Affordable Housing Energy Efficiency Demonstration Project

INTEGRATED ENERGY MASTER PLAN

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ALL ONE SKY FOUNDATION

1 EXECUTIVE SUMMARY

This project is a joint partnership between All One Sky Foundation, the Calgary Housing Corporation (CHC), and Environmental & Safety Management (ESM) and Infrastructure & Information Services (IIS) of the City of Calgary. It is funded through the Council Innovation Fund (CIF).

1.1 ENERGY POVERTY IS A REALITY IN CALGARY

Many households experience pressure in paying their utility bills. These pressures are most acute among low-income families and individuals. The poorest 20 per cent of households in Alberta spent about $1,865 on utility bills in 2011, equivalent to about 10 per cent of their after-tax income. In contrast, the richest 20 per cent of households spent under 2.5 per cent of their after-tax income on utility bills (i.e., four time less). This seems grossly inequitable. Worryingly, the figure for the poorest households very likely understates their true ‘energy burden’ and the disparity with the richest households, since utility costs are often included in non-market rents.

The costs incurred to maintain a satisfactory heating regime as a ratio of after-tax household income is often used to measure the extent of energy poverty in a population. In many jurisdictions a household is considered to be ‘energy poor’ if it needs to spend 10 per cent or more of its after-tax income to maintain a satisfactory heating regime. By this definition, about 42,500 households in Calgary are in a state of energy poverty.

1.2 ENERGY POVERTY IS A SERIOUS PROBLEM

The poorest households are unlikely to be able to address key factors that determine the energy costs they face—namely, the energy efficiency and age of their home. Addressing these factors requires a level of expenditure that is almost certainly beyond what is affordable for the lowest income families and individuals. They can, nonetheless, more readily adjust expenditures on other goods and services. Faced with such choices, two outcomes of concern arise: a low-income household may either reduce spending on energy at the expense of maintaining an adequately warm home; or it may prioritize spending on keeping the home warm, but reduce spending on other necessities (e.g., food and education) potentially resulting in other forms of deprivation. In either case, low-income households face a lower standard of living, and may experience a range of adverse impacts on health and well-being.

Most of the evidence of health impacts linked to energy poverty relate to living at low temperatures. Key health impacts associated, directly and indirectly, with energy poverty include excess winter deaths, increased incidence of cardiovascular disease, respiratory disease, colds and flu, mental health issues, and accidents in the home, as well as poor nutrition. Elderly people, very young children, and people with a long-term sickness or disability are particularly vulnerable. The adverse impacts of energy poverty extend beyond those related to physical and mental health. A number of wider social impacts have been identified, including social isolation and exclusion, and increased truancy, anti-social behavior and educational attainment.

The persistence of energy poverty in Calgary is also a concern for achieving the goals of the Calgary Community GHG Reduction Plan. The poorest households tend to live in some of the oldest and least energy efficient buildings in Calgary—e.g., only 9 per cent of the nearly 600 buildings with non-market rental units in the city were built within the last 20 years. Buildings constructed before the mid-1980s use, on average, 75-100 per cent more energy per square meter than those built recently. The scope for large energy and GHG emission savings in low-income properties is thus significant. Despite this potential, low-income households are very unlikely to be able to participate in efforts to improve the energy efficiency of their homes. Relative to average households, low-income households need much higher levels of up-front technical and financial assistance to upgrade their homes. In the absence of comprehensive support they will be excluded from any policy push to improve the energy efficiency of Calgary’s housing stock. Not only is this an undesirable, regressive outcome, it will compromise the cost-effectiveness of the overall Plan.

1.3 REDUCING ENERGY POVERTY IN CALGARY

Tackling energy poverty clearly offers a potential 'win-win-win' for several policy agendas—climate change mitigation and GHG emission reductions, health and well-being, and poverty alleviation. There are three broad types of policy response to take low-income households out of energy poverty, each focused on one of the key drivers of whether or not a household is energy poor: (1) incomes (response—increase incomes); (2) energy prices (response—manage the energy prices faced by the poorest households); and (3) home energy consumption (response—increase home energy efficiency and conservation). Of these options, the latter has been shown to be the most cost-effective way to make sustained reductions in energy burdens.

1.4 DEMONSTRATION PROJECT

The Calgary Housing Corporation (CHC) is in the midst of a capital investment program to renew the buildings it manages. Using one of the buildings scheduled for refurbishment in 2014 as a case study, the main objectives of this project are:

- To prove (or disprove) the business case for using comprehensive ('whole building') energy efficiency improvements to
  - reduce the energy burdens faced by low-income households and take them out of energy poverty;
  - free-up cash for property owners to extend capital renewal programs to more sites;
  - reduce GHG emissions cost-effectively;
- To create a replicable model for performing 'whole building' energy efficiency improvements of public and private affordable housing properties in Calgary;
- To develop tools to support the replicable model in practice, including:
  - a Financial Decision Support Tool to assist public and private providers of affordable housing assess the incremental costs, benefits ,and GHG emission savings of implementing integrated portfolios of energy saving measures;
  - a Tenant Engagement Guide to help public and private providers of affordable housing meaningfully engage their residents on behavioral change for energy conservation; and
- To form partnerships between social service and affordable housing agencies and the energy management and GHG mitigation community.

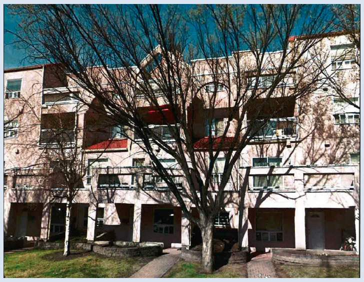
1.5 REPLICABLE MODEL FOR WHOLE BUILDING ENERGY EFFICIENCY UPGRADES

A replicable model for performing 'whole building' energy efficiency improvements of public and private affordable housing properties across Calgary comprises seven tasks:

1. **Select the building(s)**.

The reality is that most owners and managers of low-income housing will have limited financial resources. To maximize the contribution of energy efficiency improvements to energy poverty alleviation for a given level of spend, a number of factors should be considered when selecting sites (e.g., age and energy efficiency of building, past refurbishments or upgrades, unit size, nature or existing capital renewal plan, tenant pays utility bills, etc.). Bearing these factors in mind a CHC property scheduled for refurbishment in 2014—Bankview 1—was selected as a case study.

Box 1: Case Study Building – Bankview 1



Bankview 1 building is a low-rise apartment block constructed in 1982. It has a gross conditioned area of 28,312 ft^2 (2,630 m^2), including the underground parkade with 18 vehicle stalls. There are 26 separate apartments, including 3 in the basement level, each with street-level entry, and 23 units in the three above-ground storeys. Residential suites are individually metered for electricity, but not for natural gas. Residents are obliged to have private contracts for electricity supply, and the CHC divides the natural gas bill based on the floor area of each suite.

The building is in reasonably good condition for its age and the energy consumption is in the middle of the range for similar building types of this vintage.

2. **Review the existing capital refurbishment program for the selected building(s)**.

For deep energy efficiency upgrades to be most cost-effective, the upgrades need to be aligned and integrated with planned building refurbishments and equipment replacement. A key task is to review the existing refurbishment plan for the building, and in particular identify planned upgrades that will have implications for energy use. The focus of the business case is the incremental cost of energy efficiency improvements and the associated incremental energy savings that are additional to the planned capital refurbishment plan for the building.

The existing capital renewal plan for Bankview 1 includes upgrading the insulation in the north and south walls, and replacing all windows and exterior steel doors with moderately more efficient units. These upgrades define the project *Reference Case* against which additional energy efficiency improvements to the building are appraised. Analytically, the situation that could exist following any additional improvements defines the *Low Carbon Case*, while the situation that exists prior to the existing planned upgrades defines the project *Base Case*.

3. **Undertake energy (audit) assessment**.

The third task involves identifying where, and how much, energy is consumed in the building. To this end, ATCO Energy Sense was commissioned to perform a standard energy audit of Bankview 1 in May 2014. The project team separately took infra-red images of the building to identify areas of heat loss. The audit summarized energy use by different systems at the site under Base Case conditions and provided a provisional list of recommended energy efficiency improvements, encompassing communal lighting, the mechanical systems, the building envelope, and communal laundry facilities.

In 2013 energy consumption at Bankview 1 comprised 2,169 GJ of natural gas and 47,620 kWh of electricity (excluding electricity use in the rental units). The project team separately estimated potable water consumption at 6,505 liters per day. Electricity consumption by residents within the rental units was estimated at 282 kWh per day.

The information provided by the audit and the infra-red images served as a basis for the development of an energy model for the building.

4. **Build and calibrate energy model**.

Buildings are like systems. They comprise many materials and components which work together to determine overall energy use. Evaluating energy efficiency improvements in isolation of each other, and without accounting for external factors (e.g., exposure to sunlight, humidity, and external temperature) will likely (over)understate actual savings and costs. When appraising ‘whole building’ energy efficiency upgrades it is thus necessary to use a computer simulation model to capture interactions between building components and the influence of external factors. Using architectural, mechanical, and electrical drawings provided by the CHC, the project team developed a comprehensive energy simulation model of Bankview 1 in the Hot2000 software—a free software package available from Natural Resources Canada’s CanmetENERGY group. The model was constructed to reflect Base Case conditions and calibrated to match monthly utility bills averaged over the past three years. With the model calibrated to the actual utility billing data, the project team could model the project Reference Case and Low Carbon Case with reasonable confidence.

Whole building energy consumption under the project Base Case is 2,598 GJ. The corresponding GHG emissions are 205 t CO_2-eq per year. Whole building energy consumption under the project Reference Case, which includes three planned improvements to the building envelope, is 2,402 GJ. The corresponding GHG emissions are about 5 per cent lower than the project Base Case—at 195 t CO_2-eq per year.

5. **Identify additional energy saving opportunities**.

The next task involves identifying energy savings opportunities additional to those in the project Reference Case. In total, twenty-two potential energy efficiency upgrades (encompassing windows, doors, lighting, wall insulation, deck insulation, roof insulation, draft proofing, heating controls, boilers, water heaters, appliances, laundry facilities, and water use in rental units) and two renewable energy projects (solar thermal hot water and solar photovoltaic (PV) power) were identified for Bankview 1. The chosen upgrades are based on recommendations contained in the energy audit and the project team's own examination of the building and the planned capital renewal plan.

6. **Iteratively appraise identified opportunities**.

The penultimate task consists of, first, evaluating the financial and environmental performance of each identified energy saving opportunity, and second, to create and evaluate portfolios of opportunities for Bankview 1. Energy saving opportunities and portfolios are appraised on the basis of incremental discounted cash flows, where:

Energy savings = Discounted lifetime energy use at building under project Reference Case *less* discounted lifetime energy use at building with energy saving opportunity installed under project Low Carbon Case; and

Costs = Discounted lifetime costs (capital and annual O&M costs, net of available financial incentives) of energy saving opportunity *less* discounted lifetime costs of Reference Case upgrade. Costs are defined to reflect the full price paid by the property owner, including equipment costs, material costs, labor costs, and overhead and profit.

Water savings and reductions in GHG emissions are similarly defined. Opportunities are appraised using a variety of standard financial decision criteria, including Net Present Value (NPV). The analysis is performed using the Financial Decision Support Tool and conducted from two perspectives: (1) *private* (benefits include the dollar value of lifetime utility bill reductions only); and (2) *public* (in addition to private benefits, the dollar value of lifetime GHG emission reductions are included).

Four portfolios of energy savings opportunities where constructed: (1) *LCC-Max* which maximizes lifetime GHG emission reductions, regardless of costs; (2) *LCC-Private* which maximizes NPV to property owners or managers; (3) *LCC-Public* which maximizes NPV from cost-effective reductions in GHG emissions; and (4) *LCC-Social* which maximizes the NPV from cost-effective reductions in GHG emissions and energy poverty.

Table 1: Financial and Environmental Performance of Low Carbon Case (LCC) Portfolios

	LCC-Max	LCC-Private	LCC-Public	LCC-Social
Total energy saving projects	19	10	12	13
Investment costs	$434,900	$159,500	$197,200	$237,800
Lifetime energy savings	$613,700	$416,900	$475,900	$525,800
Lifetime water savings	$116,200	$116,200	$116,200	$116,200
Average annual bill savings	$18,200	$13,300	$14,800	$16,100
Lifetime GHG emission savings	2,710 t CO_2-eq	1,610 t CO_2-eq	1,950 t CO_2-eq	2,250 t CO_2-eq
Reduction on Reference Case	41%	26%	31%	35%

7. **Formulate recommendations**.

The final task is to formulate a package of recommended energy efficiency, conservation, and clean energy projects for consideration by the property owner or manager for inclusion within a modified capital renewal program for the building. The recommended portfolio of additional energy saving opportunities for Bankview 1—in terms of striking the best balance between (public and private) NPV and lifetime GHG emission savings—is LCC-Public. The portfolio includes:

Installing low-flow faucet aerators in in all apartments;	Upgrading all windows to achieve R5 and increase window air tightness from CSA A1 to A2;
Installing low-flow showerheads in all apartments;	Replacing existing electric clothes dryers with natural gas dryers;
Weather stripping and air sealing to increase building air tightness from 'loose' to 'average' (4.5 ACH @ 50 Pa);	Upgrading lighting in apartments (full LED package);
Replacing existing communal clothes washing machines with Energy Star qualified appliances;	Installing programmable thermostats in all apartments;
Upgrading lighting in common areas (T12 to T8, plus CFL to LED);	Installing a solar PV system, 72 panels with PTC rating of 221 W (15.9 kW installed capacity);
Upgrading hot water heaters from existing tanks to condensing units (seeking improvement in efficiency = 30%); and	Upgrading all patio doors with Energy Star in-swing French Doors to achieve R 3.85.

Annual operating cost savings amount to about $350 per resident. For the poorest 20 per cent of households in Alberta spend, utility bill savings of this magnitude would:

- Cover the cost of health care for 12 weeks;
- Cover the cost of education for 20 weeks;
- Cover the cost of public transport for 26 weeks; or
- Cover the cost of food for four weeks.

1.6 THE BIGGER PICTURE

Bankview 1 comprises 26 non-market rental units and is currently "of average efficiency" for its age. There are about 11,760 non-market rental units for low-income families and individuals in the Calgary. About 72 per cent of these units are in buildings roughly the same age as Bankview 1. If these buildings underwent a similar energy efficiency upgrade as part of a planned capital refurbishment program, the outcomes would be very significant:

- Lifetime energy savings of 8.9 PJ;
- Lifetime net benefits for low-income households of $51.6 million in present value terms;
- Average energy bill savings of about $3.9 million per year;
- Average water bill savings of about $0.9 million per year;
- Average total operating cost savings of about $4.8 million per year; and
- Lifetime GHG emission savings of 0.6 Mt CO_2-eq.

Clearly, a program of energy efficiency upgrades in low-income buildings at this scale would put a huge dent in energy poverty in Calgary, and generate significant 'win-win-wins' for poverty alleviation, health and well-being, and climate change mitigation.