a total initial capital cost of $4,553,295 and are predicted to generate an annual energy cost savings of $311,956 resulting in a total lifecycle cost savings of

$4,339,605 with an SIR of 2.19. They are predicted to create an annual reduction of 975 tonnes of CO_2 equivalent and will avoid approximately $19,500 annually in carbon emissions (assuming and offset cost of $20 per tonne).

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1.0 OVERVIEW

Lifecycle Costing Analysis (LCCA) allows for the evaluation of multiple contemplated design options over the decision making life of a project. By completing the LCCA it is possible to evaluate not only initial capital costs but the total cost of ownership including utilities, operations, and maintenance. Calculating the total cost of ownership allows the project team to choose the best project alternative, inclusive of initial costs and ongoing annual or non-annual costs.

Why do we perform the LCCA?

Lifecycle costing allows for better decision making and avoid the additional emphasis on up-front costs that is typically applied in the absence of more complete information. The LCCA can optimize both capital and operating budgets, demonstrate a superior business case and justify investment in superior systems that are more energy efficient and contribute to a better project.

Optimizing for lowest life cycle cost often facilitates investment in superior alternatives that contribute to better air quality, better lighting, better acoustics and a superior indoor environment. These systems also generate annual energy savings and reduction in Greenhouse Gas (GHG) emissions but may require additional investment in initial costs. The importance of LCCA is indicated by the fact that approximately 2% of total building lifecycle costs are incurred in design and construction (based on a study of office buildings referenced by the National Institute of Building Sciences[1]). The remaining 98% of costs are spent on energy, maintenance and salary and benefits for building occupants. There is a strong business case for carrying out LCCA and choosing high performance systems.

It has been agreed that DIALOG will carry out an LCCA study to evaluate the inclusion of various Energy Conservation Measures (ECMs) included in the Laboratory Modernization Plan (LMP) for levels 4 through 7 of the Canada Centre for Inland Waters (CCIW). Measures that are planned for inclusion in the Concept Design (ex. LED lighting fixtures) will be evaluated to confirm that they make good business sense. Additional measures that are not currently in scope (ex. wall insulation and window replacement) will be evaluated to determine whether they are attractive to add into the project scope.

[1] Source: Sustainable Building Technical Manual / Joseph J. Romm, *Lean and Clean Management*, 1994.

Carrying out the LCCA requires the calculation of Total Life Cycle Cost (TLCC):

Total Life Cycle Cost (TLCC) = I + U + OM + Repl + Res + OC

where

I = Initial cost in today's dollars
U = annual utility costs
OM = ongoing operations & maintenance costs
Repl = cost for replacement of equipment
Res = residual value of systems and equipment at the end of the study
OC = other costs affecting the project (eg. future carbon price)

In order to carry out the LCCA all of the life cycle costs for the system need to be calculated and estimated in present day dollars – so that options can be compared in like terms. To allow for comparison between costs incurred today and costs incurred in the future, the 'time value of money' is considered by applying a discount factor to all future costs.

The following factors are applied to the financial cash flow calculations:

Project service life: The anticipated useful life of the project and equipment, this is the time period over which life cycle costs are calculated and discount factors are applied.

Discount rate: The interest rate applied annually to future costs to make them equivalent to present day dollars. This represents the opportunity cost of investment in the project versus investing elsewhere.

Escalation: The adjustment of price for a chosen good relative to general inflation. For energy conservation projects there is typically a positive escalation factor for energy costs.

Inflation: The decline in purchasing power of money over time.

Typically the 'real' discount and escalation rates are used, which are adjusted to include for the effects of inflation.

The LCCA is intended primarily to present a financial case for the project alternative with the

lowest financial costs. There are several other decision making factors that could make a project attractive which are not calculated but are meaningful in this study:

Quality of the indoor environment: Projects that create energy savings frequently generate other impacts that enhance the quality of the space, including better light, better air quality, better acoustics and better comfort. These effects have a corresponding impact on worker satisfaction and productivity.

GHG reduction: The Federal Government and Environment Canada have committed to reduction target for greenhouse gas; projects that generate GHG reductions are attractive for their contributions beyond financial returns (and may offset costs of GHG projects elsewhere).

Scheduling and bundling of projects: Often projects are best conducted in 'bundles' to minimize total overall cost. Projects that are otherwise marginal can be conducted while occupants are already in swing space, a contractor is on site, and other work is ongoing. For example, wall insulation is much cheaper to install when interior finishes are removed and staff are relocated for existing work.

While dollar figures are not applied to these factors their importance cannot be overlooked. Per the building lifecycle report previously cited salary and personnel costs are in the range of 90% of building lifecycle costs. Meaningful increases in environmental quality drive a tangible increase in productivity, decrease in sick days and absenteeism, and increase in staff satisfaction. The economic value of these is likely to be far higher than the magnitude of energy cost savings calculated[2].

The LCCA report is intended to provide useful projections of life cycle costs to facilitate informed decision making. Factoring for ongoing life cycle costs allows for selection of better systems that have lower cost when combining capital and operating budgets. The LCCA report is not an attempt to predict real energy use, construction costs, utility bills, operating budgets, or equipment life expectancy. Values included in the report are estimates for the purpose of making informed decisions.

[2] Source: Health, Wellbeing and Productivity in Offices / World Green Building Council, *Published Online* http://www.worldgbc.org/activities/health-wellbeing-productivity-offices/ 2014

2.0 ENERGY CONSERVATION MEASURES FOR CONSIDERATION

The following measures are included in the LCCA for evaluation:

1. **Baseline System:** The baseline system for the LCCA is meant to be the lowest first-cost alternative that will meet the operational requirements of the LMP project and the minimum standards of PWGSC and EC for energy efficiency. The baseline system is based on the new, proposed floor plan for floors 4-7 as proposed in the LMP.

   In the baseline system the existing HVAC configuration is maintained (without the addition of the Central Exhaust System or airside heat recovery loop). Central supply AHUs will be refurbished with new fans, filters, coils etc. All exhaust fans are to be replaced and supply/exhaust ductwork is to be cleaned and re-routed as necessary.

   The baseline system includes the conversion of the South side of the building to an upgraded curtainwall façade. Existing walls and windows are maintained on the other sides of the building. Lighting is modeled on fluorescent fixtures with no lighting controls installed for occupancy or daylight.

2. **Central Exhaust System Upgrade:** Install two central exhaust fan units on the rooftop and tie to a central mechanical exhaust system with two separate vertical shafts: one for the North wing and another for the South wing. The exhaust units will be approximately 50,000 CFM and 75,000 CFM with variable air volume control and a manifold duct arrangement connected to fume hood exhaust and general exhaust from labs.

   Supply AHUs will be converted to 100% OA and venture valves will be added to the existing hot deck / cold deck distribution system to control air flow to the labs.

3. **Add Heat Recovery System:** A glycol heat recovery loop will be added to capture waste heat from the exhaust air stream. Heat recovery coils will be installed in the exhaust and supply AHUs with pumps and piping circulation to transfer energy between the two air streams.

4. **Upgrade Lighting to High Efficiency LEDs:** Lighting design on floors 4-7 will be revised to include high-efficiency LED fixtures and achieve lower installed Lighting Power Density (LPD).

5. **Add lighting controls for occupancy and daylight:** Add daylight sensors for all

perimeter spaces to automatically turn down light fixtures when natural light is available. Incorporate occupancy sensors for all offices, labs, washrooms and storage areas to automatically turn off lights when there is no activity in the space (time adjustable for different space uses).

6. **Replace the existing windows:** Remove the existing windows and frames and replace with a new thermally broken framing system and double pane, high performance glazing with warm-edge spaces, argon fill and two low-e coatings.

7. **Add wall insulation:** A 1" layer of continuous insulation will be added to improve the thermal performance for exterior walls.

8. **Add VIEW dynamic glazing:** Replace the high performance glass described in item # 7 with the VIEW dynamic glazing, which is electro-chromatically controlled to provide automatic shading and glare control.

9. **Add air sampling system for Demand Control Ventilation in labs:** Incorporate a dynamic air sampling system to monitor air quality and pollutant levels in labs. When air quality is high, baseline air change rates can be reduced to save on fan energy and heating costs.

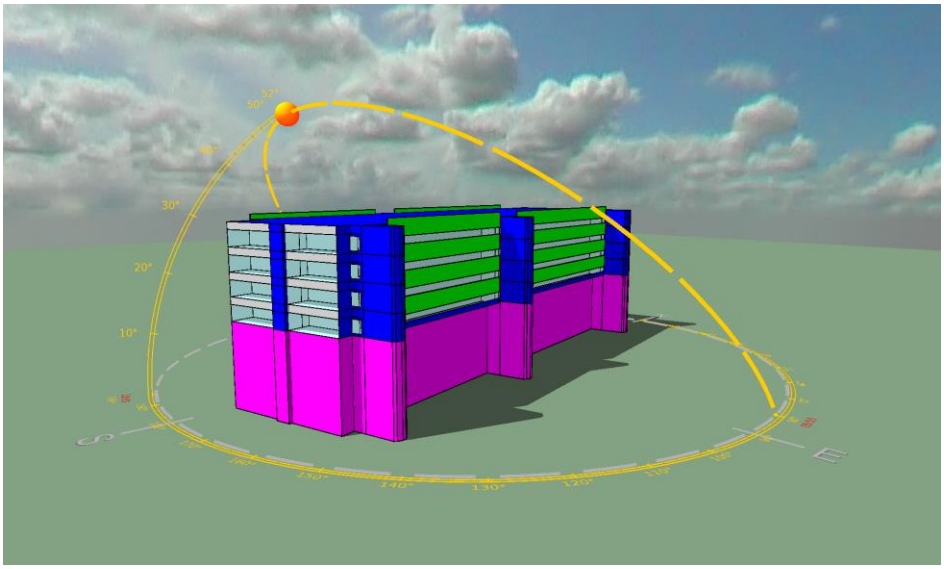
The study also investigated the implementation of an exhaust fan turndown strategy: including air sensing and HVAC controls to reduce discharge velocity on central exhaust fans when wind speeds are high enough to ensure safe transportation of effluents. Wind tunnel testing was conducted by RWDI to determine appropriate discharge velocities; it was determined that exhaust fan turn down is not necessary as lower velocities are appropriate in all weather conditions. This measure is now reflected in the baseline scenario.

Energy conservation measures are further described in Appendix B Energy Modeling Assumptions.

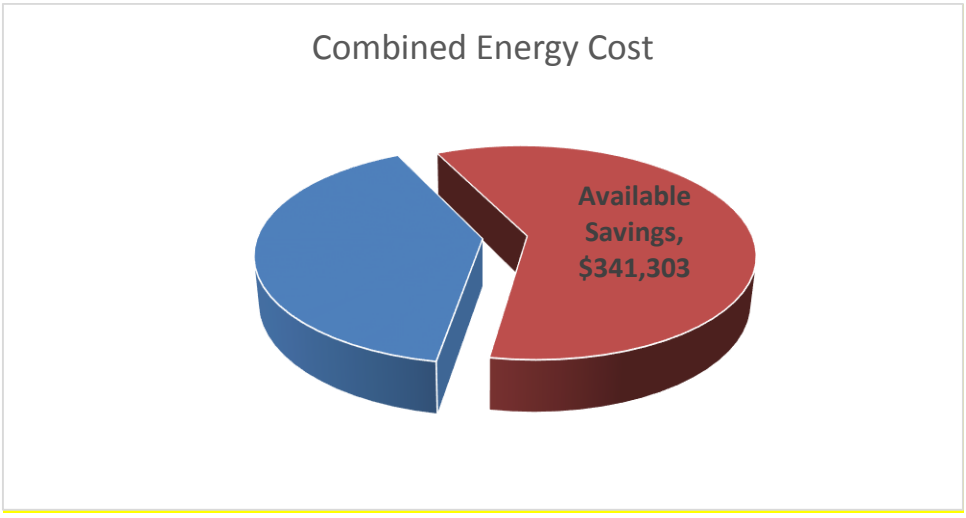
3.0 ENERGY MODELING STUDY

A building energy model (BEM) was generated of the existing CCIW building in order to evaluate the potential energy savings and interactive effects of the ECMs described in the previous section. Using a BEM for this type of analysis provides detailed feedback of how a building systems operate in concert with one another; reduced lighting power will increase required heating energy, for example.

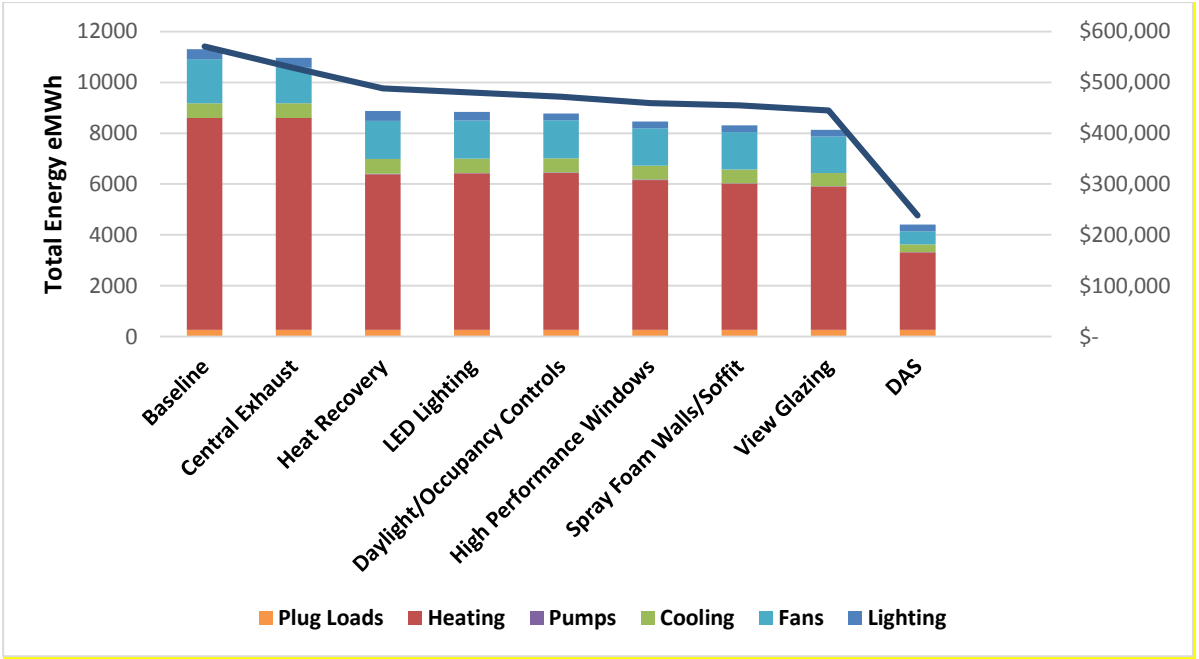
Only the LMP target area for the building (floors 4-7) were simulated with lower portions of the building treated as adjacent space with no heat transfer to the study area. Space allocations were made in bulk based on the "Option A" space layout presented on April 30th, 2015. Though not explicitly included in the LCCA study the effect of the central plant for both heating and cooling was captured to inform utility consumption. A steady-state efficiency was developed for each plant from previous engineering studies and applied to determine the amount of electricity or natural gas required to meet the heating and cooling demands of the modeled upgrades. Assumptions to form the basis of the LCCA baseline are included in Appendix A.



Results of the LCCA baseline simulation estimate a combined energy use intensity (EUI) of 3.62 GJ/m^2 for the LMP area of study, with an associated energy cost of $570,400. The ECMs described above were simulated sequentially with each new measure added on to the simulation with the previous ECMs remaining. If all ECMs are implemented the EUI of the LMP study area would be reduced by over 60% to 1.38 GJ/m^2 and an associated energy cost savings of $342,300.



Examining the potential savings more closely it becomes obvious that they are heavily weighted towards the adoption of a dedicated air sampling (DAS) system. The largest single area of energy consumption in this facility is the conditioning of outdoor air to maintain the prescribed 10 ACH during occupied periods. As such the inclusion of a DAS to lower this value to ~6 ACH has a massive impact on the amount of energy consumed. The chart below provides a breakdown of the total energy consumed for various end-uses throughout the building as well as estimated energy cost with each ECM.



Greenhouse gas (GHG) emissions associated with the operation of such an energy intensive building can be significant. Modeled results for the baseline case estimate GHG emissions of 1,620 tonnes of CO2e per year or the equivalent of 340 passenger vehicles. Given the relatively low carbon sources of electricity generation in Ontario the biggest reductions in GHG emissions are associated with measures that reduce natural gas combustion, namely heat recovery and the DAS. The table below summarizes the estimated energy cost savings and reductions in GHG emissions associated with each ECM.

Measure	EUI [GJ/m²] (% Reduction)	Utility Cost [$/yr] (% Reduction)	GHG Emissions [tn CO_2e/yr] (% Reduction)
1. LCCA Baseline	3.62 -	$570,400 -	1,620 -
2. Central Exhaust System	3.51 (3%)	$526,800 (8%)	1,605 (1%)
3. Exhaust Heat Recovery	2.83 (22%)	$485,900 (15%)	1,205 (26%)
4. High Efficiency LED	2.81 (22%)	$478,100 (16%)	1,207 (25%)
5. Occupancy/Daylight Controls	2.79 (23%)	$470,000 (18%)	1,208 (25%)
6. Replace Existing Windows	2.69 (26%)	$457,700 (20%)	1,156 (29%)
7. Additional Wall Insulation	2.65 (27%)	$453,600 (20%)	1,130 (30%)
8. VIEW Dynamic Glazing	2.60 (28%)	$444,600 (22%)	1,115 (31%)
9. Dynamic Air Sampling (DAS)	1.41 (61%)	$237,100 (58%)	602 (63%)

4.0 FINANCIAL ANALYSIS

Financial analysis of the Energy Conservation measures was carried out using the US Department of Energy Federal Energy Management Program (FEMP) 'BLCC5' Software. BLCC5 is developed specifically for building LCCA projects to perform calculations and generate reports to investigate potential energy upgrade projects.

Assumptions for Financial Analysis

The following parameters were incorporated in the LCCA calculations following consultation with PWGSC and Environment Canada:

Economic Factor	Rate	Notes
General Inflation Rate	3.0%	1
Discount Rate (nominal, excluding inflation)	6.0%	1
Real Discount Rate (including for inflation)	2.91%	2
Escalation Rate (nominal, excluding inflation)	5.15%	1
Escalation Rate (including for inflation)	2.09%	2

Notes:

1. Economic Factors are Canadian averages from Public Works and Government Services Canada 'The Environmentally Responsible Office at a Glance' http://www.tpsgc-pwgsc.gc.ca/biens-property/env/annd-eng.html
2. 'Real' rates are calculated by accounting for inflation: R = (1+N)/(1+I) - 1

Length of the Study

Based on discussions with the client we have identified a study length of 30 years.

The Base Date, the date on which the study begins, is June 15th 2017. The LCCA will estimate all costs in 2017 dollars.

The Service Date, the date on which the system is expected to be put into service, is approximated as June 15th, 2018. This allows for an average period for Planning, Construction and Installation of 1 year. We understand that actual construction will be phased and is likely to occur approximately between the years of 2017-2021.

Initial Costs

Initial costs for the LCCA are construction cost estimates delivered by Hanscomb, the cost consultant. In every case the initial cost used is the difference between the baseline case and the ECM upgrade.

For the VIEW Dynamic glazing, pricing was provided by View glazing and Clearstream Architectural.

For the Aircuity Dynamic Ventilation system for labs, pricing was provided by Airgenuity.

Utility Costs

Utility costs are estimated based on the predicted annual energy use which is determined by the energy modeling study. Energy use and energy costs are assumed to be consistent on a yearly basis.

Present day utility rates were provided by the Client:

Charge	Rate ($)
Electricity Consumption	0.112 / kWh
Electricity Demand (monthly peak)	8.13 / kW
Natural Gas Consumption	0.26 / m3

Future utility rates are escalated at a nominal annual rate of 5.15%, as described above, to account for future price hikes.

Ongoing Operations & Maintenance Cost

Operation and maintenance costs are included in the LCCA when there is a difference in the expected annual cost between the baseline case and the contemplated ECM. In this case the difference in O&M cost is shown as a yearly cash flow (positive or negative) to represent the cost difference.

O&M costs are shown as the difference between the baseline case and the proposed ECM. For example, for the Central Exhaust System there is an annual cost add to maintain and repair the two new exhaust AHUs; there is also a deducted annual cost for maintaining the 149 dedicated exhaust fans included in the baseline case. For walls and windows there is no O&M cost shown

because there is no difference between maintaining the 'baseline' and 'proposed' case. If the proposed and baseline scenarios require identical maintenance then the cost is zero.

For the purpose of this study O&M costs have been included as follows:

#	Energy Conservation Measure	O&M Activities Included
1	Baseline - refurbish / replace existing HVAC	Maintain 149 fan motors for penthouse exhaust fans. Replace fluorescent lighting after 30,000 hours. Repair or replace window blinds as needed.
2	Central Exhaust System upgrade	Replace 149 dedicated exhaust fans with two exhaust AHUs. Regular maintenance for fans and motors: clean, lubricate, and replace worn parts.
3	Add Heat Recovery System	Add HR coils and pump. Regular maintenance for pumps and coils: clean, lubricate, and replace worn parts.
4	Upgrade Lighting to High Efficiency LEDs	Replace fluorescent lighting with LEDs. Include labour to replace LED lamps after 60,000 hours (LED).
5	Add lighting controls for occupancy and daylight	Inspection and repair of sensors, ongoing as needed.
6	Replace the existing windows	Spot repair / replacement of failed window units approximately 1% annually.
7	Add wall insulation	-
8	Add VIEW dynamic glazing	Replace window blinds with electronic controls for dynamic glazing. Inspection and repair of sensors, ongoing as needed.
9	Add air sampling system for Demand Control Ventilation in Labs	Add air sampling sensors and controls. Change sensors twice yearly via maintenance contract.
10	Exhaust Fan turndown strategy	Add weather station and control sequence. Inspection and repair of weather station ongoing as needed.

Replacement Costs and Residual Costs

Where equipment or systems are not expected to last for the full length of the study, costs are included for labour and equipment to replace the failed components.

For equipment and systems that still have useful service life remaining at the end of the 30 year study period, or that can be resold, residual costs are included.

Replacement and residual costs are shown as the difference between the baseline case and the proposed ECM. If the proposed and baseline scenarios have identical requirements for replacement or identical residual value then the value is zero.

Air handlers, fans, pumps, and coils are estimated to have a 30 year service life. This represents the upper range of the equipment life expectancy as documented by ASHRAE. We find this is a reasonable estimate based on the expected maintenance activity and condition of existing equipment observed on site. Motors are estimated to have a 15 year service life.

Fluorescent lights are estimated to run for 30,000 hours per the manufacturer's literature and experience with installed lighting. LED lights are estimated to run for 60,000 hours per the manufacturer's literature and industry practice.

The existing windows are close to the end of their useful service life. We have assumed that a window replacement, if not conducted as part of the LMP, will be required in 15 years.

Carbon Pricing

Currently there is no mandatory framework in place for carbon pricing in Ontario however there is proposed legislation to enact a carbon price (though carbon tax or 'cap and trade' system) and a voluntary market for carbon offsets. It is likely that in the somewhat near future, and very likely within the 30 year study period, that federal projects will be subject to a price signal on carbon.

It was agreed with the client team that LCC calculations would be conducted both with and without Carbon pricing. CO2 reductions are shown for each measure, based on current emissions factors published by NRCan, and a market price of $20 per ton of CO2 has been used to value GHG reductions generated by energy savings measures.

Life Cycle Cost Calculations

Life cycle cost calculations were carried out using the US Department of Energy 'Building Life Cycle Cost' software BLCC 5.3. The program is developed by the National Institute of Standards and Technology (NIST) specifically to help federal government project teams assess the long term cost implications of contemplated capital projects.

Each proposed system was inputted into the software as a separate iteration to evaluate the impact on initial cost, operating costs and develop a comparative total life cycle cost. The total LCC for each option can be compared to determine whether it represents a cost effective alternative with favourable returns.

The inputs and results of the BLCC simulations are summarized on the following page.

Appendix C contains the Detailed LCC reports from BLCC, indicating total lifecycle costs for initial cost, energy, maintenance and replacements for each option.

Appendix D contains the Cash Flow reports from BLCC, indicating the annual expenditures for each scenario through May 31st, 2047.

For the entire bundle of proposed measures, there is a total capital cost of $5,775,995. The calculated energy cost savings are $333,283 with an increase in annual operating costs of $5,253. If the full bundle of proposed measures is accepted, there will be a resulting reduction in lifecycle costs of $3,536,902 over the 30 year study period. The energy savings project would generate an annual GHG reduction of 1017 tonnes CO_2e, equivalent to eliminating emissions from 215 passenger vehicles[3].

[3] Calculated as per US EPA http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results

Table 1: Life Cycle Costing Analysis Results

	Energy Conservation Measures	Initial Capital Cost	Annual Energy Savings	LCC Savings[1]	Carbon Savings (Annual Tonnes Co2e)	LC Carbon Cost Savings[2]	Recommendation[3]
1	Baseline - refurbish / replace existing HVAC	$ -	$ -	$ -	-	$ -	-
2	Central Exhaust System upgrade	$ 2,545,125	$ 43,638	-$ 1,132,072	14	$ 8,207	**PROCEED**
3	Add Heat Recovery System	$ 307,500	$ 40,874	$ 722,016	399	$ 239,643	**PROCEED**
4	Upgrade Lighting to High Efficiency LEDs	$ 360,400	$ 7,757	$ 46,404	-2	-$ 1,174	**PROCEED**
5	Add lighting controls for occupancy & daylight	$ 216,200	$ 8,097	-$ 106,036	-1	-$ 369	**To be evaluated**
6	Replace the existing windows	$ 1,144,100	$ 12,376	$ 221,784	51	$ 30,834	**PROCEED**
7	Add wall insulation	$ 351,300	$ 4,079	-$ 246,822	26	$ 15,453	**REJECT**
8	Add VIEW dynamic glazing	$ 655,200	$ 8,971	-$ 425,179	16	$ 9,720	**To be evaluated**
9	Add air sampling system for DCV in Labs	$ 196,170	$ 207,492	$ 4,456,807	512	$ 307,404	**PROCEED**
10	**Recommended Bundle**	**$ 4,553,295**	**$ 311,956**	**$ 4,339,605**	**975**	**$ 584,614**	

Notes

1. Lifecycle cost (LCC) savings is the difference in total cost of ownership between the design option vs. the row above. A negative value for LCC savings indicates that the measure is more expensive than the previous option
2. Lifecycle carbon savings are based on a constant value of $20 per ton.
3. Items classified as 'PROCEED' are included in the Recommended Bundle in row 10. Items classified as 'To be evaluated' do not offer LCC savings but may be desireable for environmental impacts. Items marked 'REJECT' do not justify the capital investment.

Evaluating LCCA Results

Energy savings projects are attractive when they generate significant reductions in energy use, utility costs, operation and maintenance costs, and lower the overall cost of ownership over the study period. We can look at total lifecycle costs to compare the baseline and the proposed scenarios to determine whether a proposed ECM is a good investment. ECMs that result in a lower lifecycle cost will provide a positive financial return over 30 years.

In addition to cost savings and positive financial returns, building retrofits can provide many other benefits including better air quality, better acoustics, increased natural light, improved thermal comfort, better morale, and increased productivity. The benefits in the workforce might generate returns that are far greater than those created by lower energy bills. Building owners will frequently prioritize projects that result in an improved work environment to enjoy a return on their investment through a more productive work force.

5.0 RECOMMENDATIONS

To evaluate the ECM's reviewed in this study we are considering three important metrics:

i) Lifecycle cost savings: Does the ECM result in a reduced cost to operate the system over 30 years? Attractive projects should lower lifecycle costs.
ii) Savings-to-Investment Ratio (SIR): Savings generated per unit of capital invested.
iii) Environmental benefits: Contribution from the measure to improve the indoor environment and contribute to worker satisfaction plus contribution to GHG reduction targets.

Based on the above and the results of the financial analysis presented in Section 4.0 we recommend the following:

1. **PROCEED with the HVAC upgrades including the Central Exhaust System (CES), Heat Recovery System and the air sampling system for DCV in the laboratories.** The comprehensive modernization of the HVAC systems is essential for the modernization of the building to today's standard and generates significant energy savings (note that while the CES is not an energy savings measure individually it facilitates the implementation of the HRS and DCV measures). When bundled together these items generate annual energy cost savings of $287,874, and a lifecycle cost savings of $3,987,605 with an SIR of 2.31.

2. **PROCEED with the lighting upgrade to high efficiency LEDs.** The LED lighting option contributes to lower energy use, better indoor environment and lower costs for maintenance and replacement. The LED lighting generates an annual energy cost savings of $9,222, and a lifecycle cost savings of $42,321 with an SIR of 1.12.

3. **PROCEED with the replacement of the existing strip windows with a high performance glazing system.** Replacing this system as part of the LMP system saves on maintenance and replacement costs over the next 30 years and results in savings in heating energy and GHG footprint. The window replacement results in annual energy savings of $12,376, and a lifecycle cost savings of $221,734 with an SIR of 1.19.

4. **DECLINE adding insulation to exterior walls.** The energy savings and GHG reduction provided by the insulation don't justify the investment and result in an added life cycle cost of $244,849 with an SIR of 0.30.

5. **Consider adoption of the daylight and occupancy control for lighting after further analysis.** The implementation of sensor control is not financially attractive over the whole project area based on the LCCA; the added lifecycle cost is $104,585 with an SIR of 0.52.

   Daylight and occupancy sensors are typically incorporated in high performance labs and offices; in addition to saving energy they enhance the quality of the space and contribute to occupant comfort. We recommend that daylight and occupancy sensors be incorporated in the LMP design, located in areas where they are most effective to capture return on investment.

6. **Consider adoption of the VIEW dynamic glazing after further analysis.** The implementation of the VIEW dynamic glazing results in an increased life cycle cost of approximately $420,000 over the 30 year study period. The dynamic glazing is not evidently attractive purely as an energy savings measure.

   The dynamic glazing will, however have several benefits outside of energy cost savings including control of solar gains, glare reduction and improved quality of environment in perimeter areas. Implementing this measure is expected to create in improvement in quality of the space and worker satisfaction that is not easily quantified and is not included in the LCCA study. It's recommended to further investigate the VIEW glazing as part of the detailed design process to properly way costs and benefits.

Based on the above rationale we are recommending a bundle of options including the Central Exhaust System upgrade, installation of the Heat Recovery System, high efficiency LED lighting, replacement of the windows with a new high performance glazing system and installation of an air sampling system for reduced ventilation volume in labs.

The recommended upgrades have a total initial capital cost of $4,553,295 and are predicted to generate an annual energy cost savings of $311,956 resulting in a total lifecycle cost savings of $4,339,605 with an SIR of 2.19. They are predicted to create an annual reduction of 975 tonnes of CO_2 equivalent and will avoid approximately $19,500 annually in carbon emissions (assuming and offset cost of $20 per tonne).

APPENDIX A: ENERGY MODEL ASSUMPTIONS

DIALOG

CCIW – Lab Modernization Program
Baseline Design and Proposed Energy Measures

DRAFT Issued 28 July 2015

As part of the Lab Modernization Process (LMP) at the Canada Centre for Inland Waters (CCIW) DIALOG will be performing energy modeling analysis and a Life Cycle Costing Analysis (LCCA).

Through this exercise the potential benefits of various Energy Conservation Measures (ECMs) will be evaluated based on reduced operating costs and greenhouse gas (GHG) emission reductions.

This document outlines the proposed design options to be investigated as well as the financial parameters that will be used to evaluate lifecycle costs over a 30-year period.

Energy Modeling Assumptions – Baseline Case

The Baseline Design should be regarded as the lowest first cost alternative that meets the minimum standards of PWGSC & EC/CCIW for energy efficiency. This is the starting point for investigation into further measures that will improve the environmental, energy, and financial performance of the project over the full project lifecycle.

It is important that the assumptions which form the baseline of the energy modeling study are reviewed, understood and agreed upon by the client and the design team. Simple changes to design inputs may have significant impacts on results and project timeline.

Since the central heating and cooling plant of the CCIW is not a part of this analysis, the baseline model will include a simplified 'steady state' efficiency for heating and cooling energy. This will allow central plant energy associated with the operation of the A&L portion of the building to be included in the LCCA analysis with simplified, but realistic, estimates of utility costs.

North and south laboratory ventilation and exhaust systems will be simulated with the existing design maintained but updated to meet code mandated ACH rates and fan efficiencies. Similarly the office area induction system will be simulated with the same essential function but with ventilation rates and fan efficiencies updated.

Lighting systems will be modeled as compliant with the current energy code, and no additional controls for occupancy or daylight harvesting will be considered.

Interior layout and space planning is based on "Option A" floor plans as they were presented on April 30th, 2015. Further changes to floor plan will have minimal impact on overall energy use. Likewise the building envelope will be simulated with the South wall replaced with a glazed façade.

The simulation will be created using the IES Virtual Environment VE 2014 software and is based on the available drawings and existing conditions reports. A detailed list of energy modeling assumptions is provided below for review by the client and the design team. Once approved by all parties these assumptions will form the baseline case for comparison in the LCCA.

1.0 ENERGY MODEL INPUTS AND ASSUMPTIONS

Table 1 Energy Model Simulation Summary

No.	Item	Input/Assumption
GENERAL		
1.	Simulation Software	IES-VE 2014
2.	Baseline Standard (where applicable)	ASHRAE 90.1-2010 except where superseded by NECB 2011
BUILDING INFO		
3.	Building Type	Laboratory/Office
4.	Building Area (LCCA Study area only)	11,500 m^2
5.	Location, Climate and weather file	Burlington, Ontario Pearson International Airport (Toronto) CWEC Weather file
6.	Occupancy	233 FTUs spread across proposed office and laboratory space
7.	Operation Schedule	Building usage will be simulated based on the following assumed occupancy • Weekdays 0600 – 1800; Fully Occupied • Weekdays 1800 – 2100; 5% Occupied • Weekends 1000 – 1600; 5% Occupied
8.	Utility rates (energy portion only)	**Electricity**: • $0.112/kWh

		• $8.13/kW (monthly peak) **Natural Gas:** • $0.26/$m^3$ ***Confirmed in email from client 1-Jun-2015***
9.	Design documents provided for energy model analysis	Existing systems: per DIALOG RS 2.2.1 Investigation and Report issued 2015-01-13 and Filer Engineering Study New systems: per DIALOG RS 2.2.3 Feasibility Studies issued 2015-02-20 and supplemented by discussions with A/M/E design disciplines

BUILDING ENVELOPE		
10.	Window to wall ratio (glazing area, including framing, as a ratio of total façade area)	Total W2W: 27% Including new glazed south facade
11.	Window Glazing	Existing Glazing: • Double pane IGUs with 100% air fill • Aluminum spacer • Bronze tinted outer lite, clear inner lite • U-factor (system)*: 3.14 W/m^2K (0.55 Btu/ft^2F) • SHGC: 0.503 New Glazing • Double pane IGUs with 100% air fill • Warm-edge spacer • Clear outer lite, clear inner lite with low-emissivity coating on surface #3 • U-factor (system): 1.99 W/m^2K (0.35 Btu/ft^2F) • SHGC: 0.35
12.	Opaque walls	RSI (system): 1.41 m^2K/W (R-8)
13.	Roof	RSI (system): 3.52 m^2K/W (R-20)

HEATING, VENTILATION & AIR CONDITIONING		

14.	Indoor heating and cooling temperature set points (°C).	Indoor temperature:
		• Heating
		  ○ 20˚C during occupied hours
		  ○ 18˚C during unoccupied hours
		• Cooling
		  ○ 24˚C during occupied hours
		  ○ 28˚C during unoccupied hours

15.	Design condition	Winter design: -15˚C Summer design: 32/23˚C db/wb
16.	Central Heating Plant	Central heating plant performance has been estimated based on understanding of cogeneration system, waste heat steam boiler, and three high-efficiency/low NOx steam boilers **Combined heating efficiency – 80%** HW pumping power – 301.2 W/L/s (19 W/gpm) VFD Control
17.	Central Cooling Plant	Central cooling plant performance has been estimated based on understanding of two centrifugal chillers, each with a dedicated closed circuit fluid cooler with variable speed fan. **Combined cooling efficiency – 1.25 COP** ***Includes chiller, fluid cooler, and all associated pump energy***

18.	North/South Lab Air Handling	Single fan, dual-duct system with VAV supply complete with pumped hydronic heating and cooling coils, glycol pre-heat coil, pre and final filter banks. Supply fans in both units are to be refurbished with variable flow fan arrays to allow staged control of airflow. AHU 27 to be refurbished to deliver 23,500 L/s (50,000 CFM) and AHU 28 to be refurbished to deliver 35,350 L/s (75,000 CFM). Hydronic coils for glycol preheat, glycol heating, and chilled water cooling to be removed and replaced to suit revised airflows. Pumps and control valves serving the hydronic coils be replaced as well. Existing duct distribution will remain intact. Exhaust arrangement to match existing with independent exhaust fans for fume hoods and general exhaust. Performance of exhaust system assumes that the existing separate exhaust fans are to be replaced with new fans properly sized for the exhaust capacity demanded by the LMP lab configuration and capable of variable flow. The existing exhaust ductwork could remain largely intact. Supply Air Temperature: • Hot Deck – 35°C (95°F) max • Cold Deck – 11.7°C (53°F) dew point Laboratory Supply Volume: • 10 ACH (Occupied) / 6 ACH (Unoccupied) Fan System Total Static Pressure • Supply – 1,744 Pa (7” w.g) • Exhaust – 1,245 Pa (5” w.g) Minimum OA:

		• Laboratories – 49,300 L/s (104,500 CFM) to match exhaust and maintain pressurization • Corridor – 0.3 L/s/m^2 (0.06 CFM/ft^2) • Restrooms – 850 L/s (1,800 CFM)
19.	Office Air Handling	Perimeter induction system with VAV control of 100% OA complete with glycol pre-heat coil, pumped hydronic cooling coil, pre and final filter banks The unit will be refurbished by replacing the existing supply fan with a new supply fan array. The total supply air capacity will be approximately 9,400 L/s (20,000 CFM). The new array will be complete with VFD's. The hydronic pre-heat and cooling coils will be removed and replaced, complete with new circulating pumps and control valves. Supply Air Temperature: • Primary – 13 – 20°C (55 – 68°F) • Secondary (Heating) – 35°C (95°F) max Average Induction Ratio – 2.5:1 Fan System Total Static Pressure • Supply – 1,245 Pa (5" w.g) • Exhaust – 498 Pa (2" w.g) Minimum OA – 9.4 L/s/person (20 CFM/person)

LIGHTING AND POWER		
20.	Lighting Power Densities	New lighting systems will be installed to match space types and areas of the LMP. Installed lighting power densities are to be the maximum allowance of ASHRAE 90.1-2010: • Laboratories – 19.5 W/m^2 (1.8 W/ft^2) • Office – 11.6 W/m^2 (1.1 W/ft^2)* • Storage – 6.8 W/m^2 (0.6 W/ft^2) • Restrooms – 10.5 W/m^2 (1.0 W/ft^2) • Stairways – 7.4 W/m^2 (0.7 W/ft^2) • Corridors – 7.1 W/m^2 (0.7 W/ft^2) ***Weighted average of open/enclosed offices and support spaces***
21.	Controls	On/off switch control for lights, adjusted as per the occupancy schedule and diversity between offices & labs. 5% of connected lighting load is assumed to operate at all times to account for emergency lighting
22.	Plug load density (Average)	8.8 W/m^2 (0.8 W/ft^2) ***As per ASHRAE 90.1-2010 and proposed space planning***

2.0 ENERGY CONSERVATION MEASURES

Table 2 Proposed ECMs with Design Brief

No.	Item	Input/Assumption
LIGHTING		
1.	Upgrade Lighting to High Efficiency LED Fixtures	LED lighting fixtures are incorporated in the LMP design.
2.	Add lighting controls to respond to space occupancy and daylight levels.	Daylight sensors are incorporated in the LMP design for all perimeter spaces. Occupancy sensors are incorporated for offices, labs, washrooms and storage areas.
BUILDING ENVELOPE		
3.	Replace existing windows with new high performance glazing system	New, high-performance windows as per the following: Double pane insulated IGUs with 90% Argon fill Warm-edge spacer Low-e coatings on surfaces # 2 and #4 U-factor (COG): 1.12 W/m2K (0.197 Btu/ft2F) SHGC: 0.356 Approximate glazing areas: • Punch – 2,000 ft^2 • Strip – 8,500 ft^2 • Curtainwall – 2,500 ft^2 ***Sample construction: 6mm Solarban 60 (2) on clear + 12mm Argon + 6mm Sungate 600 (4)*** ***Optional Analysis for Triple Pane glazing if LCCA is favourable for double pane system.***
4.	Add the VIEW dynamic glazing with integrated solar shading	Include window treatment on surface # 2 for VIEW dynamic shading (controlled automatically) in lieu of window shades.

5.	Add wall insulation	Add one inch of continuous rockwool insulation (R-4.3) to the existing wall assembly.

HVAC		
5.	Add a central exhaust system with VAV manifold	Replace the current exhaust arrangement with a central exhaust system, as described in the Central Exhaust System Report RS2.2.1 Issued 2015-04-21. • Two new central exhaust units with multiple fans, 50,000 CFM & 75,000 CFM • Manifold duct arrangement connected to lab fume hoods and general exhaust • VFD exhaust controlled by static pressure • Existing AHUs 27 & 28 will be converted to 100% OA The new central exhaust fans will remove exhaust air from the laboratories on floors four through seven via ductwork located within the existing service corridors. New fast acting venturi valves will be installed to remove general exhaust and fume hood exhaust from each lab. A vertical duct will transfer the exhaust air to two roof mounted exhaust fans. At the time of the installation of the central exhaust system, venturi valves will be installed to regulate the supply air flow to each laboratory. Supply side venturi valves will be added to the hot deck and cold deck ductwork serving each lab.
6.	Add heat recovery device for laboratory exhaust air	Glycol heat recovery coils will be added to the Exhaust and Supply air streams with associated piping and pumps. The heat recovery coils will be routed between AHU-27 and AHU-28, located on the third floor mechanical level, and the central exhaust fans mounted at roof level. Glycol will be pumped

		through these two loops to capture waste heat from the exhaust stream.
7.	Add exhaust fan turndown strategy for central exhaust	Install controls for active turn-down of the central exhaust fans including a locally sited meteorological station and building control systems. Reduce fan speed when wind speed and direction permit. The speed of the central exhaust plume fan will be controlled by VFD, and slowed down to reduce plume height when high flow is not demanded by the local weather conditions. Control of the VFD and the wind data will be connected to the BMS.
8.	Add air sampling system for Demand Control Ventilation (DCV)	The air sampling system and associated controls are added to monitor air quality and pollutant levels, and allow for lower base ACH levels in the lab. Indoor air quality sensors will be installed in each laboratory space to monitor pollutant levels within allowable limits. When not demanded by the IAQ sensors, the supply and general exhaust air valves to the laboratory will reduce the air change rate. Each sensor will be connected to the building management system.

APPENDIX B: BLCC5 DETAILED LCC REPORT

NIST BLCC 5.3-14: Detailed LCC Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files (x86)\BLCC 5\projects\CCIW LMP LCCA R1.xml
Date of Study:	Fri Jun 26 11:31:00 EDT 2015
Analysis Type:	FEMP Analysis, Energy Project
Project Name:	Canada Centre for Inland Waters - Lab Modernization Project
Project Location:	U.S. Average
Analyst:	cmarshall
Base Date:	June 1, 2017
Service Date:	June 1, 2018
Study Period:	30 years 0 months (June 1, 2017 through May 31, 2047)
Discount Rate:	2.9%
Discounting Convention:	End-of-Year

Discount and Escalation Rates are REAL (exclusive of general inflation)

Alternative: Baseline

Initial Cost Data (not Discounted)

Initial Capital Costs

(adjusted for price escalation)

Initial Capital Costs for All Components: $0

Component:

Cost-Phasing

Date	Portion	Yearly Cost
June 1, 2017	100%	$0
Total (for Component)		$0

Energy Costs: Electricity

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
2,978,466.0 kWh	$0.11200	$333,588	$32,523	$0

Energy Costs: Natural Gas

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
8,330,465.0 kWh	$0.02438	$203,097	$0	$0

Life-Cycle Cost Analysis

	Present Value	Annual Value

Initial Capital Costs	$0	$0
Energy Costs		
Energy Consumption Costs	$13,745,564	$692,313
Energy Demand Charges	$832,978	$41,954
Energy Utility Rebates	$0	$0
Subtotal (for Energy):	$14,578,542	$734,267
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Operating, Maintenance & Repair Costs		
Component:		
Annually Recurring Costs	$966,309	$48,669
Non-Annually Recurring Costs	$0	$0
Subtotal (for OM&R):	$966,309	$48,669
Replacements to Capital Components		
Component:	$927,058	$46,692
Subtotal (for Replacements):	$927,058	$46,692
Residual Value of Original Capital Components		
Component:	$0	$0
Subtotal (for Residual Value):	$0	$0
Residual Value of Capital Replacements		
Component:	$0	$0
Subtotal (for Residual Value):	$0	$0
Total Life-Cycle Cost	$16,471,910	$829,629

Emissions Summary

Energy Name	Annual	Life-Cycle
Electricity:		
CO2	1,947,270.89 kg	56,464,191.75 kg
SO2	9,813.22 kg	284,529.04 kg

SO2	9,812.22 kg	284,520.94 kg
NOx	2,906.13 kg	84,267.95 kg
Natural Gas:		
CO2	1,501,460.27 kg	43,537,209.33 kg
SO2	12,117.26 kg	351,359.02 kg
NOx	449.90 kg	13,045.51 kg
Total:		
CO2	3,448,731.16 kg	100,001,401.09 kg
SO2	21,929.48 kg	635,879.96 kg
NOx	3,356.03 kg	97,313.46 kg

Alternative: CES upgrade

Initial Cost Data (not Discounted)

Initial Capital Costs

(adjusted for price escalation)

Initial Capital Costs for All Components: $2,545,125

Component:
Cost-Phasing

Date	Portion	Yearly Cost
June 1, 2017	100%	$2,545,125
Total (for Component)		$2,545,125

Energy Costs: Electricity

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
2,636,514.0 kWh	$0.11200	$295,290	$28,438	$0

Energy Costs: Natural Gas

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
8,330,465.0 kWh	$0.02438	$203,097	$0	$0

Life-Cycle Cost Analysis

	Present Value	Annual Value
Initial Capital Costs	$2,545,125	$128,188
Energy Costs		
Energy Consumption Costs	$12,764,660	$642,908
Energy Demand Charges	$728,353	$36,684

Energy Utility Rebates	$0	$0
Subtotal (for Energy):	$13,493,014	$679,593
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Operating, Maintenance & Repair Costs		
Component:		
Annually Recurring Costs	$716,635	$36,094
Non-Annually Recurring Costs	$0	$0
Subtotal (for OM&R):	$716,635	$36,094
Replacements to Capital Components		
Component:	$849,208	$42,771
Subtotal (for Replacements):	$849,208	$42,771
Residual Value of Original Capital Components		
Component:	$0	$0
Subtotal (for Residual Value):	$0	$0
Residual Value of Capital Replacements		
Component:	$0	$0
Subtotal (for Residual Value):	$0	$0
Total Life-Cycle Cost	$17,603,982	$886,647

Emissions Summary

Energy Name	Annual	Life-Cycle
Electricity:		
CO2	1,723,708.44 kg	49,981,645.61 kg
SO2	8,685.70 kg	251,855.64 kg
NOx	2,572.49 kg	74,593.31 kg
Natural Gas:		
CO2	1,501,460.27 kg	43,537,209.33 kg
SO2	12,117.26 kg	351,359.02 kg
NOx	449.90 kg	13,045.51 kg

Total:

CO2	3,225,168.71 kg	93,518,854.94 kg
SO2	20,802.96 kg	603,214.66 kg
NOx	3,022.38 kg	87,638.82 kg

Alternative: Add heat recovery system

Initial Cost Data (not Discounted)

Initial Capital Costs

(adjusted for price escalation)

Initial Capital Costs for All Components: $2,852,625

Component:
Cost-Phasing

Date	Portion	Yearly Cost
June 1, 2017	100%	$2,852,625
Total (for Component)		$2,852,625

Energy Costs: Electricity

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
2,750,613.0 kWh	$0.11200	$308,069	$29,494	$0

Energy Costs: Natural Gas

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
6,086,195.0 kWh	$0.02438	$148,381	$0	$0

Life-Cycle Cost Analysis

	Present Value	Annual Value
Initial Capital Costs	$2,852,625	$143,676
Energy Costs		
Energy Consumption Costs	$11,690,591	$588,812
Energy Demand Charges	$755,400	$38,047
Energy Utility Rebates	$0	$0
Subtotal (for Energy):	$12,445,991	$626,858
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0

Water Disposal Costs	$0	$0
Operating, Maintenance & Repair Costs		
Component:		
Annually Recurring Costs	$732,877	$36,912
Non-Annually Recurring Costs	$0	$0
Subtotal (for OM&R):	$732,877	$36,912
Replacements to Capital Components		
Component:	$850,474	$42,835
Subtotal (for Replacements):	$850,474	$42,835
Residual Value of Original Capital Components		
Component:	$0	$0
Subtotal (for Residual Value):	$0	$0
Residual Value of Capital Replacements		
Component:	$0	$0
Subtotal (for Residual Value):	$0	$0
Total Life-Cycle Cost	$16,881,966	$850,282

Emissions Summary

Energy Name	Annual	Life-Cycle
Electricity:		
CO2	1,798,304.44 kg	52,144,674.43 kg
SO2	9,061.59 kg	262,755.06 kg
NOx	2,683.81 kg	77,821.44 kg
Natural Gas:		
CO2	1,096,959.17 kg	31,808,061.83 kg
SO2	8,852.81 kg	256,701.10 kg
NOx	328.69 kg	9,530.98 kg
Total:		
CO2	2,895,263.61 kg	83,952,736.26 kg
SO2	17,914.40 kg	519,456.16 kg
NOx	3,012.51 kg	87,352.42 kg

Alternative: Upgrade Lighting to LED

Initial Cost Data (not Discounted)

Initial Capital Costs

(adjusted for price escalation)

Initial Capital Costs for All Components: $3,213,025

Component: Copy of:
Cost-Phasing

Date	Portion	Yearly Cost
June 1, 2017	100%	$3,213,025
Total (for Component)		$3,213,025

Energy Costs: Electricity

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
2,677,887.0 kWh	$0.11200	$299,923	$29,276	$0

Energy Costs: Natural Gas

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
6,113,231.0 kWh	$0.02438	$149,041	$0	$0

Life-Cycle Cost Analysis

	Present Value	Annual Value
Initial Capital Costs	$3,213,025	$161,828
Energy Costs		
Energy Consumption Costs	$11,498,855	$579,155
Energy Demand Charges	$749,816	$37,765
Energy Utility Rebates	$0	$0
Subtotal (for Energy):	$12,248,671	$616,920
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Operating, Maintenance & Repair Costs		
Component: Copy of:		
Annually Recurring Costs	$523,392	$26,361
Non-Annually Recurring Costs	$0	$0

Subtotal (for OM&R):	$523,392	$26,361
Replacements to Capital Components		
Component: Copy of:	$850,474	$42,835
Subtotal (for Replacements):	$850,474	$42,835
Residual Value of Original Capital Components		
Component: Copy of:	$0	$0
Subtotal (for Residual Value):	$0	$0
Residual Value of Capital Replacements		
Component: Copy of:	$0	$0
Subtotal (for Residual Value):	$0	$0
Total Life-Cycle Cost	$16,835,562	$847,945

Emissions Summary

Energy Name	Annual	Life-Cycle
Electricity:		
CO2	1,750,757.41 kg	50,765,973.18 kg
SO2	8,822.00 kg	255,807.83 kg
NOx	2,612.85 kg	75,763.85 kg
Natural Gas:		
CO2	1,101,832.07 kg	31,949,359.10 kg
SO2	8,892.13 kg	257,841.41 kg
NOx	330.15 kg	9,573.32 kg
Total:		
CO2	2,852,589.47 kg	82,715,332.28 kg
SO2	17,714.13 kg	513,649.25 kg
NOx	2,943.01 kg	85,337.17 kg

Alternative: Add lighting controls

Initial Cost Data (not Discounted)

Initial Capital Costs

(adjusted for price escalation)

Initial Capital Costs for All Components: $3,429,225

Component: Copy of: Copy of:
Cost-Phasing

Date	Portion	Yearly Cost
June 1, 2017	100%	$3,429,225
Total (for Component)		$3,429,225

Energy Costs: Electricity

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
2,602,093.0 kWh	$0.11200	$291,434	$29,175	$0

Energy Costs: Natural Gas

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
6,133,495.0 kWh	$0.02438	$149,535	$0	$0

Life-Cycle Cost Analysis

	Present Value	Annual Value
Initial Capital Costs	$3,429,225	$172,717
Energy Costs		
Energy Consumption Costs	$11,294,090	$568,841
Energy Demand Charges	$747,230	$37,635
Energy Utility Rebates	$0	$0
Subtotal (for Energy):	$12,041,320	$606,476
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Operating, Maintenance & Repair Costs		
Component: Copy of: Copy of:		
Annually Recurring Costs	$620,580	$31,256
Non-Annually Recurring Costs	$0	$0
Subtotal (for OM&R):	$620,580	$31,256
Replacements to Capital Components		
Component: Copy of: Copy of:	$850,474	$42,835

Subtotal (for Replacements):	$850,474	$42,835

Residual Value of Original Capital Components

Component: Copy of: Copy of:	$0	$0
Subtotal (for Residual Value):	$0	$0

Residual Value of Capital Replacements

Component: Copy of: Copy of:	$0	$0
Subtotal (for Residual Value):	$0	$0

Total Life-Cycle Cost	$16,941,598	$853,285

Emissions Summary

Energy Name	Annual	Life-Cycle
Electricity:		
CO2	1,701,204.57 kg	49,329,110.39 kg
SO2	8,572.31 kg	248,567.54 kg
NOx	2,538.90 kg	73,619.46 kg
Natural Gas:		
CO2	1,105,484.39 kg	32,055,264.11 kg
SO2	8,921.61 kg	258,696.10 kg
NOx	331.25 kg	9,605.05 kg
Total:		
CO2	2,806,688.96 kg	81,384,374.51 kg
SO2	17,493.91 kg	507,263.63 kg
NOx	2,870.15 kg	83,224.51 kg

Alternative: Replace existing windows

Initial Cost Data (not Discounted)

Initial Capital Costs

(adjusted for price escalation)

Initial Capital Costs for All Components: $4,573,325

Component:

Cost-Phasing

Date	Portion	Yearly Cost
June 1, 2017	100%	$4,573,325
Total (for Component)		$4,573,325

Energy Costs: Electricity

(base-year dollars)

Average Annual Usage	Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
2,558,956.0 kWh	$0.11200	$286,603	$28,354	$0

Energy Costs: Natural Gas

(base-year dollars)

Average Annual Usage	Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
5,857,578.0 kWh	$0.02438	$142,808	$0	$0

Life-Cycle Cost Analysis

	Present Value	Annual Value
Initial Capital Costs	$4,573,325	$230,341
Energy Costs		
Energy Consumption Costs	$10,998,062	$553,931
Energy Demand Charges	$726,202	$36,576
Energy Utility Rebates	$0	$0
Subtotal (for Energy):	$11,724,264	$590,508
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Operating, Maintenance & Repair Costs		
Component:		
Annually Recurring Costs	$404,503	$20,373
Non-Annually Recurring Costs	$0	$0
Subtotal (for OM&R):	$404,503	$20,373
Replacements to Capital Components		
Component:	$17,722	$893
Subtotal (for Replacements):	$17,722	$893
Residual Value of Original Capital Components		
Component:	$0	$0

Subtotal (for Residual Value):	$0	$0

Residual Value of Capital Replacements

Component:	$0	$0
Subtotal (for Residual Value):	$0	$0

Total Life-Cycle Cost	$16,719,814	$842,115

Emissions Summary

Energy Name	Annual	Life-Cycle
Electricity:		
CO2	1,673,002.32 kg	48,511,341.84 kg
SO2	8,430.20 kg	244,446.83 kg
NOx	2,496.81 kg	72,399.01 kg
Natural Gas:		
CO2	1,055,753.87 kg	30,613,249.03 kg
SO2	8,520.27 kg	247,058.58 kg
NOx	316.35 kg	9,172.97 kg
Total:		
CO2	2,728,756.19 kg	79,124,590.87 kg
SO2	16,950.46 kg	491,505.41 kg
NOx	2,813.16 kg	81,571.97 kg

Alternative: Add wall insulation

Initial Cost Data (not Discounted)

Initial Capital Costs

(adjusted for price escalation)

Initial Capital Costs for All Components: $4,924,625

Component:

Cost-Phasing

Date	Portion	Yearly Cost
June 1, 2017	100%	$4,924,625
Total (for Component)		$4,924,625

Energy Costs: Electricity

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
2,554,171.0 kWh	$0.11200	$286,067	$28,273	$0

Energy Costs: Natural Gas

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
5,715,562.0 kWh	$0.02438	$139,345	$0	$0

Life-Cycle Cost Analysis

	Present Value	Annual Value
Initial Capital Costs	$4,924,625	$248,035
Energy Costs		
Energy Consumption Costs	$10,895,658	$548,774
Energy Demand Charges	$724,128	$36,472
Energy Utility Rebates	$0	$0
Subtotal (for Energy):	$11,619,785	$585,245
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Operating, Maintenance & Repair Costs		
Component:		
Annually Recurring Costs	$404,503	$20,373
Non-Annually Recurring Costs	$0	$0
Subtotal (for OM&R):	$404,503	$20,373
Replacements to Capital Components		
Component:	$17,722	$893
Subtotal (for Replacements):	$17,722	$893
Residual Value of Original Capital Components		
Component:	$0	$0
Subtotal (for Residual Value):	$0	$0
Residual Value of Capital Replacements		
Component:	$0	$0

Subtotal (for Residual Value):	$0	$0
Total Life-Cycle Cost	$16,966,636	$854,546

Emissions Summary

Energy Name	Annual	Life-Cycle
Electricity:		
CO2	1,669,873.97 kg	48,420,630.32 kg
SO2	8,414.43 kg	243,989.74 kg
NOx	2,492.14 kg	72,263.63 kg
Natural Gas:		
CO2	1,030,157.29 kg	29,871,035.92 kg
SO2	8,313.69 kg	241,068.69 kg
NOx	308.68 kg	8,950.57 kg
Total:		
CO2	2,700,031.26 kg	78,291,666.24 kg
SO2	16,728.13 kg	485,058.43 kg
NOx	2,800.82 kg	81,214.20 kg

Alternative: Add VIEW dynamic glazing

Initial Cost Data (not Discounted)

Initial Capital Costs

(adjusted for price escalation)

Initial Capital Costs for All Components: $5,579,825

Component: Copy of:
Cost-Phasing

Date	Portion	Yearly Cost
June 1, 2017	100%	$5,579,825
Total (for Component)		$5,579,825

Energy Costs: Electricity

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
2,499,661.0 kWh	$0.11200	$279,962	$27,296	$0

Energy Costs: Natural Gas

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
5,637,676.0 kWh	$0.02438	$137,447	$0	$0

Life-Cycle Cost Analysis

	Present Value	Annual Value
Initial Capital Costs	$5,579,825	$281,035
Energy Costs		
Energy Consumption Costs	$10,690,660	$538,449
Energy Demand Charges	$699,105	$35,211
Energy Utility Rebates	$0	$0
Subtotal (for Energy):	$11,389,765	$573,660
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Operating, Maintenance & Repair Costs		
Component: Copy of:		
Annually Recurring Costs	$404,503	$20,373
Non-Annually Recurring Costs	$0	$0
Subtotal (for OM&R):	$404,503	$20,373
Replacements to Capital Components		
Component: Copy of:	$17,722	$893
Subtotal (for Replacements):	$17,722	$893
Residual Value of Original Capital Components		
Component: Copy of:	$0	$0
Subtotal (for Residual Value):	$0	$0
Residual Value of Capital Replacements		
Component: Copy of:	$0	$0
Subtotal (for Residual Value):	$0	$0
Total Life-Cycle Cost	$17,391,815	$875,961

Emissions Summary

Energy Name	Annual	Life-Cycle

Energy Name	Annual	Life-Cycle
Electricity:		
CO2	1,634,236.25 kg	47,387,258.42 kg
SO2	8,234.86 kg	238,782.62 kg
NOx	2,438.96 kg	70,721.41 kg
Natural Gas:		
CO2	1,016,119.33 kg	29,463,983.12 kg
SO2	8,200.40 kg	237,783.64 kg
NOx	304.47 kg	8,828.60 kg
Total:		
CO2	2,650,355.58 kg	76,851,241.54 kg
SO2	16,435.26 kg	476,566.26 kg
NOx	2,743.43 kg	79,550.01 kg

Alternative: Add air sampling system for DCV

Initial Cost Data (not Discounted)

Initial Capital Costs

(adjusted for price escalation)

Initial Capital Costs for All Components: $5,775,995

Component: Copy of: Copy of:
Cost-Phasing

Date	Portion	Yearly Cost
June 1, 2017	100%	$5,775,995
Total (for Component)		$5,775,995

Energy Costs: Electricity

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
1,358,700.0 kWh	$0.11200	$152,174	$10,815	$0

Energy Costs: Natural Gas

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
3,044,891.0 kWh	$0.02438	$74,234	$0	$0

Life-Cycle Cost Analysis

	Present Value	Annual Value
Initial Capital Costs	$5,775,995	$290,915

Energy Costs

Energy Costs		
Energy Consumption Costs	$5,798,779	$292,063
Energy Demand Charges	$276,994	$13,951
Energy Utility Rebates	$0	$0
Subtotal (for Energy):	$6,075,772	$306,014
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Operating, Maintenance & Repair Costs		
Component: Copy of: Copy of:		
Annually Recurring Costs	$1,065,518	$53,666
Non-Annually Recurring Costs	$0	$0
Subtotal (for OM&R):	$1,065,518	$53,666
Replacements to Capital Components		
Component: Copy of: Copy of:	$17,722	$893
Subtotal (for Replacements):	$17,722	$893
Residual Value of Original Capital Components		
Component: Copy of: Copy of:	$0	$0
Subtotal (for Residual Value):	$0	$0
Residual Value of Capital Replacements		
Component: Copy of: Copy of:	$0	$0
Subtotal (for Residual Value):	$0	$0
Total Life-Cycle Cost	$12,935,008	$651,488

Emissions Summary

Energy Name	Annual	Life-Cycle
Electricity:		
CO2	888,295.17 kg	25,757,519.92 kg
SO2	4,476.09 kg	129,791.18 kg
NOx	1,325.70 kg	38,440.88 kg
Natural Gas:		

CO2	548,802.84 kg	15,913,404.22 kg
SO2	4,429.01 kg	128,426.19 kg
NOx	164.44 kg	4,768.30 kg
Total:		
CO2	1,437,098.01 kg	41,670,924.14 kg
SO2	8,905.10 kg	258,217.37 kg
NOx	1,490.15 kg	43,209.18 kg

Alternative: Recommended Bundle of Measures

Initial Cost Data (not Discounted)

Initial Capital Costs

(adjusted for price escalation)

Initial Capital Costs for All Components: $4,553,295

Component:

Cost-Phasing

Date	Portion	Yearly Cost
June 1, 2017	100%	$4,553,295
Total (for Component)		$4,553,295

Energy Costs: Electricity

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
1,494,994.0 kWh	$0.11200	$167,439	$10,815	$0

Energy Costs: Natural Gas

(base-year dollars)

Average Annual Usage	Average Price/Unit	Average Annual Cost	Average Annual Demand	Average Annual Rebate
3,247,031.0 kWh	$0.02438	$79,163	$0	$0

Life-Cycle Cost Analysis

	Present Value	Annual Value
Initial Capital Costs	$4,553,295	$229,333
Energy Costs		
Energy Consumption Costs	$6,315,964	$318,112
Energy Demand Charges	$276,994	$13,951
Energy Utility Rebates	$0	$0
Subtotal (for Energy):	$6,592,958	$332,063

Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Operating, Maintenance & Repair Costs		
Component:		
Annually Recurring Costs	$968,330	$48,771
Non-Annually Recurring Costs	$0	$0
Subtotal (for OM&R):	$968,330	$48,771
Replacements to Capital Components		
Component:	$17,722	$893
Subtotal (for Replacements):	$17,722	$893
Residual Value of Original Capital Components		
Component:	$0	$0
Subtotal (for Residual Value):	$0	$0
Residual Value of Capital Replacements		
Component:	$0	$0
Subtotal (for Residual Value):	$0	$0
Total Life-Cycle Cost	$12,132,305	$611,059

Emissions Summary

Energy Name	Annual	Life-Cycle
Electricity:		
CO2	977,401.89 kg	28,341,309.89 kg
SO2	4,925.09 kg	142,810.80 kg
NOx	1,458.69 kg	42,296.97 kg
Natural Gas:		
CO2	585,236.00 kg	16,969,841.22 kg
SO2	4,723.04 kg	136,951.97 kg
NOx	175.36 kg	5,084.85 kg
Total:		
CO2	1,562,637.89 kg	45,311,151.11 kg
SO2	9,648.13 kg	279,762.77 kg

SO_2	9,648.13 kg	279,762.77 kg
NOx	1,634.05 kg	47,381.82 kg

APPENDIX C: BLCC5 CASH FLOW REPORT

NIST BLCC 5.3-14: Cash Flow Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name: C:\Program Files (x86)\BLCC 5\projects\CCIW LMP LCCA R1.xml

Date of Study: Fri Jun 26 11:35:04 EDT 2015

Analysis Type: FEMP Analysis, Energy Project

Project Name: Canada Centre for Inland Waters - Lab Modernization Project

Project Location: U.S. Average

Analyst: cmarshall

Base Date: June 1, 2017

Service Date: June 1, 2018

Study Period: 30 years 0 months (June 1, 2017 through May 31, 2047)

End-of-year cash-flow convention used

All costs in constant dollars (excluding general inflation)

Alternative: Baseline

Initial Capital Costs

Component:

Year Beginning	Total
Jun 2017	$0
Total	$0

Capital Investment Costs

Year Beginning	Initial	Replacement	Total
Jun 2017	$0	$0	$0
Jun 2018	$0	$0	$0
Jun 2019	$0	$0	$0
Jun 2020	$0	$0	$0
Jun 2021	$0	$0	$0
Jun 2022	$0	$0	$0
Jun 2023	$0	$0	$0
Jun 2024	$0	$0	$0
Jun 2025	$0	$0	$0
Jun 2026	$0	$0	$0
Jun 2027	$0	$0	$0
Jun 2028	$0	$0	$0
Jun 2029	$0	$0	$0
Jun 2030	$0	$0	$0
Jun 2031	$0	$0	$0
Jun 2032	$0	$0	$0
Jun 2033	$0	$1,464,715	$1,464,715
Jun 2034	$0	$0	$0
Jun 2035	$0	$0	$0
Jun 2036	$0	$0	$0
Jun 2037	$0	$0	$0
Jun 2038	$0	$0	$0
Jun 2039	$0	$0	$0
Jun 2040	$0	$0	$0
Jun 2041	$0	$0	$0
Jun 2042	$0	$0	$0
Jun 2043	$0	$0	$0
Jun 2044	$0	$0	$0
Jun 2045	$0	$0	$0
Jun 2046	$0	$0	$0
Total	$0	$1,464,715	$1,464,715

Operating-Related Costs

Year Beginning	Recurring	Energy Consumption	Energy Demand	Energy Rebate	Total
Jun 2017	$0	$0	$0	$0	$0
Jun 2018	$51,165	$559,305	$33,894	$0	$644,364
Jun 2019	$51,165	$571,019	$34,604	$0	$656,788
Jun 2020	$51,165	$582,945	$35,326	$0	$669,436
Jun 2021	$51,165	$595,120	$36,064	$0	$682,349
Jun 2022	$51,165	$607,550	$36,817	$0	$695,532
Jun 2023	$51,165	$620,274	$37,588	$0	$709,027
Jun 2024	$51,165	$633,228	$38,374	$0	$722,767
Jun 2025	$51,165	$646,454	$39,175	$0	$736,794
Jun 2026	$51,165	$659,955	$39,993	$0	$751,113
Jun 2027	$51,165	$673,777	$40,831	$0	$765,773
Jun 2028	$51,165	$687,849	$41,684	$0	$780,698
Jun 2029	$51,165	$702,215	$42,554	$0	$795,934
Jun 2030	$51,165	$716,881	$43,443	$0	$811,489
Jun 2031	$51,165	$731,895	$44,353	$0	$827,413
Jun 2032	$51,165	$747,181	$45,279	$0	$843,625
Jun 2033	$51,165	$762,787	$46,225	$0	$860,176
Jun 2034	$51,165	$778,718	$47,190	$0	$877,073
Jun 2035	$51,165	$795,027	$48,178	$0	$894,370
Jun 2036	$51,165	$811,631	$49,185	$0	$911,981
Jun 2037	$51,165	$828,583	$50,212	$0	$929,960
Jun 2038	$51,165	$845,888	$51,261	$0	$948,314
Jun 2039	$51,165	$863,604	$52,334	$0	$967,103
Jun 2040	$51,165	$881,641	$53,427	$0	$986,233
Jun 2041	$51,165	$900,054	$54,543	$0	$1,005,763
Jun 2042	$51,165	$918,853	$55,682	$0	$1,025,700
Jun 2043	$51,165	$938,096	$56,848	$0	$1,046,110
Jun 2044	$51,165	$957,689	$58,036	$0	$1,066,890
Jun 2045	$51,165	$977,691	$59,248	$0	$1,088,104
Jun 2046	$51,165	$998,054	$60,482	$0	$1,109,701
Total	$1,483,785	$21,993,966	$1,332,830	$0	$24,810,581

Sum of All Cash Flows

Year Beginning	Capital	OM&R	Total
Jun 2017	$0	$0	$0
Jun 2018	$0	$644,364	$644,364
Jun 2019	$0	$656,788	$656,788
Jun 2020	$0	$669,436	$669,436
Jun 2021	$0	$682,349	$682,349
Jun 2022	$0	$695,532	$695,532
Jun 2023	$0	$709,027	$709,027
Jun 2024	$0	$722,767	$722,767
Jun 2025	$0	$736,794	$736,794
Jun 2026	$0	$751,113	$751,113
Jun 2027	$0	$765,773	$765,773
Jun 2028	$0	$780,698	$780,698
Jun 2029	$0	$795,934	$795,934
Jun 2030	$0	$811,489	$811,489

Jun 2031	$0	$827,413	$827,413
Jun 2032	$0	$843,625	$843,625
Jun 2033	$1,464,715	$860,176	$2,324,891
Jun 2034	$0	$877,073	$877,073
Jun 2035	$0	$894,370	$894,370
Jun 2036	$0	$911,981	$911,981
Jun 2037	$0	$929,960	$929,960
Jun 2038	$0	$948,314	$948,314
Jun 2039	$0	$967,103	$967,103
Jun 2040	$0	$986,233	$986,233
Jun 2041	$0	$1,005,763	$1,005,763
Jun 2042	$0	$1,025,700	$1,025,700
Jun 2043	$0	$1,046,110	$1,046,110
Jun 2044	$0	$1,066,890	$1,066,890
Jun 2045	$0	$1,088,104	$1,088,104
Jun 2046	$0	$1,109,701	$1,109,701
Total	$1,464,715	$24,810,581	$26,275,296

Alternative: CES upgrade

Initial Capital Costs

Component:

Year Beginning	Total
Jun 2017	$2,545,125
Total	$2,545,125

Capital Investment Costs

Year Beginning	Initial	Replacement	Total
Jun 2017	$2,545,125	$0	$2,545,125
Jun 2018	$0	$0	$0
Jun 2019	$0	$0	$0
Jun 2020	$0	$0	$0
Jun 2021	$0	$0	$0
Jun 2022	$0	$0	$0
Jun 2023	$0	$0	$0
Jun 2024	$0	$0	$0
Jun 2025	$0	$0	$0
Jun 2026	$0	$0	$0
Jun 2027	$0	$0	$0
Jun 2028	$0	$0	$0
Jun 2029	$0	$0	$0
Jun 2030	$0	$0	$0
Jun 2031	$0	$0	$0
Jun 2032	$0	$0	$0
Jun 2033	$0	$1,341,715	$1,341,715
Jun 2034	$0	$0	$0
Jun 2035	$0	$0	$0
Jun 2036	$0	$0	$0
Jun 2037	$0	$0	$0
Jun 2038	$0	$0	$0
Jun 2039	$0	$0	$0
Jun 2040	$0	$0	$0
Jun 2041	$0	$0	$0
Jun 2042	$0	$0	$0
Jun 2043	$0	$0	$0
Jun 2044	$0	$0	$0
Jun 2045	$0	$0	$0
Jun 2046	$0	$0	$0
Total	$2,545,125	$1,341,715	$3,886,840

Operating-Related Costs

Year Beginning	Recurring	Energy Consumption	Energy Demand	Energy Rebate	Total
Jun 2017	$0	$0	$0	$0	$0
Jun 2018	$37,945	$519,392	$29,637	$0	$586,974
Jun 2019	$37,945	$530,270	$30,257	$0	$598,473
Jun 2020	$37,945	$541,345	$30,889	$0	$610,179
Jun 2021	$37,945	$552,652	$31,534	$0	$622,131
Jun 2022	$37,945	$564,194	$32,193	$0	$634,332
Jun 2023	$37,945	$576,010	$32,867	$0	$646,822
Jun 2024	$37,945	$588,040	$33,554	$0	$659,539
Jun 2025	$37,945	$600,322	$34,254	$0	$672,521
Jun 2026	$37,945	$612,860	$34,970	$0	$685,775
Jun 2027	$37,945	$625,695	$35,702	$0	$699,343
Jun 2028	$37,945	$638,763	$36,448	$0	$713,156
Jun 2029	$37,945	$652,104	$37,209	$0	$727,258
Jun 2030	$37,945	$665,724	$37,986	$0	$741,655
Jun 2031	$37,945	$679,666	$38,782	$0	$756,393
Jun 2032	$37,945	$693,861	$39,592	$0	$771,398
Jun 2033	$37,945	$708,353	$40,419	$0	$786,717
Jun 2034	$37,945	$723,147	$41,263	$0	$802,355
Jun 2035	$37,945	$738,293	$42,127	$0	$818,365
Jun 2036	$37,945	$753,712	$43,007	$0	$834,664
Jun 2037	$37,945	$769,454	$43,905	$0	$851,304
Jun 2038	$37,945	$785,524	$44,822	$0	$868,292
Jun 2039	$37,945	$801,976	$45,761	$0	$885,682
Jun 2040	$37,945	$818,726	$46,717	$0	$903,387
Jun 2041	$37,945	$835,825	$47,692	$0	$921,462
Jun 2042	$37,945	$853,282	$48,688	$0	$939,915
Jun 2043	$37,945	$871,152	$49,708	$0	$958,806
Jun 2044	$37,945	$889,347	$50,746	$0	$978,038
Jun 2045	$37,945	$907,921	$51,806	$0	$997,673
Jun 2046	$37,945	$926,831	$52,885	$0	$1,017,662
Total	$1,100,405	$20,424,445	$1,165,422	$0	$22,690,272

Sum of All Cash Flows

Year Beginning	Capital	OM&R	Total
Jun 2017	$2,545,125	$0	$2,545,125
Jun 2018	$0	$586,974	$586,974
Jun 2019	$0	$598,473	$598,473
Jun 2020	$0	$610,179	$610,179
Jun 2021	$0	$622,131	$622,131
Jun 2022	$0	$634,332	$634,332
Jun 2023	$0	$646,822	$646,822
Jun 2024	$0	$659,539	$659,539
Jun 2025	$0	$672,521	$672,521
Jun 2026	$0	$685,775	$685,775
Jun 2027	$0	$699,343	$699,343

Jun 2027	$0	$699,343	$699,343
Jun 2028	$0	$713,156	$713,156
Jun 2029	$0	$727,258	$727,258
Jun 2030	$0	$741,655	$741,655
Jun 2031	$0	$756,393	$756,393
Jun 2032	$0	$771,398	$771,398
Jun 2033	$1,341,715	$786,717	$2,128,432
Jun 2034	$0	$802,355	$802,355
Jun 2035	$0	$818,365	$818,365
Jun 2036	$0	$834,664	$834,664
Jun 2037	$0	$851,304	$851,304
Jun 2038	$0	$868,292	$868,292
Jun 2039	$0	$885,682	$885,682
Jun 2040	$0	$903,387	$903,387
Jun 2041	$0	$921,462	$921,462
Jun 2042	$0	$939,915	$939,915
Jun 2043	$0	$958,806	$958,806
Jun 2044	$0	$978,038	$978,038
Jun 2045	$0	$997,673	$997,673
Jun 2046	$0	$1,017,662	$1,017,662
Total	$3,886,840	$22,690,272	$26,577,112

Alternative: Add heat recovery system

Initial Capital Costs

Component:

Year Beginning	Total
Jun 2017	$2,852,625
Total	$2,852,625

Capital Investment Costs

Year Beginning	Initial	Replacement	Total
Jun 2017	$2,852,625	$0	$2,852,625
Jun 2018	$0	$0	$0
Jun 2019	$0	$0	$0
Jun 2020	$0	$0	$0
Jun 2021	$0	$0	$0
Jun 2022	$0	$0	$0
Jun 2023	$0	$0	$0
Jun 2024	$0	$0	$0
Jun 2025	$0	$0	$0
Jun 2026	$0	$0	$0
Jun 2027	$0	$0	$0
Jun 2028	$0	$0	$0
Jun 2029	$0	$0	$0
Jun 2030	$0	$0	$0
Jun 2031	$0	$0	$0
Jun 2032	$0	$0	$0
Jun 2033	$0	$1,343,715	$1,343,715
Jun 2034	$0	$0	$0
Jun 2035	$0	$0	$0
Jun 2036	$0	$0	$0
Jun 2037	$0	$0	$0
Jun 2038	$0	$0	$0
Jun 2039	$0	$0	$0
Jun 2040	$0	$0	$0
Jun 2041	$0	$0	$0
Jun 2042	$0	$0	$0
Jun 2043	$0	$0	$0
Jun 2044	$0	$0	$0
Jun 2045	$0	$0	$0
Jun 2046	$0	$0	$0
Total	$2,852,625	$1,343,715	$4,196,340

Operating-Related Costs

Year Beginning	Recurring	Energy Consumption	Energy Demand	Energy Rebate	Total
Jun 2017	$0	$0	$0	$0	$0
Jun 2018	$38,805	$475,689	$30,737	$0	$545,231
Jun 2019	$38,805	$485,651	$31,381	$0	$555,837
Jun 2020	$38,805	$495,794	$32,036	$0	$566,636
Jun 2021	$38,805	$506,149	$32,705	$0	$577,660
Jun 2022	$38,805	$516,720	$33,388	$0	$588,914
Jun 2023	$38,805	$527,542	$34,088	$0	$600,435
Jun 2024	$38,805	$538,560	$34,800	$0	$612,165
Jun 2025	$38,805	$549,808	$35,526	$0	$624,140
Jun 2026	$38,805	$561,291	$36,268	$0	$636,365
Jun 2027	$38,805	$573,047	$37,028	$0	$648,880
Jun 2028	$38,805	$585,015	$37,801	$0	$661,622
Jun 2029	$38,805	$597,234	$38,591	$0	$674,629
Jun 2030	$38,805	$609,707	$39,397	$0	$687,909
Jun 2031	$38,805	$622,476	$40,222	$0	$701,503
Jun 2032	$38,805	$635,477	$41,062	$0	$715,344
Jun 2033	$38,805	$648,749	$41,920	$0	$729,474
Jun 2034	$38,805	$662,299	$42,795	$0	$743,899
Jun 2035	$38,805	$676,170	$43,691	$0	$758,666
Jun 2036	$38,805	$690,292	$44,604	$0	$773,701
Jun 2037	$38,805	$704,709	$45,536	$0	$789,050
Jun 2038	$38,805	$719,427	$46,487	$0	$804,719
Jun 2039	$38,805	$734,494	$47,460	$0	$820,760
Jun 2040	$38,805	$749,835	$48,451	$0	$837,091
Jun 2041	$38,805	$765,496	$49,463	$0	$853,764
Jun 2042	$38,805	$781,483	$50,496	$0	$870,785
Jun 2043	$38,805	$797,850	$51,554	$0	$888,209
Jun 2044	$38,805	$814,514	$52,631	$0	$905,949
Jun 2045	$38,805	$831,525	$53,730	$0	$924,060
Jun 2046	$38,805	$848,844	$54,849	$0	$942,498
Total	$1,125,345	$18,705,850	$1,208,698	$0	$21,039,893

Sum of All Cash Flows

Year Beginning	Capital	OM&R	Total
Jun 2017	$2,852,625	$0	$2,852,625
Jun 2018	$0	$545,231	$545,231
Jun 2019	$0	$555,837	$555,837
Jun 2020	$0	$566,636	$566,636
Jun 2021	$0	$577,660	$577,660
Jun 2022	$0	$588,914	$588,914
Jun 2023	$0	$600,435	$600,435

Jun 2024	$0	$612,165	$612,165
Jun 2025	$0	$624,140	$624,140
Jun 2026	$0	$636,365	$636,365
Jun 2027	$0	$648,880	$648,880
Jun 2028	$0	$661,622	$661,622
Jun 2029	$0	$674,629	$674,629
Jun 2030	$0	$687,909	$687,909
Jun 2031	$0	$701,503	$701,503
Jun 2032	$0	$715,344	$715,344
Jun 2033	$1,343,715	$729,474	$2,073,189
Jun 2034	$0	$743,899	$743,899
Jun 2035	$0	$758,666	$758,666
Jun 2036	$0	$773,701	$773,701
Jun 2037	$0	$789,050	$789,050
Jun 2038	$0	$804,719	$804,719
Jun 2039	$0	$820,760	$820,760
Jun 2040	$0	$837,091	$837,091
Jun 2041	$0	$853,764	$853,764
Jun 2042	$0	$870,785	$870,785
Jun 2043	$0	$888,209	$888,209
Jun 2044	$0	$905,949	$905,949
Jun 2045	$0	$924,060	$924,060
Jun 2046	$0	$942,498	$942,498
Total	$4,196,340	$21,039,893	$25,236,233

Alternative: Upgrade Lighting to LED

Initial Capital Costs

Component: Copy of:

Year Beginning	Total
Jun 2017	$3,213,025
Total	$3,213,025

Capital Investment Costs

Year Beginning	Initial	Replacement	Total
Jun 2017	$3,213,025	$0	$3,213,025
Jun 2018	$0	$0	$0
Jun 2019	$0	$0	$0
Jun 2020	$0	$0	$0
Jun 2021	$0	$0	$0
Jun 2022	$0	$0	$0
Jun 2023	$0	$0	$0
Jun 2024	$0	$0	$0
Jun 2025	$0	$0	$0
Jun 2026	$0	$0	$0
Jun 2027	$0	$0	$0
Jun 2028	$0	$0	$0
Jun 2029	$0	$0	$0
Jun 2030	$0	$0	$0
Jun 2031	$0	$0	$0
Jun 2032	$0	$0	$0
Jun 2033	$0	$1,343,715	$1,343,715
Jun 2034	$0	$0	$0
Jun 2035	$0	$0	$0
Jun 2036	$0	$0	$0
Jun 2037	$0	$0	$0
Jun 2038	$0	$0	$0
Jun 2039	$0	$0	$0
Jun 2040	$0	$0	$0
Jun 2041	$0	$0	$0
Jun 2042	$0	$0	$0
Jun 2043	$0	$0	$0
Jun 2044	$0	$0	$0
Jun 2045	$0	$0	$0
Jun 2046	$0	$0	$0
Total	$3,213,025	$1,343,715	$4,556,740

Operating-Related Costs

Year Beginning	Recurring	Energy Consumption	Energy Demand	Energy Rebate	Total
Jun 2017	$0	$0	$0	$0	$0
Jun 2018	$27,713	$467,887	$30,510	$0	$526,110
Jun 2019	$27,713	$477,686	$31,149	$0	$536,548
Jun 2020	$27,713	$487,663	$31,799	$0	$547,175
Jun 2021	$27,713	$497,848	$32,464	$0	$558,025
Jun 2022	$27,713	$508,246	$33,142	$0	$569,100
Jun 2023	$27,713	$518,890	$33,836	$0	$580,439
Jun 2024	$27,713	$529,727	$34,542	$0	$591,983
Jun 2025	$27,713	$540,791	$35,264	$0	$603,768
Jun 2026	$27,713	$552,086	$36,000	$0	$615,799
Jun 2027	$27,713	$563,648	$36,754	$0	$628,116
Jun 2028	$27,713	$575,420	$37,522	$0	$640,655
Jun 2029	$27,713	$587,438	$38,306	$0	$653,457
Jun 2030	$27,713	$599,707	$39,106	$0	$666,526
Jun 2031	$27,713	$612,267	$39,925	$0	$679,905
Jun 2032	$27,713	$625,055	$40,759	$0	$693,526
Jun 2033	$27,713	$638,109	$41,610	$0	$707,432
Jun 2034	$27,713	$651,437	$42,479	$0	$721,629
Jun 2035	$27,713	$665,080	$43,368	$0	$736,161
Jun 2036	$27,713	$678,971	$44,274	$0	$750,958
Jun 2037	$27,713	$693,151	$45,199	$0	$766,063
Jun 2038	$27,713	$707,628	$46,143	$0	$781,484
Jun 2039	$27,713	$722,448	$47,109	$0	$797,270
Jun 2040	$27,713	$737,537	$48,093	$0	$813,343
Jun 2041	$27,713	$752,941	$49,098	$0	$829,751
Jun 2042	$27,713	$768,666	$50,123	$0	$846,502
Jun 2043	$27,713	$784,765	$51,173	$0	$863,651
Jun 2044	$27,713	$801,155	$52,242	$0	$881,110
Jun 2045	$27,713	$817,888	$53,333	$0	$898,933
Jun 2046	$27,713	$834,922	$54,444	$0	$917,079
Total	$803,677	$18,399,058	$1,199,764	$0	$20,402,499

Sum of All Cash Flows

Year Beginning	Capital	OM&R	Total
Jun 2017	$3,213,025	$0	$3,213,025
Jun 2018	$0	$526,110	$526,110
Jun 2019	$0	$536,548	$536,548

Jun 2020	$0	$547,175	$547,175
Jun 2021	$0	$558,025	$558,025
Jun 2022	$0	$569,100	$569,100
Jun 2023	$0	$580,439	$580,439
Jun 2024	$0	$591,983	$591,983
Jun 2025	$0	$603,768	$603,768
Jun 2026	$0	$615,799	$615,799
Jun 2027	$0	$628,116	$628,116
Jun 2028	$0	$640,655	$640,655
Jun 2029	$0	$653,457	$653,457
Jun 2030	$0	$666,526	$666,526
Jun 2031	$0	$679,905	$679,905
Jun 2032	$0	$693,526	$693,526
Jun 2033	$1,343,715	$707,432	$2,051,147
Jun 2034	$0	$721,629	$721,629
Jun 2035	$0	$736,161	$736,161
Jun 2036	$0	$750,958	$750,958
Jun 2037	$0	$766,063	$766,063
Jun 2038	$0	$781,484	$781,484
Jun 2039	$0	$797,270	$797,270
Jun 2040	$0	$813,343	$813,343
Jun 2041	$0	$829,751	$829,751
Jun 2042	$0	$846,502	$846,502
Jun 2043	$0	$863,651	$863,651
Jun 2044	$0	$881,110	$881,110
Jun 2045	$0	$898,933	$898,933
Jun 2046	$0	$917,079	$917,079
Total	$4,556,740	$20,402,499	$24,959,239

Alternative: Add lighting controls

Initial Capital Costs

Component: Copy of: Copy of:

Year Beginning	Total
Jun 2017	$3,429,225
Total	$3,429,225

Capital Investment Costs

Year Beginning	Initial	Replacement	Total
Jun 2017	$3,429,225	$0	$3,429,225
Jun 2018	$0	$0	$0
Jun 2019	$0	$0	$0
Jun 2020	$0	$0	$0
Jun 2021	$0	$0	$0
Jun 2022	$0	$0	$0
Jun 2023	$0	$0	$0
Jun 2024	$0	$0	$0
Jun 2025	$0	$0	$0
Jun 2026	$0	$0	$0
Jun 2027	$0	$0	$0
Jun 2028	$0	$0	$0
Jun 2029	$0	$0	$0
Jun 2030	$0	$0	$0
Jun 2031	$0	$0	$0
Jun 2032	$0	$0	$0
Jun 2033	$0	$1,343,715	$1,343,715
Jun 2034	$0	$0	$0
Jun 2035	$0	$0	$0
Jun 2036	$0	$0	$0
Jun 2037	$0	$0	$0
Jun 2038	$0	$0	$0
Jun 2039	$0	$0	$0
Jun 2040	$0	$0	$0
Jun 2041	$0	$0	$0
Jun 2042	$0	$0	$0
Jun 2043	$0	$0	$0
Jun 2044	$0	$0	$0
Jun 2045	$0	$0	$0
Jun 2046	$0	$0	$0
Total	$3,429,225	$1,343,715	$4,772,940

Operating-Related Costs

Year Beginning	Recurring	Energy Consumption	Energy Demand	Energy Rebate	Total
Jun 2017	$0	$0	$0	$0	$0
Jun 2018	$32,859	$459,555	$30,405	$0	$522,819
Jun 2019	$32,859	$469,180	$31,041	$0	$533,080
Jun 2020	$32,859	$478,979	$31,690	$0	$543,528
Jun 2021	$32,859	$488,983	$32,352	$0	$554,193
Jun 2022	$32,859	$499,195	$33,027	$0	$565,082
Jun 2023	$32,859	$509,650	$33,719	$0	$576,228
Jun 2024	$32,859	$520,294	$34,423	$0	$587,577
Jun 2025	$32,859	$531,161	$35,142	$0	$599,162
Jun 2026	$32,859	$542,255	$35,876	$0	$610,990
Jun 2027	$32,859	$553,611	$36,628	$0	$623,098
Jun 2028	$32,859	$565,174	$37,393	$0	$635,425
Jun 2029	$32,859	$576,978	$38,173	$0	$648,010
Jun 2030	$32,859	$589,028	$38,971	$0	$660,858
Jun 2031	$32,859	$601,364	$39,787	$0	$674,010
Jun 2032	$32,859	$613,924	$40,618	$0	$687,401
Jun 2033	$32,859	$626,746	$41,466	$0	$701,072
Jun 2034	$32,859	$639,836	$42,332	$0	$715,028
Jun 2035	$32,859	$653,237	$43,219	$0	$729,314
Jun 2036	$32,859	$666,880	$44,122	$0	$743,860
Jun 2037	$32,859	$680,808	$45,043	$0	$758,710
Jun 2038	$32,859	$695,027	$45,984	$0	$773,870
Jun 2039	$32,859	$709,583	$46,947	$0	$789,389
Jun 2040	$32,859	$724,403	$47,927	$0	$805,190
Jun 2041	$32,859	$739,533	$48,928	$0	$821,320
Jun 2042	$32,859	$754,978	$49,950	$0	$837,788
Jun 2043	$32,859	$770,790	$50,996	$0	$854,645
Jun 2044	$32,859	$786,888	$52,061	$0	$871,809
Jun 2045	$32,859	$803,323	$53,149	$0	$889,331
Jun 2046	$32,859	$820,054	$54,256	$0	$907,169
Total	$952,911	$18,071,418	$1,195,625	$0	$20,219,954

Sum of All Cash Flows

Year Beginning	Capital	OM&R	Total
Jun 2017	$3,429,225	$0	$3,429,225
Jun 2018	$0	$522,819	$522,819
Jun 2019	$0	$533,080	$533,080
Jun 2020	$0	$543,528	$543,528
Jun 2021	$0	$554,193	$554,193
Jun 2022	$0	$565,082	$565,082
Jun 2023	$0	$576,228	$576,228
Jun 2024	$0	$587,577	$587,577
Jun 2025	$0	$599,162	$599,162
Jun 2026	$0	$610,990	$610,990
Jun 2027	$0	$623,098	$623,098
Jun 2028	$0	$635,425	$635,425
Jun 2029	$0	$648,010	$648,010
Jun 2030	$0	$660,858	$660,858
Jun 2031	$0	$674,010	$674,010
Jun 2032	$0	$687,401	$687,401
Jun 2033	$1,343,715	$701,072	$2,044,787
Jun 2034	$0	$715,028	$715,028
Jun 2035	$0	$729,314	$729,314
Jun 2036	$0	$743,860	$743,860
Jun 2037	$0	$758,710	$758,710
Jun 2038	$0	$773,870	$773,870
Jun 2039	$0	$789,389	$789,389
Jun 2040	$0	$805,190	$805,190
Jun 2041	$0	$821,320	$821,320
Jun 2042	$0	$837,788	$837,788
Jun 2043	$0	$854,645	$854,645
Jun 2044	$0	$871,809	$871,809
Jun 2045	$0	$889,331	$889,331
Jun 2046	$0	$907,169	$907,169
Total	$4,772,940	$20,219,954	$24,992,894

Alternative: Replace existing windows

Initial Capital Costs

Component:

Year Beginning	Total
Jun 2017	$4,573,325
Total	$4,573,325

Capital Investment Costs

Year Beginning	Initial	Replacement	Total
Jun 2017	$4,573,325	$0	$4,573,325
Jun 2018	$0	$0	$0
Jun 2019	$0	$0	$0
Jun 2020	$0	$0	$0
Jun 2021	$0	$0	$0
Jun 2022	$0	$0	$0
Jun 2023	$0	$0	$0
Jun 2024	$0	$0	$0
Jun 2025	$0	$0	$0
Jun 2026	$0	$0	$0
Jun 2027	$0	$0	$0
Jun 2028	$0	$0	$0
Jun 2029	$0	$0	$0
Jun 2030	$0	$0	$0
Jun 2031	$0	$0	$0
Jun 2032	$0	$0	$0
Jun 2033	$0	$28,000	$28,000
Jun 2034	$0	$0	$0
Jun 2035	$0	$0	$0
Jun 2036	$0	$0	$0
Jun 2037	$0	$0	$0
Jun 2038	$0	$0	$0
Jun 2039	$0	$0	$0
Jun 2040	$0	$0	$0
Jun 2041	$0	$0	$0
Jun 2042	$0	$0	$0
Jun 2043	$0	$0	$0
Jun 2044	$0	$0	$0
Jun 2045	$0	$0	$0
Jun 2046	$0	$0	$0
Total	$4,573,325	$28,000	$4,601,325

Operating-Related Costs

Year Beginning	Recurring	Energy Consumption	Energy Demand	Energy Rebate	Total
Jun 2017	$0	$0	$0	$0	$0
Jun 2018	$21,418	$447,510	$29,549	$0	$498,477
Jun 2019	$21,418	$456,882	$30,168	$0	$508,468
Jun 2020	$21,418	$466,424	$30,798	$0	$518,640
Jun 2021	$21,418	$476,166	$31,441	$0	$529,025
Jun 2022	$21,418	$486,111	$32,098	$0	$539,627
Jun 2023	$21,418	$496,292	$32,770	$0	$550,480
Jun 2024	$21,418	$506,657	$33,455	$0	$561,530
Jun 2025	$21,418	$517,239	$34,153	$0	$572,810
Jun 2026	$21,418	$528,042	$34,867	$0	$584,326
Jun 2027	$21,418	$539,101	$35,597	$0	$596,115
Jun 2028	$21,418	$550,360	$36,340	$0	$608,118
Jun 2029	$21,418	$561,855	$37,099	$0	$620,372
Jun 2030	$21,418	$573,589	$37,874	$0	$632,881
Jun 2031	$21,418	$585,602	$38,667	$0	$645,687
Jun 2032	$21,418	$597,833	$39,475	$0	$658,726
Jun 2033	$21,418	$610,319	$40,299	$0	$672,036
Jun 2034	$21,418	$623,066	$41,141	$0	$685,625
Jun 2035	$21,418	$636,115	$42,003	$0	$699,535
Jun 2036	$21,418	$649,400	$42,880	$0	$713,698
Jun 2037	$21,418	$662,963	$43,775	$0	$728,157
Jun 2038	$21,418	$676,810	$44,690	$0	$742,917
Jun 2039	$21,418	$690,984	$45,626	$0	$758,028
Jun 2040	$21,418	$705,416	$46,579	$0	$773,413
Jun 2041	$21,418	$720,149	$47,551	$0	$789,118
Jun 2042	$21,418	$735,190	$48,545	$0	$805,152
Jun 2043	$21,418	$750,587	$49,561	$0	$821,566
Jun 2044	$21,418	$766,263	$50,596	$0	$838,278
Jun 2045	$21,418	$782,267	$51,653	$0	$855,338
Jun 2046	$21,418	$798,560	$52,729	$0	$872,707

Total	$621,122	$17,597,750	$1,161,980	$0	$19,380,852

Sum of All Cash Flows

Year Beginning	Capital	OM&R	Total
Jun 2017	$4,573,325	$0	$4,573,325
Jun 2018	$0	$498,477	$498,477
Jun 2019	$0	$508,468	$508,468
Jun 2020	$0	$518,640	$518,640
Jun 2021	$0	$529,025	$529,025
Jun 2022	$0	$539,627	$539,627
Jun 2023	$0	$550,480	$550,480
Jun 2024	$0	$561,530	$561,530
Jun 2025	$0	$572,810	$572,810
Jun 2026	$0	$584,326	$584,326
Jun 2027	$0	$596,115	$596,115
Jun 2028	$0	$608,118	$608,118
Jun 2029	$0	$620,372	$620,372
Jun 2030	$0	$632,881	$632,881
Jun 2031	$0	$645,687	$645,687
Jun 2032	$0	$658,726	$658,726
Jun 2033	$28,000	$672,036	$700,036
Jun 2034	$0	$685,625	$685,625
Jun 2035	$0	$699,535	$699,535
Jun 2036	$0	$713,698	$713,698
Jun 2037	$0	$728,157	$728,157
Jun 2038	$0	$742,917	$742,917
Jun 2039	$0	$758,028	$758,028
Jun 2040	$0	$773,413	$773,413
Jun 2041	$0	$789,118	$789,118
Jun 2042	$0	$805,152	$805,152
Jun 2043	$0	$821,566	$821,566
Jun 2044	$0	$838,278	$838,278
Jun 2045	$0	$855,338	$855,338
Jun 2046	$0	$872,707	$872,707
Total	$4,601,325	$19,380,852	$23,982,177

Alternative: Add wall insulation

Initial Capital Costs

Component:

Year Beginning	Total
Jun 2017	$4,924,625
Total	$4,924,625

Capital Investment Costs

Year Beginning	Initial	Replacement	Total
Jun 2017	$4,924,625	$0	$4,924,625
Jun 2018	$0	$0	$0
Jun 2019	$0	$0	$0
Jun 2020	$0	$0	$0
Jun 2021	$0	$0	$0
Jun 2022	$0	$0	$0
Jun 2023	$0	$0	$0
Jun 2024	$0	$0	$0
Jun 2025	$0	$0	$0
Jun 2026	$0	$0	$0
Jun 2027	$0	$0	$0
Jun 2028	$0	$0	$0
Jun 2029	$0	$0	$0
Jun 2030	$0	$0	$0
Jun 2031	$0	$0	$0
Jun 2032	$0	$0	$0
Jun 2033	$0	$28,000	$28,000
Jun 2034	$0	$0	$0
Jun 2035	$0	$0	$0
Jun 2036	$0	$0	$0
Jun 2037	$0	$0	$0
Jun 2038	$0	$0	$0
Jun 2039	$0	$0	$0
Jun 2040	$0	$0	$0
Jun 2041	$0	$0	$0
Jun 2042	$0	$0	$0
Jun 2043	$0	$0	$0
Jun 2044	$0	$0	$0
Jun 2045	$0	$0	$0
Jun 2046	$0	$0	$0
Total	$4,924,625	$28,000	$4,952,625

Operating-Related Costs

Year Beginning	Recurring	Energy Consumption	Energy Demand	Energy Rebate	Total
Jun 2017	$0	$0	$0	$0	$0
Jun 2018	$21,418	$443,343	$29,465	$0	$494,226
Jun 2019	$21,418	$452,628	$30,082	$0	$504,128
Jun 2020	$21,418	$462,081	$30,710	$0	$514,209
Jun 2021	$21,418	$471,732	$31,351	$0	$524,502
Jun 2022	$21,418	$481,585	$32,006	$0	$535,009
Jun 2023	$21,418	$491,671	$32,677	$0	$545,765
Jun 2024	$21,418	$501,939	$33,359	$0	$556,716
Jun 2025	$21,418	$512,423	$34,056	$0	$567,896
Jun 2026	$21,418	$523,125	$34,767	$0	$579,310
Jun 2027	$21,418	$534,081	$35,495	$0	$590,994
Jun 2028	$21,418	$545,236	$36,236	$0	$602,890
Jun 2029	$21,418	$556,623	$36,993	$0	$615,034
Jun 2030	$21,418	$568,248	$37,766	$0	$627,432
Jun 2031	$21,418	$580,149	$38,557	$0	$640,124
Jun 2032	$21,418	$592,266	$39,362	$0	$653,046
Jun 2033	$21,418	$604,636	$40,184	$0	$666,238
Jun 2034	$21,418	$617,264	$41,023	$0	$679,706
Jun 2035	$21,418	$630,192	$41,883	$0	$693,492
Jun 2036	$21,418	$643,354	$42,757	$0	$707,529
Jun 2037	$21,418	$656,790	$43,650	$0	$721,859
Jun 2038	$21,418	$670,508	$44,562	$0	$736,488
Jun 2039	$21,418	$684,551	$45,495	$0	$751,464
Jun 2040	$21,418	$698,848	$46,446	$0	$766,711
Jun 2041	$21,418	$713,444	$47,416	$0	$782,277
Jun 2042	$21,418	$728,344	$48,406	$0	$798,168

Jun 2043	$21,418	$743,598	$49,420	$0	$814,436
Jun 2044	$21,418	$759,129	$50,452	$0	$830,999
Jun 2045	$21,418	$774,984	$51,506	$0	$847,907
Jun 2046	$21,418	$791,125	$52,578	$0	$865,121
Total	$621,122	$17,433,896	$1,158,660	$0	$19,213,678

Sum of All Cash Flows

Year Beginning	Capital	OM&R	Total
Jun 2017	$4,924,625	$0	$4,924,625
Jun 2018	$0	$494,226	$494,226
Jun 2019	$0	$504,128	$504,128
Jun 2020	$0	$514,209	$514,209
Jun 2021	$0	$524,502	$524,502
Jun 2022	$0	$535,009	$535,009
Jun 2023	$0	$545,765	$545,765
Jun 2024	$0	$556,716	$556,716
Jun 2025	$0	$567,896	$567,896
Jun 2026	$0	$579,310	$579,310
Jun 2027	$0	$590,994	$590,994
Jun 2028	$0	$602,890	$602,890
Jun 2029	$0	$615,034	$615,034
Jun 2030	$0	$627,432	$627,432
Jun 2031	$0	$640,124	$640,124
Jun 2032	$0	$653,046	$653,046
Jun 2033	$28,000	$666,238	$694,238
Jun 2034	$0	$679,706	$679,706
Jun 2035	$0	$693,492	$693,492
Jun 2036	$0	$707,529	$707,529
Jun 2037	$0	$721,859	$721,859
Jun 2038	$0	$736,488	$736,488
Jun 2039	$0	$751,464	$751,464
Jun 2040	$0	$766,711	$766,711
Jun 2041	$0	$782,277	$782,277
Jun 2042	$0	$798,168	$798,168
Jun 2043	$0	$814,436	$814,436
Jun 2044	$0	$830,999	$830,999
Jun 2045	$0	$847,907	$847,907
Jun 2046	$0	$865,121	$865,121
Total	$4,952,625	$19,213,678	$24,166,303

Alternative: Add VIEW dynamic glazing

Initial Capital Costs

Component: Copy of:

Year Beginning	Total
Jun 2017	$5,579,825
Total	$5,579,825

Capital Investment Costs

Year Beginning	Initial	Replacement	Total
Jun 2017	$5,579,825	$0	$5,579,825
Jun 2018	$0	$0	$0
Jun 2019	$0	$0	$0
Jun 2020	$0	$0	$0
Jun 2021	$0	$0	$0
Jun 2022	$0	$0	$0
Jun 2023	$0	$0	$0
Jun 2024	$0	$0	$0
Jun 2025	$0	$0	$0
Jun 2026	$0	$0	$0
Jun 2027	$0	$0	$0
Jun 2028	$0	$0	$0
Jun 2029	$0	$0	$0
Jun 2030	$0	$0	$0
Jun 2031	$0	$0	$0
Jun 2032	$0	$0	$0
Jun 2033	$0	$28,000	$28,000
Jun 2034	$0	$0	$0
Jun 2035	$0	$0	$0
Jun 2036	$0	$0	$0
Jun 2037	$0	$0	$0
Jun 2038	$0	$0	$0
Jun 2039	$0	$0	$0
Jun 2040	$0	$0	$0
Jun 2041	$0	$0	$0
Jun 2042	$0	$0	$0
Jun 2043	$0	$0	$0
Jun 2044	$0	$0	$0
Jun 2045	$0	$0	$0
Jun 2046	$0	$0	$0
Total	$5,579,825	$28,000	$5,607,825

Operating-Related Costs

Year Beginning	Recurring Energy	Consumption	Energy Demand	Energy Rebate	Total
Jun 2017	$0	$0	$0	$0	$0
Jun 2018	$21,418	$435,002	$28,446	$0	$484,866
Jun 2019	$21,418	$444,112	$29,042	$0	$494,572
Jun 2020	$21,418	$453,388	$29,649	$0	$504,454
Jun 2021	$21,418	$462,857	$30,268	$0	$514,543
Jun 2022	$21,418	$472,524	$30,900	$0	$524,842
Jun 2023	$21,418	$482,420	$31,547	$0	$535,385
Jun 2024	$21,418	$492,496	$32,206	$0	$546,120
Jun 2025	$21,418	$502,782	$32,879	$0	$557,079
Jun 2026	$21,418	$513,283	$33,566	$0	$568,266
Jun 2027	$21,418	$524,032	$34,269	$0	$579,719
Jun 2028	$21,418	$534,977	$34,984	$0	$591,379
Jun 2029	$21,418	$546,150	$35,715	$0	$603,283
Jun 2030	$21,418	$557,557	$36,461	$0	$615,436
Jun 2031	$21,418	$569,234	$37,224	$0	$627,877
Jun 2032	$21,418	$581,123	$38,002	$0	$640,543
Jun 2033	$21,418	$593,260	$38,796	$0	$653,474
Jun 2034	$21,418	$605,651	$39,606	$0	$666,674
Jun 2035	$21,418	$618,335	$40,435	$0	$680,188
Jun 2036	$21,418	$631,249	$41,280	$0	$693,947
Jun 2037	$21,418	$644,433	$42,142	$0	$707,993
Jun 2038	$21,418	$657,893	$43,022	$0	$722,333

Jun 2039	$21,418	$671,671	$43,923	$0	$737,012
Jun 2040	$21,418	$685,699	$44,841	$0	$751,958
Jun 2041	$21,418	$700,020	$45,777	$0	$767,216
Jun 2042	$21,418	$714,641	$46,733	$0	$782,792
Jun 2043	$21,418	$729,608	$47,712	$0	$798,738
Jun 2044	$21,418	$744,846	$48,708	$0	$814,972
Jun 2045	$21,418	$760,402	$49,726	$0	$831,546
Jun 2046	$21,418	$776,240	$50,761	$0	$848,419
Total	$621,122	$17,105,884	$1,118,622	$0	$18,845,627

Sum of All Cash Flows

Year Beginning	Capital	OM&R	Total
Jun 2017	$5,579,825	$0	$5,579,825
Jun 2018	$0	$484,866	$484,866
Jun 2019	$0	$494,572	$494,572
Jun 2020	$0	$504,454	$504,454
Jun 2021	$0	$514,543	$514,543
Jun 2022	$0	$524,842	$524,842
Jun 2023	$0	$535,385	$535,385
Jun 2024	$0	$546,120	$546,120
Jun 2025	$0	$557,079	$557,079
Jun 2026	$0	$568,266	$568,266
Jun 2027	$0	$579,719	$579,719
Jun 2028	$0	$591,379	$591,379
Jun 2029	$0	$603,283	$603,283
Jun 2030	$0	$615,436	$615,436
Jun 2031	$0	$627,877	$627,877
Jun 2032	$0	$640,543	$640,543
Jun 2033	$28,000	$653,474	$681,474
Jun 2034	$0	$666,674	$666,674
Jun 2035	$0	$680,188	$680,188
Jun 2036	$0	$693,947	$693,947
Jun 2037	$0	$707,993	$707,993
Jun 2038	$0	$722,333	$722,333
Jun 2039	$0	$737,012	$737,012
Jun 2040	$0	$751,958	$751,958
Jun 2041	$0	$767,216	$767,216
Jun 2042	$0	$782,792	$782,792
Jun 2043	$0	$798,738	$798,738
Jun 2044	$0	$814,972	$814,972
Jun 2045	$0	$831,546	$831,546
Jun 2046	$0	$848,419	$848,419
Total	$5,607,825	$18,845,627	$24,453,452

Alternative: Add air sampling system for DCV

Initial Capital Costs

Component: Copy of: Copy of:

Year Beginning	Total
Jun 2017	$5,775,995
Total	$5,775,995

Capital Investment Costs

Year Beginning	Initial	Replacement	Total
Jun 2017	$5,775,995	$0	$5,775,995
Jun 2018	$0	$0	$0
Jun 2019	$0	$0	$0
Jun 2020	$0	$0	$0
Jun 2021	$0	$0	$0
Jun 2022	$0	$0	$0
Jun 2023	$0	$0	$0
Jun 2024	$0	$0	$0
Jun 2025	$0	$0	$0
Jun 2026	$0	$0	$0
Jun 2027	$0	$0	$0
Jun 2028	$0	$0	$0
Jun 2029	$0	$0	$0
Jun 2030	$0	$0	$0
Jun 2031	$0	$0	$0
Jun 2032	$0	$0	$0
Jun 2033	$0	$28,000	$28,000
Jun 2034	$0	$0	$0
Jun 2035	$0	$0	$0
Jun 2036	$0	$0	$0
Jun 2037	$0	$0	$0
Jun 2038	$0	$0	$0
Jun 2039	$0	$0	$0
Jun 2040	$0	$0	$0
Jun 2041	$0	$0	$0
Jun 2042	$0	$0	$0
Jun 2043	$0	$0	$0
Jun 2044	$0	$0	$0
Jun 2045	$0	$0	$0
Jun 2046	$0	$0	$0
Total	$5,775,995	$28,000	$5,803,995

Operating-Related Costs

Year Beginning	Recurring	Energy Consumption	Energy Demand	Energy Rebate	Total
Jun 2017	$0	$0	$0	$0	$0
Jun 2018	$56,418	$235,952	$11,271	$0	$303,640
Jun 2019	$56,418	$240,893	$11,507	$0	$308,818
Jun 2020	$56,418	$245,924	$11,747	$0	$314,090
Jun 2021	$56,418	$251,061	$11,993	$0	$319,471
Jun 2022	$56,418	$256,304	$12,243	$0	$324,965
Jun 2023	$56,418	$261,672	$12,499	$0	$330,590
Jun 2024	$56,418	$267,137	$12,760	$0	$336,316
Jun 2025	$56,418	$272,717	$13,027	$0	$342,162
Jun 2026	$56,418	$278,412	$13,299	$0	$348,129
Jun 2027	$56,418	$284,243	$13,578	$0	$354,239
Jun 2028	$56,418	$290,180	$13,861	$0	$360,459
Jun 2029	$56,418	$296,240	$14,151	$0	$366,809
Jun 2030	$56,418	$302,428	$14,446	$0	$373,292
Jun 2031	$56,418	$308,761	$14,749	$0	$379,928
Jun 2032	$56,418	$315,210	$15,057	$0	$386,685
Jun 2033	$56,418	$321,793	$15,371	$0	$393,583
Jun 2034	$56,418	$328,514	$15,692	$0	$400,625

Jun 2035	$56,418	$335,394	$16,021	$0	$407,833
Jun 2036	$56,418	$342,399	$16,356	$0	$415,173
Jun 2037	$56,418	$349,550	$16,697	$0	$422,666
Jun 2038	$56,418	$356,851	$17,046	$0	$430,315
Jun 2039	$56,418	$364,325	$17,403	$0	$438,146
Jun 2040	$56,418	$371,934	$17,766	$0	$446,118
Jun 2041	$56,418	$379,702	$18,137	$0	$454,257
Jun 2042	$56,418	$387,632	$18,516	$0	$462,566
Jun 2043	$56,418	$395,750	$18,904	$0	$471,073
Jun 2044	$56,418	$404,016	$19,299	$0	$479,733
Jun 2045	$56,418	$412,454	$19,702	$0	$488,574
Jun 2046	$56,418	$421,045	$20,112	$0	$497,575
Total	$1,636,122	$9,278,495	$443,211	$0	$11,357,828

Sum of All Cash Flows

Year Beginning	Capital	OM&R	Total
Jun 2017	$5,775,995	$0	$5,775,995
Jun 2018	$0	$303,640	$303,640
Jun 2019	$0	$308,818	$308,818
Jun 2020	$0	$314,090	$314,090
Jun 2021	$0	$319,471	$319,471
Jun 2022	$0	$324,965	$324,965
Jun 2023	$0	$330,590	$330,590
Jun 2024	$0	$336,316	$336,316
Jun 2025	$0	$342,162	$342,162
Jun 2026	$0	$348,129	$348,129
Jun 2027	$0	$354,239	$354,239
Jun 2028	$0	$360,459	$360,459
Jun 2029	$0	$366,809	$366,809
Jun 2030	$0	$373,292	$373,292
Jun 2031	$0	$379,928	$379,928
Jun 2032	$0	$386,685	$386,685
Jun 2033	$28,000	$393,583	$421,583
Jun 2034	$0	$400,625	$400,625
Jun 2035	$0	$407,833	$407,833
Jun 2036	$0	$415,173	$415,173
Jun 2037	$0	$422,666	$422,666
Jun 2038	$0	$430,315	$430,315
Jun 2039	$0	$438,146	$438,146
Jun 2040	$0	$446,118	$446,118
Jun 2041	$0	$454,257	$454,257
Jun 2042	$0	$462,566	$462,566
Jun 2043	$0	$471,073	$471,073
Jun 2044	$0	$479,733	$479,733
Jun 2045	$0	$488,574	$488,574
Jun 2046	$0	$497,575	$497,575
Total	$5,803,995	$11,357,828	$17,161,823

Alternative: Recommended Bundle of Measures

Initial Capital Costs

Component:

Year Beginning	Total
Jun 2017	$4,553,295
Total	$4,553,295

Capital Investment Costs

Year Beginning	Initial	Replacement	Total
Jun 2017	$4,553,295	$0	$4,553,295
Jun 2018	$0	$0	$0
Jun 2019	$0	$0	$0
Jun 2020	$0	$0	$0
Jun 2021	$0	$0	$0
Jun 2022	$0	$0	$0
Jun 2023	$0	$0	$0
Jun 2024	$0	$0	$0
Jun 2025	$0	$0	$0
Jun 2026	$0	$0	$0
Jun 2027	$0	$0	$0
Jun 2028	$0	$0	$0
Jun 2029	$0	$0	$0
Jun 2030	$0	$0	$0
Jun 2031	$0	$0	$0
Jun 2032	$0	$0	$0
Jun 2033	$0	$28,000	$28,000
Jun 2034	$0	$0	$0
Jun 2035	$0	$0	$0
Jun 2036	$0	$0	$0
Jun 2037	$0	$0	$0
Jun 2038	$0	$0	$0
Jun 2039	$0	$0	$0
Jun 2040	$0	$0	$0
Jun 2041	$0	$0	$0
Jun 2042	$0	$0	$0
Jun 2043	$0	$0	$0
Jun 2044	$0	$0	$0
Jun 2045	$0	$0	$0
Jun 2046	$0	$0	$0
Total	$4,553,295	$28,000	$4,581,295

Operating-Related Costs

Year Beginning	Recurring	Energy Consumption	Energy Demand	Energy Rebate	Total
Jun 2017	$0	$0	$0	$0	$0
Jun 2018	$51,272	$256,996	$11,271	$0	$319,539
Jun 2019	$51,272	$262,378	$11,507	$0	$325,157
Jun 2020	$51,272	$267,858	$11,747	$0	$330,877
Jun 2021	$51,272	$273,452	$11,993	$0	$336,717
Jun 2022	$51,272	$279,164	$12,243	$0	$342,679
Jun 2023	$51,272	$285,010	$12,499	$0	$348,782
Jun 2024	$51,272	$290,963	$12,760	$0	$354,995
Jun 2025	$51,272	$297,040	$13,027	$0	$361,339
Jun 2026	$51,272	$303,244	$13,299	$0	$367,815
Jun 2027	$51,272	$309,595	$13,578	$0	$374,444
Jun 2028	$51,272	$316,061	$13,861	$0	$381,194
Jun 2029	$51,272	$322,662	$14,151	$0	$388,084
Jun 2030	$51,272	$329,401	$14,446	$0	$395,119
Jun 2031	$51,272	$336,289	$14,749	$0	$402,330

Jun 2031	$51,272	$336,299	$14,749	$0	$402,320	
Jun 2032	$51,272	$343,323	$15,057	$0	$409,652	
Jun 2033	$51,272	$350,494	$15,371	$0	$417,137	
Jun 2034	$51,272	$357,814	$15,692	$0	$424,778	
Jun 2035	$51,272	$365,308	$16,021	$0	$432,601	
Jun 2036	$51,272	$372,937	$16,356	$0	$440,565	
Jun 2037	$51,272	$380,726	$16,697	$0	$448,696	
Jun 2038	$51,272	$388,678	$17,046	$0	$456,996	
Jun 2039	$51,272	$396,818	$17,403	$0	$465,493	
Jun 2040	$51,272	$405,106	$17,766	$0	$474,144	
Jun 2041	$51,272	$413,567	$18,137	$0	$482,976	
Jun 2042	$51,272	$422,205	$18,516	$0	$491,993	
Jun 2043	$51,272	$431,047	$18,904	$0	$501,223	
Jun 2044	$51,272	$440,050	$19,299	$0	$510,620	
Jun 2045	$51,272	$449,240	$19,702	$0	$520,214	
Jun 2046	$51,272	$458,597	$20,112	$0	$529,981	
Total	$1,486,888	$10,106,032	$443,211	$0	$12,036,131	

Sum of All Cash Flows

Year Beginning	Capital	OM&R	Total
Jun 2017	$4,553,295	$0	$4,553,295
Jun 2018	$0	$319,539	$319,539
Jun 2019	$0	$325,157	$325,157
Jun 2020	$0	$330,877	$330,877
Jun 2021	$0	$336,717	$336,717
Jun 2022	$0	$342,679	$342,679
Jun 2023	$0	$348,782	$348,782
Jun 2024	$0	$354,995	$354,995
Jun 2025	$0	$361,339	$361,339
Jun 2026	$0	$367,815	$367,815
Jun 2027	$0	$374,444	$374,444
Jun 2028	$0	$381,194	$381,194
Jun 2029	$0	$388,084	$388,084
Jun 2030	$0	$395,119	$395,119
Jun 2031	$0	$402,320	$402,320
Jun 2032	$0	$409,652	$409,652
Jun 2033	$28,000	$417,137	$445,137
Jun 2034	$0	$424,778	$424,778
Jun 2035	$0	$432,601	$432,601
Jun 2036	$0	$440,565	$440,565
Jun 2037	$0	$448,696	$448,696
Jun 2038	$0	$456,996	$456,996
Jun 2039	$0	$465,493	$465,493
Jun 2040	$0	$474,144	$474,144
Jun 2041	$0	$482,976	$482,976
Jun 2042	$0	$491,993	$491,993
Jun 2043	$0	$501,223	$501,223
Jun 2044	$0	$510,620	$510,620
Jun 2045	$0	$520,214	$520,214
Jun 2046	$0	$529,981	$529,981
Total	$4,581,295	$12,036,131	$16,617,426