Evaluation of Actions and Policies to Reduce Urban GHG Emissions Using Multiple Criteria:

A Contribution Towards Energy Efficiency in British Columbia's Built Environment

by

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Abstract

In this report, we evaluate policies to reduce GHG emissions in urban areas according to multiple criteria, based on an extensive literature review. Municipal governments implement policies (regulations, charges, subsidies, etc.) to induce actions (such as improved energy efficiency in buildings or a shift to public transit). We include the standard policy evaluative criteria of financial cost-effectiveness, environmental effectiveness (at reducing GHG emissions), administrative feasibility, and political acceptability. We seek to contribute to the discourse in this area by adding two factors that are not usually considered: intangible values and heterogeneity. The intangible values perceived by consumers and firms can result in actions not being widely adopted, even though they appear to offer financial benefits. Heterogeneity can also influence the performance of government policies; in the context of this research, heterogeneity refers to variation across demographic groups and in urban form. The city of Vancouver is used as a case study, since the policy evaluation process requires information specific to a particular jurisdiction. We conclude with recommendations for Vancouver in light of its GHG emissions reduction and 100% renewable energy goals, and comment on the relevance of our findings to other communities in BC. We note that the literature examined is primarily concerned with energy efficiency as a means to achieve modest reductions in GHG emissions, a strategy that is insufficient given the aspirational targets adopted by a number of jurisdictions.

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Chapter 1.

Introduction

Over half of the world's population currently lives in urban areas and by 2030 that number is expected to reach two-thirds (OECD, 2008). As urban populations continue to rise, the amount of energy needed to sustain these areas will increase, along with greenhouse gas (GHG) emissions if the combustion of fossil fuels continues to dominate the global energy system. Urban areas account for 71-76% of carbon dioxide emissions from final energy use (Seto et al., 2014). As a result, there is increasing interest in the potential for cities to reduce emissions.

The built environment is a feature of our cities that can significantly affect energy use and emissions for decades. Improving building design and operations, or altering urban form and land use can potentially reduce emissions. Recognizing this potential, municipal leaders in North America and around the world have stated objectives to reduce emissions from their built environments. A number of municipalities and other jurisdictions have also announced plans to shift to 100% renewable energy by the middle of this century.

In order to reach their objectives, municipal governments can implement policies (regulations, charges, subsidies, etc.) to mandate or encourage actions (such as increased energy efficiency in buildings or a shift from personal vehicles to public transit). The policy evaluation and design process ideally takes into account benefits and costs to society, as well as equity or fairness in terms of how benefits and costs are distributed. In practice, these considerations may be either complimented or replaced entirely by concerns relating to administrative feasibility and political acceptability.

There are a number of complications that make it extremely difficult to conduct reliable research on the full spectrum of social benefits and costs arising from energy and climate policies. First of all, there is the problem of how to monetize the benefits of reducing GHG emissions, as well as the benefits and costs of co-impacts, such as reduced local air pollution. Second, actions to reduce emissions are associated with costs and benefits related to changes in intangible values, such as the loss or gain in value a family might experience living in an apartment as opposed to a detached home. Third, benefits and costs may exhibit significant variation or heterogeneity. In this report, we focus on heterogeneity linked to demographic characteristics (income, age, and family size) and urban form (as measured by population density). Public transit that is fast and convenient can be of high value to users. However, it is difficult to provide adequate service without a high urban population density. Finally, benefits and costs can be dynamic (changing over time). For example, a lifestyle that involves living in an apartment near an urban centre and not owning a car appears to be increasingly desirable, at least among some segments of the urban population in North America, just as it always has been in the urban core of most European cities.

Much of the research in this area has historically focused on estimating the benefits and costs of policies and actions in a fairly narrow and static sense: emphasizing the average financial costs of changes in the built urban environment and its technologies. A key objective of our research is to broaden the range of analysis by: 1) evaluating policies to reduce GHG emissions in urban areas using an expanded list of criteria that includes the intangible values of actions, and 2) considering associations between actions and key sources of heterogeneity. We also take into account the real-world concerns of administrative feasibility and political acceptability, which are sometimes overlooked in academic policy analysis.

An extensive literature review was conducted to collect information on the performance of policies to induce specific actions in the built environment. We use this information to develop qualitative ratings across a series of evaluative criteria. We note, however, that the literature review does not provide all the data necessary for evaluation. Often, empirical evidence is available only on the performance of actions; this is of limited usefulness to governments because (outside of their own operations) governments generally have control over policies only. Where such information gaps exist, we base our assessments also on the theoretical performance of generic policy options.

Factors that are difficult to quantify can be easily confused. We offer a way of categorizing unobserved values, distinguishing between intangible values, market failure, co-impacts, and equity impacts. These distinctions are helpful analytically and have implications for policy design.

Our analytical approach often requires information that is highly contextual. Therefore, we use the city of Vancouver, British Columbia as a case study. The City of Vancouver adopted a Greenest City Action Plan in 2011, with ambitions to reduce GHG emissions 33% relative to 2007 by 2020 and 80% by 2050 (City of Vancouver, 2015). This was followed in 2015 by a commitment to obtain 100% of its energy from renewable sources by 2050. Our report was researched as the City of Vancouver was developing its Renewable City Strategy (2015); therefore, it does not represent a comment on or critique of the strategy and related planning exercises, but rather an analysis carried out in parallel.

We focus on six specific actions that are relevant to the built environment. In order of increasing spatial scale these are: 1) retrofitting existing buildings, 2) constructing new buildings, 3) increasing urban density, 4) increasing mixed-use development, 5) increasing the share of travel by public transit, and 6) expanding or creating district energy systems. We divide the policies available to achieve these actions into four broad categories: regulations, economic incentives, economic disincentives, and information. This classification results in 24 possible action + policy combinations; however, we consider information as a stand-alone policy only when combined with the two buildings actions, leaving 20 combinations in our analysis.

We use the following criteria to evaluate action + policy combinations and make recommendations: 1) financial cost-effectiveness, 2) intangible values, 3) co-impacts, 4) equity impacts, 5) GHG emissions reduction, 6) administrative feasibility, and 7) political acceptability. Our assessments of the 20 action + policy combinations against these seven criteria are summarized in a matrix at the end of the report.

We begin with a discussion of possible actions to reduce GHG emissions in urban areas and policies that municipal governments can use to achieve these actions (section 2). This is followed, in section 3, by an overview of the concept of economic efficiency, various components of social benefits and costs, and how these translate into some of the more commonly used policy evaluative criteria. In section 4, we select policy evaluative criteria and explain how we assess performance in terms of these criteria. We provide a summary of the theoretical performance of generic policy options with respect to standard evaluative criteria in section 5. A literature review was conducted to obtain information on the performance of specific actions and action + policy combinations against criteria relating to social benefits, social costs, and equity. In section 6, we report on this literature review and analyse the findings. We examine political acceptability and administrative feasibility specifically for Vancouver given its population, legislative, and other local circumstances in section 7. A second literature review – this time for possible associations between actions and demographic and urban form characteristics – is summarized in section 8. The evaluation matrix is presented in the final section of the report (section 9); it is build up from tables provided in sections 6 and 7. Section 9 also contains our concluding remarks, which include recommendations for the city of Vancouver and our comments on the relevance of this study to other BC communities.

Chapter 2.

Actions and Policies

In order to reduce GHG emissions, one or more actions must occur. For our purposes, an action is defined as “a change in the choice of equipment, buildings, infrastructure and land use, or in operating and management practices, or in lifestyles” (Jaccard, 2005, p. 260). Too often, analysts focus on actions without due consideration of how to achieve these changes through policy, defined as “an effort by public authorities to induce actions by consumers, businesses and perhaps other levels of government” (Jaccard, 2005, p. 260). In this report, we analyze action + policy combinations to reduce GHG emissions in urban areas. The rest of this section describes the actions and policies that we consider.

2.1. Actions to Reduce Urban GHG Emissions

This report deals with GHG emissions from fossil fuel combustion and electricity use in urban areas. These emissions are reduced through three fundamental types of actions: energy efficiency, energy conservation, and energy switching. These are manifested through specific actions, depending on the context. In this study, we focus on six specific actions related to the built environment: 1) retrofitting existing buildings, 2) constructing new buildings, 3) increasing urban density, 4) increasing mixed-use development, 5) increasing the share of travel by public transit, and 6) expanding or creating district energy systems. These actions are listed in order of increasing spatial scale; we classify actions 1) and 2) as occurring at the building scale, actions 3) and 4) as occurring at the site scale, and actions 5) and 6) as occurring at the node scale.

2.1.1. Fundamental Types of Actions

Energy Efficiency

In technical terms, energy efficiency is the ratio of useful energy output to energy input. As efficiency improves, people receive the same or greater quantity of energy services (outputs) with less energy inputs. A more efficient car drives farther for the same amount of gas. A high-efficiency air conditioner uses less electricity to cool the same space. In both of these cases, the user does not sacrifice their level of energy services to achieve energy savings.

Efficiency improvements do not always result in energy reductions. One explanation for this is the rebound effect. William Jevons first discussed this in 1865 when he realized that more efficient steam engines actually caused an acceleration of Britain's coal consumption rather than the expected reduction. Efficiency improvements decreased the cost of steam-powered coal extraction, thereby increasing its use. Direct rebound effects occur when efficient technologies result in people using the technology more, diminishing actual energy savings. For example, installing a high-efficiency furnace reduces heating costs and may cause people to maintain a higher temperature level in their homes. Indirect rebound effects occur when the cost savings from efficient technologies are used to purchase other energy-intensive services. People may not use their new high-efficiency furnace more, but they may instead use the money saved on energy bills to pay for flights to exotic vacation destinations or an extra television set. These additional expenditures have energy implications that can erode or even override efficiency improvements.

Energy Conservation

Energy conservation and efficiency are often confused; however, they create distinct differences in the user experience. Conservation focuses entirely on reducing energy use by decreasing the level of energy services, while under efficiency the level of service remains the same. In the case of energy conservation, rather than install a high-efficiency light bulb, a user would simply use the existing bulb less to conserve energy (Jones & Zoppo, 2014).

The majority of energy conservation opportunities lie in behavioural change. Turning off unnecessary lights, lowering the thermostat, or using appliances less are common conservation strategies. These actions typically come at no or very low cost to the user, but they present additional challenges. As most conservation actions rely on human behavioural change, their success is dependent on individual preferences and lifestyles. Energy consumption is woven into our everyday lives, and conservation must alter that everyday life in order to be successful (Wilson & Dowlatabadi, 2007).

Energy Switching

While efficiency and conservation limit energy use, energy switching changes the type of energy used to power goods and services. By switching to a lower-carbon energy source, emissions are reduced without decreasing the amount of energy used or the quantity of services delivered. If the goal is to dramatically reduce GHG emissions and obtain close to 100% of energy from renewable sources, energy switching away from fossil fuels is crucial.

Energy switching can have a large impact on emissions regardless of how much energy is used. From 1990-2010, while Canadian residential energy use increased 6%, associated GHG emissions fell 0.5% as utility systems switched to less GHG-intensive fuel sources (NRCan, 2013). Both small- and large-scale renewable electricity supply technologies are available. Small-scale generating units can create a distributed network of technologies located close to the loads being serviced, reducing transmission losses (McLean-Conner, 2009). At the larger grid-scale, switching utility systems over to nuclear, hydroelectricity or other technologies can reduce emissions across the existing grid. Energy switching is also possible at the personal level. In the transportation sector, for example, consumers may switch to electric or plug-in hybrid vehicles, or shift from gasoline personal cars to low-carbon electricity-powered public transit.

Impacts on Emissions

Simply undertaking any of the three energy actions described above may not necessarily reduce emissions. If energy is already supplied by a low-carbon source such as hydroelectricity, nuclear, or solar, then conservation or efficiency will have a negligible impact on emissions, and switching the energy source may increase emissions. Switching from a 90% efficient gas boiler to a 100% efficient electric heater will increase emissions if that electricity comes from a fossil fuel power source (Herring, 2006). Conversely, switching from a 90% efficiency gas-fired combined heat and power system to electricity that runs resistance heaters or heat pumps will reduce emissions if the electricity comes from hydropower, wood waste, wind, or geothermal electricity generating stations. In British Columbia, where most electricity comes from low-carbon hydroelectricity, actions that focus on high-carbon fuel sources such as gasoline for vehicles will have a more significant impact on emissions than a campaign to turn off lights or switch to solar-powered electricity systems.

2.1.2. **Specific Actions**

Building Scale: Existing and New

Retrofitting existing buildings and constructing new buildings can reduce emissions through energy switching or efficiency. Energy switching may include installing heat pumps and/or electric baseboard heaters instead of gas furnaces, or other technologies that alter existing energy sources. Efficiency actions maintain existing energy sources, but upgrade appliances or features to use less energy while maintaining the quality of delivered energy service. Although energy switching is of vital importance to stated goals regarding GHG emissions and renewable energy, there is less literature available on its impact; therefore, a large amount of the evidence presented in this report relates to efficiency. While mostly the same technical options apply to both retrofits and new buildings, there may be more options in the case of new buildings as contractors are less restricted by pre-existing building design or technologies.

Site Scale: Density and Mixed-Use

Increasing urban density concentrates buildings around existing municipal services. This may reduce emissions through a combination of energy efficiency and conservation in one of three ways: reducing vehicle use, reducing energy use in buildings, or reducing municipal service requirements. Similarly, mixed-use development alters urban form; but instead of solely increasing the amount or height of buildings in an area, mixed-use creates a variety of building types and uses within a single area. This can include mixing employment and residential use, mixing various types of housing, or mixing different social functions. Mixed-use development can reduce emissions primarily through conservation. By condensing business, retail, and residential services into single complexes rather than dispersed through a city, vehicle trip rates or vehicle miles travelled per trip can be reduced (Koster & Rouwendal, 2002; Ewing & Cevero, 2001). Changes to the built environment such as density and mixed-use have the potential to achieve energy conservation without altering or impinging upon human preferences (Wilson, 2008). For example, if we gradually transform aspects of the built environment so that it becomes relatively more convenient to shop on foot than by car in some places, we may reduce vehicle use with no impact on preferences or values.

Node Scale: Public Transit and District Energy

The impact of a shift to public transit on emissions is interpreted differently depending on how one defines the transportation energy service; all three of the fundamental types of actions may be involved. Public transit allows for a reduction in the distance travelled by personal vehicles (energy conservation). Transit vehicles are able to move the same number of people the same distance using less energy than personal vehicles, assuming that ridership is high enough (energy efficiency). Buses and rail systems may also use energy sources that are less emissions-intense than personal vehicles (energy switching). Here again, it is possible to achieve energy conservation without impacting preferences or values.

District energy systems use centralized plants to generate thermal energy for hot water and space heating and cooling in urban areas. They reduce emissions primarily through a combination of efficiency and energy switching. District energy can be a very efficient energy source: conventional power stations convert only about 35% of their input fuel energy into electricity, while district energy systems can convert up to 85% of the input energy into cogenerated heat and power. Both renewables and fossil fuels may power these systems.

2.2. Policies Available to Municipal Governments

Policies can be categorized based on the degree to which they are compulsory, leading to three types: regulations, economic instruments, and information (Mickwitz, 2003; Vedung, 1998). Regulatory policies impose practices, technologies, or emissions limits. Economic instruments (incentives and disincentives) attempt to influence technology acquisition decisions or behavior by increasing the relative economic attractiveness of certain actions. Economic disincentives are compulsory in the sense of requiring either action or payment to government, but are more flexible than regulations because of the choice between these two options. Economic incentives are not compulsory because they do not require action or payment. Information policies use awareness and education to encourage people to voluntarily adopt more actions that reduce emissions (Sunikka, 2006). Table 1 lists policies in each of these categories that municipalities may use to reduce emissions. Market-oriented regulations that combine the certainty of a regulation with the flexibility of an economic instrument (e.g., emissions cap and trade systems) are also a possibility, but one that we do not consider in detail in this report.

Table 1: Potential Municipal Policies by Category

Regulatory	Economic	Information
Building standards Building codes Zoning Urban growth boundaries Road-entry restrictions Urban planning mandates Bylaws	**Incentives:** Tax credits/breaks Loans Subsidies Grants Innovative financing **Disincentives:** Taxes Development cost charges Impact fees Vehicle charges	Voluntary certifications Public leadership Information campaigns Detailed billing/feedback Auditing

As listed above, there are many policies to choose from. Both energy efficiency and energy switching in buildings can be encouraged through technology subsidies, grants, loans, or tax credits. Regulations may mandate minimum efficiency or energy source requirements. Zoning regulations can specify transit accessibility requirements, mixed-use development, and minimum densities. Density bonusing allows developers greater height allowances or other relaxed standards in exchange for features such as green space, sidewalks, or funding for local community services. Transit use may be encouraged through disincentive mechanisms targeting personal vehicles, such as road pricing or parking charges. Bylaws, information, or technology subsidies may increase the prevalence of district energy systems. Information campaigns or auditing can demonstrate the benefits of many different types of efficiency, energy switching, or conservation actions.

Governments face risks when deciding amongst both actions to target and policies to implement. They may spend time and money to promote actions that are inappropriate – for example, subsidizing public transit expansion in areas that will not have a strong demand for the service, or implementing regulations for the construction of new buildings rather than retrofits in areas where the building stock turnover is low. They face additional risks when selecting policies: an energy tax can place low-income groups at a disadvantage and result in political backlash, while a subsidy with a large amount of free-ridership (people accepting money for actions they would have taken regardless) is a questionable use of government resources. Policy evaluations carried out prior to implementation can help avoid these unintended outcomes while achieving emissions objectives. Evaluations carried out after the fact allow analysts to gain valuable knowledge from what has been tried in the past. A number of the criteria commonly used to evaluate government policy are related to the overarching concept of economic efficiency and its pursuit through the application of benefit-cost analysis.

Chapter 3.

Economic Efficiency and Benefit-Cost Analysis

The purpose of this section is to explain the rationale for environmental policy, introduce policy evaluation based on the concept of economic efficiency and the related procedure of benefit-cost analysis, and classify types of social benefits and costs. Some benefits and costs are difficult to quantify, and this affects the criteria commonly used to evaluate policy.

Government intervention in the form of environmental policy is warranted when a negative externality prevents the market system from functioning in an optimal way. An externality exists when environmental damage that occurs as a result of economic activity goes uncompensated. It is difficult to imagine an economic system that could exist without environmental impacts; however, because of the externality more damage occurs than would be desirable from the perspective of society as a whole.

Economic efficiency is ideally a central evaluative criterion for government policy. In the context of an environmental pollutant, the economically efficient emissions level is that at which the marginal abatement cost (cost of one more unit of abatement) is equal to the marginal pollution damage (damage from one more unit of pollution). A policy that achieves this point of maximum social welfare or brings us closer to it is considered economically efficient.

The efficiency of a policy instrument can be assessed by comparing its benefits and costs in monetary terms, to see if the benefits outweigh the costs. Benefits and costs must be calculated relative to a business-as-usual condition in which the policy is not implemented. When such an exercise is carried out from a social perspective (as opposed to a private perspective), the external costs referred to above are taken into consideration. Although the principle is straightforward, a full social benefit-cost analysis is virtually impossible to carry out in practice. Benefits and costs are each made up of a number of elements, some of which are more easily quantified than others. Furthermore, there is the difficulty of establishing the business-as-usual scenario against which all benefits and costs must be measured.

It is helpful to distinguish between direct and indirect benefits and costs in the context of social benefit-cost analysis of climate policies (IPCC, 2014; Urge-Vorsatz et al., 2014). Direct benefits are those that are in line with the primary objective of the policy. In the case of a GHG emissions tax, these would be the climate benefits associated with decreased emissions. However, it is not always so clear. A system of road tolls, for instance, could be used to reduce congestion, improve local air quality, reduce GHG emissions, or some combination of these objectives. Direct costs, on the other hand, include the costs of carrying out a particular action (or actions). In addition to direct impacts, policies have co-impacts on other objectives; these can be either positive (co-benefits) or negative (IPCC, 2014; Urge-Vorsatz et al., 2014). For example, a reduction in urban air pollution as a result of GHG abatement policy could be expected to have health co-benefits.

The difficulties inherent to monetizing direct benefits have led to the frequent use of cost-effectiveness as an evaluative criterion rather than economic efficiency. A policy that achieves a particular abatement target at the least possible cost is cost-effective, as is a policy that achieves the greatest abatement possible for a particular cost. A cost-effective policy is not necessarily economically efficient (e.g., when the cost-effective solution is applied to reduce pollution to a level that is not socially optimal), whereas an economically efficient policy is always cost-effective. A separate criterion of environmental effectiveness is reported alongside cost-effectiveness to describe the magnitude of the direct benefits of a policy in physical units. Cost-effectiveness estimates generally represent only the direct cost of a policy relative to its direct benefit, leaving co-benefits and negative co-impacts as separate evaluative criteria that may be assessed in physical units, qualitatively, or not at all.

Furthermore, the vast majority of cost-effectiveness analyses take into account only the more obvious financial costs associated with policy and business-as-usual conditions. Estimates of financial costs may include government administration costs, capital costs of equipment and infrastructure, operating and maintenance costs, and energy costs. This is not the whole picture. Actions to reduce GHG emissions are often associated with intangible values that may affect the success of policy initiatives. One of the key contributions of this study is to research intangible values and include them along with more conventional criteria in our analysis of policies to reduce GHG emissions in urban areas. Intangible values can influence the uptake of any action; however, they are perhaps best understood in the context of the debate surrounding what is known as the "energy efficiency gap."

An efficiency gap is apparent when the direct financial cost of an energy efficiency action is estimated to be not a cost but a benefit, and yet the action is not widely adopted. This can occur when the extra up-front cost of investing in a more energy efficient technology is offset by expected savings on energy expenditures over time. If a low social discount rate is used to compare future benefits from energy savings with present costs (thereby placing a relatively high value on future costs and benefits), the efficiency gap is more likely to be manifest. According to some analysts, opportunities for profitable energy efficiency investments exist throughout the economy, contributing to a massive efficiency gap (e.g., Lovins, 1977; McKinsey, 2009). Proponents of energy efficiency have postulated that a number of market barriers account for the efficiency gap; they argue that these barriers should be addressed through government intervention to shrink the size of the gap (Sutherland, 1991).

Mainstream economists, on the other hand, tend to dispute such calls for widespread government intervention to improve energy efficiency. A possible explanation for the efficiency gap offered by Allcott & Greenstone (2012) and Jaffe et al. (1999) is a discrepancy between actual energy savings and estimates of potential energy savings. This can occur, for example, because technology specifications are based on ideal conditions that diverge substantially from the circumstances under which technologies are used in the real world. Those who are more skeptical of the energy efficiency gap argue that many of the barriers to energy efficiency are not market failures and their presence does not, therefore, reduce economic efficiency (Jaffe et al., 1999; Jaffe & Stavins, 1994; Sutherland, 1991).

Market failure explanations for the efficiency gap generally relate to a lack of information on energy efficient technologies (Allcott & Greenstone, 2012; Jaffe et al., 1999; Jaffe & Stavins, 1994; Sutherland, 1991). Government policy that addresses a market failure (through information provision in this case) can result in a net benefit to society if the administrative cost of the policy is not too high. However, the empirical evidence suggests that the portion of the reported energy efficiency gap that can be attributed to market failures is quite small (Allcott & Greenstone, 2012).

We refer to the other barriers to energy efficiency as intangible costs. Such costs may include the risk associated with an energy efficiency investment (e.g., a newer technology with a higher failure rate or a long payback), qualitative attributes of an energy efficient technology that make it less attractive to users (e.g., some efficient lighting technologies do not provide the same quality of light as the incandescent bulbs they are meant to replace), along with other unobserved or unquantified costs not related to market failure (Allcott & Greenstone, 2012; Jaffe & Stavins, 1994; Sutherland, 1991). Intangible benefits exist as well, although they do not help to explain the energy efficiency gap. Intangible values are, by definition, not accounted for in estimates of direct financial costs; however, they are real social costs that form part of the direct costs of policies.

Even when an energy efficiency investment is attractive to the average household or firm, there will be individuals in a heterogeneous population for whom this is not the case (Allcott & Greenstone, 2012; Jaffe et al., 1999; Jaffe & Stavins, 1994). Differences in financial costs, technology performance, market failures, and intangible values across individuals can all help to explain why some percentage of the population does not adopt an energy efficient technology when analysis based on average conditions indicates that they should. Another contribution we intend to make with this research is to examine how heterogeneity may affect the performance of municipal climate policies.

In the context of this research, heterogeneity refers to both demographic variation and urban form variation. People in different demographic groups may perceive and respond differently towards actions, with implications for the social costs and benefits of policies, including environmental outcomes. For example, despite ongoing densification in United States city centres, the enduring values that some citizens hold for lower-density suburban living have been found to generate increases in emissions that completely offset emissions reductions gained through city densification (Jones & Kammen, 2014). Age, income level, and family size are all demonstrated to affect responses towards energy actions (Banfi, Farsi, Filippini, & Jakob, 2008; Howley, 2009). However, despite recognition by some researchers of a need to tailor policies to different demographic populations, energy policy evaluations generally do not consider demographic variation.

Urban form heterogeneity refers to variation in the built environment. This can be measured in terms of density, building type mix, infrastructure, or transportation systems. These existing urban features can affect future policy success. For example, expanded public transit or mixed-use development in low-density suburban areas may have a limited impact on actual emissions if there are insufficient population levels to sustain the developments. Heterogeneity of demographics or urban form is of little importance if the variation is quite small. However, we do not fully understand the effect of this variation because it has not been systematically studied (Clark, 2013; Heinonen, Jalas, Juntunen, Ala-Mantila, & Junnila, 2013).

Chapter 4.

Policy Evaluation Method

In the chapters that follow, we evaluate 20 action + policy combinations across a series of criteria. In sub-section 2.1.2., we identified six specific actions for reducing GHG emissions from the urban built environment: 1) retrofitting existing buildings, 2) constructing new buildings, 3) increasing urban density, 4) increasing mixed-use development, 5) increasing the share of travel by public transit, and 6) expanding or creating district energy systems. These are combined with four policy approaches: regulations, economic incentives, economic disincentives, and information. Information policies are often implemented in conjunction with other policies, making it difficult to evaluate the performance of information programs on their own (Somanathan et al., 2014). Therefore, we consider information as a stand-alone policy instrument only in combination with the two buildings actions, resulting in a total of 20 combinations instead of 24.

Distinctions between policy options are not always as clear as might be implied by the categories listed above. Some policies, such as market-oriented regulation, are hybrid instruments. Other policies are regularly bundled together, as in the case of subsidy programs combined with information provision. Policies that are implemented separately may also interact with each other. Despite these caveats, in the absence of perfect information, an analytical approach to policy evaluation is a useful support to decision-making.

We assess the 20 action + policy combinations across seven evaluative criteria: 1) financial cost-effectiveness, 2) intangible values, 3) co-impacts, 4) equity impacts, 5) GHG emissions reduction, 6) administrative feasibility, and 7) political acceptability. These criteria are described below in sub-section 4.1, while the rating system used to assess policy performance is laid out in sub-section 4.2. Throughout sections 6 and 7, we build tables showing our ratings of action + policy performance across the evaluative criteria. We bring these tables together in a matrix in section 9.

A literature review was conducted to obtain information on the performance of the specific actions and action + policy combinations considered in this study. However, there are substantial gaps where the review does not provide the information required to assess action + policy combinations. In these cases, we use what is known about the theoretical performance of generic policy options to fill in the blanks. A general discussion of the performance of policy options is provided in the following section (5).

4.1. Evaluative Criteria

4.1.1. Financial Cost-Effectiveness

This is a measure of economic efficiency that, in the context of climate policy, takes into account the cost per (physical) unit of GHG emissions reduction. The general emphasis in the literature leads us to highlight the concept of cost-effectiveness, rather than economic efficiency. We consider co-impacts and intangible values separately in our analysis; when we use the term “cost-effectiveness,” we are referring to direct financial costs: government administration costs, capital costs of equipment and infrastructure, operating and maintenance costs, and energy costs. Depending on the availability of cost-effectiveness information in the literature, we also report findings of cost-effectiveness at reducing energy use, financial cost relative to some other condition, financial cost or benefit to a particular stakeholder group, and the extent to which costs are recovered under this heading as part of our review. Net benefits are often expressed as a negative cost in the literature.

4.1.2. GHG Emissions Reduction

In this analysis, environmental effectiveness is measured as the reduction in GHG emissions in physical units (e.g., megatonnes of carbon dioxide abatement). However, many of the studies that were reviewed report reductions in energy consumption instead. In these cases, we speculate on the implications for GHG emissions. The relationship between energy consumption and GHG emissions is highly contextual because it is dependent on the emissions intensity of the existing energy mix. Therefore, our assessments of the potential for action + policy combinations to reduce emissions are specific to the Vancouver area. Some of the actions contemplated by municipalities are only indirectly linked to GHG emissions. Where this is true, we discuss how the action may lead to energy and GHG emissions reductions, any evidence on the strength of these relationships, and under what conditions they hold.

4.1.3. **Intangible Values, Co-Impacts, and Equity Impacts**

Benefit-cost analysis seeks to maximize the net benefits to society, but is not concerned with who bears the costs and who enjoys the benefits. Nonetheless, distributional issues are of concern on the grounds of equity or fairness. A policy that results in greater net benefits to the poor as a proportion of income (progressive) may be chosen over a policy that results in greater proportional net benefits to the rich (regressive), even if the second policy has the greater net social benefit. Therefore, we add equity to our list of policy evaluative criteria.

Although they are conceptually distinct, it can be challenging to disentangle intangible values, co-impacts, and equity considerations. A further complication is that the empirical data required to differentiate between market failure costs and intangible costs is generally not available. Despite these difficulties, we attempt to evaluate action + policy combinations based on a qualitative assessment of intangible values, co-impacts, and equity considerations as separate criteria. Our intent is primarily to contribute to the understanding of intangible values and how they may be influenced by heterogeneity. Therefore, while we provide some information on co-impacts and equity impacts, the literature review did not specifically target these criteria. Creative policy design can be used to maximize positive co-impacts, minimize negative co-impacts, and address equity considerations. Intangible values, on the other hand, are often tied to actions themselves (in the context of the existing built environment) and are therefore not easily influenced through policy choices.

4.1.4. Administrative Feasibility and Political Acceptability

In addition to the difficulties inherent in assessing economic efficiency and social equity, political and administrative hurdles can stand in the way of rational policy implementation. Successful policy design must therefore take these factors into account. We tailor our consideration of administrative feasibility and political acceptability to Vancouver based on information about its population, legislative and municipal environment, and other local circumstances.

4.1.5. Heterogeneity

We do not evaluate action + policy combinations on the basis of their performance against a “heterogeneity” criterion. However, in section 8, we consider how the six actions included in this study may interact with demographic characteristics and urban form. The demographic characteristics we consider are age, income, and family size. Population density (people/hectare) is used as an indicator of urban form. In our review of potential positive and negative associations, we focus on surveys of Vancouver residents where possible.

4.2. Rating System

We assign ratings to actions, policies, and action + policy combinations on a scale ranging from positive to negative for most of the evaluative criteria considered in this analysis; the ratings ‘somewhat positive’ and ‘somewhat negative’ refer to intermediate states. If our findings indicate that financial benefits exceed financial costs, cost-effectiveness is rated as ‘positive’; if the opposite is true, the rating is ‘negative.’ Similarly, in the case of intangible values, a ‘positive’ rating is assigned if intangible benefits appear to outweigh intangible costs. For co-impacts, we specify the category (e.g., health, economy) as well as the rating (‘positive’ or ‘negative’). Equity impacts are assessed using the same scale, with a ‘positive’ rating indicating a qualitative improvement in social equity and a ‘negative' rating indicating deterioration. The associations between actions and demographic and urban form characteristics are rated using this scale as well. GHG emissions reduction potential, administrative feasibility, and political acceptability, on the other hand, are assessed in relative terms as ‘high,’ ‘medium,’ or ‘low.’

A rating of ‘variable’ is used to flag cases in which the results from different sources are contradictory or exhibit a wide range (e.g., with respect to the balance of benefits vs. costs). This rating is also assigned if performance with respect to a criterion is influenced by more than one component, with variability between the components. A rating of ‘inconclusive’ is used if there is not enough evidence to provide another rating.

This procedure is subjective in the sense that the ratings depend on our judgement of not only what the study data shows, but also the quality of the research and resulting data. We must interpret findings that are at times conflicting, and use results from different methodologies, sources, and situations. Not all studies are equal in comprehensiveness, quality, and validity. We try to be mindful of quality and other concerns such as scope, context, and susceptibility to bias when interpreting the primary research findings.

The exact interpretation of the rating terms we apply varies with context. For example, a rating of ‘somewhat positive’ could indicate that benefits only slightly outweigh costs; that evidence of net benefits is thin or that studies indicating net benefits have quality issues; or that there is variability between components influencing the criterion, with the majority of the components indicating net benefits. Therefore, throughout the sections that follow, we explain the reasoning behind our assessments.

Chapter 5.

General Discussion of Policy Performance

Here we consider how the policies identified in sub-section 2.2 – regulations, economic incentives, economic disincentives, and information – perform against standard evaluative criteria, in the context of reducing GHG emissions at the municipal level. It is commonplace to assess the performance of generic policy options in relative terms; options can be ordered along a spectrum with respect to a particular criterion. Therefore, this section is organized according to the criteria rather than the policies. The information provided here will be useful later on, in cases where the literature review is not informative for a specific action + policy combination. Much of the evidence presented is theoretical, whereas much of the evidence presented in the literature review that follows is empirical.

In this section, all considerations with respect to the balance of societal benefits and costs, including intangible costs and co-impacts, fall under the heading of "economic efficiency and cost-effectiveness." As noted in sub-section 4.1.1, the emphasis in the literature we examined was on cost-effectiveness rather than economic efficiency, leading us to select cost-effectiveness as an evaluative criterion for our analysis. However, when it comes to the theoretical performance of generic policy options, we can comment on economic efficiency as well.

5.1. Economic Efficiency and Cost-Effectiveness

Of the generic policy options we examine here, economic disincentives have the greatest potential in terms of economic efficiency. A tax applied to each unit of GHG emissions can improve efficiency by pricing the negative environmental externality associated with those emissions. The optimal emissions reduction is achieved when the tax is set at the point of equality between the marginal cost of emissions damage and the marginal cost of emissions abatement. In practice, it is extremely difficult to identify this tax level, due to uncertainty surrounding the marginal cost curves.

Even if an emissions tax is not set so as to reach the economically efficient reduction in emissions, theoretically the outcome will still be cost-effective. According to what economists call the equi-marginal principal, in order to minimize the cost of achieving a given reduction in emissions (or maximize emissions reduction for a given cost), the marginal abatement costs for all sources must be equal. An emissions tax is flexible, allowing those with higher costs to abate less (they will pay more tax), and those with lower costs to abate more (they will pay less tax). This process leads to an equalization of marginal abatement costs across the emissions sources. On the other hand, when sources with different marginal costs must comply with the same regulation, the equi-marginal principle is not satisfied and the policy is not cost-effective.

Another advantage of an emissions tax over a conventional regulatory approach is that a tax provides stronger incentives for consumers and firms to apply their knowledge and creativity to the task of reducing emissions in the least costly way. Meanwhile, governments need not be involved in judgements about technological choice or individual behavior. Regulations that specify particular equipment choices or management practices do not encourage investment in research and development with respect to pollution control. Performance-based regulations (that allow flexibility in terms of meeting a specified emissions target) can reward innovation, but the incentives are not as strong as they would be under an equivalent emissions tax. This quality of an emissions tax makes it attractive from the perspective of dynamic efficiency; as a result of innovation, potential net benefits to society can increase over time.

Despite the theoretical performance of a broad-based carbon tax with respect to economic efficiency, this instrument has had a very slow uptake, largely due to political acceptability considerations. Economic disincentive policies such as parking charges, road pricing, and development cost charges are more likely to be considered, especially at the municipal level. While these targeted policies may be more politically acceptable, they do not have the cost-effectiveness properties of a broad-based emissions tax. An emissions tax applied only to a particular sector or energy end-use can achieve cost-effectiveness within that sector or end-use, but not across the entire economy. If the disincentive applies only indirectly to emissions, further compromise in terms of economic efficiency is to be expected.

Economic incentive (subsidy) programs can provide the same motivation for pollution reduction as economic disincentives; however, they are associated with at least two additional challenges from the perspective of economic efficiency. First, governments must fund the incentive payments, either by incurring debt, raising taxes, or cutting back on spending in other areas. If an existing tax is raised, this is likely to exacerbate any distortion in the economy associated with the tax (e.g., distortion in the labour market caused by income tax). As we will also discuss in sub-section 5.3 below, the funding requirement of economic incentives is in contrast to disincentives, which can generate revenues to reduce existing taxes. Second, subsidy programs can be costly to administer, requiring adjudication of applications, monitoring of performance, and hindsight evaluations.

Programs that provide information to consumers and firms have the potential to improve economic efficiency by directly addressing a lack of information due to market failure. If the administrative cost of the policy is not too high, a net social benefit may be realized.

5.2. Environmental Effectiveness

It is not meaningful to assess generic policy options on the basis of environmental effectiveness. This is because the magnitude of the reduction in energy consumption or GHG emissions associated with a policy is influenced by characteristics of the specific instrument, such as its stringency or the implied departure from business-as-usual conditions. As Jaffe et al. (1999) point out: “typical command-and-control approaches [such as state building codes] can actually have little effect if they are set below existing standards of practice” (p. 11). Of course, regulations that mandate a significant improvement from existing norms can be highly effective (although they might not be economically efficient). In the case of economic instruments, departure from business-as-usual conditions refers to the change in prices. For example, an economic disincentive such as a carbon tax will likely be ineffective at reducing emissions if the tax is set at a very low level (even though it would be relatively economically efficient). The scope of a policy initiative is also important; if only a small proportion of the emissions from a particular sector are covered, the program cannot be expected to have a large impact economy-wide.

Environmental effectiveness also depends on how closely the policy instrument is aligned with a particular environmental objective. The effectiveness of energy efficiency regulation as a policy to reduce GHG emissions, for example, may be compromised due to the rebound effect. Likewise, economic instruments may apply only indirectly to GHG emissions. Parking charges, for instance, are expected to discourage private vehicle trips, and may even encourage the purchase of efficient vehicles and vehicles using alternative energy sources (if factored into the policy design). However, parking fees are not expected to reduce the average distance per trip. An emissions tax, on the other hand, would theoretically influence all three factors related to emissions from private vehicles, since it is directly aligned with the objective.

It is worth noting that the subsidies provided through economic incentive programs may cause unwanted outcomes in terms of the environmental objective. If subsidies for emissions abatement are awarded to firms, the resulting payments can draw more firms into the industry. If this occurs, total emissions from the industry could increase, even as emissions per firm decrease.

The environmental effectiveness of a policy instrument is not always what it appears to be on paper. Regulations, for instance, have the advantage of specifying a particular outcome. However, one cannot assume full compliance with regulation. Enforcement is required to achieve compliance, and there are administrative costs associated with enforcement. Another example pertains to economic incentives. These programs attract “free-riders” who would have carried out the desired action anyway. The participation of free-riders means that incentives are almost never as effective as they appear to be based on a tally of the number of subsidies handed out.

5.3. Equity Considerations

Regulations and economic disincentives have been criticized on equity grounds, and such criticisms can, in turn, influence political acceptability. The equity impacts of a disincentive policy arise through different pathways depending on who the policy applies to. If the disincentive program is applied to consumers, there may be equity concerns when low-income people must spend a greater proportion of their income on abatement costs (e.g., purchasing a more efficient vehicle, investing in improved home insulation, etc.) and/or disincentive payments than high-income people. If the program applies to firms, abatement and disincentive payment costs may be passed on to consumers, again with equity implications if the price of goods consumed by low-income individuals or families rises. When policy costs cannot easily be passed on by firms, either because demand for their final products is highly responsive to price, or because competing firms – notably those in other jurisdictions – are not subject to the same policy environment, output may be affected and jobs lost. Output changes due to competitiveness impacts are also related to the concept of leakage, whereby it is argued that disincentives, when not universally applied, may cause pollution-intensive industries simply to relocate rather than reduce their emissions.

Regulatory programs are associated with similar concerns, although disincentive payments are not an issue in this case. For example, it has been noted that energy efficiency regulations can increase the up-front capital costs of equipment and buildings, thereby reducing access to these goods by lower-income households. Although economic incentives tend to escape criticisms on the basis of equity, they too can have implications, especially if funds for the subsidy payments are obtained by raising regressive taxes or cutting back on social programs.

Government can redirect revenues from disincentive payments in order to address equity or competitiveness concerns. Through environmental fiscal reform, revenues may be returned to consumers or firms as lump sum payments (this can be done without altering the incentive for pollution abatement) or used to reduce other taxes. Government can explicitly commit to revenue-neutrality, as in the case of British Columbia's carbon tax, in order to improve the political acceptability of a disincentive program. According to the “double dividend” hypothesis, if taxes that decrease the incentives to invest and work – such as payroll taxes or income taxes – are reduced, there is a potential benefit with respect to economic efficiency in addition to the environmental benefit of pollution mitigation.

5.4. Administrative Feasibility

Regulations and information programs are administratively feasible, as are economic disincentives when they can be integrated with existing methods of establishing prices and collecting taxes. We have already discussed some of the administrative challenges of economic incentive programs.

5.5. Political Acceptability

Generally speaking, incentives and information programs are more politically acceptable than regulations, and disincentives have the greatest challenges of all in terms of this evaluative criterion. Disincentive policy is often portrayed as an instrument of intrusive and coercive government, associated with the suspicion that the charges reflect government revenue needs rather than a legitimate attempt to correct prices to reflect environmental harms and risks. Environmental fiscal reform and revenue neutrality can help to address the equity and competitiveness concerns with respect to economic disincentives, but in no way do these features ensure acceptance.

Incentives and information programs do not impose costs on polluters; therefore, political opposition is unlikely. Incentive programs are obviously popular with the beneficiaries; however, subsidy payments require funds that governments may have to acquire through unpopular taxes or spending cuts. In the case of information policies, governments do not have to fund subsidy payments, yet they can still claim they are taking action to address the problem. While the environmental impact of information programs on their own may not be very large, by increasing awareness of a particular issue, they may pave the way for political acceptance of more stringent policies.

5.6. Summary

Based on the previous discussion, we assess the four policy options against the criteria of economic efficiency, environmental effectiveness, administrative feasibility, and political acceptability; our ratings are summarized in Table 2. Equity is not taken into account here, since we argue that equity and competitiveness impacts can be addressed through policy design. Policy performance is assessed in relative terms as ‘high,’ ‘medium,’ or ‘low’ for each of the four criteria. This exercise highlights the trade-offs between evaluative criteria. All of the policy options receive a rating of ‘high’ and a rating of ‘low’ on at least one criterion. Market-oriented regulations such as emissions cap and trade systems (not shown in the table) can ease the trade-off between economic efficiency and political acceptability.

Table 2: Evaluation of Generic Policy Options Against Standard Criteria

	Economic Efficiency	**Environmental Effectiveness**	**Administrative Feasibility**	**Political Acceptability**
Regulation	Low	Medium	High	Medium
Disincentive	High	Medium	High	Low
Incentive	Low	Medium	Medium	High
Information	Medium	Low	High	High

Economic efficiency is rated as ‘high’ for disincentive policies, the reasons for which are discussed at length earlier in this section. Regulations are rated as ‘low’ because marginal abatement costs can vary widely between sources; an outcome which is not cost-effective. Also, the regulatory approach does not perform well in terms of rewarding creativity and innovation. Incentive programs are rated ‘low’ as well because they require funds that may be raised through distortionary taxes, and because they can be costly to administer. Information policies are rated as ‘medium’ because, while they do not have the broad efficiency and cost-effectiveness properties of economic disincentives, they offer the potential to address a lack of information due to market failure.

Regulation and economic instruments can be equally effective in terms of achieving an environmental objective, depending on the strength, scope, and alignment of the policy. Information programs, on the other hand, are more limited in that they are non-compulsory and do not affect the incentives of consumers and firms. Information is therefore rated as ‘low’ in terms of environmental effectiveness, while the other three policy options are rated as ‘medium.’ Regulatory, disincentive, and information programs are administratively feasible, and are rated as ‘high’ in terms of this criterion. Incentives are rated as ‘medium,’ because they present an extra administrative burden. Political acceptability is low for economic disincentives and high for incentives and information, with regulations falling in between.

Chapter 6.

Literature Review: Social Benefits, Social Costs, and Equity

We review literature on the performance of actions and action + policy combinations against the following five criteria: financial cost-effectiveness, intangible values, co-impacts, equity impacts, and GHG emissions reduction (administrative feasibility and political acceptability are covered in section 7). Our emphasis is on peer-reviewed academic meta-analyses from recognized journals. Where the peer-reviewed academic literature was sparse, we sometimes carefully relied on some non-peer-reviewed literature, including studies by independent institutes, conference proceedings papers, and in some cases government policy evaluations. In the case of information relating specifically to district energy systems, we used research reports funded by the Pacific Institute for Climate Solutions due to a lack of relevant evaluations in academic journals.

The literature review was useful in obtaining information on the performance of the six actions for the built environment addressed by this study; however, there are substantial gaps in terms of the coverage of action + policy combinations. Therefore, this section is organized by action (sub-sections 6.1 to 6.6). The final sub-section (6.7) brings together information from the literature review with the general assessment of policy performance in section 5 to rate action + policy combinations in terms of the evaluation criteria.

Intangible values, co-impacts, equity impacts, and costs arising from market failure are conceptually distinct; however, in practice, factors that are difficult to quantify often become intermingled. Therefore, all of these aspects are discussed under the heading “unobserved values and equity” in sub-sections 6.1 to 6.6. In sub-section 6.7, we analyse the results of the literature review in an effort to disentangle the unobserved values and equity impacts. Collecting information on co-impacts and equity impacts is not the main focus of this research project; however, we do take note of findings with respect to these criteria as we come across them.

While most studies have evaluated energy reductions, as noted previously that does not necessarily translate into emissions reductions. Where relevant, after we review energy reduction estimates, we discuss the emissions-reduction potential for Vancouver given its local energy sources and current policy environment.

6.1. Existing Buildings

6.1.1. Financial Cost-Effectiveness

Evaluations on policies targeted towards retrofitting existing buildings mainly review economic incentives and information programs, although retrofitting actions can also be mandated through regulatory policies. Most retrofit incentives seem relatively cost-effective when measured in terms of program costs and energy saved (Rezessy, Dimitrov, Urge-Vorsatz, & Baruch, 2006; Rosenow & Galvin, 2013). In a review of the UK's Energy Efficiency Commitment Schemes, Rosenow & Galvin (2013) estimate the cost for delivering policies at 0.007 Euros/kWh, lower than the market cost of delivering the energy. However, the authors note household investment costs are not included in this estimate, when participants were likely required to pay for at least a percentage of the investments. A French study of a subsidy and tax credit program for energy switching investments in wood stoves and boilers, solar hot water heating systems, heat pumps and efficiency investments in double glazed windows finds the program to be cost-effective for participants (Suerkemper, 2012). This study considers the energy bill savings, incentive payments, and costs of the investment for participants. The most cost-effective investments were fuel switching actions: condensing boilers and wood stove investments. The least cost-effective measures were double glazed windows. However, windows were also the most popular investment, suggesting people may be getting other intangible benefits from this type of investment than those evaluated, such as reduction of external sound. In a global review of policies to encourage energy switching and efficiency investments Urge-Vorsatz (2009) finds subsidies, grants, and loans ranged from US$-66/tonne of carbon dioxide (CO_2) in (negative) costs to end-users (only considering energy costs saved) and up to $105/tonne of CO_2 in costs to society (considering program costs and energy costs saved).

Information policies to encourage retrofits show more variable evidence of cost-effectiveness. In an evaluation of a UK television, radio, and online advertising campaign, Murray (2010) conducts a door-to-door survey asking respondents about their energy savings, if they recalled the ad campaign, and whether the campaign influenced their actions. Murray then estimates energy savings from those self-reported actions. He finds the program to be cost-effective, although the study omits discussion on how actions convert into estimates of energy savings, so it is difficult to check the methods for accuracy or bias. Urge-Vorsatz (2009) finds a range in information policies with lows of US$-66/t$CO_2$ in Brazil to a high of US$8/t$CO_2$ in the UK. This wide variation may suggest costs depend on program delivery or other contextual factors such as local culture or political climate. Some researchers find evidence that information campaigns targeted at lower income groups may be ineffective if not accompanied by economic instruments (Wade & Eyre, 2015).

6.1.2. **Unobserved Values and Equity**

Economic incentives that encourage retrofitting investments are associated with unobserved transaction costs. For example, in order to receive loans, grants or subsidies, recipients must first know the programs exist, determine eligibility, book an audit if required, select the appropriate investment, hire a contractor, and in the case of loans, manage an additional repayment bill. The amount of required paperwork and time can be substantial, placing large demands on decision-making abilities.

Based on available data, the unobserved costs of undertaking energy efficiency and energy switching investments may be high. Michaelowa & Jotzo (2005) estimate transaction costs of energy efficiency to be as high as 20.5% of investment costs for building envelope investments, while fuel switching intangible costs may be as high as 14.4%. Kiss & Mundaca (2013) estimate the intangible costs of investing in CFL lightbulbs at 10% of the bulb costs, while cavity wall insulation costs are estimated to be

30% of the investment price. Furthermore, assistance throughout the process may not be enough to overcome the costs. In an analysis of the United States' Weatherization Assistance Program, which provides subsidies and information specifically to low-income groups, Fowlie (2015) finds that even when assisted, people still opt to not undertake seemingly cost-effective retrofit investments which had an average value of $5,000 in energy savings. There is limited quantitative evidence; however, the available data seems to show that intangible costs of retrofitting existing buildings are relatively large. It is unclear whether there is a difference in intangible costs between retrofit actions and similar actions when a new building is constructed, though intangible costs may be lower in new buildings because of fewer restrictions related to accommodating existing building design and technologies, as well as the existing inhabitants.

On the other hand, investments in energy efficiency may bring unobserved benefits. There is a consistent, although somewhat variable price premium for more energy-efficient buildings, ranging from 3-13% (Popescu, Bienert, Schützenhofer, & Boazu, 2012). Buildings officially certified through independent agencies such as LEED or EnergyStar command a slightly higher minimum price premium of 5%. Specific unobserved benefits of improved energy efficiency that are discussed in the literature include: reduced energy infrastructure costs, improved health, and local employment. Clinch and Healy (2003) estimate 21% of the total benefits from efficiency investments were due to improved comfort. In another study, Clinch estimates that energy benefits represent 57% of total program benefits, followed by health (25%), additional comfort (10%), and emissions reductions (10%). Some researchers find a net social benefit from retrofits at discount rates ranging from 0-10% (Clinch & Healy, 2001). We found no evidence on the unobserved values associated with energy switching investments.

6.1.3. **Energy & GHG Emissions Reduction**

When estimating energy reduced from retrofits, there is evidence of a gap between technical estimates and actual results, ranging from 40-70% of the expected savings (Wade & Eyre, 2015). In a sample of over 300 homes, Bundgaard (2013) finds subsidies reduced energy use by about 44% of the level estimated by the program. In an evaluation of an Irish retrofit scheme, Scheer & Clancy (2011) find reductions were 22 –

25% lower than estimates. In a review of the UK's Warm Front Program, which provides subsidies and grants to low income households for insulation, fuel-use was reduced 10-17% when the models predicted reductions of 45-49%. Sunikka-Blank and Galvin (2012) term this problem the 'pre-bound effect', a situation where dwellings use less baseline energy than what is modelled, resulting in lower-than-estimated savings from efficiency investments. As a result, models of potential energy reductions tend to overestimate savings. Free riders can also cause actual reductions in energy to be lower than even ex-post estimates indicate. Free ridership rates can be very high. In a review of Canadian energy efficiency subsidies, Rivers and Shiell (2014) find rates of around 70%. Keeping these additional factors in mind, while studies indicate that retrofits do reduce energy use, the amount is usually lower than estimations predict.

Vancouver's electricity system is largely based on low-carbon hydroelectricity. Space heating in BC is 39% electricity-based and 55% natural gas-based, with the remaining energy sources being biomass and oil (NRCan, 2013). Retrofit actions that reduce energy use will only have the potential to significantly reduce emissions if they affect natural gas-heavy end-uses such as space or water heating.

The current policy environment in Vancouver with respect to building retrofits leaves room for significant reductions in GHG emissions. Renovations over $5,000 require consultation with a certified energy advisor; however, consultation is simply an information program. At present, the impact of regulations on emissions at this level is limited. With respect to economic incentives to retrofit existing buildings, the city of Vancouver relies on third-party programs offered by the provincial government and other organizations, which may or may not specify the energy sources to be targeted. The city developed an energy retrofit strategy released in June 2014. However, the strategy report only lists general actions rather than specific policies or methods to cause those actions. For example, the report lists a goal to "support voluntary benchmarking with training" and provide "consultation to develop data sharing" but does not elaborate on how this will be done through either programs or policies (p. 37; Vancouver Energy Retrofit Strategy, 2014).

6.2. New Buildings

6.2.1. Financial Cost-Effectiveness

Evaluations for efficient new buildings primarily focus on regulatory measures; however, these results may also apply to existing buildings if cities enact similar policies for retrofitting. Building standards and codes are relatively cost-effective when measured in terms of program costs and energy saved (Ó Broin et al., 2015; Suerkemper et al., 2012; ürge-Vorsatz, Koeppel, & Mirasgedis, 2007). In a meta-analysis of sixty *ex-post* policy evaluation reports, Urge-Vorsatz (2009) finds best practice costs for regulations ranged from US $-5 to -189 per tonne of CO_2. A meta-review of the United States Building Energy Code Program administered by the US Department of Energy estimates $400 in savings for each dollar spent on building energy codes, measured as a comparison of program costs to estimated full-fuel cycle energy savings to consumers (Cole, Livingston, Elliott, & Bartlett, 2014). In an analysis of 250 energy efficiency building policies in European Union countries, Broin (2015) finds regulatory measures to be the most effective and suggests they be given a high priority in future policy consideration. All studies, including academic and government sources, find regulations to be moderately or highly cost-effective when measured in terms of program costs and energy saved.

6.2.2. Unobserved Values and Equity

There is no evidence available regarding intangible costs to homeowners of energy efficiency and energy switching actions in new construction, although we speculated in sub-section 6.1.2 that these costs may be lower than with retrofits. Presumably, unobserved benefits similar to those found with retrofitting (increased comfort, reduced morbidity) would apply.

Since most evaluations of new buildings focus on building regulations, here we provide an overview of the potential unobserved costs of these policies. Building regulations present a number of challenges, particularly to developers and building contractors. A government survey of British Columbian contractors, architects, developers, and builders identifies numerous concerns that may represent negative impacts of these policies. Stakeholders state that a lack of specialists, expertise, resources, and time limits their ability to meet building code requirements. They are also concerned with frequent code changes causing confusion and new technologies that are not properly modelled in existing design software (Province of BC, 2014). While not quantitatively estimated, these factors represent transaction costs of regulations that may contribute to lower than expected code compliance rates and decrease policy impact. In British Columbia, Tiedemann (2012) finds compliance rates of 63% during on-site investigations of 187 dwellings while in the United States, compliance rates range from 0-73% (Williams, Vine, Price, Sturges, & Rosenquist, 2013).

6.2.3. Energy & GHG Emissions Reduction

There is fairly robust academic evidence that building regulations modestly reduce energy use, but actual reductions are likely to be significantly lower than technical estimates made beforehand (Meijer, Itard, & Sunikka-Blank, 2009; Rosenow & Galvin, 2013). In a review of seven European Union country building codes, Saussay (2012) demonstrates a statistically significant increase in energy efficiency in all countries since building codes were implemented. Saussay finds the effect of codes increased over time, but also notes the potential for declining returns as the building stock gradually improves in efficiency. In a review of Denmark’s building standards program Kjaerbye (2009) finds an efficiency improvement of 7% where the technical program estimations anticipated 25% reductions in natural gas use. In an Irish evaluation of 1997 and 2002 homes built to different standards, Rogan & O Gallachoir (2011) find the 2002 homes had actual efficiency improvements of 10%; compared to the technical estimate of 20%. In contrast to the previous studies, Deason & Hobbs (2012) estimate the overall impacts of British Columbia building standards and find reductions of 10%, higher than the technical estimates of 5%. While the results are variable, all surveyed studies find energy reductions from building codes, despite discrepancies between anticipated and actual reductions.

There may be less opportunity for additional emissions reductions from new construction than from retrofits in Vancouver, due to stronger existing regulations for new buildings. Vancouver already has some of the most stringent new building regulations in Canada and an additional two ‘stretch’ policies further encourage new building efficiency. However, these two policies only target energy savings, not emissions: 1) developers must meet LEED Gold (energy rating) requirements in some rezoning cases, and 2) a Higher Building Policy requires all buildings that exceed current height limits or enter certain view corridors must achieve a 45% reduction in energy consumption as compared to the 2014 Vancouver Building Bylaw.

6.3. Urban Density

6.3.1. Financial Cost-Effectiveness

Density cost-effectiveness is normally measured in comparison to traditional alternatives such as dispersed or suburban development. Strict financial analyses of density tend to find cost-effectiveness. Three meta-analyses of dense development find it costs less with respect to road and utility costs, but may be the same or even slightly more expensive when delivering schools. Road costs of dense development range from 40-93% of the cost of sprawling development, utility costs range from 60-92% and school costs range from 97-102% (Burchell, 1997). Mukherji (2003) finds sprawl increases public service costs about 10% and housing developments about 8%. An analysis of 2,500 Spanish municipal budgets finds low-density neighbourhoods increase per capita costs of providing local services (Hortas-Rico & Solé-Ollé, 2010). However, Gordon, a critic of density argues that the few available studies on costs reveal a u-shaped cost function that bottoms at relatively low residential densities, below 1,250 people per mile (Gordon & Richardson, 2008). Most studies show some cost-effectiveness of density.

6.3.2. Unobserved Values and Equity

Many researchers point to substantial unobserved benefits of dense development including lower land consumption, resource protection and improved access to services (Beatley & Manning, 2000). Density is also associated with increases in neighbourhood walkability, declines in obesity, heart disease, and diabetes (Frank &

Pivo, 1994). There is evidence that in more dispersed urban areas, limited access to community facilities, services, and employment can have negative impacts (Ewing, 1997).

However, density may also be accompanied by neighbourhood problems and dissatisfaction (Howley, 2009). There are also housing affordability concerns. In British Columbia, housing affordability is found to decline with increases in density (Quastel & Moos, 2012). Jones (2015) finds developers are demolishing affordable rental apartments near Burnaby skytrain stations in favour of denser high-rise condominiums, and in the process displacing low-income immigrant families from what is otherwise a highly valued neighbourhood.

Furthermore, price studies that statistically control for other variables (hedonic analysis) show people generally prefer to live in larger homes and are willing to pay price premiums to do so when incomes allow (Bajari & Kahn, 2004; Olaru, Smith, & Taplin, 2011). Bajari & Kahn (2004) find increasing density in Los Angeles and decreasing lot sizes 10% would lower average utility (satisfaction) by $1,119 dollars per year. They find almost all of the negative utility comes from homebuyers living in smaller homes, not lot sizes. If the lot size shrinks without shrinking home size, people on average are better off by about $2,000 a year due to the decreased commuting times. With shrinking lot sizes, however, there are issues with on-street parking, noise, loss of privacy, and impacts on the neighbourhood character that were not considered in the study.

6.3.3. Energy & GHG Emissions Reduction

There are three major ways density can reduce energy use and its resulting emissions. These are reduced vehicle use, reduced energy use in buildings, and by reducing services required in cities. There seems to be common agreement that density can reduce city infrastructure requirements by condensing them in smaller areas (Chao & Qing, 2011). The other two claims have been consistently under examination in academic literature. However, density is necessary in many cases as a way to encourage other emissions-reducing actions such as transit expansion.

The relationship between density and energy-related transport emissions is complex, limited and variable across urban areas (Clark, 2013). While Handy (2005) and others find residents of dense areas drive less, other researchers note a paradox of intensification, where increasing population densities increase the concentration of vehicle use on the intensified areas, causing local environmental and social problems (Parkhurst, & Barton, 2011). While there may be increases in local air pollutants, overall there seems to be a reduction in GHG emissions.

While density may reduce energy use in buildings in certain studies, this result can change drastically with units of measurement and reporting scopes. An empirical assessment of energy use and GHG emissions of high and low-density residential development in Toronto finds the measurement unit may alter results significantly. Measuring emissions per unit of living space, suburban areas are just 1 – 1.5 times more emissions-intensive than city-centres, with the difference being mostly due to increased emissions from transportation in lower density areas, not from building energy use. When measuring emissions on a per capita basis, emissions in suburban areas are 2 – 2.5 times as intensive as high density development (Wilson et al., 2013).

Reporting scopes are another consideration. Many studies omit indirect energy and emissions associated with consumption of goods such as food or clothing and services such as airline transportation. Incorporating these indirect effects can alter results substantially and researchers are recognizing a need to include the full impacts of consumption on energy use (Seto et al., 2014). The Energy Information Administration (EIA) (1991), in an analysis of data from 1984, 1987 and 1990, shows that detached single-family homes used roughly 18-20% more energy than multi-unit homes, and used nearly 80% more than housing units in large buildings (those with more than five units). However, the EIA does not adjust for differences in square footage, income, or other controls that are often part of the comparison in other studies, and only considers energy for heating, cooling, and appliance use. In contrast, after comparing the emissions of Finnish capital Helsinki against the less dense area of Porvoo and finding the denser Helsinki produces more emissions, Heinonen (2012) concludes that simply packing people into denser urban forms is not sufficient for effective city-level carbon management.

6.4. Mixed-Use

6.4.1. **Financial Cost-Effectiveness**

Mixed-use development shows variation in cost-effectiveness based on location. In denser and more populous cities such as Vancouver or Toronto, it can be profitable. In small cities or areas that are less familiar with mixed-use development, it can be risky for developers to take on mixed-use projects. It is significantly more expensive to build and service, particularly in the initial planning and construction stages, but can also provide better returns if there is demand (Rabianski & Clements, 2007). In smaller cities or suburban areas, it may not create a premium value for sales and developers may struggle to sell units. McKenzie Towne, a mixed-use development project touted by urban planners as the future of urban planning for Calgary, boasted a range of housing types, commercial property and a proposed light rail station. Once built, developers struggled to sell commercial spaces and leased them out instead with high vacancy rates. Resident opposition forced a private school out of the complex and the developer ultimately cancelled plans for more apartments because market rents would not cover the costs (Grant, 2002). Other projects in Toronto that focus more on a mix of housing types are more successful and consistently sell at high prices. While mixed-use development can be a profitable venture, many developers are hesitant to build in suburban areas and usually for good reason. In large cities like Vancouver, mixed-use is usually financially lucrative despite requiring longer development periods, substantially higher equity requirements, and high upfront capital costs (J. S. Rabianski & Clements, 2007). Though it may have trouble competing with simpler property investment options, particularly in smaller cities or highly dispersed neighbourhoods.

6.4.2. **Unobserved Values and Equity**

Proponents of mixed-use development suggest a number of unobserved benefits: neighbourhood revitalization, increased housing stock, facilitated transit use, and increased accessibility. The intangible benefits of mixed-use for residents contribute to building sale price premiums. A mix of land uses such as business and leisure activities may increase housing values up to 6% in urban areas. The intangible costs (noise, light, traffic, trash) depress the price of immediately adjacent houses as much as $14,453 while accessibility benefits result in a $9,675 premium. Additionally, mixed-use development can contribute to gentrification, opening up infill sites for redevelopment into upscale residential buildings that drive out lower-income groups. Housing costs may escalate, vacancy rates decrease and homelessness can become a concern (Grant, 2002). Developers too face barriers. Mixed-use buildings are more difficult to finance than single use development and the multitude of business services creates additional complexity in the planning process. As a result of these and other factors, investors sometimes perceive mixed-use development as a higher risk investment (Rabianski, 2009).

6.4.3. **Energy & GHG Emissions Reduction**

Studies on mixed-use development show increased emissions in comparison to conventional development in terms of building energy use, although the extent to which mixed-use development can support other emissions-reducing strategies such as transit and district energy may assist in overall emissions reductions (Tong & Wong, 2011.). Modeling by Ewing (2007) in a six-region study in the United States finds mixed-use development with diverse activities reduces GHG emissions from traffic relative to conventional suburban developments. As noted with density, these relationships are variable depending on specific situations. Mixed-use development in suburban areas will not reduce emissions as much as similar development in already dense areas.

6.5. Public Transit

6.5.1. **Financial Cost-Effectiveness**

Cost-effectiveness is a concern for transit systems. Public transit is subsidized by governments. In an evaluation of United States light rail systems, Guerra and Cevero (2011) find most systems are not cost-effective, while Frank (1994) finds systems are only cost-effective at densities ranging from 20-75 employees per acre. In Canada, the results are similar: the most cost-effective system in Canada is Toronto’s GoTransit, with a cost recovery ratio of 80%, followed by Montreal (57%) and Vancouver (52%). Highest cost recovery ratios in the United States are in San Francisco, Washington, and Philadelphia, which range from 60-65%. Transit can be profitable in areas with very high urban population densities. In Hong Kong, Taipei, and Singapore transit systems generate a profit (BC Auditor General, 2013). To be fair, no passenger transportation system covers all of its costs without government funds, including highways and roads (Vuchic, 2005).

6.5.2. Unobserved Values and Equity

Unobserved values of transit can include benefits from accessibility and mobility. However, users may experience intangible costs from increased travel times and a lack of convenience, privacy, and status relative to the personal vehicle. Again, quantitative research is limited. A number of meta-analyses have tried to estimate the effect of transit accessibility on residential home prices. Most find positive relationships, but a small number indicate a negative relationship in certain circumstances (Guerra & Cevero, 2011). Cevero's (2002) review shows price premiums for housing within ¼ to ½ miles of rail transit stations of between 6.4 - 45% compared to housing outside of the transit area. Another meta-analysis of 57 studies concludes residential property values increase 2.4% for every 250m closer to transit rail stations, yet in the case of bus stations, data show a price discount for nearby properties (Debrezion, Pels, & Rietveld, 2007). Overall, studies tend to show price premiums for light rail transit stations and variable results for bus transit.

6.5.3. Energy & GHG Emissions Reduction

Analyses of the environmental benefits for transit generally show it to have a positive effect. Nahlik & Chester (2014) reviewed new rail and bus transit systems in Los Angeles and found potential GHG emission reductions of up to 470 $GgCO_2e$[1] and a decrease in user costs of $3100/household/year despite the higher rental costs in the transit-serving areas. Transit as a method of reducing vehicle transportation has high potential to reduce emissions. Light rail transit emits less than half the emissions of CO_2

[1] Gigagrams of carbon dioxide-equivalent (1 gigagram = 1,000,000 kilograms)

per passenger mile as private cars, and bus transit emits about 2/3 the emissions (Department of Transportation, 2010).

6.6. District Energy

6.6.1. Financial Cost-Effectiveness

While some propose district energy as a highly profitable alternative to conventional systems, in practice the net financial costs seem more variable. In a review of seven district energy systems in British Columbia, Ostergaard (2012) estimates the cost per megawatt hour paid by residential customers of seven district energy systems for heat and hot water in 2011, plus comparable costs for BC Hydro electric heating and Fortis gas. He finds that the costs to the customer of the systems, in particular newer ones, may be higher than conventional systems. District energy systems also may have high upfront costs. Despite these issues, Ostergaard finds that the district energy providers can be confident of a revenue stream through the life of the systems. Though he also notes that from the consumer's perspective, energy efficiency investments can provide comparable energy services and GHG reductions at similar costs.

6.6.2. Unobserved Values and Equity

Because there is a single centralized boiler, district energy systems eliminate the need for a boiler or furnace in each serviced building. As a result, they are about 1/5th the area of conventional systems and so free up space for other uses and reduce noise from mechanical rooms. Furthermore, they can ease retrofitting time and costs by requiring the retrofit of just one central energy centre rather than hundreds of small boilers in large complexes or campuses. They can also provide a platform to share the risks of adopting new technologies by spreading costs out amongst many buildings. Despite these benefits, research on two Ontario district energy projects finds that the development of a district energy system is a complex process, requiring the expertise of many specialists and support from local stakeholders. Drawbacks of district energy include lack of energy choices and sometimes-higher rates. There are also major planning implications of district energy systems which require forethought by government (Bradford, 2012). Furthermore, while the systems do spread the risk out amongst customers, specific district energy projects in British Columbia have found customer dissatisfaction with recurring system technical failures (Ostergaard, 2012).

6.6.3. Energy & GHG Emissions Reduction

For district energy systems, there is a wide range of potential emissions reductions based on project size, type, and energy source. For example, a natural gas-sourced system with oil backup in Vancouver estimates zero GHG emissions reduced, while a natural gas and biomass system at Simon Fraser University estimates 10,000 tonnes of CO_2/yr reduced (Ostergaard, 2012). Of fifteen district energy systems in BC, Ostergaard (2012) finds eleven of those systems are likely to reduce at least some GHG emissions. The remaining four systems that do not show reductions are natural gas-powered or did not have the information available. District energy has potential to reduce emissions as long as it uses low-carbon energy sources. A review of BC district energy systems shows the majority rely on non-fossil fuel sources for their primary energy source or have plans to switch.

6.7. Evaluation

In the sub-sections below, we evaluate action + policy combinations on the basis of the specified criteria. Our analysis takes into account the findings of the literature review, as well as the general discussion of policy performance in section 5. The material is presented by action; with an accompanying table for each (Tables 3 to 8) in which the action + policy combinations are assigned to rows and the evaluative criteria are assigned to columns.

With respect to the criterion of financial cost-effectiveness, we found literature that addresses at least one specific action + policy combination for each of the buildings actions (existing buildings + economic incentives, existing buildings + information, new buildings + regulation). For buildings combinations that are not covered by the literature review, cost-effectiveness ratings are subjectively assessed relative to a combination for which we do have information. The relative assessments are based on what is known about the performance of policy options in general (sub-section 5.1). Therefore, the combination of a given action with an economic disincentive policy is rated one level higher (e.g., from ‘somewhat positive’ to ‘positive’) than its combination with an economic incentive because the administrative costs of incentive programs tend to be higher. The disincentive combination is also rated one level higher than the regulatory combination due to the cost-effectiveness properties of disincentives, which are not shared by regulations.

The literature we examined for the actions at higher spatial scales generally considers cost-effectiveness in isolation from policy. For urban density, mixed-use, public transit, and district energy, the information we collected on the cost-effectiveness of the action was used to determine the rating for its combination with an economic disincentive. Combinations with a regulatory policy or an economic incentive were assessed one level lower.

For intangible values and GHG emissions reduction, our assessments generally do not vary across policies; cells in the corresponding columns are merged to indicate this. In the case of intangible values, the reason is that these values tend to be linked to actions instead of policies. For GHG emissions reduction, we do not distinguish between regulation, incentives, and disincentives because (as alluded to in sub-section 5.2) these options can be designed to be equally effective with respect to an environmental objective. We therefore base our ratings on the performance of each action according to the literature review, with adjustments specific to Vancouver. Information programs are more limited in their potential to reduce GHG emissions and are assessed as ‘low’ for the buildings actions.

Co-impacts and equity impacts are often attached to actions and policies specifically. Therefore, we evaluate the action and policy components of the various combinations separately for these criteria. This is indicated in Tables 3 to 8 by splitting the row associated with an action + policy combination into two. Any action ratings for these criteria are based on the literature review, while the any policy ratings are based on the general discussion in section 5, interpreted as follows.

Indirect impacts on the economy are classified as co-impacts in our analysis. In our review of the general characteristics of policy options, we noted that incentive programs can have a negative impact on economic efficiency if funds for the subsidy payments are obtained through distortionary taxes. Conversely, economic disincentives raise revenues, allowing governments to reduce other taxes if they choose to. Therefore, we assign a 'positive' co-impact to the policy component for disincentive policies and a 'negative' co-impact to the policy component for incentive policies. These co-impacts are identified by 'economy' in the tables below. Economic theory suggests that information programs too can have broader impacts, potentially improving economic efficiency by addressing a lack of information due to market failure; this results in a 'positive' ('economy') rating under co-impacts.

Whether a policy is progressive or regressive is highly dependent on the context in which it is implemented and the design of the specific policy instrument. Therefore, we assume that social equity is 'neutral' for information programs and that it is a function of design for the other policy categories.

6.7.1. **Existing Buildings**

There is evidence that incentives to encourage energy efficiency and energy switching retrofits in existing buildings can generate financial benefits (energy cost savings) in excess of costs. However, studies do not necessarily include all the standard components of financial costs; some focus on program costs, while others focus on participant costs. Financial cost-effectiveness is rated as 'somewhat positive.' In accordance with the literature review, the combination of information and retrofits is rated as 'variable' for cost-effectiveness. The review was not informative with respect to the application of regulation and economic disincentive policies to building retrofits; therefore, these ratings are subjectively assessed in relative terms based on what is known about the performance of policy options in general. The use of economic disincentives to promote building retrofits is rated as 'positive,' while the use of regulations is rated as 'somewhat positive.'

The literature review indicated that the intangible costs to residents of both energy efficiency and energy switching actions in existing buildings may be high. It is possible that some portion of the transaction costs discussed in the literature is the result of information shortages due to market failure. Also, there may be intangible benefits from energy efficiency due to factors such as higher levels of comfort. However, the balance of evidence seems to suggest that intangible costs are greater than benefits. Evidence of price premiums on energy efficient buildings was presented, but this is not necessarily indicative of intangible benefits to residents. Efficiency investments reduce energy costs over time, and it may be these future savings that are reflected in the higher prices. Therefore, we rate all policy combinations with retrofits as ‘negative’ with respect to the criterion of intangible values. Incentive programs may have additional transaction costs for participants relative to the other policy options.

On the other hand, we found evidence in the literature of positive co-impacts (co-benefits) associated with energy efficiency retrofits; the case is strongest for health co-benefits. We summarize this by rating the action component of co-impacts as ‘positive’ for all policy combinations with retrofits, using the notation ‘health (EE)’ in Table 3. We did not identify any specific equity concerns for retrofits to existing buildings in the literature review.

Studies indicate that retrofits do reduce energy use; however, results obtained after program implementation are usually lower than initial estimates. Also, because most of the policy evaluation literature on retrofits pertains to subsidies and information programs, even measurements taken after implementation may overstate energy savings if free-riders are not taken into account. The emissions associated with electricity consumption in BC are low, meaning there is less potential for energy efficiency retrofits to reduce emissions than there might be in other jurisdictions. On the other hand, existing policies with respect to retrofits in Vancouver represent a significant opportunity for improvement. The effectiveness of regulations and economic instruments aimed at reducing GHG emissions through retrofits to existing buildings in Vancouver is rated as ‘medium.’

Table 3: Evaluation of Existing Buildings Combinations

<table>
<tr><th></th><th>Financial Cost-Effective</th><th>Intangible Values</th><th>Co-Impacts</th><th>Equity Impacts</th><th>Emissions Reduction (Vancouver)</th></tr>
<tr><td>Exist Build</td><td rowspan="2">Somewhat Positive</td><td rowspan="8">Negative</td><td>Positive: Health (EE)</td><td>None Identified</td><td rowspan="6">Medium</td></tr>
<tr><td>Regulation</td><td>None Identified</td><td>Design Dependent</td></tr>
<tr><td>Exist Build</td><td rowspan="2">Positive</td><td>Positive: Health (EE)</td><td>None Identified</td></tr>
<tr><td>Disincentive</td><td>Positive: Economy</td><td>Design Dependent</td></tr>
<tr><td>Exist Build</td><td rowspan="2">Somewhat Positive</td><td>Positive: Health (EE)</td><td>None Identified</td></tr>
<tr><td>Incentive</td><td>Negative: Economy</td><td>Design Dependent</td></tr>
<tr><td>Exist Build</td><td rowspan="2">Variable</td><td>Positive: Health (EE)</td><td>None Identified</td><td rowspan="2">Low</td></tr>
<tr><td>Information</td><td>Positive: Economy</td><td>Neutral</td></tr>
</table>

6.7.2. **New Buildings**

The literature review indicates financial benefits in excess of costs for energy efficiency regulations that apply to new buildings. Here the evidence is somewhat stronger than for retrofits to existing buildings. We therefore rate the financial cost-effectiveness of regulations for new buildings as ‘positive.’ Both types of economic instruments are also rated as ‘positive’ based on what is known about the cost-effectiveness of these policies in general (disincentives are normally rated higher than regulations and incentives, but we have already assigned the highest rating to regulations). Information programs for new buildings are rated as ‘variable’ – the same as for building retrofits – due to a lack of other information.

We expect that intangible costs to residents are lower when energy efficiency and energy switching actions are carried out during building construction, rather than as retrofits, although the literature review was uninformative on this point. We therefore rate intangible values as only ‘somewhat negative’ for all policies applied to new construction (as opposed to ‘negative’ for retrofits). There is evidence that building regulations present a number of challenges to developers and building contractors; however, this information did not enter into our assessment of intangible values. A portion of the costs associated with these challenges may be financial costs. Some of the barriers may, in fact, be market failures associated with a lack of information and therefore not relevant to the discussion of intangible values. It is not clear to what extent similar issues arise with other action + policy combinations. Finally, some of the challenges cited may be addressed through improved policy design. Ratings for co-impacts and social equity are the same as for retrofits to existing buildings.

The literature on new building regulations consistently indicates modest reductions in energy use, although (as with retrofits) actual reductions are likely to be lower than estimated. New construction provides an opportunity to carry out energy efficiency and energy switching actions without the restriction of accommodating an existing building design. Emissions reductions can theoretically be as high as 100% if policies are designed to accomplish this. However, in Vancouver, the existing policies for new buildings are stronger than for retrofits, leaving less potential for further emissions reductions. We rate the emissions reduction potential for regulations and economic instruments targeting new buildings as 'medium' for Vancouver.

Table 4: Evaluation of New Buildings Combinations

	Financial Cost-Effective	**Intangible Values**	**Co-Impacts**	**Equity Impacts**	**Emissions Reduction (Vancouver)**
New Build	Positive	Somewhat Negative	Positive: Health (EE)	None Identified	Medium
Regulation			None Identified	Design Dependent	
New Build	Positive		Positive: Health (EE)	None Identified	
Disincentive			Positive: Economy	Design Dependent	
New Build	Positive		Positive: Health (EE)	None Identified	
Incentive			Negative: Economy	Design Dependent	
New Build	Variable		Positive: Health (EE)	None Identified	Low
Information			Positive: Economy	Neutral	

6.7.3. **Urban Density**

The financial costs of delivering public services tend to be lower for dense development than for more dispersed development according to the literature, although there is some controversy and costs may be higher for schools. We therefore rate the combination of density + disincentive as ‘somewhat positive’ in terms of financial cost-effectiveness. Density + regulation and density + incentive are assessed based on the relative performance of the generic policy options as ‘somewhat negative.’

Our review indicates that intangible benefits (improved access to services, lifestyle) and intangible costs (smaller homes, lack of parking, noise, loss of privacy) may be associated with density. A proportion of the population is clearly amenable to denser dwellings, smaller lot sizes, and smaller homes. However, the most consistent quantitative evidence in this area shows price premiums for more space in houses, streets, and blocks and this evidence is recognized even by proponents of denser development (Ewing, 1997; Gordon & Richardson, 2007). For this reason, we assess the intangible value of density as ‘negative.’ We discuss demographic variation as it relates to density further in sub-section 8.3.

The reported co-benefits of density include environmental improvements (besides the climate benefits) and reduced health problems. With respect to social equity, the literature review identified housing affordability as a concern; however, the direction of causation is not clear. It is also plausible that increased density is a consequence of higher land values. We therefore assign a rating of ‘inconclusive’ to the equity criterion for the density action.

Emission reductions from density are assessed as ‘variable’ due to the differing study results when accounting for scales, reporting scopes, and calculation methods. However, density is important to encourage other actions such as transit, mixed-use development, and district energy.

Table 5: Evaluation of Urban Density Combinations

	Financial Cost-Effective	Intangible Values	Co-Impacts	Equity Impacts	Emissions Reduction (Vancouver)
Density	Somewhat Negative	Negative	Positive: Environment, Health	Inconclusive	Variable
Regulation			None Identified	Design Dependent	
Density	Somewhat Positive		Positive: Environment, Health	Inconclusive	
Disincentive			Positive: Economy	Design Dependent	
Density	Somewhat Negative		Positive: Environment, Health	Inconclusive	
Incentive			Negative: Economy	Design Dependent	

6.7.4. **Mixed-Use**

Mixed-use development research measures financial cost-effectiveness in terms of profitability for developers; the results vary by location with density and population size. As with density, residents are likely to experience both intangible benefits (improved access to services, lifestyle) and intangible costs (noise, light, traffic, trash). However, in this case, analysis of building sale prices suggests that the intangible benefits outweigh the costs. Barriers to developers are described in the literature. These are not necessarily intangible costs; some may be financial costs, while others may be market failures. Our literature review presented limited information on co-impacts, although neighborhoods may benefit from the changes associated with mixed-use development. Equity is rated as 'somewhat negative' due to concerns that housing affordability will decline as a result of gentrification. Emissions reduction potential is rated as 'variable'; mixed-use development can support other emissions-reducing actions such as transit.

Table 6: Evaluation of Mixed-Use Combinations

<table>
<tr><th></th><th>Financial Cost-Effective</th><th>Intangible Values</th><th>Co-Impacts</th><th>Equity Impacts</th><th>Emissions Reduction (Vancouver)</th></tr>
<tr><td>Mixed-Use</td><td rowspan="2">Variable</td><td rowspan="6">Positive</td><td>Positive: Neighborhood</td><td>Somewhat Negative</td><td rowspan="6">Variable</td></tr>
<tr><td>Regulation</td><td>None Identified</td><td>Design Dependent</td></tr>
<tr><td>Mixed-Use</td><td rowspan="2">Variable</td><td>Positive: Neighborhood</td><td>Somewhat Negative</td></tr>
<tr><td>Disincentive</td><td>Positive: Economy</td><td>Design Dependent</td></tr>
<tr><td>Mixed-Use</td><td rowspan="2">Variable</td><td>Positive: Neighborhood</td><td>Somewhat Negative</td></tr>
<tr><td>Incentive</td><td>Negative: Economy</td><td>Design Dependent</td></tr>
</table>

6.7.5. **Public Transit**

Generally speaking, public transit systems do not recover their full costs and rely on government subsidies to make up the difference. Therefore, the action of shifting travel from personal vehicles to public transit is inherently associated with an economic incentive policy to provide the service in the first place. Government subsidies to public transit are justified for a number of reasons. Personal vehicles are also subsidized through expenditures such as those required to build and maintain the road network. In addition, transit use can benefit society by reducing traffic congestion. Once service is available, additional policies may be used to encourage transit use (e.g., road tolls as a disincentive to personal vehicle use or reduced transit fares for students as an incentive).

Evidence that public transit systems do not recover costs is not indicative of a negative rating in terms of cost-effectiveness. In order to make an assessment with respect to this criterion, it would be necessary to consider cost relative to a default option, which in this case is the use of personal vehicles. In the absence of such a comparison, we rate financial cost-effectiveness as ‘inconclusive.’

There are both intangible costs and intangible benefits associated with public transit use. Consideration of these intangible values, along with evidence on the relationship between residential home prices and proximity to transit stations, suggests that rail travel is associated with intangible benefits overall, while bus use is associated with intangible costs. There are potential health co-benefits of transit due to an increase in physical mobility. Although equity impacts were not identified in our literature review, we assign a 'somewhat positive' rating because public transit allows low-income people to access to transportation services. Emissions reduction potential is rated as 'high' due to lower emissions per passenger distance travelled in comparison to private vehicles.

Table 7: Evaluation of Public Transit Combinations

<table>
<tr><th></th><th>Financial Cost-Effective</th><th>Intangible Values</th><th>Co-Impacts</th><th>Equity Impacts</th><th>Emissions Reduction (Vancouver)</th></tr>
<tr><td>Transit</td><td rowspan="2">Inconclusive</td><td rowspan="6">Negative: Bus
Positive: Rail</td><td>Positive: Health</td><td>Somewhat Positive</td><td rowspan="6">High</td></tr>
<tr><td>Regulation</td><td>None Identified</td><td>Design Dependent</td></tr>
<tr><td>Transit</td><td rowspan="2">Inconclusive</td><td>Positive: Health</td><td>Somewhat Positive</td></tr>
<tr><td>Disincentive</td><td>Positive: Economy</td><td>Design Dependent</td></tr>
<tr><td>Transit</td><td rowspan="2">Inconclusive</td><td>Positive: Health</td><td>Somewhat Positive</td></tr>
<tr><td>Incentive</td><td>Negative: Economy</td><td>Design Dependent</td></tr>
</table>

6.7.6. **District Energy**

The literature on district energy systems is inconsistent with respect to financial cost-effectiveness; we have assigned a rating of 'variable.' Unobserved benefits include increased space in buildings, reduced noise, reduced retrofitting time, and risk sharing. Unobserved costs are associated with the complexity of the planning process, a lack of energy choices, and the risk of technical system failures. The literature sources we examined were not helpful in assessing the overall performance of district energy with respect to intangible values; therefore, we rate the action as 'inconclusive.' Neither co-impacts nor equity impacts were identified in the literature review. A review of BC district energy systems shows most reduce emissions; therefore, this potential is rated as 'medium.'

Table 8: Evaluation of District Energy Combinations

<table>
<tr><th></th><th>Financial Cost-Effective</th><th>Intangible Values</th><th>Co-Impacts</th><th>Equity Impacts</th><th>Emissions Reduction (Vancouver)</th></tr>
<tr><td>District Energy</td><td rowspan="2">Variable</td><td rowspan="6">Inconclusive</td><td>None Identified</td><td>None Identified</td><td rowspan="6">Medium</td></tr>
<tr><td>Regulation</td><td>None Identified</td><td>Design Dependent</td></tr>
<tr><td>District Energy</td><td rowspan="2">Variable</td><td>None Identified</td><td>None Identified</td></tr>
<tr><td>Disincentive</td><td>Positive: Economy</td><td>Design Dependent</td></tr>
<tr><td>District Energy</td><td rowspan="2">Variable</td><td>None Identified</td><td>None Identified</td></tr>
<tr><td>Incentive</td><td>Negative: Economy</td><td>Design Dependent</td></tr>
</table>

Chapter 7.

Administrative Feasibility & Political Acceptability

Here we assess the administrative feasibility and political acceptability of action + policy combinations, with summaries provided in Tables 9 to 14. Performance with respect to these two criteria can be significantly influenced by local conditions; therefore, our evaluation is specific to the city of Vancouver. It is our intent that other municipalities may glean important insights by comparison. We consider academic studies, as well as government, business, and utility company reports and websites. The data informing this section is less comprehensive and more subjective than the literature informing the reviews in sections 6 and 8. In our evaluations, we assume a typical application of actions and policies within a municipal setting.

We assess the administrative feasibility of a typical policy combined with each of the actions taking place at the building and site scales as follows: existing buildings + economic incentives, new buildings + regulation, urban density + regulation, and mixed-use + regulation. For public transit and district energy, which take place at the node scale, concerns specific to the actions begin to dominate the discussion, while policy choice fades into the background. As a result, we do not consider how administrative feasibility may vary when different policies are combined with these actions.

Political acceptability is an attribute of government policies; however, actions can have political implications too. It is intuitive that the broader the scale of the action, the more likely it is to have political consequences. We discuss the political acceptability of the actions taking place at the site and node scales below and assign ratings accordingly. The action and policy components of the various combinations are evaluated separately at these scales, with policy ratings based on our assessment of the generic policy options in sub-section 5.6. For actions taking place at the building scale, ratings for the action + policy combinations are determined solely on the basis of the policy component (as per sub-section 5.6).

7.1. Existing Buildings

7.1.1. Administrative Feasibility: Incentives

Economic incentives for retrofit actions may be more difficult to implement if they require negotiation or partnerships with banks, utility companies or other stakeholders to implement the programs. One issue with economic incentives is the amount of monitoring and enforcement required. Loans require repayment systems and subsidies necessitate application processes and funding administration. Furthermore, with the high chance of free-ridership, agencies need to ensure some way of limiting the incentives to those who are least likely to carry out the desired action otherwise.

There is also the option of introducing innovative financing schemes. Innovative financing options include property tax and utility bill financing. These programs provide upfront capital for homeowners, who then repay loan interest and principal in installments. These policies present particular issues with respect to administrative feasibility. In the case of property tax financing, repayment is made as part of a voluntary property tax assessment. The loan transfers between owners upon sale of the home. The city of Vancouver's legal department believes that while this form of financing is supported by the city's Charter, there is a small chance it could be challenged in court leading to loan defaults and open the city to risk (Bierth, Peyman, & Svedova, 2010). Utility financing is similar, but administered through utility companies instead of municipal government and uses the monthly utility bill as a way to collect loan repayments. Currently, no legislation in BC permits on-utility bill financing that is transferable between owners. It also requires consultation and partnership between the municipality and the utility company, in addition to approval through the utility regulator. Due to all of the factors described above, the administrative feasibility for encouraging retrofits primarily through economic incentives is rated as 'medium.'

Table 9: Administrative Feasibility and Political Acceptability of Existing Buildings Combinations

	Admin Feasibility (Vancouver)	Political Acceptability (Vancouver)
Exist Build **Regulation**	Not Assessed	Medium
Exist Build **Disincentive**	Not Assessed	Low
Exist Build **Incentive**	Medium	High
Exist Build **Information**	Not Assessed	High

7.2. New Buildings

7.2.1. Administrative Feasibility: Regulations

The city is in a unique position in comparison to other cities in BC to control the efficiency of its building stock through bylaws. The Vancouver Charter provides the city with the ability to enact bylaws that mandate efficiencies. City council approves new bylaws or amendments to existing bylaws. These amendments do not normally require consultation with other governments, making changes in this area relatively straightforward from the perspective of local government. While regulations may be straightforward to enact, the issue of enforcement may create an administrative burden on city staff, given limited resources. Administrative feasibility in the case of new builds is rated as ‘high.’

Table 10: Administrative Feasibility and Political Acceptability of New Buildings Combinations

	Admin Feasibility (Vancouver)	Political Acceptability (Vancouver)
New Build Regulation	High	Medium
New Build Disincentive	Not Assessed	Low
New Build Incentive	Not Assessed	High
New Build Information	Not Assessed	High

7.3. Urban Density

7.3.1. Administrative Feasibility: Regulations

The 2008 British Columbia Local Government Statutes Amendment Act increased the authority of municipal governments to mitigate the environmental effects of development projects by establishing specific development permit areas for promoting energy efficiency, reduced GHG emissions and water conservation. Through this act, local governments such as Vancouver can tie project approvals to specific performance requirements such as density or mixed-use.

In addition, rezoning can encourage both density and mixed-use development. City staff initiate rezoning following a change in policy or when the public makes a rezoning application. Zones are customized to specific sites, changed from one zone to another standard zone, or amended. Planning staff review the applications, and then report to city council, where council either approves or refuses the applications. While procedures to change zones, create new zones, or approve density bonusing are straightforward, they normally require research and public consultation, which can increase the administrative burden. Zoning and density bonusing policies are regulatory policies similar to building standards. Administrative feasibility for density action is rated as ‘medium.’

7.3.2. **Political Acceptability**

While Vancouver is a relatively dense city, increasing density has been a contentious topic in the past. Rosol (2013) traces how some types of density increases in some areas has faced opposition from residents, community groups, and social activists concerned with gentrification and housing affordability.

Former mayor Sam Sullivan proposed the EcoDensity initiative (2006-2009) to extend densification throughout the city with the goal of improving livability, environmental performance and housing affordability. City planners conducted two years of workshops, community meetings, public forums, and fairs attracting thousands of participants. Concerns that density would simply mean more condominiums for high-income professionals dominated the consultations (Bula, 2008). EcoDensity met with a reluctance of many residents to embrace the initiative. Because of the lack of support, a municipal government change in 2008 dropped the EcoDensity initiative and replaced it with the Greenest City goals. These goals focus on bike paths, community gardens, composting and emergency beds for the homeless. The new government also pushed forward with relaxed height and density requirements for developments that provide rental-only towers, sold off lands for dense development and promoted infill as well as mixed-use development without the strong branding of EcoDensity.

Vancouver’s low vacancy rates for rental housing suggest there is still a considerable level of demand for existing dense development in the city. Engaging community members and stakeholders in the development process may reduce public opposition to new dense development. Though even when consulted, there is no guarantee residents will be receptive to increased density. Because of this, increasing density may have low political acceptability.

Table 11: Administrative Feasibility and Political Acceptability of Urban Density Combinations

	Admin Feasibility (Vancouver)	Political Acceptability (Vancouver)
Density	Medium	Low
Regulation		Medium
Density	Not Assessed	Low
Disincentive		Low
Density	Not Assessed	Low
Incentive		High

7.4. Mixed-Use

7.4.1. Administrative Feasibility: Regulations

Mixed-use development is encouraged at the city level in the same manner as density with zoning regulations or development charges. The city of Vancouver has complete jurisdictionally authority over this development; however, as with density, there is usually some level of public consultation involved when rezoning for mixed-use. Therefore administrative feasibility is rated as ‘medium.’

7.4.2. Political Acceptability

While density and mixed-use are generally supported with the same policies and public consultation processes, there is no record of similar strong opposition to mixed-use development. However, mixed-use development requires minimum densities; therefore, the opposition to density may also affect mixed-use development. Accounting for this dynamic, the political acceptability for mixed-use development is slightly higher than density, at ‘medium.’

Table 12: Administrative Feasibility and Political Acceptability of Mixed-Use Combinations

	Admin Feasibility (Vancouver)	Political Acceptability (Vancouver)
Mixed-Use	Medium	Medium
Regulation		Medium
Mixed-Use	Not Assessed	Medium
Disincentive		Low
Mixed-Use	Not Assessed	Medium
Incentive		High

7.5. Public Transit

7.5.1. Administrative Feasibility

Vancouver is part of the broader Metro Vancouver transit system managed by Translink. Any changes to Translink revenues, routes, or other operating procedures typically require consultation or approval from the province, mayor's council, and the Regional Transportation Commissioner, in addition to extensive public consultation. To improve or change transit service, the city of Vancouver must lobby Translink and the provincial government, in addition to consulting with the 21 other municipalities that make up Metro Vancouver. Failure of the recent Metro Vancouver transit referendum that proposed a sales tax to fund transportation improvements highlights the difficulty in initiating changes to public transit. Making changes to transit in British Columbia is a relatively time-consuming process that requires multiple levels of consultation and partnerships. Administrative feasibility is 'low.'

7.5.2. Political Acceptability

Transit improvements that affect area residents or require tax increases (as in the case of the recent transit referendum) can face large public opposition. The negative impacts of public opposition include delayed projects, lack of funding sources, or low use of the infrastructure once it is built. Because of these considerations, political acceptability of transit actions is 'low.'

Table 13: Administrative Feasibility and Political Acceptability of Public Transit Combinations

<table>
<tr><th></th><th>Admin Feasibility (Vancouver)</th><th>Political Acceptability (Vancouver)</th></tr>
<tr><td>Transit</td><td rowspan="6">Low</td><td>Low</td></tr>
<tr><td>Regulation</td><td>Medium</td></tr>
<tr><td>Transit</td><td>Low</td></tr>
<tr><td>Disincentive</td><td>Low</td></tr>
<tr><td>Transit</td><td>Low</td></tr>
<tr><td>Incentive</td><td>High</td></tr>
</table>

7.6. District Energy

7.6.1. Administrative Feasibility

District energy systems can be challenging to build without government support, regulations, and subsidies. Within BC, the BC Utilities Commission regulates most systems unless a local government provides the service. In Vancouver, municipal and provincial government policy supports district energy systems. The provincial government amended the Vancouver Charter in 2007 to enable the city to provide energy utility services, after which the city created the Energy Utility System Bylaw to mandate mandatory connection for all new buildings within a development plan area. However, there is still a large burden in terms of administration, oversight, and management of these systems. Consultation with local area residents and businesses is also required, in addition to cooperation with provincial utility companies. Administrative feasibility is assessed as 'medium.'

7.6.2. **Political Acceptability**

Public awareness of district energy systems is low, and this can influence political acceptability. When Vancouver city staff were planning the Southeast False Creek Neighbourhood Energy Utility, they held a number of public consultations and workshops to gauge support. The public consultation process found public perception was not always based on technological facts. The public was apprehensive about the construction of what some thought of as an industrial facility near a high-density residential neighbourhood, as well as concerns about technical failure (The Challenge Series, 2010). District energy systems, in addition to transit improvements, suffer from NIMBY-thinking (not in my backyard). This refers to cases where certain infrastructure improvements are negatively valued by nearby residents, even if they provide important area benefits. Opposition to these types of infrastructure can be fierce (Hyslop, 2005). Because of these factors, political acceptability of district energy is 'low.'

Table 14: Administrative Feasibility and Political Acceptability of District Energy Combinations

<table>
<tr><th></th><th>Admin Feasibility (Vancouver)</th><th>Political Acceptability (Vancouver)</th></tr>
<tr><td>District Energy</td><td rowspan="6">Medium</td><td>Low</td></tr>
<tr><td>Regulation</td><td>Medium</td></tr>
<tr><td>District Energy</td><td>Low</td></tr>
<tr><td>Disincentive</td><td>Low</td></tr>
<tr><td>District Energy</td><td>Low</td></tr>
<tr><td>Incentive</td><td>High</td></tr>
</table>

Chapter 8.

Literature Review: Demographic and Urban Form Heterogeneity

We seek a better understanding of demographic heterogeneity by examining positive and negative associations between the demographic characteristics of age, income, and family size and the six actions included in this study. We define such associations based on the relative likelihood of carrying out an action, the relative preference for a style of development linked to an action, or the relative financial cost or benefit of an action. When we assign a rating of 'somewhat positive' (as opposed to 'positive') or 'somewhat negative' (as opposed to 'negative') this is generally to indicate that less evidence is available with respect to a particular combination of demographic characteristic and action. We also consider how the actions may interact in positive or negative ways with density as a measure of urban form. The conclusions section contains a table summarizing our assessments.

When possible, we focus on surveys of Vancouver residents to maximize the relevance for application in this jurisdiction. Researchers note a general lack of understanding of the demographic and social factors that play a role in energy efficiency and energy switching actions (Friege & Chappin, 2014; Judson & Maller, 2014). The review includes some peer-reviewed academic studies on the impact of demographic and urban form variations for each action. Due to a lack of data, the review was expanded to include consulting surveys by the Pembina Institute, the Canadian Energy Efficiency Association, and the American Real Estate Association.

8.1. Existing Buildings

In a survey of Canadians regarding retrofit investments for energy efficiency, the Canadian Energy Efficiency Association (CEEA) finds that while all groups were equally interested, higher income groups were more likely to engage in more costly measures. Lower income groups were practicing more 'low cost' behavioural change actions rather that investing in efficiency or energy switching. A significant barrier to retrofitting, particularly for low income groups was the belief that retrofits are not worth the effort for too little savings, suggesting that economic incentives may help encourage action. Furthermore, energy switching actions that do not reduce energy costs may not be well-received by these groups without additional incentives. Similarly, a Swedish study of retrofit behaviour explores the relationship between income and propensity to undertake retrofits (Nair, 2010). Low-income groups were least likely to invest, while mid-income groups were more likely than high-income groups to invest. It is unknown the extent to which these outcomes are the result of values held by specific demographic groups, or rather the constraints that low-income groups face. Nair suggests that economic incentive mechanisms may be better suited towards low-income groups to overcome the discrepancy in uptake. Other studies also support this suggestion while noting a higher potential for free-ridership with higher income groups (Galvin, 2014). Based on this information, we rate the association between higher income and retrofits to existing buildings as 'somewhat positive.' For lower income we assign a 'negative' rating.

Nair (2010) finds those most likely to adopt energy efficiency or energy switching retrofits, both on their own and with incentive programs, were between 36 and 45 years of age. Older groups (ages 60+) were least likely to implement measures. In terms of family size, American government researchers note greater potential energy savings in larger households (Woo & Guldmann, 2011). We assign a 'somewhat positive' rating to mid-age for retrofits to existing buildings and a 'somewhat negative' rating to older age. Younger ages are assessed as 'neutral.' The association with larger households for this action is rated as 'somewhat positive.'

8.2. New Buildings

No demographic or urban form information is available specifically relating to new building actions.

8.3. Urban Density

Childless young adults and older empty nesters are found to be more likely to prefer dense living (Myers & Gearin, 2001). A number of surveys agree that younger singles who aren't looking to purchase homes are more likely to prefer dense living within a city centre (Winston, 2013). Yang (2013) also finds that those over 65 express a higher level of agreement with the willingness to trade off house size for proximity to amenities. In an Irish survey, Senior (2006) finds few households would consider moves to denser development in the city or redeveloped docklands, and those that would consider the moves are mostly seniors or younger couples. However those 'preferences' may be the results of income constraints. Dawkins (2009) finds that despite first-time homebuyers' characteristics of having lower incomes and younger ages, they do not seem to express stronger preferences for housing located in denser areas, and instead search first for affordable housing.

In stated preference surveys, Winston (2013) and Howley (2009) find preferences of those already living in dense areas were weighted towards ultimately living in areas with lower density once they had the financial means to do so, with the push to move coming strongest from families. Liao et al. (2014), Howley (2009), and Winston (2013) all find those with families or the intention to start families preferring lower density development. Laio finds that, in Utah, stronger preferences for suburban neighbourhoods mainly occur among bigger families with school-aged children and high-income households. The literature suggests that younger people, smaller households, and seniors may prefer or be more constrained towards density; while larger and higher income households exhibit a preference for low density. 'Positive' and 'negative' interactions are assigned accordingly, with higher income rated as only 'somewhat negative' with respect to density.

8.4. Mixed-Use

Mixed-use shows high preferences across most demographic characteristics, particularly for Vancouver (Frank, Kershaw, Chapman, & Perrotta, 2014). Although, preferences in the city of Vancouver are not the same as preferences in the surrounding municipal areas. While 53% of Vancouver respondents preferred a mix of different housing types in their neighbourhoods, only 29% of respondents in the outlying metro Vancouver neighbourhoods shared this preference. This type of development is not ideal in dispersed locations with limited accessibility; therefore, there is a positive association with density in relation to mixed-use development. In a survey of Toronto residents, the Pembina Institute (2014) finds that when housing costs are not a factor, 81% of respondents choose to live in an urban or suburban neighbourhood where they can walk to stores, restaurants or other amenities. Mixed-use is rated as ‘somewhat positive’ for all demographic groups. This action is potentially negative for lower density areas due to studies suggesting a ‘disamenity’ effect where commercial mixed-use development is less desirable in lower density neighbourhoods.

8.5. Public Transit

Public transit is generally valued among younger age groups, lower incomes, and smaller family sizes. In a study of Metro Vancouver, researchers find 60% of respondents strongly preferred design features that support walking and public transit, with these preferences higher in the younger (under 35) age groups (Frank et al., 2014). Families with children showed slightly higher preferences for less-dense neighbourhoods.

Singles, those with no children, and those ages 60 and over or 18-34 value a pedestrian and transit-friendly city more according to the Pembina Institute (2014) survey. People with children, married, and ages 35-59 value suburban living more. Lewis (2010) finds a major constituency for transit-oriented development is lower income groups and younger ages. We rate the association between younger age and transit as ‘positive’; the associations for smaller household, older age, and lower income are rated as ‘somewhat positive.’ The interactions for larger household size and mid-age are assessed as ‘somewhat negative.’ Because higher population densities facilitate public transit, the association between higher density and transit is rated as ‘positive.’

8.6. District Energy

No demographic information is available specifically relating to district energy systems, though district energy shows higher financial profitability when combined in denser urban settings and mixed-use development such as large academic or corporate campuses. Therefore, as with mixed-use and public transit, we rate the association with density as ‘positive.’

Chapter 9.
Conclusions and Recommendations

In this study, we evaluate action + policy combinations for reducing urban GHG emissions from the built environment. Our aim is to do so using an expanded set of criteria including intangible values and to take into account heterogeneity associated with demographics and urban form. This is achieved through an extensive review of the literature, supplemented by knowledge of the theoretical performance of generic policy options. The policy evaluation process requires jurisdiction-specific information; therefore, we use the city of Vancouver as a case study. We summarize our results in tabular form below.

The summary tables are followed, in sub-section 9.1, with a series of recommendations by action based on our analysis. We take as given a strategy that focuses on particular actions, as we assume municipal governments are unlikely to adopt broad-based carbon taxes or emissions cap and trade systems. Recommendations are for the city of Vancouver in the context of published targets for GHG emissions reduction and renewable energy. However, as mentioned previously, much of the research for this report was completed prior to the release of the City of Vancouver's Renewable City Strategy (2015) and, as such, our work should not be interpreted as a response to the Strategy and ongoing efforts towards its implementation. Although some of our more general recommendations apply to other jurisdictions as well, there are important differences between communities that must be taken into account; we comment on the relevance of this study for other communities in BC in sub-section 9.2. Sub-section 9.3 reviews some of the limitations of this study, and sub-section 9.4 outlines potential future research directions.

In chapters 6 and 7, we evaluated 20 action + policy combinations against four standard evaluation criteria: financial cost-effectiveness, environmental effectiveness (at reducing GHG emissions), administrative feasibility, and political acceptability. To these standard criteria, we added intangible values, co-impacts, and equity impacts. The results are summarized in Table 15 below.

Among the additional evaluation criteria included in this study, our focus is on intangible values; information on co-impacts and equity impacts was noted as we came across it. Whereas co-impacts and equity impacts can be significantly influenced by policy design, intangible values tend to be attached to actions themselves. This may make intangible values less malleable; however, the intangible costs of some actions (e.g. a shift to public transit) can be reduced through changes to urban form brought about by other actions or policies (e.g. increased urban density, improved public transit infrastructure and service).

Table 15 simply brings together the Tables already presented by action in sections 6 and 7, except that the equity impacts column is merged with the co-impacts column to save space. For the buildings actions and district energy, there were no equity impacts identified. Potential impacts were identified for urban density, mixed-use, and public transit; we note these in the table. We judge the equity consequences of regulation and economic instruments to be dependent on the specific design of the policy, while information programs are rated as neutral. As these assessments with respect to equity are not particularly helpful in trading off the consequences of different policy choices, we do not include them in the table.

Table 15: Matrix Summarizing Evaluations of Action + Policy Combinations Against All Criteria

<table>
<tr><th></th><th>Financial Cost-Effective</th><th>Intangible Values</th><th>Co-Impacts (Equity Impacts)</th><th>Emissions Reduction (Vancouver)</th><th>Admin Feasibility (Vancouver)</th><th>Political Acceptability (Vancouver)</th></tr>
<tr><td>Exist Build</td><td rowspan="2">Somewhat Positive</td><td rowspan="8">Negative</td><td>Positive: Health (EE)</td><td rowspan="6">Medium</td><td rowspan="2">Not Assessed</td><td rowspan="2">Medium</td></tr>
<tr><td>Regulation</td><td>None Identified</td></tr>
<tr><td>Exist Build</td><td rowspan="2">Positive</td><td>Positive: Health (EE)</td><td rowspan="2">Not Assessed</td><td rowspan="2">Low</td></tr>
<tr><td>Disincentive</td><td>Positive: Economy</td></tr>
<tr><td>Exist Build</td><td rowspan="2">Somewhat Positive</td><td>Positive: Health (EE)</td><td rowspan="2">Medium</td><td rowspan="2">High</td></tr>
<tr><td>Incentive</td><td>Negative: Economy</td></tr>
<tr><td>Exist Build</td><td rowspan="2">Variable</td><td>Positive: Health (EE)</td><td rowspan="2">Low</td><td rowspan="2">Not Assessed</td><td rowspan="2">High</td></tr>
<tr><td>Information</td><td>Positive: Economy</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>New Build</td><td rowspan="2">Positive</td><td rowspan="8">Somewhat Negative</td><td>Positive: Health (EE)</td><td rowspan="6">Medium</td><td rowspan="2">High</td><td rowspan="2">Medium</td></tr>
<tr><td>Regulation</td><td>None Identified</td></tr>
<tr><td>New Build</td><td rowspan="2">Positive</td><td>Positive: Health (EE)</td><td rowspan="2">Not Assessed</td><td rowspan="2">Low</td></tr>
<tr><td>Disincentive</td><td>Positive: Economy</td></tr>
<tr><td>New Build</td><td rowspan="2">Positive</td><td>Positive: Health (EE)</td><td rowspan="2">Not Assessed</td><td rowspan="2">High</td></tr>
<tr><td>Incentive</td><td>Negative: Economy</td></tr>
<tr><td>New Build</td><td rowspan="2">Variable</td><td>Positive: Health (EE)</td><td rowspan="2">Low</td><td rowspan="2">Not Assessed</td><td rowspan="2">High</td></tr>
<tr><td>Information</td><td>Positive: Economy</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>Density</td><td rowspan="2">Somewhat Negative</td><td rowspan="6">Negative</td><td>Positive: Environment, Health
Inconclusive: Equity</td><td rowspan="6">Variable</td><td rowspan="2">Medium</td><td>Low</td></tr>
<tr><td>Regulation</td><td>None Identified</td><td>Medium</td></tr>
<tr><td>Density</td><td rowspan="2">Somewhat Positive</td><td>Positive: Environment, Health
Inconclusive: Equity</td><td rowspan="2">Not Assessed</td><td>Low</td></tr>
<tr><td>Disincentive</td><td>Positive: Economy</td><td>Low</td></tr>
<tr><td>Density</td><td rowspan="2">Somewhat Negative</td><td>Positive: Environment, Health
Inconclusive: Equity</td><td rowspan="2">Not Assessed</td><td>Low</td></tr>
<tr><td>Incentive</td><td>Negative: Economy</td><td>High</td></tr>
</table>

<table>
<tr><th></th><th>Financial Cost-Effective</th><th>Intangible Values</th><th>Co-Impacts
(Equity Impacts)</th><th>Emissions Reduction (Vancouver)</th><th>Admin Feasibility (Vancouver)</th><th>Political Acceptability (Vancouver)</th></tr>
<tr><td>Mixed-Use</td><td rowspan="2">Variable</td><td rowspan="6">Positive</td><td>Positive: Neighborhood
Somewhat Negative: Equity</td><td rowspan="6">Variable</td><td rowspan="2">Medium</td><td>Medium</td></tr>
<tr><td>Regulation</td><td>None Identified</td><td>Medium</td></tr>
<tr><td>Mixed-Use</td><td rowspan="2">Variable</td><td>Positive: Neighborhood
Somewhat Negative: Equity</td><td rowspan="2">Not Assessed</td><td>Medium</td></tr>
<tr><td>Disincentive</td><td>Positive: Economy</td><td>Low</td></tr>
<tr><td>Mixed-Use</td><td rowspan="2">Variable</td><td>Positive: Neighborhood
Somewhat Negative: Equity</td><td rowspan="2">Not Assessed</td><td>Medium</td></tr>
<tr><td>Incentive</td><td>Negative: Economy</td><td>High</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>Transit</td><td rowspan="2">Inconclusive</td><td rowspan="6">Negative: Bus
Positive: Rail</td><td>Positive: Health
Somewhat Positive: Equity</td><td rowspan="6">High</td><td rowspan="6">Low</td><td>Low</td></tr>
<tr><td>Regulation</td><td>None Identified</td><td>Medium</td></tr>
<tr><td>Transit</td><td rowspan="2">Inconclusive</td><td>Positive: Health
Somewhat Positive: Equity</td><td>Low</td></tr>
<tr><td>Disincentive</td><td>Positive: Economy</td><td>Low</td></tr>
<tr><td>Transit</td><td rowspan="2">Inconclusive</td><td>Positive: Health
Somewhat Positive: Equity</td><td>Low</td></tr>
<tr><td>Incentive</td><td>Negative: Economy</td><td>High</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>District Energy</td><td rowspan="2">Variable</td><td rowspan="6">Inconclusive</td><td>None Identified</td><td rowspan="6">Medium</td><td rowspan="6">Medium</td><td>Low</td></tr>
<tr><td>Regulation</td><td>None Identified</td><td>Medium</td></tr>
<tr><td>District Energy</td><td rowspan="2">Variable</td><td>None Identified</td><td>Low</td></tr>
<tr><td>Disincentive</td><td>Positive: Economy</td><td>Low</td></tr>
<tr><td>District Energy</td><td rowspan="2">Variable</td><td>None Identified</td><td>Low</td></tr>
<tr><td>Incentive</td><td>Negative: Economy</td><td>High</td></tr>
</table>

In considering the results of this study, it is important to bear in mind that the literature in this area tends to be concerned with how to achieve modest GHG emissions reductions, primarily through energy efficiency actions. If, on the other hand, the goal is to reach near-zero GHG emissions from energy consumption through a shift to almost 100% renewable energy, then future actions and policies must be different from those that have dominated the literature in the past, and this will be reflected in the performance of action + policy combinations. Of particular importance is the role of compulsory policy to induce energy switching. Although energy efficiency and energy conservation actions can ease the transition away from fossil fuels by reducing the amount of energy consumption that must be replaced by renewable sources, human societies will continue to consume large quantities of energy, even in the event of dramatic energy efficiency improvements. Compulsory policies – that is to say regulations, economic disincentives, and/or market-oriented regulations – will be necessary to achieve the momentous shift from fossil fuels to renewable energy.

In chapter 8, we considered positive and negative associations between the actions and key sources of heterogeneity: demographic characteristics (age, income, and family size) and density as a measure of urban form. These assessments are summarized in Table 16.

Table 16: Associations Between Actions and Sources of Heterogeneity

	Existing Buildings	New Buildings	Density	Mixed-Use	Transit	District Energy
Lower Income	Negative	Inconclusive	Somewhat Positive	Somewhat Positive	Somewhat Positive	Inconclusive
Higher Income	Somewhat Positive	Inconclusive	Somewhat Negative	Somewhat Positive	Somewhat Negative	Inconclusive
Smaller Household	Somewhat Negative	Inconclusive	Positive	Somewhat Positive	Somewhat Positive	Inconclusive
Larger Household	Somewhat Positive	Inconclusive	Negative	Somewhat Positive	Somewhat Negative	Inconclusive
Younger Age	Neutral	Inconclusive	Positive	Somewhat Positive	Positive	Inconclusive
Mid-Age	Somewhat Positive	Inconclusive	Negative	Somewhat Positive	Somewhat Negative	Inconclusive
Older Age	Somewhat Negative	Inconclusive	Positive	Somewhat Positive	Somewhat Positive	Inconclusive
Lower Density	Inconclusive	Inconclusive	Not applicable	Negative	Negative	Negative
Higher Density	Inconclusive	Inconclusive	Not applicable	Positive	Positive	Positive

9.1. Recommendations for Vancouver

9.1.1. All Actions

- In many cases, regulations may be the best option for municipal governments to achieve their environmental objectives in a manner that is politically acceptable, yet does not require scarce government funds be allocated as subsidies.

- Economic disincentives are relatively economically efficient, but are unlikely to perform well in terms of environmentally effectiveness if they result in only small changes to prices. On the other hand, large changes to prices may not be acceptable politically.

- Revenue neutrality can address equity impacts and improve the political acceptability of disincentives. There can be additional environmental benefits if revenues are dedicated to emissions reduction. Funds directed towards reducing existing taxes can also mitigate distortions to the economy associated with those taxes.

- Economic incentives should be used sparingly and ideally only when funding is available from disincentive policies. Tax increases, budget shortfalls, and spending cuts may have undesirable impacts on the health of the economy and on social equity.

- We recommend information policies, but only when combined with other initiatives. There is the potential for information programs to improve social welfare by addressing a lack of information due to market failure. Information campaigns may also increase awareness of the co-benefits of actions to reduce emissions and help gain political acceptance for more compulsory policies, such as regulation and economic disincentives. However, information policies are limited in terms of their environmental effectiveness and will not succeed as the main policy strategy of municipal governments for achieving any of the actions.

9.1.2. Buildings Actions

- Given that electricity generation in BC is low in GHG emissions, policies that achieve more efficient use of electricity will have a limited impact on emissions within the province.

- To the extent that natural gas can be replaced by biomethane that does not result in significant lifecycle GHG emissions, the potential for efficiency gains in natural gas consumption and switching to electricity is limited as well.

- If natural gas is not replaced with biomethane, energy switching from natural gas to electricity or distributed renewable energy sources will be necessary.

- In terms of policies, focus on regulation (i.e. building codes), with perhaps some economic instruments (ideally revenue-neutral).

- Intangible costs should be taken into account when considering actions to target and policies to achieve those actions; such costs may be especially important for retrofits.

Existing Buildings

- Regulating retrofits to existing buildings across the board is clearly more problematic than regulating the construction of all new buildings.

- Regulations can, however, be used to oblige renovations to meet certain requirements.

- A feebate system (combination of economic disincentives and incentives) for near-zero emissions performance that comes into effect upon the sale of a building is also a possibility.

- Another potential economic instrument that the city of Vancouver might consider is to apply for a FortisBC franchise fee reflecting GHG emissions associated with the fuel product delivered.[1] Although, if possible, negotiation with Fortis or provincial regulators to achieve a desired shift to biomethane over time would be preferable.

- Economic incentives offered by third parties may target energy efficiency with little impact on GHG emissions. Additionally, studies suggest high rates of free-ridership amongst higher income groups for subsidies and grants. There may be an argument for only allowing lower income groups to participate in retrofit incentive programs.

- Innovative financing may be successful in addressing uncertainty about whether up-front investments in retrofit actions will be recovered. However, innovative financing systems are administratively complex.

New Buildings

- Regulations are certainly the dominant policy instrument for new buildings, and administrative feasibility of this approach is high. However, economic disincentives should not be ruled out.

- Modify existing building bylaws or create new mandates that specify emissions reductions, not just energy reductions.

- As the city tightens regulations, care should be taken to address some of the challenges to builders discussed previously. High unobserved costs to this stakeholder group may decrease compliance rates and render the regulatory measures ineffective without high levels of monitoring and enforcement.

[1] Whistler's Community Energy and Climate Action Plan (The Resort Municipality of Whistler, 2016) suggests such a fee as a possible way to fund energy efficiency programs.

9.1.3. **Urban Density**

- There is some ambiguity with respect to the emissions reduction potential for urban density. The evidence in the literature points to intangible costs. Also, there appears to be some political resistance in Vancouver to pursuing this strategy. Although density is important to encourage other actions, Vancouver is already a relatively dense city.

- Therefore, we recommend only using density as a means to achieve ends such as establishing minimum densities to make mixed-use, transit, or district energy cost-effective. Policies should be framed in relation to those three actions, which may be more well-received by the public and, in the case of transit and district energy, show greater potential to reduce emissions. Policies under a goal to simply increase density may create political opposition related to concerns of gentrification, as well as increased crime, noise, and other impacts.

- Vancouver has the authority to tie project approvals to specific performance requirements such as density and mixed-use development.

- Other policies that encourage urban density include zoning changes, density bonusing, developer tax credits, adjustments to property taxes, and accelerated permits. The options are similar for mixed-use.

- Engagement of community members and stakeholders may help to minimize public opposition.

- Our review of associations between demographic characteristics and urban density suggests that there may be more resistance to this style of development among those with higher incomes, larger household sizes, and who are middle-aged.

9.1.4. **Mixed-Use**

- Mixed-use does not appear to face the same challenges in terms of intangible values and political acceptability as density; however, here too, the link to GHG emissions reduction is not direct.

- Therefore, we recommend policies to promote mixed-use development only as necessary to enable public transit and district energy actions.

- Existing rapid transit stations in the city of Vancouver provide an opportunity for increased density, mixed-use development, and district energy systems. There are still a number of underdeveloped transit nodes throughout the city where mixed-use development supporting district energy is a possibility.

9.1.5. **Public Transit**

- Emissions reduction potential is greater the lower the emissions of transit vehicles are, so emphasis should be placed on low- or zero-emission options. Our review of the literature on intangible values suggests that a focus on rail systems as opposed to bus transit is preferable.

- Metro Vancouver's ability to fund transit improvements on its own is limited, although differentiated taxes could possibly be used to capture some of the increase in property values due to rezoning along rapid transit corridors. Lobbying higher levels of government to fund transit infrastructure will likely also be necessary.

- Regulatory mechanisms that support transit development include zoning and planning strategies. The city can also improve pedestrian accessibility, walkability, and cycling infrastructure through zoning strategies.

- Economic disincentives to personal vehicle use such as vehicle charges, road pricing, congestion pricing, parking charges, and bridge tolls can encourage transit use but may experience low political acceptability. If economic disincentives take into account the GHG emissions associated with different personal vehicle technologies, energy switching within the personal vehicle fleet may be encouraged as well.

- Economic incentive programs (beyond the initial subsidy making up the difference between regular transit fares and the cost of the system) should be pursued with caution as a means to shift people from personal vehicles to public transit. Our research indicates positive or somewhat positive associations between public transit and lower income, younger age, and older age – the demographic groups most likely to receive a transit subsidy. There is certainly an argument on equity grounds for such subsidies; however, if the purpose of the program is a change in behavior, free-ridership may be higher with these groups.

- Information on scheduling, transit services, and service areas can encourage transit use and may help dispel negative perceptions regarding quality, timing, or speed of services.

- In addition, as the majority of Vancouver's emissions come from personal vehicles, another strategy to reduce those emissions is to lobby other levels of government for policies that support zero- or partial-zero emission vehicles.

9.1.6. **District Energy**

- District energy has potential to reduce emissions as long as it uses low-carbon energy sources. Additional regulations in the form of bylaws can mandate acceptable energy sources within city boundaries to ensure near-zero emissions.

- The systems themselves can be encouraged through the mandatory connection bylaw, information, and potentially funded through taxes such as the Federal Gas Tax Fund.

- Information programmes may help to improve public awareness of district energy and address the NIMBY response to projects.

- Related policies that can encourage district energy systems include zoning for mixed-use development or densities that support district energy, technology subsidies, grants to help with connection costs and piping infrastructure, and information campaigns informing developers of system benefits.

9.2. Relevance for Other BC Communities

Vancouver is a large, relatively dense city on average with a history of progressive environmental policies and authority under the Vancouver Charter to pursue a range of policies. Other municipalities in BC do not enjoy the same jurisdictional authority. These communities may be more constrained in terms of the actions and policies that can be successful and may be more reliant on advocacy and lobbying with federal and provincial governments. A large part of city emissions are not under the jurisdictional authority of municipal governments, and without federal and provincial leadership it will be difficult for municipalities to meet ambitious climate targets.

This study suggests to policymakers that demographic and urban form variation are important to consider when choosing desired actions and developing policies, particularly across different communities. Many smaller cities and towns in BC have more dispersed urban forms than Vancouver, making a shift to public transit, mixed-use development, and provision of district energy more challenging. Differences in the financial cost-effectiveness – and indeed the technical feasibility – of actions in these communities mean that the strategies to achieve energy sustainability must be different as well, with a greater focus on near-zero emissions buildings and personal vehicles.

9.3. Study Limitations

We have already drawn attention to a disconnect that exists between the literature in this area and the implications of recent aspirational commitments for municipal energy systems. Additional limitations are discussed below.

In the literature reviews, we tried to use studies from peer-reviewed journals; however, in the case of district energy systems, some building policy evaluations, and demographic research, we used some reports from independent institutes, governments, and consultants. These studies have not been subject to peer-review, which would have provided independent scrutiny by qualified peers.

By nature, this research is very broad, which poses challenges in evaluating the quality of the literature sources under review. The study requires analysis and review of a wide range of literature in different disciplines that use different research methods and techniques. In some cases (transportation and spatial modeling techniques, for example), we may not have captured more nuanced factors in our analysis.

Our evaluations of action + policy combinations are based on subjective judgement given the available information, which in many cases is thin. We often had to combine specific empirical information from the literature review with general information on the theoretical performance of policy options.

Despite the limitations of the data and analytical method, the framework of this study illustrates a way to include intangible values, as well as demographic and urban form interactions in action and policy evaluations. It also questions some standard planning literature that encourages certain actions without regard to demographic preferences or existing urban form.

9.4. Future Research

Data quality can be greatly improved by more consistent action and policy evaluation guidelines. Different reporting scopes, units, timescales, and perspectives make comparing results a challenging exercise that necessitates speculation, judgement and greatly increases the margin of error. Improved consistency would help researchers and policymakers make the best decisions possible. Furthermore, there is a lack of monitoring of policies, therefore policymakers and researchers are not always able to determine whether actions or policies did achieve goals, or at what cost goals were achieved.

There is limited empirical peer-reviewed literature relating to intangible values and how different consumer groups respond to policy. Allcott & Greenstone (2012) advocate for the use of “randomized controlled trials and quasi-experimental techniques” to learn more in the context of energy efficiency policy (p. 25). Increased and more comprehensive surveys regarding people’s perceptions of policies and actions can also improve knowledge of intangible values and demographic variation. Policy evaluations that consider urban form interactions such as building type, mix, or land use can further improve knowledge of how urban form impacts policy effectiveness.

This study did not consider the potential for intangible costs and benefits to vary over time. There may be value in researching whether preferences for dense development are gradually increasing in certain locations. Or whether, as technology improves over time, intangible costs for certain policies or actions gradually decrease. It is also possible that what appear to be changes in intangible values over time are really changes in demographic characteristics or urban form.

Quantitative modelling efforts can help municipal staff in developing environmental policy. Integrated modelling of efficiency and energy use policies for buildings with other policies at the municipal level (e.g. urban form, density) is recommended in order to improve understanding of their interactive effects. A further step would involve integrating policies at the provincial and national levels (e.g. emissions pricing, regulations on vehicles and fuels, regulation of electricity generation, etc.). Modelling the costs and benefits of reducing GHG emissions through actions at the municipal level can assist in designing regulations that crudely approximate the equi-marginal outcome of an emissions tax, thereby improving economic efficiency.

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