DEVELOPING MUNICIPAL POLICY AND PROGRAMS TO ACCELERATE MARKET TRANSFORMATION IN THE BUILDING SECTOR

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INTRODUCTION

Edmonton's cold climate and strong economic connections to the energy sector have made energy vital to the city's quality of life. The fossil fuel industry has helped the city's economy grow and Edmonton boasts one of the lowest unemployment rates in Canada at just over four percent. But Edmonton's economic prosperity does not shelter it from the realities of global environmental challenges. Just like other jurisdictions, climate change and the possibility of future energy constraints means that Edmonton must reevaluate its sources and use of energy across all sectors, including its buildings.

To this end, on June 20, 2012, the Edmonton City Council approved the Green Building Plan and Policy, designed to help accelerate the greening of Edmonton's building stock. The policy outlines the strong role the city of Edmonton can play in supporting a green building sector to improve the environmental, health, and socioeconomic performance of all existing and new commercial, institutional, industrial, mixed-use, multifamily residential, and single-family residential buildings in Edmonton. The policy goes on to provide the mandate for the city to lead and support the delivery of public and industry education campaigns, provide incentives and engage in capacity-building activities, and use its authority in land-use planning and development approvals to help transform the local green building market.

The Green Building Plan outlines the high-level approach and details a suite of tools and programs that will help Edmonton achieve its Green Building Policy. The information and recommendations in the plan are the results of collaboration between the city of Edmonton and building industry representatives. Over the course of nearly a year, from the autumn of 2010 to the autumn of 2011, the city of Edmonton coordinated conversations, meetings, and workshops to confirm the case for action, understand market transformation theory and how it could be applied in Edmonton, clarify the role of local government, and research local market conditions in an effort to develop an implementation approach that will make the policy reality. Using a Community Energy and Emissions Mapping and Planning (CEEMAP) tool and assisted by HB Lanarc (now Golder Associates), the city of Edmonton evaluated the energy and emissions implications of program implementation.

KEYWORDS

municipal planning, green building policy, climate change mitigation, building energy mapping, residential GHG emissions

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THE CASE FOR ACTION: IDENTIFYING THE CHALLENGES & BARRIERS

When *The Way We Green*—Edmonton's Environmental Strategic Plan—was developed in 2011, significant effort was made to understand the environmental challenges facing the city, including climate change, energy scarcity, loss of biodiversity, water quality and quantity, air quality, and food systems and waste management. To obtain a clear understanding of these complex challenges, the city engaged experts from various fields to produce over twenty papers on the top environmental issues facing the globe and help the city understand how these issues could impact Edmonton's long-term sustainability and resiliency.

Many of these papers, particularly those relating to greenhouse gases, energy, and ecological footprint, highlighted the importance of the building stock in finding solutions to the sustainability challenges Edmonton was facing. As a result of the in-depth research into the fundamental environmental challenges facing human society today, the city's objective of greening its present and future building stock is driven and supported by a compelling logic for action and an associated understanding of the risks in doing nothing. Although building and retrofitting buildings to higher performance standards can positively impact other components of sustainability (e.g., restoration of biodiversity), the twin challenges of climate change and possible future energy constraints emerged as the primary drivers of the Green Building Policy and Plan. But how does Edmonton's building stock factor into these challenges and how can Edmonton's buildings contribute to the solutions?

Contributing to Climate Change Mitigation

The city of Edmonton is committed to reducing its greenhouse gas (GHG) emissions with an aspirational goal of achieving the sustainable end-state of carbon neutrality. The city has been monitoring its GHGs since 1997 for both its own operations and the greater community. Figure 1 shows the general trend from 1990 to 2008. In 2011, buildings generated nearly 60 percent of Edmonton's greenhouse gases. This is generally higher than other jurisdictions for a number of reasons, one of which is the carbon intensity of the Alberta electricity grid. Although electricity makes up only 20 percent of the energy used in Edmonton, it contributes to more than 40 percent of the GHG emissions. If Edmonton is to move

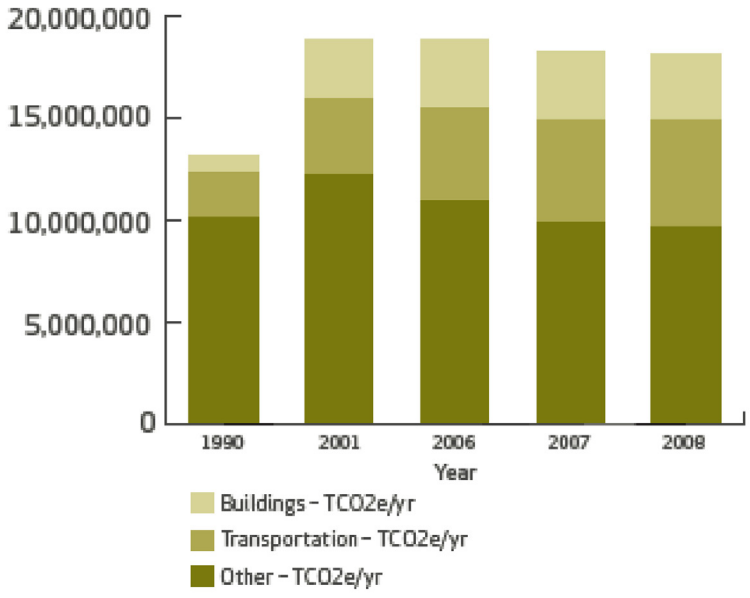


FIGURE 1. Edmonton's Greenhouse Gas Emission by Sector.

towards its long-term sustainability goal of carbon neutrality, significant effort needs to be made to transform its building stock to be more efficient while at the same time transitioning to low-carbon energy sources.

Energy Vulnerability Assessment

Energy vulnerability indicates potential financial challenges or hardship that residents face as their energy spending increases versus their income.[1] Residents who are particularly vulnerable are typically lower-income residents who live in older dwellings that have not been upgraded and who do not have practical alternatives to driving to work or other necessary destinations, such as using transit, walking, or cycling.

Those households that are energy vulnerable are sensitive not only to ongoing energy spending, but also susceptible to energy price volatility, or "price shocks." Improving the efficiency of buildings, in combination with improvements in public transit and location efficiency, will limit the impacts of both long-term price increases and shorter-term price volatility.

To conduct an analysis of energy spending vulnerability, the following factors are taken into account:

- Average household income
- Average annual cost of energy

The results of the work conducted indicated that today approximately 50 percent of households in Edmonton are considered vulnerable to escalating and/or volatile energy costs, as Figure 2 shows. Table 1 outlines the baseline and two energy spending forecasts, one that assumes relatively modest increase in energy prices and a second that uses a higher price forecast. Both of the price forecasts were developed using published forecasts for the Edmonton region. Energy spending and vulnerability was forecasted for three different scenarios including a reference scenario (i.e., business as usual), a reduced-carbon scenario representing modest policy changes, and a low-carbon scenario that represents an aggressive policy approach to promoting a low-energy, low-carbon future.

Lowering energy costs can be achieved through promoting location efficiency (live-work-play communities), increasing transit and active transportation options, and increased building efficiency. The energy vulnerability assessment provided additional reasons to move forward with implementation of policy tools and programming to green Edmonton's building stock. Pursuing greener buildings can be shown to not only contribute to environmental objectives but also to the objective of building a socially sustainable and economically competitive city. Greater efficiency can significantly decrease operating costs for businesses that locate within Edmonton, as well as reduce household vulnerability to price shocks, making it a more attractive place to live and work. The concept of Total Affordability (capital + operating) is a key concept that helps to provide support for potential increases in capital costs (green premiums) as the market transitions to greener products. The focus on reducing energy vulnerability is particularly significant for lower-income households, as they are less likely to be able reallocate disposable income to meet the increasing energy costs.

[1]For the purposes of the Green Building program a household was defined as "energy vulnerable" if it spends a share of income on energy that is twice that of a household with median income in the specific jurisdiction being reviewed. This leads to defining energy vulnerability in the context of the specific location where the assessment is being done. In Edmonton, energy vulnerability is defined as those households that are spending 10% of their income on energy.

FIGURE 2. Share of Energy Vulnerable Households.

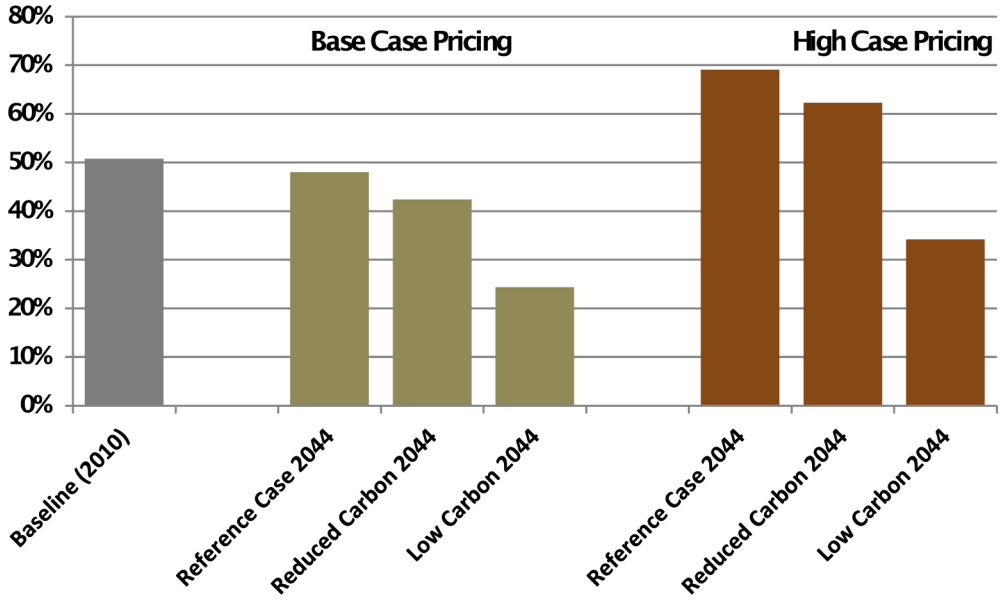


TABLE 1. Energy Vulnerability Summary Table.

Pricing	Scenario	Average annual spending on energy		"Energy vulnerable" share of total households
		per capita	household	
Baseline	Baseline (2010)	$1,550	$3,565	51%
Base Case Pricing[2]	Reference 2044	$1,580	$3,318	48%[2]
	Reduced Carbon 2044	$1,410	$2,961	42%
	Low Carbon 2044	$770	$1,617	24%
High Pricing	Reference 2044	$2,400	$5,040	69%
	Reduced Carbon 2044	$2,130	$4,473	62%
	Low Carbon 2044	$1,130	$2,373	34%

APPLYING MARKET TRANSFORMATION THEORY

The idea of using Market Transformation Theory (see Figure 3) as a way to structure the city of Edmonton's environmental policy and develop program implementation frameworks was formally introduced in *The Way We Green*. Market transformation theory is based on observing time and time again how innovations are adopted and diffused through society and the marketplace. New technologies like hybrid electric vehicles or new practices like smart growth will, with consumer interest, be taken up first by innovators, then early adopters, and successively larger and larger percentages of the market.

[2]Under base case pricing, the per household energy spending and vulnerability share decrease under the reference case in part because average household size (population per household) is assumed to decrease from 2.3 persons to 2.1 persons.

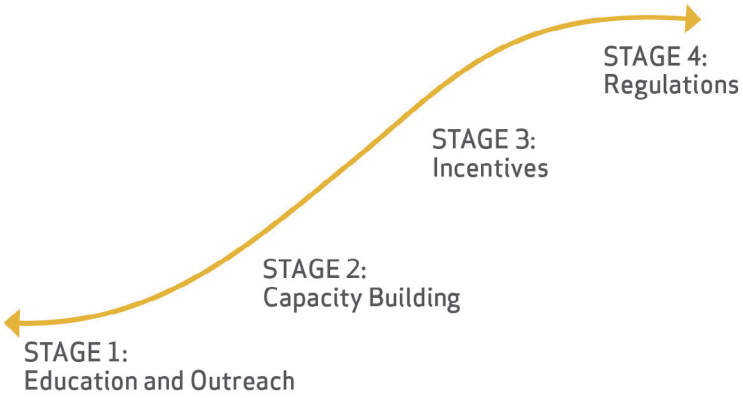


FIGURE 3. Market Transformation Curve.

One of the challenges the city had when developing an implementation approach that was based in Market Transformation Theory is that the theory is at times vague in the literature. In some ways the theory is an overall policy objective while at the same time it is a methodology that is close to being a programming strategy. Moreover, the theory attempts to root itself in economic theory, yet in practice it is much more like a social marketing approach to changing behaviours and influencing choices.

The *Way We Green* took some license with the theory by approaching the theory as not just a tool to shift the market but as a transformative framework that had the power to guide the shift of society to desired sustainable end-states. Fittingly, given the rooting of Market Transformation Theory in energy efficiency, the Green Building Policy and Plan is the first green plan in the city to take the time to research the components of Market Transformation Theory and understand the local conditions preventing market adoption of the desired outcomes. The result is a set of policy and programs which are targeted to directly remove the barriers identified in the local market that have prevented the shift to greener outcomes.

UNDERSTANDING REGULATORY CONTEXT AND LOCAL MARKET CONDITIONS

Market Transformation Theory suggests that policies designed to overcome specific barriers can dramatically accelerate the shift to greener buildings in the local market. Often, the municipal government has influence over these barriers if not direct control. The market transformation curve in Figure 3 explains the intervention of some of these policies over time. Although best practices can be gathered from other municipalities with an eye to applying them regionally, the applicability of those tools in the local jurisdiction is not clear without first clarifying the role of local government within the current system and understanding the local market conditions. Among many other design considerations, the local context will determine what tool is most appropriate at what time and with what constituency.

The Role of Local Government

Canada's provincial governments are responsible for the creation, modification, and elimination of municipal governments and control exactly which powers a municipal government is entitled to execute. The Government of Alberta enables local government, primarily through the Municipal Government Act (MGA), and secondarily through various other statutes and

regulations. Each local government is responsible for water and sewage, waste collection, public transit, land-use planning, civic services, emergency services, animal control, and economic development within its geographic boundaries.

Buildings and land use in Alberta are governed by a number of provincial acts and statutes, including the Municipal Government Act, the Safety Codes Act, and the Building Code. Taken together, these regulations provide the framework within which local governments are able to set their own bylaws with respect to green building measures. Under the Municipal Government Act, local governments in Alberta may pass bylaws for municipal purposes respecting a number of areas, including "the safety, health, and welfare of people and the protection of people and property." However, Section 66(1) of the Safety Codes Act states: "a bylaw of a municipality that purports to regulate a matter that is regulated by this Act is inoperative." Therefore, the Safety Codes Act and the Building Code prohibits local governments in Alberta from creating bylaws that interfere or present concurrent authority on a topic already regulated.

However, local governments are able to create bylaws in areas that are not addressed or regulated by the Act and Building Code. It is within this area that bylaws for green buildings may be feasible for local governments to pursue including, but not limited to, the efficiency of water- and energy-using devices, the energy efficiency of existing buildings, energy generation requirements, water use and disposal, waste generation and disposal, and energy labeling requirements.

That being said, regulations are often deemed by industry as onerous and inflexible and as barriers to the natural evolution of the market. Perhaps more important than their ability to create bylaws, local governments have a unique opportunity to interface with the various market players and implement enabling programs around education, industry capacity building, and incentives. These other components of market transformation are often necessary precursors to regulation that can be undervalued by policy makers. In fact, these components alone can lead to the market becoming self-selecting for the desired outcome by sending appropriate and sustained price signals to the market players.

Benchmarking & Local Market Assessment

While developing the Green Building Plan, stakeholders, senior administration, and political leaders sent strong messages that a made-in-Edmonton approach to encouraging green buildings was required. Therefore, effort was made to understand the local conditions, seek input and advice from industry and other stakeholders, and get an idea about how green Edmonton was building today compared to other jurisdictions. An analysis of industry capacity to supply a green product, the local barriers to adopting green building practices, and the levels of demand for green buildings was conducted so that a justifiable, evidence-based program could be developed.

Benchmarking

While developing the Green Building Plan, mixed messages were observed with respect to the current level of green being delivered in the market. There was (and continues to be) a lack of quantifiable data to establish a baseline of where Edmonton was with respect to market transformation. Despite the challenges with respect to available data, the current status of Edmonton's building stock was deemed an important piece of information and effort was made to obtain a better understanding of its relative greenness. For the municipality to

effectively implement programs that accelerate market transformation, a general baseline of the market was required.

The benchmarking analysis established baseline information on the performance of Edmonton's buildings in a number of key categories, and then compared this with baseline performance in other comparable cities (where possible), as well as with high performers inside and outside of Edmonton. Key benchmarking categories examined were: Energy and Emissions; Household Water Use; and Green Building Certification.

Building Energy Mapping. Figure 4 shows energy intensities for homes by census dissemination area. The mapping exercise shows that there is a relationship between home location, age, and energy consumption, whereby older homes generally use more energy per square metre than newer homes. Although this may not be a revelation for many, the visual tool is

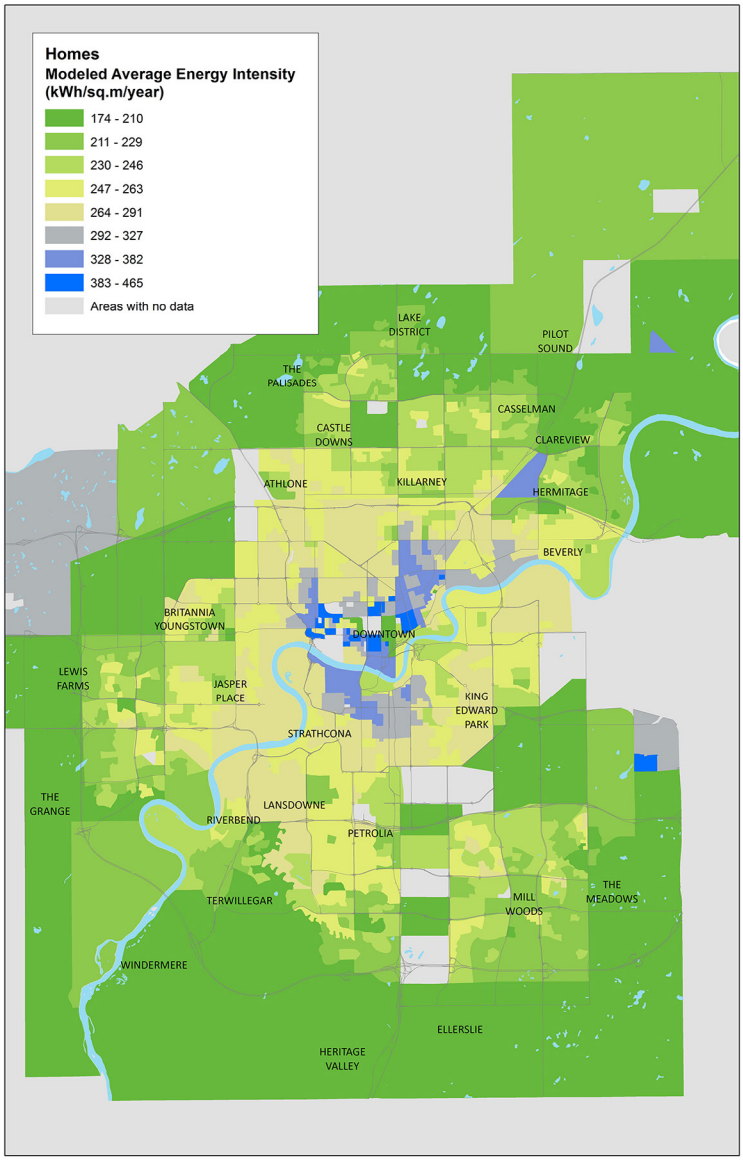


FIGURE 4. Modeled Average Energy Intensity (KWh/Sq.m/year) for Homes.

an excellent way to quickly show decision makers and the public the differences in energy use of different ages of homes. It also helps to highlight how important the retrofitting of existing homes is when talking about improving the energy resiliency of the community. The maps can also be used to show the opportunity and rationale for targeting certain areas or neighbourhoods for potential energy retrofit efforts.

Modeled residential GHG emissions per person, including both buildings and transportation, are shown in Figure 5. Although Edmonton's Green Building Plan is designed to focus on lot-level construction, it was important to not totally ignore the importance of location efficiency when doing the benchmarking/baseline analysis. Residential GHG emissions are affected strongly by both building efficiency and location efficiency. As the map shows, although energy efficiency of newer homes in the suburbs is greater than older homes in mature areas, transportation emissions are higher in the suburbs. Again, this is not a revolutionary concept, but the visual is an excellent communication device when discussing the need for smart growth programs with decision makers and stakeholders.

Building Energy and Emissions Mapping Methodology. Within each Dissemination Area (DA) unit of analysis, the total building energy consumption is estimated by multiplying the total floor area of each building type by average energy intensity for that type; average energy intensity is then calculated by dividing energy by floor area for that DA. Energy intensities for each building type are based on Natural Resources Canada data, and modified by the average building age for that area. Figure 5 is based on modeling GHG emissions from residential transportation plus emissions associated with building energy consumption. The buildings methodology is similar to that described for the previous map; instead of adjusting for location-based building age the buildings methodology uses Alberta average intensity figures for each building type. The transportation methodology is based on a spatialized implementation of the Canadian Mortgage and Housing Corporation/IBI land use/transportation model, driven by Edmonton demographics, land use, and transportation information. Total modeled emissions in each DA are divided by the estimated population in that DA to estimate a per-resident value.

Market Assessment & Green Building Plan's Response

The research shows evidence that there is a positive business case for green buildings in many North American jurisdictions. However, surveys, interviews, and stakeholder response gathered during the creation of the Green Building Plan suggest that Edmonton needs local market evidence of the viability of green building development and the experience of other jurisdictions is immediately discounted as not being reflective of the Edmonton market.

The Edmonton industry is unwilling to extrapolate the successes of other jurisdictions and apply them to the local market. The challenge, of course, is that Edmonton is a rather late entrant into the Green Building market and in the early stages of market transformation; therefore, local evidence is not readily available. Further complicating the development of the local business case is the lack of access to data. Builders and their clients rarely share information on the costs of a project and even more rarely share post-occupancy evaluations. Even when capital outlay costs are known and a comparison to standard construction is made, initial cost premiums are only one component of project cost accounting and business case evaluation. The long-term operating costs post-occupancy are a significant component of a business case for green, and that data is nearly impossible to find in the local market. A further complication is that the overall business case performance indicators such as return on

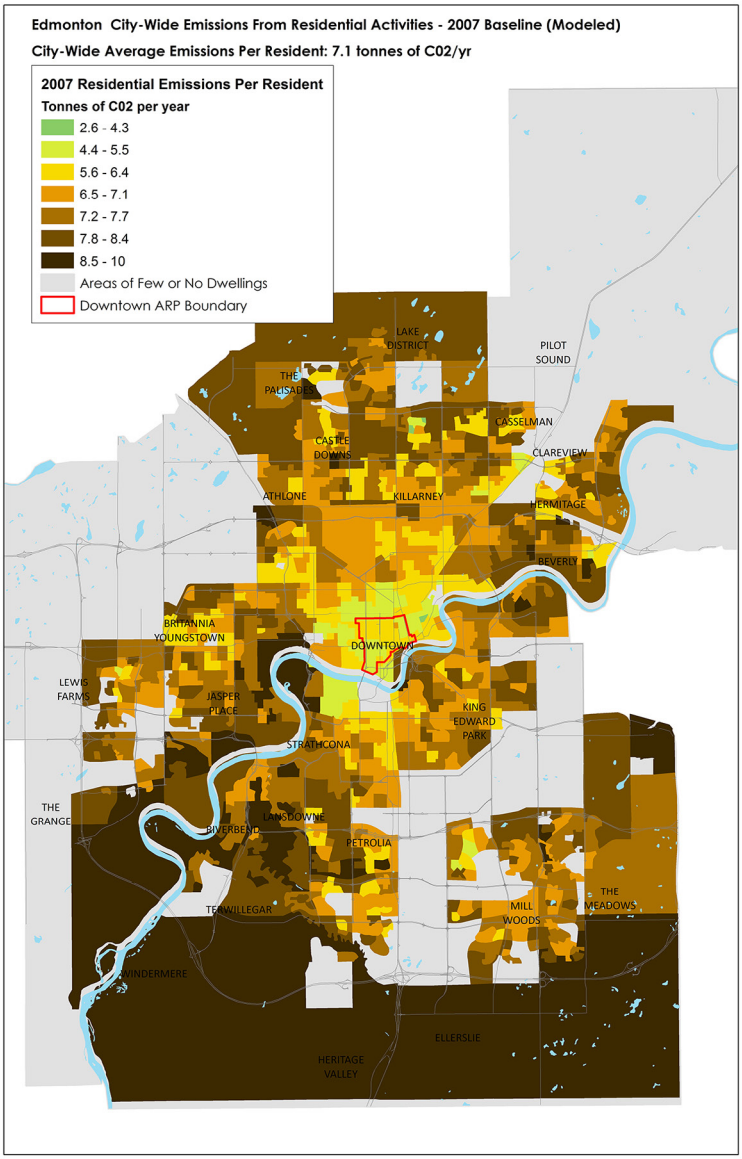


FIGURE 5. Modeled City-Wide Emissions (CO2/yr) from Residential Activities.

investment (ROI) are also dependent on the accounting methodology and which costs and savings are included—in other words embedded in the business model of the stakeholder firm or individual. The accounting methodology is generally not something readily supplied to the city upon simple request.

All of this leaves the policy makers in a difficult situation in that data is needed to justify the program, but data from other jurisdictions is not acceptable and local data is not available. To assist the city of Edmonton in building a better business case (or at least to understand the gaps in information and the market psychology) a market assessment was conducted. G.P. Rollo & Associates, a firm specializing in land economics, prepared a report that included the results of a review of existing research, personal interviews, and a survey of local builders and others that participated in the management of Edmonton's building stock.

Given that the stakeholder feedback suggested that Edmonton-specific information is the most valuable, the findings from the interviews and surveys are of most interest when

developing a municipal Green Building Program. Essentially the market assessment helped us localize some of the findings in the literature and at times we found disagreement between local industry and what was ascertained as part of the literature research. This information was invaluable when looking at opportunities to be pursued as part of the Green Building Plan. A good example of this follows:

> **An Unwillingness for Tenants to Pay Premiums to Rent or Lease Green Space:** Amongst Edmonton developers, there is strong agreement that retail tenants are largely *unwilling* to pay any extra rent for locating in a green building. This is contrary to what the literature suggests is occurring in larger markets where corporate sustainability policy combined with sophisticated operating cost analysis is driving mid to large corporate entities to locate their operations in green space. Only half of the survey respondents believed that green office buildings in Edmonton can command higher rents today than non-green buildings, all else being equal.
>
> **Improving the Business Case:** The Green Building Plan responds to this perceived lack of value for green space in three ways. First, by suggesting a social marketing campaign be pursued that helps retail/building owners understand the financial benefits of green. Second, by developing financing incentives that help address the upfront premiums. Third, the city of Edmonton must also place value on building and leasing green space within its own operations. While the city already mandates a minimum LEED Silver standard, the Green Building Plan suggests a potential Green Lease program for city lease space be evaluated. The city's internal Greenhouse Gas Reduction Plan also suggests ratcheting up its Sustainable Building Policy to move beyond the LEED Silver standard.

IMPLEMENTATION

The plan's proposed programs were organized into a framework that distinguishes buildings by building type. The four basic building types used by the plan are:

- New Homes
- New Large and Commercial Buildings
- Existing Homes
- Existing Large and Commercial Buildings

The framework was devised to facilitate the development of programs and policies tailored to the unique opportunities and challenges of each major building type. The different policy actions and programming are designed to remove barriers to market transformation that were identified through stakeholder consultations and the market assessment. Market Transformation Theory suggests that the different types of policies do not necessarily need to occur sequentially as shown in the market transformation curve as long as they are logically staged.

Edmonton is a late entrant into the green building market and in the early stages of market transformation. Support programs are needed in order to build both the demand for green buildings as well as ensure that industry and local government has the capacity to respond to that demand. Research shows that to be effective and successful, regulations need to be supported by industry and local government or compliance and/or performance issues will result.

Examples of programs currently being implemented in the new home category include the Green Home Buyer's Guide and Home Promotion. It is expected that the Buyer's Guide will also be made applicable to the resale market and multi-family dwellings. Late in 2013, an energy labeling program is being planned that utilizes Natural Resource Canada's EnerGuide for Houses program. Information on the status of implementation of all of the Green Building programs can be found at www.edmonton.ca/greenbuilding.

A framework to deliver financial incentives for building green is also being developed by the city of Edmonton in 2012 for implementation in 2013. The financial incentives framework is building on the successful incentives program offered under the city's Carbon Dioxide Reduction program (CO_2RE). Past CO_2RE incentives included everything from rebates for high efficiency furnaces to grants for achieving a third-party rating system.

The city of Edmonton's New Home "Green" Builder Rebate program is a good example of a successful incentive that was offered between January 1, 2007 and December 31, 2009. The purpose of this program was to incentivize the supply of new energy-efficient homes by encouraging new homebuilders to build to "green standards." Contractors, builders, and individual owner/builders could apply for rebates for single-family and multi-family houses that had received their building permits and LEED, Built Green™, or R-2000 certifications. In order to recognize the improvements that builders had made in their building practices, rebates were awarded at three Built Green™ levels. Homes receiving a Bronze certification were eligible for a $100 rebate, $200 for a Silver certification, and $450 for a Gold certified home.

The increase in the rate of participation in the program between 2007 and 2009 was significant. A total of 35 rebates were issued in 2007. This increased to 158 in 2008, and to 381 in 2009. At the peak of this program in 2009, the average cost per rebate awarded was $361 and total rebates for the year amounted to $137,700. More Gold certified homes, as a percentage of total homes built, were awarded rebates in the final year. This increase in the number of higher rated new 'green' homes suggests that both the capacity and willingness of builders to build to higher standards had increased between 2007 and 2009.

It is estimated that the impact of the program in 2009 for 381 homes was a decrease of 1,400 tonnes GHG emissions, or an average of 3.7 tonnes per home.

Supporting the supply side is a Green Building Checklist, which is a tool designed to be integrated into the planning approvals process. The checklist sets voluntary performance goals that are designed to educate and build industry capacity. The voluntary program will be supported by recognition and coordination incentives to help accelerate the market shift.

A green renovation program is already being implemented in the existing homes market. In 2012, the city of Edmonton partnered with a third-party service provider, C Returns, to provide an integrated energy retrofit program that is simple and easy to understand and access for home owners. C Returns provides its clients with:

- General information on green buildings, energy efficiency, and associated benefits (costs and other benefits)
- A comprehensive energy audit using state-of-the-art software that calculates energy savings, greenhouse gas impacts as well as generates detailed work plans and cost estimates for doing the retrofit
- EnerGuide assessment and rating before and after the retrofits
- Assistance with project management, linking homeowners to approved contractors, and assistance in obtaining government rebates

- Ready access to conventional financial services (a more turn-key financing program that is tied to the energy savings and repaid through the homeowner's utility bill is in development)

Jurisdictions that have been the most successful in stimulating green home retrofits have put all of these elements together into a "full service" package that makes it very easy and attractive for building owners to undertake upgrades.

For the most part, programs aimed at the institutional, commercial, and industrial sectors both new and existing will be implemented post-2013 with the exception of an overarching green marketing campaign that that will focus on linking sustainability messaging to Edmonton's building stock, both new and existing.

MONITORING THE SHIFT AND MEASURING SUCCESS

Monitoring and measuring the success of the Green Building Plan will be challenging. Data tracking systems are being developed including a mapping tool to track permits and approvals associated with renewables, green roofs, and geoexchange, etc. The tracking system is being developed utilizing the city of Edmonton's database/document management system POSSE, combined with the Geographical Information System (GIS) software, SLIM Geomedia. Permits and approvals are already tracked in POSSE; however, green technologies such as solar panels and geoexchange systems are not currently separated from standard permits. This lack of a unique identifier has made it difficult to query and map. Also, third-party rating systems are only tracked by the city of Edmonton if they are associated with a site-specific Direct Control zoning and not if they are constructed within a standard zone. This has made it difficult to know if the uptake of these third-party rating systems is increasing or not without going to all of the individual certification bodies (e.g., Canada Green Building Council, BuiltGreen, Passive House, Green Globes, etc.) and making manual requests for information. Methods to track the uptake in green ratings systems are being explored with our partners including the possible development of an open source hub that can be linked to a tool like Google maps.

Regardless of the tracking of these other performance measures, it is thought that the most important trends to understand and monitor will be those related to greenhouse gases and energy. To try to understand the implications of the Green Building Policy and Plan on Edmonton's future community energy use and greenhouse gas (GHG) emissions, a dynamic model called the Community Energy and Emissions Modeling and Planning tool (CEEMAP) was utilized. CEEMAP was created by HB Lanarc–Golder Associates Ltd. to specifically assist local governments with the task of GHG goal setting and policy development. CEEMAP is comprised of up to five integrated modules: land use; transportation; buildings; solid waste; and energy costing (see Figure 6). Although CEEMAP analyzes the effect of various modules and their interactions, the buildings module was used to assess the impact of the green building policies on energy consumption and GHG emissions.

Forecasting future emissions is challenging due to the number of factors that influence GHG emissions, the interrelationship of some of these factors, and the difficulty in estimating how they will change over time. For example, GHG modeling is complicated by the fact that long-term emission reductions usually occur in the context of population and economic cycles, an aging building stock, various rates of building replacement and renovation, and the progressive improvement in technological efficiencies. Further complicating the task is con-

siderable uncertainty about the introduction of federal and provincial policy and legislative changes. In other words, forecasting energy and emissions should not rely on static assumptions; rather, it should take into account dynamic changes over long time periods. This is what CEEMAP does.

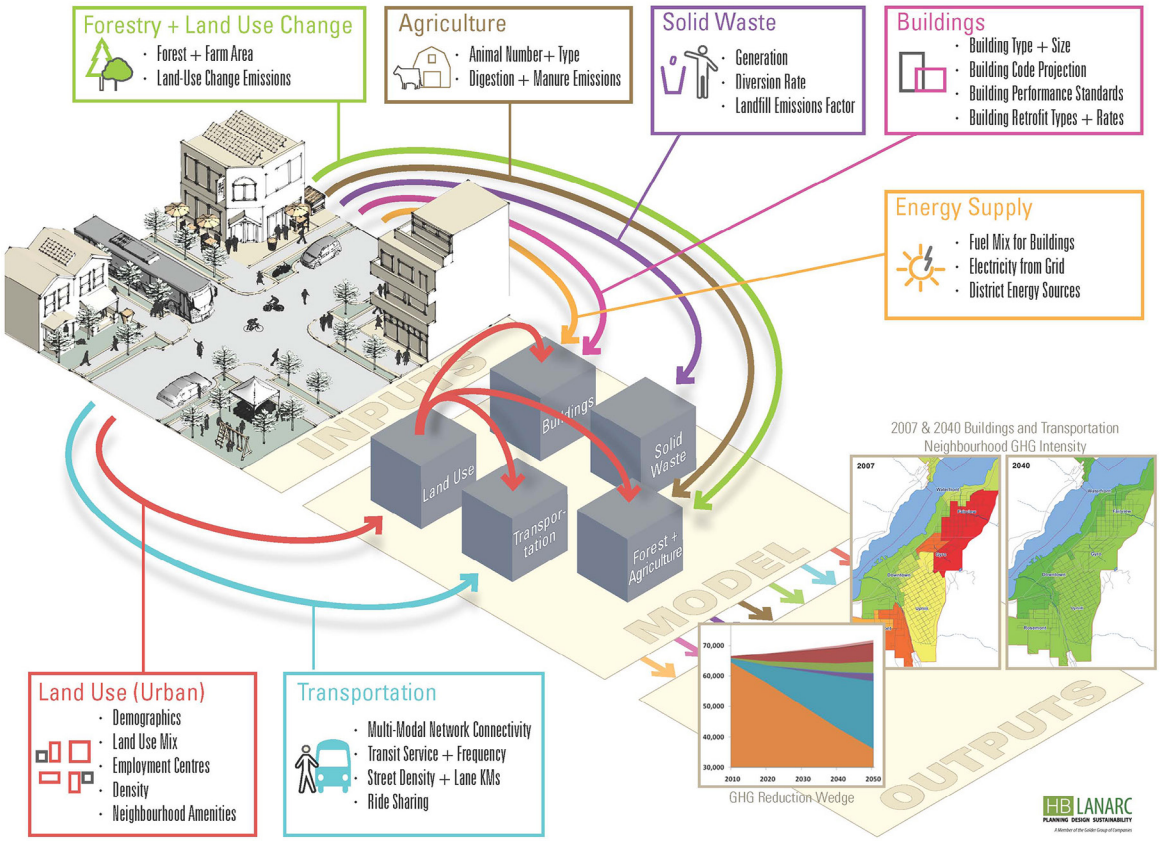
CEEMAP Buildings Module

The energy use and GHG emissions resulting from the Buildings and Energy Supply sectors can be simplified into four main components:

- Building characteristics, including type and size, as determined by the Land Use Module
- The efficiency of buildings, or Energy Intensity, expressed as gigajoules per square metre or kilowatt-hours per square metre
- The type and source of energy consumed (such as natural gas vs. electricity vs. solar), referred to as the Fuel Mix
- The Emissions Factor for each fuel type, expressed as tonnes CO2e per unit of energy

In general, existing building characteristics are known and future building characteristics are determined by land-use planning. Efficiency and fuel mix are less certain over the long term, but by using a combination of building code projections and assumptions made by local electricity and natural gas utilities for demand forecasting, a defensible forecast of building sector energy use and emissions can be made.

FIGURE 6. Community Energy and Emissions Mapping and Planning Tool Schematic.



In its most simple form buildings and energy supply emissions are calculated according to the following formula (For each building archetype, aggregated by dissemination area):

Building Floor Area × Building Energy Intensity × Fuel Mix × Emissions Factor
= Total Annual Emissions (Tonnes CO2e)

There are two key data sources for forecasting building energy intensity, fuel mix, and emissions in CEEMAP: The Natural Resources Canada Comprehensive Energy Use Database (NEUD) and residential and non-residential building stock, growth, replacement, and spatial characteristics. From here a baseline is generated which is calibrated to the community greenhouse gas inventory Edmonton already produces. Peer-reviewed literature and case studies on the impacts of specific strategies are consulted and used to produce forecasts. Various outputs are than put into tables, graphs and maps to visualize the data.

CEEMAP Results

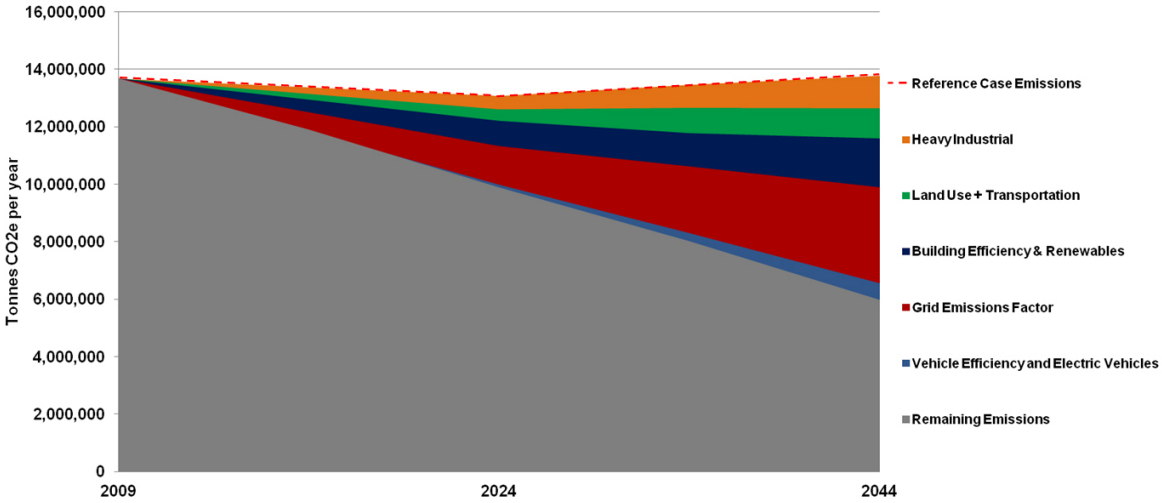
In 2009, the base year of measurement, Edmonton's building stock contributed 9,614,000 tonnes of greenhouse gases annually to the atmosphere. It is expected that through forecasted improvements in the building code this will decline to 9,298,000 by 2044. This decline in greenhouse gases is expected to occur even though Edmonton is anticipated to add 26,913,000 m^2 of residential floorspace and 8,646,000 m^2 of commercial, industrial, and institutional sectors in the next 30 years.

However, the anticipated greenhouse gas reductions without additional policy intervention are only expected to be 3.3 percent by 2044. Partial implementation will result in an additional five percent reduction in greenhouse gases from the business-as-usual scenario while full implementation of the programs outlined in the Green Building Plan are modeled to reduce Edmonton's greenhouse gas emissions an additional 14 percent below the business as usual scenario (see Table 2). It is important to note that these modeled implementation scenarios include assumptions about the decarbonization of the Alberta electricity grid that are held constant (a reduction from 880 tonnes of CO2e/GWh to 538 CO2e/GWh by 2044). If more aggressive action is taken to lower the carbon intensity of the grid, the percentage reductions from business-as-usual would decrease but overall greenhouse gases would also be less than forecasted.

TABLE 2. Building Sector GHG Emissions by Scenario in 2044—Tonnes CO2e.

	Base Year	BAU	Partial Implementation	Full Implementation
Total GHG Emissions from buildings (Tonnes)	9,614,000	9,298,000	8,838,000 (–5% from BAU)	7,980,000 (–14% from BAU)
Per capita GHG Emissions from buildings (Tonnes)	12	7.9	7.5 (–5% from BAU)	6.7 (–14% from BAU)
GHG emissions from residential buildings (Tonnes)	2,950,000	3,375,000	3,269,000 (–3% from BAU)	2,849,000 (–16% from BAU)
GHG Emissions from ICI Buildings (Tonnes)	6,665,000	5,924,000	5,569,000 (–6% from BAU)	5,131,000 (–13% from BAU)

FIGURE 7. Emissions Reduction Possibilities for the Low Carbon Scenario.



At first glance, it can seem like the policies and tools in the Green Building Plan will result in a relatively small reduction in Edmonton's overall carbon footprint. However, this is the nature of climate change mitigation; there are no singular, grand solutions that lead to a low carbon future. As Figure 7 shows, Edmonton will need to take action across many sectors if it is to achieve deep carbon reductions by mid century.

CONCLUSION

Edmonton's Green Building Plan aims to advance green buildings across all sectors—existing and new—in Alberta's capital. At the same time, the plan recognizes current market realities and incorporates a range of strategies designed to ease the transitional challenges. The key lessons learned while developing this plan include:

1. Application of Market Transformation Theory requires knowledge of local market conditions and obtaining that data is time consuming and, at times, difficult, so sufficient time must be allocated to preliminary research and stakeholder consultation.
2. A phased approach that will help improve both market capacity and market demand is recommended. Simultaneously implementing programs on both the demand creation side and the supply capacity side seems necessary for both industry buy-in and political support.
3. Regulation is only one tool and developing programs that can build awareness, improve industry capacity, educate the consumer, and incentivize early adopters should not be undervalued. Regulation is not the only mechanism that works to sustain market shift; price signals and market forces, when supported appropriately, can also lead the market to building greener.
4. Programs need to include financial analysis and evidence that they improve the business case over time. Developing the concept of Total Affordability (capital + operations) and producing data to support this concept is extremely valuable when presenting ideas to stakeholders and decision makers. Energy vulnerability is a readily

understandable concept that helps integrate social and economic sustainability into climate change mitigation and resource conservation, two issues that are often referred to, often erroneously, as "environmental" challenges.

5. Modeling and emissions mapping helps decision makers scope the issue and allows complex concepts to be visualized and understood quickly. Forecasting expectations from a baseline combined with ongoing monitoring allows for the program's successes to be tracked and if performance expectations are not being met, directions can be adjusted accordingly.
6. Ongoing stakeholder consultation is required as the programs are implemented. This has been shown to allow for changes to be made to reflect market realities as well as build co-ownership with industry partners over the delivery of the desired outcomes of the plan. Partnerships can also help to deliver programs faster and more efficiently, as the city of Edmonton has seen with its support of the C Returns initiative.

REFERENCES/ACKNOWLEDGEMENTS:

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The following pieces of work were used to author this article:

1. Edmonton's Green Building Plan and Policy Approved by City Council on June 20, 2012. HB Lanarc–Golder Associates, DIALOG, Pembina Institute, G.P. Rollo & Associates. www.edmonton.ca/greenbuilding
2. Edmonton's Energy Transition Discussion Paper. Pembina Institute and HB Lanarc–Golder Associates. June 20, 2012.
3. Edmonton's Green Building Plan: Potential Impact on Energy & Emissions. HB Lanarc–Golder Associates. April 4, 2012.