MAKING THE CASE FOR USING DEVELOPMENT COST CHARGES FOR CLIMATE CHANGE MITIGATION

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Introduction

It is clear that there is a need for climate change mitigation and that local governments can provide and are providing this service. In British Columbia, local governments have a mandate to reduce GHG emissions and provincial policy directions have already made the connection between DCCs and climate change mitigation. The ability to waive existing DCCs can hypothetically create incentives for developers to reduce the GHG emissions of their projects and buildings. In reality, no local government has to date used this tool because the overall incentive may be too small to adequately incent action. As importantly, reducing DCCs means reduced revenue for local government, as development cost charges are monies that local governments levy on new developments to help recoup some of the capital costs resulting from development (Curran 2010).

Rather than waiving DCCs for roads, sewers, drainage, water, and parks for climate change mitigation, a potentially more powerful and practical idea is to create a new DCC to fund local government initiatives to reduce greenhouse gas emissions. A climate change mitigation DCC could be a strong fiscal mechanism for assisting local governments' mitigation efforts and would add rather than detract from local government revenue.

Hence, the central objectives of this project are:

- To develop a legally defensible concept of a development cost charge for climate change mitigation that meets the requirements of the rational nexus test; and
- To develop a technically feasible methodology for establishing a program and calculating rates for a climate change mitigation development cost charge, using the Surrey City Centre area as a case study.

An Overview of Development Cost Charges

Development cost charges (DCCs) are one-time fees that local governments collect from new developments to recoup some of the costs of growth. Residents of new developments create increased demand on physical utilities and services that often require the expansion of existing infrastructure or the installation of new facilities. These physical improvements can be significant expenditures for local governments, especially in the current context of decreased funding and revenue sharing from higher levels of government for capital improvements. Hence, DCCs were developed so that local governments could transfer some of the financial burden precipitated by growth and development onto the parties that generated the growth – the developers and the residents of the new development.

The standard legal test that the courts use to evaluate the legality of development cost charges is the dual rational nexus. The test consists of two prongs. First, there must be a reasonable connection between community growth generated by development and the need for infrastructure and services that the growth creates. Second, the development that pays the cost charges must in some way benefit from the fees collected (Nicholas 1992).

Most courts ask the following questions when evaluating whether a rational nexus exists:

- Is the impact of the new development connected to the need for public facilities?
- Is the fee proportional to the impact caused by the new development?
- Is there a reasonable connection between expenditure of the fees and the benefits accruing to the new development? (Evans-Cowley 2006)

In determining the legality of development cost charges, the courts also review whether local governments have the statutory authority to impose them. In British Columbia, the Local Government Act gives local governments the statutory authority to impose development cost charges by bylaw for subdivision approvals and building permits "to pay the capital costs of (a) providing, constructing, altering or expanding sewage, water, drainage and highway facilities, other than off-street parking facilities; and (b) providing and improving park land to service, directly or indirectly, the development for which the charge is imposed" (Local Government Act 1996).

The basic method for calculating development cost charges is simple: the net capital infrastructure costs generated by new development in a specified time period and geographical area is divided by the number of developments that will be built in that same time period and geographical area. In theory and in practice, however, determining development cost charges is a complex exercise that involves considering multiple policy issues to ensure that the resulting schedule and fees meet the principles of the rational nexus test and any other requirements imposed by the relevant legislation.

The establishment of facility standards is a key issue for satisfying the dual rational nexus test. Facility standards are benchmark levels of service that municipalities maintain for community facilities. Facility standards, in combination with community planning, are used to determine what additional facilities are needed to serve new development. Community planning assesses current population and levels of service and projects future population and land uses. This information can then be used to identify existing deficiencies in levels of service and the additional facilities that will be needed for new residents.

The *Best Practices Guide* expands on a number of practical issues that need to be addressed when creating a DCC program to apportion costs, including cost estimation, geographical extent, time period, and categories of land use to be charged.

Using Development Cost Charges for Environmental Protection and Climate Change Mitigation

The great success of development cost charges as a capital funding source has stimulated interest among practitioners and scholars to apply this creative mechanism to environmental protection. Local governments in the United States have effectively experimented with using charges to conserve wildlife habitats while academics in the fields of planning and law have explored the concept and legalities of development cost charges for air quality, energy conservation, green buildings, smart growth, and, most recently, greenhouse gas reduction. Despite the growing interest in using DCCs for environmental protection and the emergence of climate change as one of today's most pressing environmental issues, the concept of using DCCs for climate change has not been fully developed.

New buildings added by development generate a range of impacts, including increased greenhouse gas emissions from building operations. These emissions can be substantial in a growing community and can be precisely and accurately calculated, so the proportional impacts of development on climate change can be measured. This project proposes that a climate change mitigation DCC should focus on reducing GHG emissions from new buildings, since the emissions that are most directly attributable to development are those generated by the new buildings. This meets the first prong of the rational nexus test.

Theoretically, the DCC can fund the broad range of technologies and design approaches available for reducing building-related emissions. However, the convention in BC is to use DCCs for infrastructure needs. This project proposes that the climate change mitigation DCC should fun district energy systems, as they are physical infrastructure that local governments can use to effectively reduce building-related emissions by realizing energy efficiencies across the system and facilitating the move to lower carbon energy supplies. District energy systems can also yield direct cost savings and energy security benefits to the developments that will be paying the fee, meeting the second prong of the rational nexus test

Levels of Performance

Facility standards are the yardstick that communities set for measuring shortfalls in levels of service, whether they are from existing deficiencies or are created by new growth. Levels of performance have a similar function in that they provide the basis for assessing gaps between the ideal level of GHG emissions performance of buildings and the performance of current buildings and future developments. This project quantifies levels of performance in terms of energy use intensity (EUI) and emission intensity (EI) for the thermal components of building operations (e.g. heat and hot water), since these are the services provided by the case study district energy system.

A climate change mitigation DCC needs to ensure that fees are proportional to the impact caused by new development. Since the rationale is that new buildings produce emissions and therefore require mitigation by local government, fees should be waived for those that produce extremely low to negligible emissions and new buildings that produce low emissions should pay reduced fees. Structuring the DCC in this way makes it more robust against the rational nexus test.

Minimal emissions is the ideal level of performance and minimal to zero energy consumption can be taken as the practical, demand-side definition of minimal emissions. Setting minimal to zero energy consumption as the ideal performance level makes sense for several reasons. Constructing buildings that use little to no energy makes a considerable dent in addressing climate change. Setting this ideal level also encourages leaders in the building sector and development industry to be early adopters and stay ahead of the curve.

The Passive House standard serves well as the ideal level of performance. The Passive House Institute recommends 35.3 $kWh_e/m^2 \cdot a$ for space heating and hot water. The equivalent emission intensity is 6.3745 $kgCO_2e/m^2 \cdot a$. This assumes that thermal energy demand is met entirely by natural gas. Calculating the EI based on this assumption avoids penalizing developers building to Passive House energy efficiency standards but choosing to meet energy demands entirely with natural gas.

The baseline performance level is the requirements outlined by the Building Code. Currently, the BC Building Code requires Part 3 buildings to attain the ASHRAE 90.1-2004 standard and Part 0 buildings to have a minimum EnerGuide rating of 77 or meet new insulation standards. The energy use intensity associated with these standards and the associated emission intensities assuming that natural gas is used are given in Table 1 of the report.

Benchmark levels of service should ideally reward increases in performance with commensurate reductions in the cost charge. Following this reasoning, a simple way to set benchmarks is to measure a project's degree of improvement in energy and emissions performance above the baseline as a percentage of the difference between the baseline and ideal levels of performance; and to reward the same percentage discount on the development cost charge. For example, if a new high-rise multi-unit residential building (MURB) is designed to have an EUI of approximately 84 $kWh_e/m^2 \cdot a$ for heating and hot water and a resulting EI of about 14 $kgCO_2e/m^2 \cdot a$, which is 50% of the difference between the baseline and ideals levels for high-rise MURBs, then the project should only pay 50% of the mitigation DCC. Table 2 of the report gives sample benchmark levels.

Surrey City Centre Case Study

Surrey City Centre is an ideal case study, as much of the community planning related to climate change mitigation and service planning for the City's district energy system is complete or well underway.

City Centre is an area approximately 581 hectares in size located in the northwest corner of the municipality. The vision for City Centre is a dense, easily identifiable, and energetic downtown core located around the Surrey Central SkyTrain station. This core will feature high-density retail and office development, major civic, cultural and institutional facilities, and a central open space for civic celebrations. The rest of City Centre will be made up of distinct neighbourhoods, with a number of high-density residential developments concentrated around all three SkyTrain stations and lower-density residential neighbourhoods outside of these high-density nodes.

This growth presents a huge opportunity for developing a district energy system as an "efficient and effective means of reducing greenhouse gas emissions by utilizing low GHG emission energy sources", since DE systems are best suited for implementation in dense urban areas with a diverse mix of land uses. Surrey completed a City Centre District Energy Strategy in 2011 that confirmed that a system is viable given the projected land uses, densities, and energy demands of future buildings. In the same year, Council authorized the establishment of a utility to design, construct, and operate district energy in the City.

The City Centre district energy system will use a hot water distribution piping loop to provide heating and hot water to connected buildings. Sufficient demand must be in place to support district energy, so implementation of the City Centre system will roughly follow the location and timing of development in the area by taking a nodal growth pattern centred around the three Skytrain stations in the area. It will also be developed in phases.

In the first phase, temporary natural gas boiler plants will be built to service areas where there is sufficient development to create demand. This phase is expected to start in 2015 and is intended to create a critical mass of customers that will produce enough demand to support the second phase; which consists of larger scale permanent centralized heating plants located at each node. The third phase of system development consists of one or more large-scale low-carbon renewable energy plant(s). The most likely fuel source for the first of these plants is biomass from clean waste wood and the City is currently exploring whether it will be a biomass thermal or combined heat and power system

The case study only calculates development cost charges for a representative district energy node based on the City Centre system. Cost estimates for Surrey City Energy and growth projections for City Centre are still being developed and are currently not available for public dissemination. Hence, the case study is based on a fictitious district energy node that represents how one node in City Centre may implement a stand-alone district energy system consisting of a natural gas peaking plant and a biomass plant developed in three phases in an aggressive development scenario. Data for the case study was generated by the City of Surrey's district energy team with the actual financial model used for Surrey City Energy and using representative cost estimates and development projections.

This project recommends taking the following policy and technical approaches for calculating climate change mitigation DCCs. They should be area-based rather than community-wide charges, since district energy will only be built in and benefit discrete areas in the City that have sufficient demand. Mitigation DCCs should be calculated based on a build out program rather than a revolving program of five to 10 years. This is because capital expenditures associated with developing district energy systems are typically distributed unevenly throughout the asset life of the system and calculating DCCs in five or ten year increments would result in some development projects shouldering the majority of costs for the DE infrastructure. The case study follows Surrey's approach of charging DCCs by square foot of developed area. This sliding scale approach more accurately reflects the impact of development than the per lot approach, as larger buildings will consume more energy than smaller buildings of the same land use type.

The net present value (NPV) cost of constructing the representative district energy node at full build out of the system from 2015 to 2045 is estimated to be approximately $45,500,000. The case study node is expected to develop 15,219,300 sq.ft. of floor space in the same period. Dividing the cost by the projected floor space gives a climate change mitigation DCC of $3.00/sq.ft.

Discussion

At $3.00/sq.ft., the mitigation DCC would be comparable to the higher end of the City of Surrey's existing charges. Reducing the amount of the charge may make the mitigation DCC more acceptable as a concept to consider if acceptability is an issue. There are two ways to adjust the charge: including fewer costs when calculating the fee and applying a generous municipal assist factor.

Any of the costs associated with the case study node can be excluded from DCC calculations. However, since the objective of the charge is to assist with reducing GHG emissions, it would make the most sense to base the mitigation DCC only on capital costs associated with the bioenergy plant, the component of the system that delivers emissions reduction services. The net present value cost for the biomass plant for the case study is $25,100,000 (City of Surrey 2013c). This results in a mitigation DCC of $1.65/sq.ft., which is more comparable to the middle range of Surrey's current cost charges.

With an assist factor of 10%, the mitigation DCC would be $2.70/sq.ft if all costs are included and $1.49/sq.ft. if only costs for the renewable component is included. A local government can set the municipal assist factor to as high a percentage as it deems necessary for supporting development and can also impose different assist factors for different types of infrastructure; so a greater municipal factor can be applied to the mitigation DCC if needed to make it more acceptable to the development community. Municipalities typically fund MAF contributions from general revenue sources drawn from the existing tax base. In the case of the mitigation DCC, MAF contributions should be funded through higher utility rates since the system only benefits a specific area in the City.

The district energy system must provide equivalent or greater emissions reductions to the ideal level of performance for it to be an effective climate change mitigation measure. According to analysis conducted by the City of Surrey, the representative node is expected to produce 110,310 tonnes of CO_2e during the 30-year build-out period for the mitigation DCC. Biomass is assumed to be carbon neutral. Hence, the annual emission intensity of buildings connected to the system would be 2.6 kg CO_2e/m^2a, which is much lower than the ideal emission intensity of 6.37 CO_2e/m^2a.

A mitigation DCC could encourage developers to build greener if the cost of the charge is equal to or greater than the incremental costs of building to higher levels of energy efficiency. Based on the best data available, it appears that it would currently be considerably more expensive to build to the highest level of performance than to pay the full mitigation cost charge at $2.70/sq.ft. and $1.49/sq.ft. This is unsurprising, as the development industry is still relatively unfamiliar with low-emissions building design and construction. As expertise builds and equipment and materials become commonplace, the cost premium over conventional practice will shrink and the mitigation DCC will act as a stronger incentive for building to Passive House standards

The mitigation cost charge may still incent better performance in new construction, since the DCC framework rewards multiple levels of energy efficiency between the baseline and ideal levels and the incremental costs of achieving certain levels may be lower than the associated discounted fee. It appears that even a mitigation DCC of $1.49/sq.ft. is a strong incentive to build to ASHRAE 90.1-2010 for all building types except for high-rise MURBs. This is a positive finding, especially as the Province of BC is adopting the 2010 version of ASHRAE 90.1 in 2014 (Government of BC 2013).

If legal, a climate change mitigation DCC could provide an additional source of funding for municipally built district energy systems and would likely affect utility rates. Currently, the City Centre system will be entirely debt-financed through internal loans. Similar to a private energy utility, all utility costs - including capital, operation, maintenance, debt, repayment, debt servicing, and managing costs – will be accounted for in the rate structure. Rates for district energy customers would be lower with a climate change mitigation DCC, as they would not include a capital levy or include a smaller capital levy. This would be a benefit to customers, especially as energy prices are forecasted to increase in coming decades.

State and provincial governments would need to legislatively enable local governments to levy a development cost charge for climate change mitigation for this concept to be put into practice. Jurisdictions considering this should take several issues into account. A climate change mitigation DCC that can only fund district energy systems would be useful predominantly within the urban cores of larger communities. This would limit the potential of a mitigation DCC, given the large numbers of suburban developments and small communities in British Columbia and across North America. There are numerous ways for local governments to influence emissions and a mitigation cost charge that can fund a broader range of initiatives and programs would have a wider impact.

Another limitation of the mitigation DCC is that it can only be used to address emissions from new construction. Existing buildings and transportation patterns account for the bulk of a community's emissions but it would be inequitable to use development cost charges for mitigation actions that target these emissions. A more effective funding mechanism to assist local governments in their climate change mitigation efforts would be grants from a provincial or state carbon tax. Unlike development cost charges, local governments would have discretion to use these funds for any emission-reduction actions deemed appropriate by the grant.

It is possible for many local governments to use development cost charges to address GHG emissions without having the power to charge a fee for climate change mitigation. If designed appropriately, DCCs can be used as fiscal instruments to support growth management and more compact urban development. A study prepared by Coriolis Consulting (2003) for West Coast Environmental Law supports the use of development cost charges to encourage smart growth and greener building design. The report concluded that local governments should increase the use of varying residential charges by density as well as the use of different DCC rates for different locations and consider charging lower rates for green buildings that place lower demands on municipal infrastructure. These are fruitful areas that local governments can and should easily implement and explore without the need for legislative changes.

PREFACE

The purpose of this research project is to inspire planning professionals to think creatively about using development cost charges for supporting environmental initiatives.

The idea of using development cost charges for climate change mitigation was first suggested by Jason Owen, who is the Acting Manager for the District Energy Section at the City of Surrey. Mr. Owen also assisted with the design of the research project and case study and provided data for the case study based on the Surrey City Centre area.

I built on Mr. Owen's idea and crafted the concept and framework for a legally defensible and technically implementable climate change mitigation development cost charge. I also created a methodology for the case study, performed the necessary calculations, and analyzed the results.

ACKNOWLEDGEMENTS

This project would not have been possible without support from the School of Community and Regional Planning and the City of Surrey.

Dr. Timothy McDaniels provided academic supervision for me to initiate and successfully complete the project.

Mr. Jason Owen, Acting Manager for District Energy at the City of Surrey, was the second reader for the project and provided the idea, guidance, feedback, case study data, and creative suggestions that enabled me to create this research.

I am extremely grateful for the invaluable support of family, friends, and colleagues in helping me diligently complete the project while juggling work and multiple volunteer projects.

I would also like to thank the Pacific Institute for Climate Solutions, the Social Sciences and Humanities Research Council, and Mitacs for their financial support of this project.

The content of the final report is solely my responsibility. I hope that it inspires planning professionals to rethink development cost charges and enable some jurisdictions to experiment successfully with using them to support environmental and climate change initiatives.

CHAPTER 1: INTRODUCTION

In its 2007 Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) stated that the warming of the world's climate is "unequivocal" (2007a: 30). Global average annual temperatures have increased by 0.76ºC in the past century. Changes have already been observed in precipitation patterns, wind patterns, ocean salinity, and the frequency and intensity of extreme weather events such as droughts, heat waves, and storms. Anthropogenic greenhouse gas emissions are the primary driver of these changes. Between 1970 and 2004, GHG emissions due to human activities increased by 70%. To avoid dangerous threats to natural and human systems from unmitigated climate change, the global community must immediately and drastically reduce GHG emissions in order to stabilize the concentration of GHGs in the atmosphere (ibid).

Local governments have enormous potential to assist global efforts to reduce greenhouse gas emissions. Municipal governments have direct control over GHG emissions that arise from providing services and operating municipal facilities, buildings, and fleets. They also have indirect control over GHGs generated by the community at large through their responsibilities for and involvement in land use decisions, building regulation and design, transportation planning, waste management, and energy use and production (Collier 1997, Betsill 2001, FCM 2009). Data from several countries estimate that 30% to 50% of national GHG emissions are within the control of local government policy levers (Lindseth 2004). The Federation of Canadian Municipalities (FCM 2009) estimated that local governments have some level of control over 44% of emissions in Canada. In British Columbia, almost half of provincial GHG emissions are under the influence of local governments (CEA 2008a).

Many local governments across Canada are taking action (FCM 2011). In British Columbia, the provincial government adopted GHG reduction targets of 33% below 2007 levels by 2020 and 80% below 2007 levels by 2050. To help the province meet its targets, provincial legislation mandates local governments to undertake climate change mitigation. Under the Local Government (Green Communities) Statues Amendment, Bill 27, all local governments are required to set targets to reduce GHG emissions and adopt policies to meet these targets in their Official Community Plans (OCPs). Additionally, Bill 27 grants local governments additional regulatory powers to assist in mitigation efforts, including the ability to reduce or waive development cost charges (DCCs) for developments designed to have low emissions (Government of British Columbia 2008a).

It is clear that there is a need for climate change mitigation and that local government can provide and are providing this service. In British Columbia, local governments have a mandate to reduce GHG emissions and provincial policy directions have already made the connection between DCCs and climate change mitigation. The ability to waive existing DCCs can hypothetically create incentives for developers to reduce the GHG emissions of their projects and buildings. In reality, no local government has to date used this tool because the overall incentive may be too small to adequately incent action. As importantly, reducing DCCs means reduced revenue for local government, as development cost charges are monies that local governments levy on new developments to help recoup some of the capital costs resulting from development (Curran 2010).

Rather than waiving DCCs for roads, sewers, drainage, water, and parks for climate change mitigation, a potentially more powerful and practical idea is to create a new DCC to fund local government initiatives to reduce greenhouse gas emissions. A climate change mitigation DCC could be a strong fiscal mechanism for assisting local governments' mitigation efforts and would add rather than detract from local government revenue.

Development cost charges are common fiscal tools that local governments use to fund a variety of public service infrastructure needs. They are most often used to build basic facilities such as roads, water, drainage, and sewers. The types of facilities that DCCs fund can vary widely between jurisdictions, and some communities across Canada use them to finance ‘soft services’ such as parkland development, recreation facilities, libraries, schools, transit, health and long-term care, and growth studies (CMHC 2005).

There is growing interest in using development cost charges for environmental protection. A number of communities in the United States have successfully used DCCs for habitat conservation and restoration (Nicholas & Juergensmeyer 2003; Nicholas, Nelson & Juergensmeyer 1991). Planning and legal scholars have analyzed the legal and practical aspects of environmental development cost charges and proposed models and programs for funding air quality, energy conservation, green buildings, and, most recently, greenhouse gas emissions reductions. Jepson (2011) outlines the broad contours of a climate change mitigation DCC and discusses the policy and technical issues that must be addressed in order to make the idea feasible, credible, defensible, and legal in practice.

Academic work has fallen short of practically working through these issues, even though DCC programs “require very careful economic analysis and planning to determine what public facilities will be provided, the cost of providing the infrastructure, and the proportion of that cost attributable to the individual unit of development on the infrastructure facilities” for them to be legally defensible (Nicholas & Juergensmeyer 2003: 844). This project addresses the gap in research by fully developing the concept of a climate change mitigation development cost charge and using the City Centre area in the City of Surrey as a case study to design a program and calculate rates.

The project idea was originally proposed by the City of Surrey. The municipality is undertaking substantial actions to reduce its energy use and greenhouse gas emissions in order to establish it as “a model community in the areas of energy supply, reliability, sustainability and climate responsibility” and is interested in exploring cost-recovery and funding mechanisms for these actions (City of Surrey 2012). The City intends to use this report to generate support from peer local governments and from the provincial government for enabling the legislative changes required to allow local governments to charge DCCs for climate change mitigation. If successful, this report could financially assist the City and other local governments with their climate change mitigation efforts. Hence, this objective of this project is to construct a persuasive argument for a climate change mitigation development cost charge by fully delineating the concept and demonstrating its practical application.

Project Objectives and Organization

The central objectives of this project are:

- To develop a legally defensible concept of a development cost charge for climate change mitigation that meets the requirements of the rational nexus test; and
- To develop a technically feasible methodology for establishing a program and calculating rates for a climate change mitigation development cost charge, using the Surrey City Centre area as a case study.

This report is organized as follows. Chapter 2 gives an overview of development cost charges, including the legal framework in which they operate, guidelines for their calculation, and their effects on development, land prices, housing prices, and equity. Chapter 3 reviews the use of DCCs for environmental protection, explains the climate change mitigation DCC proposal in full detail, and describes how it can meet the demands of the rational nexus test. Chapter 4 details a framework for climate change mitigation DCCs, describes about the Surrey City Centre case study, outlines the methodology, and calculates rates. Chapter 5 discusses the implications of the findings, and suggests further research and next steps for implementation.

CHAPTER 2: AN OVERVIEW OF DEVELOPMENT COST CHARGES

Development cost charges (DCCs) are one-time fees that local governments collect from new developments to recoup some of the costs of growth. Residents of new developments create increased demand on physical utilities and services that often require the expansion of existing infrastructure or the installation of new facilities. These physical improvements can be significant expenditures for local governments, especially in the current context of decreased funding and revenue sharing from higher levels of government for capital improvements. Hence, DCCs were developed so that local governments could transfer some of the financial burden precipitated by growth and development onto the parties that generated the growth – the developers and the residents of the new development.

This chapter provides an overview of development cost charges. It describes their origins; outlines the legal framework to which they must adhere; details theoretical and practical methods for calculating them; summarizes the literature that examines their effect on development, land prices, housing prices, and equity; and reviews some practical issues concerning their adoption and implementation. The majority of academic work on development cost charges is by American scholars, since DCCs were first used in the United States[1]. However, most of the literature is applicable to the British Columbian context and relevant differences are highlighted.

The History of Development Cost Charges

Development cost charges are the latest tools in an "evolving toolbox" of funding mechanisms that has increasingly relied on the private sector to fund infrastructure development (Levine 1994). Before the 1920s, most local governments provided infrastructure to undeveloped land to meet existing demand and to promote economic development. As a result, speculators frequently subdivided land far outside of city boundaries, with the expectation that local governments would eventually provide city services to purchasers.

To curtail the rampant speculation, the U.S. Department of Commerce passed the Standard City Planning and Zoning Enabling Act of 1928 allowing local governments to require that developers provide all streets, water mains, sewer lines, and other utility structures as a condition of subdivision approval. As a result of the Act, developers have been required to install and dedicate roads and water and sewer lines within their subdivision since the 1920s (Nelson 1988, Evans-Cowley 2006).

In the 1950s, local governments began exacting land and fees in lieu of land for facilities external to subdivisions. Rapid new development placed demands on community park and school facilities that local governments could not easily finance by conventional methods such as general obligation bonds (Nelson 1988). Subsequently, communities began requiring exactions from developers for parkland, open spaces, and schools, justifying them as exercises of police power (Evans-Cowley 2006).

Police power is the power of government to enact and enforce laws to promote public health, safety, and well-being and is inherent to state governments. Local governments are delegated authority from state governments to exercise police power in many jurisdictions, including land use regulation. Local governments have broad discretion in terms of land use regulation, as long as the exercise of police power is for protecting public well-being, is not arbitrary or oppressive, and there is a reasonable and substantial relationship between the use of the authority and the end to be attained. Hence,

[1] In the United States, development cost charges are called development impact fees or development impact levies. This project refers to all such fees as development cost charges for simplicity.

communities justified their exactions on the premise that urban growth and its attendant congestion and impacts on quality of life required local governments to impose land use regulations – exactions of land and fees – on development to protect the public's welfare (Nicholas and Juergensmeyer 2003).

Several factors in the 1960s and 1970s led to the creation of modern development cost charges. Funding for capital projects from federal and state governments began to decline. The taxpayers revolt of the 1970s, spearheaded by California's Proposition 13, resulted in drastically reduced taxation of real property and the use of taxes for public projects. Local governments, especially communities experiencing rapid growth, suddenly needed to find new sources of funding for municipal infrastructure.

Fast-growing communities in western and southern states such as California, Colorado, Florida, Oregon, Texas and Washington began to experiment with charging development impact fees for financing a variety of public facilities. As the legality of these fees became better defined, the use of development cost charges spread to other jurisdictions and the norm in public policy became for growth to pay its own way. By the 1980s, development cost charges were being used to finance a wide range of facilities, including water and sewer drainage, fire and police, school libraries, and even museums (ibid, Ross and Thorpe 1992).

In British Columbia, it was typical for local governments to provide infrastructure services to new developments until the 1950s. In 1958, the provincial government amended the *Municipal Act* to enable an Approving Officer to reject the approval of a subdivision plan on the grounds that providing public utilities and other infrastructure for the new development would create excessive costs to the local government.

Municipal councils began to experiment with impost fees and excessive subdivision cost bylaws so that subdivisions would bear some of the costs of growth and applications could be approved. However, the courts struck down the bylaws because local governments did not have the authority to charge for infrastructure costs. In response, the provincial government passed several amendments to the *Municipal Act* that allowed local governments to define and regulate development areas. The courts found that fees charged under a land use contract were legal and legislation allowing municipalities to impose development cost charges was introduced in 1977 (Government of British Columbia 2005).

The Legal Framework for Development Cost Charges

The courts have played a significant role in defining development cost charges. DCCs have been challenged in the courts of almost every state in the U.S. in which they have been used. The frequent argument in these challenges is that development cost charges are takings of private property without just compensation. There are two key U.S. Supreme Court cases related to development cost charges: Nollan v. California Coastal Commission and Dolan vs. City of Tigard (Evans-Cowley 2006).

In the Nollan case, property owners applied for a building permit from the California Coastal Commission to tear down their beach-front bungalow and rebuild it into a larger three-bedroom house. The Commission issued a permit on the condition that the Nollans dedicate an easement that would allow public passage along the property line between the seawall and the ocean. The Commission contended that the easement was in the public interest because it would provide increased public access to the beach, ease congestion at nearby public beaches, and decrease the psychological barrier to beach use created by the continuous development between the street and the ocean. The

U.S. Supreme Court ruled that the exaction was a taking, as there was not a reasonable relationship or 'rational nexus' between the easement and the construction project (Ledman 1993).

In the Dolan case, a business owner applied to the City of Tigard to expand her hardware store and parking lot. The City conditioned the approval of her application on the dedication of land for a public greenway that would reduce flooding from the increase in impermeable surfaces from the project and a pedestrian/bicycle path to lessen traffic congestion in the central business district. The U.S. Supreme Court ruled that the exaction was a taking, since there was not a reasonable relationship or between the project and the land dedications. The Court found that the City did not demonstrate why the dedication of a greenway was needed to control flooding or how the dedication of a pedestrian/bicycle path was related to increased vehicle and bicycle trips generated by the expanded hardware store. The ruling also stated that there must be proportionality between the required dedication and the impact created by the development project (Evans-Cowley 2006).

These two cases signaled to local governments that they needed to clearly define a reasonable relationship between the impacts of a development project and the conditions imposed on the project as well as demonstrate that the conditions are proportional to the impact. Today, the courts use the dual rational nexus to test the reasonableness of development cost charges. The test consists of two prongs. First, there must be a reasonable connection between community growth generated by development and the need for infrastructure and services that the growth creates. Second, the development that pays the cost charges must in some way benefit from the fees collected (Nicholas 1992).

Most courts ask the following questions when evaluating whether a rational nexus exists:

- Is the impact of the new development connected to the need for public facilities?
- Is the fee proportional to the impact caused by the new development?
- Is there a reasonable connection between expenditure of the fees and the benefits accruing to the new development? (Evans-Cowley 2006)

In determining the legality of development cost charges, the courts also review whether local governments have the statutory authority to impose them. In British Columbia, the Local Government Act gives local governments the statutory authority to impose development cost charges by bylaw for subdivision approvals and building permits "to pay the capital costs of (a) providing, constructing, altering or expanding sewage, water, drainage and highway facilities, other than off-street parking facilities; and (b) providing and improving park land to service, directly or indirectly, the development for which the charge is imposed" (Local Government Act 1996).

Under the Act, resort regions may also charge DCCs to defray the capital costs of providing employee housing while the Vancouver Charter permits the City of Vancouver to additionally impose charges for establishing childcare facilities and constructing affordable housing for those displaced by the development. Local governments can waive or reduce DCCs for certain developments, including not-for-profit rental housing, for-profit affordable rental housing, a subdivision of small lots that is designed to reduce greenhouse gas emissions, and a development that is designed to reduce environmental impact (ibid).

The Local Government Act also requires local governments to deposit development cost charge monies collected for sewage, water, drainage, highways, and parks into special reserve funds dedicated to each purpose. These funds can only be used to pay for the capital costs of building, altering, or expanding these facilities, to ensure that the development cost charges are used exclusively to pay for the capital costs directly and indirectly related to the development that paid the fees (ibid).

Calculating Development Cost Charges

The basic method for calculating development cost charges is simple: the net capital infrastructure costs generated by new development in a specified time period and geographical area is divided by the number of developments that will be built in that same time period and geographical area. In theory and in practice, however, determining development cost charges is a complex exercise that involves considering multiple policy issues to ensure that the resulting schedule and fees meet the principles of the rational nexus test and any other requirements imposed by the relevant legislation (Taylor 2010).

The approach articulated by Nicholas and Nelson (1988) remains a widely used and robust framework for calculating development cost charges. The framework, described in the following sections, is directly based on the principles set out by the rational nexus test and is divided into three parts. The first part discusses how capital costs can be attributed to new development and demonstrates the connection between growth generated by new development and the need for capital improvements. The second examines how costs can be equitably proportioned so that development only pays for its share. The third considers issues for determining the benefits that accrue to contributing development to ensure that developments benefit from the collected charges.

While Nicholas and Nelson provide a good preliminary framework for understanding development cost charge calculations, they does not address many issues that need to be considered in actual calculations. In general, professional practice, rather than academic research, has been at the forefront of work in this area, as planners and local officials have had to grapple with the practical issues and intricacies of creating workable methods and formulas. The *Development Cost Charges Best Practices Guide*, created by the Ministry of Community, Sport and Cultural Development (2005) in partnership with local governments and the development community in British Columbia, provides a wealth of guidance on practical issues and supplies a necessary supplement to Nicholas and Nelson's work. These best practices are also described in the following sections.

Attributing Capital Costs to New Development

The establishment of facility standards and systematic community planning are the two key factors for attributing capital costs to new development. Facility standards are benchmark levels of service that municipalities maintain for community facilities. Standards are often developed through a combination of drawing on best practices and research and consulting community members on what levels of service they wish to maintain (Nicholas and Nelson 1988). For example, the City of Surrey has the broad goal of providing 4.2 hectares or 10.4 acres of parkland and open space for every 1,000 residents (City of Surrey 2010).

Facility standards, in combination with community planning, are used to determine what additional facilities are needed to serve new development. Community planning assesses current population and levels of service and projects future population and land uses. This information can then be used to identify existing deficiencies in levels of service and the additional facilities that will be needed for new residents (Nicholas and Nelson 1988).

For example, if the City of Surrey currently has 4.0 hectares of parkland for every 1,000 residents, this is an existing deficiency and the City should use taxes that only current development will pay to purchase additional parkland to achieve their standard of 4.2 hectares per 1,000 people. However, the City may also project that development will bring another 100,000 new residents over the next ten years. These new residents will require 120 additional hectares of parkland, the costs of which are directly attributable to new development and can be at least partially financed using development cost charges.

The Local Government Act and the DCC *Best Practices Guide* follow this approach closely. Section 934(4) in the *Act* specifies that a local government must consider future land use patterns and development, the phasing of works and services, and the provision of parkland when establishing development cost charges. Hence, the *Best Practices Guide* recommends that development cost charges be based on broad development objectives and policies set out in the Official Community Plan (OCP) and the capital projects listed in the Financial Plan.

The OCP should set out facility standards and include information on current population, existing land use, future population, and planned land use. These data serve as the basis for creating master servicing plans that identify capital projects for addressing existing infrastructure deficiencies and for serving new residents. Master servicing plans also include locations, schedules, and detailed cost estimates for each project. These proposed projects must then be incorporated into the local government's Financial Plan (Government of BC 2005).

Apportioning Capital Costs to New Development

The second part of Nicholas and Nelson's methodology, apportioning costs, discusses how to divide the cost of needed facilities between new developments as well as how to determine the net recoverable cost. This is perhaps the most complex part of determining development cost charges and Nicholas and Nelson's treatment is fairly basic. The *Best Practices Guide* provides valuable practical guidance in this area.

To divide capital costs between new developments, Nicholas and Nelson (1988) recommend first determining the present value of the municipality's expenditures for building or purchasing community facilities in a certain geographical area over a specified time period, then dividing that value by the number of new development units that will be built in the same area and over the corresponding time period.

For example, suppose that the City of Surrey spent a present value of $50,000 per hectare for purchasing parkland across the city over the last ten years. Using Nicholas and Nelson's methodology, the City can assume that acquiring open space will cost approximately the same rate over the next ten years. If the City needs to purchase 120 hectares of new parkland to serve a projected 100,000 new residents over the next ten years, the total capital cost for parkland in the next decade will be $6 billion.

Suppose that the City projects that 80,000 units of new development will be built in the same time period. To apportion costs equally, each unit would pay $75 for parkland development cost charges. Nicholas and Nelson recommend adjusting this amount based on the number of bedrooms or unit type, since development is obviously not uniform in size and function. They also recommend that inflation be disregarded when conducting the above calculations, also called a DCC program, since the rate of inflation is unknown and the DCC program should ideally be updated every one or two years to account for changes in cost.

The *Best Practices Guide* expands on a number of practical issues that need to be addressed when creating a DCC program to apportion costs, including cost estimation, geographical extent, time period, and categories of land use to be charged. Local governments in British Columbia are required to produce as detailed and accurate cost estimates as possible for capital projects for which they charge development cost charges, rather than approximate costs from past expenditures. The level of detail of cost estimates will depend in large part on what technical information is available when the local government drafts its DCC program. The Ministry recommends completing cost estimates of 10% to 15% level of accuracy for projects that will be constructed within five to ten years. Costs for longer term project can be estimated to an accuracy level of 15% to 25%. The Local Government Act also dictates that only planning, engineering, and legal costs are eligible for recovery using DCCs. In practice, these include costs for planning, community consultation, engineering design, right-of-way or open space acquisition, legal fees, interim financing, contract management, construction, and contingencies.

Development cost charges in British Columbia can be municipal-wide or area-specific charges. Municipal-wide DCCs apply the same rate for a particular type of land use regardless of a development's location. The rationale is that the land use imposes roughly the same capital burden across the community. Area-specific charges, on the other hand, apply different DCC rates to different geographical areas in the municipality. If the capital cost burdens in specific areas are significantly different than the average condition, an areas-specific approach is warranted.

Local governments should consider fairness and equity when considering between the two approaches, though simplicity and ease of administration should also be taken into account. The *Best Practices Guide* recommends that DCCs for roads, sewers, drainage and parkland should be municipal-wide, while water DCCs can be area-specific or municipal-wide, depending on the situation. The bias for municipal-wide charges is to reduce the administrative hassle and financial inflexibility of creating many small, specialized funds that can only be used for projects in their specified areas and that build up slowly over time (Coriolis Consulting 2003).

The time frame for development cost charges can vary depending on if they are calculated as a build out or a revolving program. A build out program includes all the DCC-eligible capital projects that are required for the full extent and level of development identified in the Official Community Plan and has a 20 to 25 year time horizon. This longer-term approach provides the most flexibility for when facilities are built and in what order, as all the projects for build-out are included in the DCC program. However, it is often difficult to accurately estimate costs for such a long time period.

A revolving program is also consistent with the OCP but only includes those projects necessary to support development in a time frame of five or ten years. In addition to having more accurate cost estimates, funds can accumulate faster in a revolving program. Depending on the type of facility and the sequencing of projects, however, DCC rates may fluctuate significantly over time, resulting in higher fees for some developments. The *Best Practices Guide* recommends coordinating the time frame of the DCC program with the time frame of a Financial Plan and leaves the policy decision open to local governments.

Since different types of land use generate different levels of demand for municipal facilities, the Local Government Act allows local governments to charge different DCCs for different types of development. Development is often broadly categorized as residential and non-residential. Local governments can choose to break these two broad groups into more detailed categories, to reflect different levels of density that each category supports and, correspondingly, different levels of impact that each have on infrastructure.

Residential land use categories have conventionally been based on building forms, as they were adequate indicators of level of demand on infrastructure. Typical residential categories include single-family residential, multi-family residential, townhouse, low-rise apartment, and high-rise apartment. Non-residential categories typically include service commercial, office commercial, light industrial, heavy industrial, and institutional.

As developments in the same category are different sizes, appropriate units of development need to be established for each category of land use in order to calculate DCC rates. Units should be accepted measures of development and will influence how development projections are made as well as the data required for those projections. Common units include lots, dwelling units, floorspace, and gross site area.

Residential DCCs commonly use lots as the unit for single-family developments and dwelling units for multi-family. Some municipalities are using these units to categorize residential developments by density gradients rather than by building forms, to better reflect recent trends in housing. Whereas the relationship between building form, density, and impact is fairly uniform in older buildings, it is now possible to find new small-lot single-family residences that are equal in size and, presumably, in density and impact to new large multi-family units.

To ensure that development cost charges are fairly distributed, the *Best Practices Guide* recommends charging residential developments based on density rather than building form. For example, “low density” could be defined as 21 independent dwelling units on a gross hectare while the definition of “high density” could be over 200 independent dwelling units on a gross hectare. While the density gradient approach is more equitable and could encourage more compact development, the data required to make development projections may be more difficult to obtain than data for building forms.

Floorspace, measured in square footage or square meters, is another development unit option. Only habitable area is factored into development cost charge calculations, as it is living and working areas that require servicing by municipal infrastructure. Habitable area excludes patios, balconies, parking stalls, storage areas, and garages. The development industry favours the use of floorspace for DCC calculations and the *Best Practices Guide* recommends establishing residential, commercial, and institutional charges on a floorspace basis, as local governments that have used this option have found it easy to use and administer. Industrial DCCs should be assessed by gross site area, as they are generally single-story developments. Nicholas (1992) also found that assessing DCCs by floorspace may also be more accurate for measuring impact and less regressive in terms of ability to pay compared to other units of development.

Before capital costs can be divided between different categories and units of development to compute development cost charge rates, local governments must first determine what are the net costs that are recoverable through DCCs. Net costs are determined by subtracting grants and external funding, the proportion of costs applicable to current development, the municipal assist factor, and existing DCC reserve monies from total capital costs. Credits and rebates should also be taken into account when calculating charges for specific projects..

Grants and other funding contributions to capital projects should be subtracted from the total capital costs of a DCC program, since the recoverable portion of capital expenditures is the net costs arising from new development. The *Best Practices Guide* recommends that grants should not be subtracted until they are confirmed, to prevent shortfalls in capital funding if grants are assumed to be part of the budget but are not approved. The DCC program can be adjusted when funding from other sources is granted.

While infrastructure funded by development cost charges must directly or indirectly service new residents, some projects naturally benefit all residents. For example, roads may be constructed to service new developments but they contribute to a community’s transportation network and will inevitably be used by all residents. Local governments need to quantify the benefit to the existing population and subtract this amount from total capital costs less funds from other sources.

Quantifying benefit may be difficult and will necessarily incorporate a degree of subjectivity. The *Best Practices Guide* recommends using a “rule of thumb” approach. If capital projects would not proceed if there was no growth, then all of the costs from those projects are attributable to new development and existing users should not have to pay for any of the costs. Local governments should pair this heuristic with a technical method for calculating community benefit. The *Best Practices Guide* gives several examples for different types of infrastructure.

The municipal assist factor is another element that influences the net DCC recoverable amount. According to the Local Government Act, the purpose of development cost charges is to assist local governments with financing municipal infrastructure and parks, rather than paying for total costs. This requires local governments to provide some level of financial assistance, separate from the portion of costs allocated to existing residents. The assist factor is commonly expressed as a percentage of costs and is politically rather than technically determined. It is a reflection of Council's interest in supporting development and, in practice, has varied between 1% and 50%. Council may also set different assist factors for different types of infrastructure.

Any monies left over from previous development cost charge programs should be carried over to new or updated programs and used to offset the net recoverable amount. Monies are typically carried over between programs for the same type of infrastructure. However, local governments are allowed to temporarily lend money from one DCC reserve fund to another if the second fund is insufficient for funding its associated projects and the first has adequate monies. This loan, plus interest should be paid back between the two reserves before monies in the lending fund are need.

For individual developments, credits or rebates should be applied against payable DCCs in certain situations. In some cases, a development might be proposed for a greenfield site for which the required trunk services have not been built. If the local government decides that the development is in line with the growth management policies in its Official Community Plan and grants it approval, it may also request the developer construct the trunk services. The development should be given a credit or rebate for front-ending these costs, as local governments are usually responsible for providing trunk services. The difference between the cost of providing trunk services and the cost of providing services to a local standard would be deducted from the applicable development cost charge, up to the maximum of the charge.

Benefits to Contributing Development

The last part of Nicholas and Nelson's methodology addresses how to determine whether contributing development receive benefit from the fees that they pay. The authors discuss exclusivity and certainty of benefit and highlight issues that a court might consider when assessing the legality of development cost charges rather than provide technical guidance.

Although development must directly or indirectly benefit from the fees that it pays, the rational nexus test does not require that development exclusively benefit from the infrastructure that it funds. Rather, the benefit should be reasonably substantial and certain. Facility location is often the main criterion by which substantial benefit and certainty are evaluated. This will vary between different services but the main test is whether facilities are located so that they are accessible to all people occupying the contributing developments.

Although the BC *Best Practices Guide* does not explicitly address this issue, one of the guiding principles of the document is that "infrastructure costs should be paid by those who will use and benefit from the installation of such systems" (Government of BC 2005: vi). The "benefiter pays" principle is a key consideration embedded in many of the approaches recommended by the Guide.

Effects of Development Cost Charges

Development cost charges are intended to shift some of the fiscal responsibilities of infrastructure provision to the development industry. However, there is evidence that these costs are actually passed to homebuyers and landowners, thus inflating housing prices and depressing land prices. Development cost charges may also have social equity ramifications, as they may affect the availability of low- to moderate-income housing and, consequentially, the ability of lower-income residents to live in better-serviced parts of the community. The following section summarizes literature on the effects of development cost charges on land and housing prices, rate of development, and social equity. In practice, the Local Government Act requires that local governments consider whether development cost charges will deter development or discourage the construction of reasonably priced housing when designing and implementing a DCC program.

Theoretical Studies on the Effects of Development Cost Charges

There is considerable academic interest in the incidence of development cost charges. In economics, the incidence of a tax refers to the relative burden of a tax among different groups. Tax incidence is said to 'fall' on the group that ultimately bears the burden of the tax and is related to the price elasticity of supply and demand. Theoretical work on the incidence of development cost charges is divided into two perspectives (Ihlanfeldt and Shaughnessy 2004). The first considers development cost charges to be an excise tax on developers. The second argues that treating cost charges as excise taxes does not account for the value of the new public infrastructure financed by the charges and the impact of property tax capitalization on the incidence of fees.

The first perspective predicts that the introduction of development cost charges in a competitive market will have effects similar to those of standard short-run excise taxes. An excise tax is a tax on a particular product or good. The tax will generally increase the price of the commodity for the consumer and reduce the net price received by the producer. It may also reduce the amount of the commodity marketed and purchased. The incidence of an excise tax depends on the factors that influence market price, which in turn depend on the extent of competition in the market. Scholars that view development cost charges as excise taxes predict that, in general, they increase the price of new housing and reduce net profits for developers. Similar to excise taxes, however, the incidence of development cost charges depends on changing housing demand and supply conditions.

On the demand side, homebuyers will vary in their sensitivity to housing prices in different areas depending on the availability of substitutions. Dowall (1980) points out that a submarket in a larger metropolitan area will likely be more sensitive to housing price than the entire metropolitan area because there is potential for substitution between submarkets. If prices increase in a community, consumers can purchase in other communities with similar characteristics. However, some communities may be more desirable than others and may not be substitutable, so submarkets in these highly desirable areas may not be as sensitive to price. In small urban areas, where substitution opportunities are scarce, the entire housing market may be fairly insensitive to housing prices. On the supply side, changing market conditions greatly influence developer entry into a housing market (Muth 1960). High land prices, land use regulation, and development cost charges affect developer entry and, therefore, housing supply (Weitz 1985).

Scholars that treat development cost charges as excise taxes expect incidence to occur in the following patterns. In strong housing markets where there are no barriers to developer entry, the fee is passed on to homebuyers. In these conditions, developers are able to pass on development cost charges to consumers because homebuyers are relatively insensitive to price. In strong housing markets where there are barriers to developer entry, it is expected that development cost charges are also passed on to homebuyers but developers target wealthier households, to overcome barriers such as high development cost charges and inflexible land and production costs. In these market conditions, homebuyers ultimately pay development cost charges but the side effect is that middle- and lower-income households are priced out (Ellickson 1977, Snyder and Stegman 1986, Huffman et al 1988, Delaney and Smith 1989, Singell and Lillydhal 1990, Altshuler and Gómez-Ibáñez 1993).

In a buyer's market, where opportunities for substitution exist and there are no barriers to developer entry, development cost charges are shared between homebuyers and developers because buyers can choose to purchase in other communities. Developers therefore need to cut into their profits, reduce production costs by producing smaller lots or unit sizes or lower-quality products, or reduce the amount they pay for land. They may also move to another community, leading to slow-downs or stoppages in construction in certain submarkets. In the long run, however, developers restore their profit margins by reducing their bids for land and driving down the price of land, passing some of the development cost charge burden onto landowners (ibid).

The newer perspective on the effects of development cost charges on housing and land prices argues that treating DCCs as excise taxes disregards the capitalization of infrastructure benefits into house values as well as the effect of property tax capitalization on the incidence of development cost charges. Yinger (1998) argues that development cost charges are capitalized in the form of higher prices for new housing. Even if homebuyers are bearing the burden of the charge by paying higher prices, they are compensated by the benefits received from the infrastructure financed by the fee if the rise in the price of new housing is equal to the amount of the development cost charge. Hence, there is no net burden for homeowners and neither developers nor landowners shoulder any of the charge.

If the benefits from fee-financed infrastructure are less valued by new residents and results in a housing price increase that is less than the amount of the development cost charge, then developers bid less for land in order to maintain their profit levels and the incidence of DCCs falls on landowners. If the benefits are greatly valued and lead to a housing price increase greater than the charge, then the price of land rises assuming that profits for developers remain normal and landowners receive a benefit.

The above scenarios presume that the property tax rate remains unchanged. Yinger (1998) further discusses that higher house values due to improved infrastructure will affect the property tax rate, the effects of which should be considered. Higher house values will result in an increase in municipal revenue that is raised at the existing tax rate. Assuming that a jurisdiction does not grow its budget, it should introduce lower tax rates. The fall in tax rates will increase the price of housing, which additionally compensates developers for the cost charge and decreases the potential for the development cost charge burden to be passed on to landowners. Existing homeowners also benefit from a capital gain due to lower taxes. When property tax capitalization is factored into the equation, this perspective predicts that the prices of new and existing housing will increase by the same percentage.

Empirical Studies on the Effects of Development Cost Charges on Housing Prices, Land Prices, and Rate of Development

There is limited empirical work on the actual influence of development cost charges on the price of housing and land. An important contribution to this body of literature is Delaney and Smith's (1989) comparison of new housing prices in four Florida communities over twelve consecutive years. Dunedin introduced a $1,150 development cost charge in 1974 while the three control communities either did not have fees or had fees of less than $250 during the study period. The authors used a hedonic model to ensure that homes between all communities could be compared. Hedonic models are often used to examine the effects of development cost charges on housing price, as they allow commodities with heterogeneous qualities, such as housing, to be deconstructed into attributes or bundles of attributes, such as number of bedrooms. Delaney and Smith found that development cost charges appeared to have an effect on new housing prices in Dunedin in comparison with two of the three control communities.

Singell and Lillydahl's (1990) study also used a hedonic model to examine the effects of development cost charges in Loveland, Colorado. The municipality experienced a significant increase in population from 1970 to 1980 and implemented development cost charges to finance needed capital improvements. The authors found that, on average, the price of new homes rose by about 7 percent after the fees were introduced and attribute the increase to the cost charges. They also found that the price of existing homes increased as well, presumably because current homeowners could set higher selling prices to match those of new homes. However, Singell and Lillydahl's study suffers from its lack of a control community and its failure to consider neighbourhood characteristics so it is difficult to draw robust conclusions from the results.

In Canada, Skaburskis and Qadeer (1992) looked at how development impact fees affect the price of vacant lots in the Toronto area from 1977 to 1986. Their findings suggest that lot prices increased with development cost charges but at a rate of 20% greater than the charge. The price increase seemed to be associated with the region's growth rate. However, their study used data from fee schedules rather than information on the actual cost charges paid by developers in one of the three cities that they examined, so their estimation of actual capitalization may not be accurate. Additionally, the study did not address differences in the quality or level of infrastructure between the three case study municipalities.

Nelson, Frank, and Nicholas (1992) examined the incidence of development cost charges in Sarasota County, Florida, using regression analysis. They found that cost charges are "positively associated with residential urban land prices" (59). The authors farther argue that DCCs are "a positive influence on urban development" (64) because they result in more certainty for development proposals, equitable treatment of similar proposals, and ensured funding for infrastructure that benefits the fee payer as well as new and existing community members. These benefits improve developer profits, which are capitalized into the urban land market.

In general, these studies indicate that the price of new housing increases when development cost charges are introduced. The extent of this effect is uncertain, however, and may be partially the result of the relatively small number of communities examined by existing research. Land prices may also rise, although the evidence suggesting this effect is still limited and does not provide a definitive answer. More empirical research using broader samples is needed to determine the degree to which development cost charges influence housing prices and whether or not DCCs affect land values.

The effects of development cost charges on the rate of development have also not been well studied. Skidmore and Peddle (1998) compared rates of development for all municipalities in DuPage County, Illinois from 1977 to 1992 and found that communities with development cost charges had rates of 3 percent a year while those without had rates of 4.3 percent per year. However, the study did not examine whether the difference in rates was due to developers choosing to build in municipalities without fees. It also did not look at whether new home values in municipalities with fees were substantially higher than in non-fee cities, to determine if developers were passing on development cost charges to homebuyers.

Social Equity Effects of Development Cost Charges

The capitalization of development cost charges in the form of higher housing prices can have consequence on social equity. Low- and moderate-income households may be squeezed out of some communities as home ownership becomes increasingly unaffordable and be forced to choose areas that are not as well serviced.

Most scholars writing on this subject agree that development cost charges are regressive, especially when viewed in isolation or when compared with a progressive income tax (Nelson 1988, Nicholas 1987, Snyder and Stegman 1986). Connerly (1988) farther argues the DCCs are bad policy. Snyder and Stegman (1986) determined that every $1,000 of DCCs adds $315 to the annual income that a household needs to purchase a home at a 10 percent interest rate with a 30-year mortgage. Connerly (1988) points out that this increase can make home ownership unaffordable to a large number of households. Lower-income households already pay a large portion of their income for housing than higher-income households. Higher housing costs further skew the housing cost-to-income ratio. Connerly recommends keeping property taxes as the main source of revenue for constructing community infrastructure, to avoid the social equity consequences of development cost charges.

While development cost charges are undeniably more regressive than a progressive income tax, Nicholas (1992) points out that DCCs are by nature regressive because they are fees and not taxes. Cost charges are intended to recoup some of the cost of municipal infrastructure so are proportional to capital costs rather than ability to pay.

Implementing Development Cost Charges

Successful implementation of development cost charges can be challenging. As Ross and Thorpe (1992) write, “the path to adoption of impact fees is often labyrinthine and strewn with the corpses of well-intentioned public servants” (115). While this statement might be slightly dramatic, there are a number of practical issues concerning public process, bylaw administration, transparency, and accountability that planners and communities need to consider when implementing development cost charges.

As with all good planning processes, communicating with and involving key stakeholders and community members are important for successful implementation. The Local Government Act does not make consultation a mandatory component of establishing development cost charges. However, the *Best Practices Guide* recommends undertaking some stakeholder and public engagement, as it may help to address important issues such as whether the charges are excessive, dampen development, or discourage the construction of reasonably priced housing. Local governments can design their consultation process as they see fit. Common approaches include soliciting feedback from select stakeholders, holding public meetings with Council, and setting up an ad hoc task force or permanent liaison committee.

Stakeholders should be involved early in the process of creating a development cost charge program and bylaw, to ensure that their concerns and ideas are heard. Important groups to involve include individual developers and builders, developer and builder associations, realtors, environmental groups, anti-growth groups, and the Chamber of Commerce (Ross and Thorpe 1992). The *Best Practices Guide* recommends that municipalities include “all persons, groups or organizations that have a perceived, actual, or potential stake or interest in the results of the decision-making process” (Government of BC 2005: 2.1). At the minimum, this includes representatives from residential and non-residential developers, the public, and staff from the planning, engineering, and finance departments.

Part of administering development cost charge bylaws is determining when to collect the fees. The Local Government Act allows development cost charges to be collected during subdivision approval or issuance of building permits. In practice, DCCs are usually collected during subdivision approval for single family developments and at issuance of building permits for multi-family and non-residential developments.

Collection at subdivision approval allows funds to accumulate faster so that trunk services can be constructed before new single-family homes need to be connected. While municipalities may prefer collecting DCCs at the subdivision approval stage for other land uses as well, it may be impractical to do so depending on how the charges are calculated; hence collection at the building permit issuance stage is recommended by the *Best Practices Guide*. The development industry also prefers deferring payment of cost charges until the building permit stage.

Ensuring that development cost charge programs and bylaws are transparent and accountable is critical for maintaining support, especially from the development industry. Builders and developers want to know that the fees they are paying will be spent on needed facilities that are efficiently planned and fairly financed. They are more willing to contribute to urban infrastructure improvement if they can see that development cost charge programs are fairly and reasonably formulated, implemented, and administered (Porter 1988).

To facilitate transparency and accountability, the Local Government Act requires municipalities to make public all considerations, information, and calculations (excepting bids for specific properties) used to craft development cost charges. All documents should also be accessible and understandable. The *Best Practices Guide* recommends drafting a relatively concise DCC bylaw that includes DCC rates, and attaching summary tables that show how DCCs were calculated in an accompanying background report.

The provincial government also provides oversight on development cost charges. The Local Government Act authorizes the Inspector of Municipalities to request reports from local governments on the status of DCC collections and actual and proposed expenditures. The Inspector can also revoke statutory approval of DCC bylaws if programs are found to be unsatisfactory. The *Best Practices Guide* recommends setting up DCC accounts so that projects, expenditures, revenue, and completion status are easy to track and management and financial reports can be periodically generated by the accounting system for monitoring.

CHAPTER 3: USING DEVELOPMENT COST CHARGES FOR ENVIRONMENTAL PROTECTION AND CLIMATE CHANGE MITIGATION

The great success of development cost charges as a capital funding source has stimulated interest among practitioners and scholars to apply this creative mechanism to environmental protection. Local governments in the United States have effectively experimented with using charges to conserve wildlife habitats while academics in the fields of planning and law have explored the concept and legalities of development cost charges for air quality, energy conservation, green buildings, smart growth, and, most recently, greenhouse gas reduction. Despite the growing interest in using DCCs for environmental protection and the emergence of climate change as one of today's most pressing environmental issues, the concept of using DCCs for climate change has not been fully developed.

This chapter describes the practical and theoretical evolution of environmental development cost charges and examines how the theory of a climate change mitigation DCC can be translated into practice. The chapter closes by outlining a proposal for a climate change mitigation DCC designed to withstand the two-pronged rational nexus test.

Using Development Cost Charges for Environmental Protection

Environmental DCCs In Practice

Local governments in the United States began to enact development cost charge programs to fund social and environmental concerns after the New Jersey Supreme Court upheld the Township of Holmdel's use of impact fees to subsidize affordable housing in 1990.

Several municipalities in the county were charging non-residential developments a fee for funding affordable housing, in recognition that the residential development community could not fulfill the entire need. The Holmdel Builders Association challenged the legality of the fee on the grounds that the charge did not meet the two prongs of the rational nexus test. The Association argued that affordable housing fees funded infrastructure unrelated to contributing developments and did not provide benefit to contributing developments.

In *Holmdel Builders Association v. Township of Holmdel*, the New Jersey Supreme Court found that there was a reasonable relationship between nonresidential development and the need for affordable residential development. Furthermore, they ruled that the rational-nexus standard was not appropriate in this case, instead using a reasonable relationship standard to uphold the affordable housing fee as a reasonable exercise of police power (Circo 2009).

The *Holmdel* ruling encouraged local governments in the United States to experiment with fees for childcare facilities, transit systems, and other social concerns. The rationale for these charges was that development created burdens in these areas, for which local governments were responsible, and developers should assist municipalities with addressing these increased burdens (Ledman 1993).

On the same premise, some local governments began using fees for environmental protection. Riverside County, California, was one of the first to implement a development cost charge for environmental purposes. All developments within a 85,000-acre habitat area for the endangered

Stephens kangaroo rat in the western party of the county are required to pay $1,950 per acre to fund the implementation of a habitat conservation plan (Nelson, Nicholas and Marsh 1992).

Many local governments in several states have also introduced programs that require developers to pay cost charges that fund activities that ameliorate the negative effects of construction on wildlife habitat and farmland. Vermont's Act No. 200 explicitly enables municipalities to "require the beneficiaries of new development to pay their proportionate share of the cost of municipal… capital projects which benefit them and to require them to pay for or mitigate the negative effects of construction" (State of Vermont 1990; quoted from Mudge 1992: 72). Recently, a Californian trial court upheld the County of El Dorado's development cost charge program to protect a rare plant species, though it required the County to conduct a full environmental impact report under the California Environmental Quality Act (Gowder et al 2010).

Environmental Development Cost Charges in Theory

The success of environmental DCC programs in the United States indicates that using development cost charges to protect the environment is of interest to local governments, technically feasible, and legally defensible. This has inspired academics to examine how development cost charges could further be used for fostering sustainability.

Nelson, Nicholas, and Marsh (1992) observe that fees for habitat protection offer benefits for ecological conservation as well as certainty for developers and suggest that development cost charges for air quality and energy conservation could "soon become a reality" (22). As a thought experiment, they put forward the idea of using energy cost charges to fund energy retrofits for existing buildings instead of building a coal plant, but do not go on to consider the legal issues and technical details of how the cost charges would work in practice.

Nicholas and Juergensmeyer (2003) see potential for development cost charges to be used as a market-based approach to environmental protection. They suggest that environmental DCC programs that combine principles of market-based regulation could incentivize developers to increase conservation, rather than merely maintaining the status quo. Such a program would present developers with three options. Developers can simply pay the fee and proceed with the project; reduce their fee by reducing the impact of their project; or pay another firm to mitigate the impact elsewhere. The program would set the baseline at zero, meaning all pollution and development would be assessed based on the societal impact to the environment. The authors caution that "any environmental mitigation fees would need very careful impact analysis in order to make them feasible and defensible" (860).

Ledman (1993) more fully fleshes out the legal and practical aspects of environmental development cost charges. Such a charge would be "a one-time assessment by a local government against new development to reimburse the community for the new development's proportional impact on the environment" (853). Unlike traditional development cost charges that are used to construct physical public assets, environmental DCCs would instead compensate for the loss of habitat, air and water quality, and other environmental resources caused by development. The rationale is that development burdens the community with environmental impacts, for which developers should reimburse the community.

Ledman argues that because environmental DCCs would not be tied to the benefit received by development and environmental impact can be difficult to precisely quantify, they should be subjected to a reasonable relationship test with other safeguards to account for the lack of precision. As with all

DCCs, environmental charge programs should be based on a comprehensive environmental conservation plan, standards for environmental levels of service, and a careful account of the actual impacts of development. Ledman concludes that, in practice, calculating proportional impact with adequate precision to survive judicial scrutiny may be very difficult and expensive and suggests that "fees will likely have to be narrow in scope and tied to specific, reasonably quantifiable environmental characteristics" (867).

Several scholars have proposed environmental DCC program models based on Ledman's analysis. Circo (2009) argues that "developer fees could be used more ambitiously to help finance the most progressive sustainability objectives" and supports using a reasonable relationship test to scrutinize environmental development charges (60). He sees potential for using DCC programs to finance progressive green building programs to encourage and incentivize the real estate industry to adopt green building design and construction practices. However, Circo's analysis is premised on his argument that DCCs should be evaluated using a reasonable relationship test, which is currently not standard practice. He also notes that there are substantial technical challenges to implementing such a program.

Kingsley (2008) suggests "a model for local governments to aggressively encourage resource-efficient building by private developers through the use of impact fees" (533). He argues that impact fees are the best policy tools available to local governments to promote green buildings. Subsidies and information provision programs are actually ineffective at stimulating high performance building. While regulatory requirements can be effective for mandating green building, ample literature suggests that they often do not allow flexibility in the actions that developers take to comply with standards and do not account for variation in costs among different builders. Kingsley proposes charging green building DCCs either based on the level of (Leadership in Energy and Environmental Design (LEED) certification that new development projects achieve or on projects' forecasted uses of energy, water, transportation, and sewage systems. However, Kingsley surmises that both proposals would have difficulties with pricing proportional impacts.

Jepson (2011) discusses the idea of using development cost charges for climate change mitigation, since "the level of CO_2 pollution can be partly attributable to how local land is developed" (204). He proposes charging new developments the per-house cost of global damages resulting from the United States' annual emissions. Jepson identifies eight legal, practical, and political issues that must be addressed for successful implementation. To resolve these issues, local governments must illustrate the cause and effect between greenhouse gases, housing characteristics, and climate change mitigation tools and techniques; assign GHG mitigation the same level of priority as other infrastructure objectives; and obtain legislative authority and public support for a climate change mitigation DCC program.

Translating Theory into Practice

Circo, Kingsley, and Jepson's proposals suggest intriguing possibilities for using development cost charges to stimulate green buildings and reduce greenhouse gas emissions. However, all of their proposals conclude that there are 'substantial technical challenges' to implementation, namely how to calculate the proportional environmental impact of development.

Circo writes that "given the current state of environmental economics… this kind of mathematical precision may be impractical for purposes of requiring a particular real estate development to shoulder a reasonably proportionate share of the adverse effects of unsustainable design and construction practices" (2009: 110). However, Circo attempts to account for all of the environmental impacts that buildings create through their entire life cycles, which is admirable in its comprehensiveness but rather impractical.

Kingsley's two proposals take a narrower approach in that they attempt to tie DCCs to a development's projected use of resources such as energy, water, transportation, and sewage or to well-recognized environmental standards. However, he acknowledges that for the resource use proposal, "it may be difficult to determine how much of a burden on a community is created by, for example, increased energy use; such a calculation requires valuing externalities that do not have clear market prices" (2008: 566). The LEED indexing proposal would not directly connect fees to any concrete measures of impact, so would fail on proportionality as well.

Jepson's proposal gets closer to Ledman's suggestion that "fees will likely have to be narrow in scope and tied to specific, reasonably quantifiable environmental characteristics" (1993: 867) in that it focuses on one environmental impact: CO_2 pollution. However, Jepson unfairly attributes all damages resulting from national emissions to development.

These issues cannot be overlooked if a climate change mitigation development cost charge is to succeed in practice. However, these proposals offer helpful directions. Jepson is right to surmise that, "[s]ince the level of CO_2 pollution can be partly attributable to how local land is developed, development impact fees are a possible policy tool for communities to adopt as part of their climate-action plans" (2011: 204). However, Jepson fails to illustrate a strong connection between development and climate change. Circo and Kingsley's focus on the environmental impacts of buildings provides the key. New buildings added by development generate a range of impacts, including increased greenhouse gas emissions from building operations. These emissions can be substantial in a growing community and can be precisely and accurately calculated, so the proportional impacts of development on climate change can be measured.

A climate change mitigation DCC should therefore focus on reducing GHG emissions from new buildings, since the emissions that are most directly attributable to development are those generated by the new buildings. Development and the additional growth that it brings also generate emissions from transportation and wastes, but the linkages between development and these emissions are less direct and may not hold up as well to a court test on reasonable relationship. This brings to question what climate change mitigation measures local government can provide, as the test requires a reasonable connection between community growth generated by development and the need for infrastructure and services that the growth creates.

To understand this, the next section first describes the relationships between the building sector, development, and GHG emissions, to clearly demonstrate the connection between community growth, climate change, and the need for mitigation. The following section then reviews the broad array of technologies and approaches for reducing building-related emissions and examines a study by Pond et al (2010), to identify the most effective mitigation measures within local government jurisdiction.

Buildings, Development, and Greenhouse Gas Emissions

The building sector is a significant source of greenhouse gas emissions. Residential, commercial, and institutional buildings are responsible for approximately 12 percent of the province's total GHG emissions (Government of British Columbia 2008a). They account for about one third of emissions in communities. This proportion varies widely depending on whether a municipality is urban or rural in nature. Buildings usually account for a higher proportion of emissions in urbanized areas. In Metro Vancouver, between 30 to 50 percent of community emissions are from buildings (CEA 2010).

Buildings are therefore a key sector to target for emissions reduction. As Light House (2012) put it, "[t]ackling GHG emissions from buildings is a critical component to achieving Provincial and municipal goals for substantial GHG reduction and long-term sustainability" (1). BC's Climate Action Secretariat also notes that "[a]ction needs to be taken in this sector not only to help meet the province's 2020 target, but also to put the province on a path to the green communities needed to reach the 2050 target" (Government of British Columbia 2008b: 22).

Buildings also represent the "most diverse, largest and most effective mitigation opportunities" (IPCC 2007b: 389). According to the Intergovernmental Panel on Climate Change, significant reductions in GHG emissions can be achieved in the building sector over the coming years using a broad array of mature technologies for energy efficiency that are proven and cost-effective. Since the existing building stock is responsible for current emissions, the largest portion of emissions reductions will be from retrofitting existing buildings.

However, the largest savings in energy use (75% or higher) will be for new buildings. Additionally, new construction provides the greatest opportunities for cost-effectively incorporating low-energy and low-emissions designs and technologies. So, while significant action needs to be taken to bring down emissions in existing buildings, development still has an important role to play in decreasing emissions in new construction (ibid). As Pond et al state (2010), development "without an overall GHG emissions strategy, will add to, rather than help solve, the GHG challenge" (68). This is especially important in communities that will be experiencing rapid development in the coming decades.

BC's population is expected to grow from 4.6 million in 2012 to 6.2 million in 2036 (BC Stats 2011), with a corresponding projected growth of 1.1 million residential units between 2011 and 2031 (Altus Group 2009) and an increase of 115 million square meters of commercial and institutional floor space by 2020 (Government of BC 2008b). This growth is a significant opportunity for development to contribute to reducing building-related emissions.

Factors Influencing Building Emissions

Buildings produce greenhouse gas emissions because they consume energy to power heating, ventilation, and air conditioning (HVAC) systems that provide comfortable indoor climates, heat water, run appliances and equipment, and keep the lights turned on. Building-related emissions can be divided into two types: direct and indirect. Direct emissions are produced by the on-site combustion of fuels. In BC, direct emissions from residential, commercial, and institutional buildings result primarily from the burning of natural gas for space and water heating. Other fuels, such as heating oil, kerosene, and wood, are also used (NRCan 2011a). These direct emissions account for more than half (57%) of all building-related emissions in the province (Government of BC 2008a).

Indirect emissions are those associated with producing the electricity that is used for operating systems, appliances, and lights in buildings. In BC, end uses of electricity in buildings include lighting, appliances and equipment, some space cooling, and a small portion of space and water heating (NRCan 2011a). Buildings consume approximately 23 percent of all electricity used in the province (Fraser Basin Council 2009). Even though this is a considerable amount of energy, the indirect emissions associated with it is proportionally not as large because BC derives much of its electricity from hydro and the amount of GHGs associated with producing hydroelectricity (i.e. the emissions factor) is relatively low (Government of British Columbia 2012).

A complex set of interacting factors influence building-related energy use and emissions. They can be categorized into three primary factors: energy demand, energy efficiency, and energy source. Energy demand is the total amount of energy that it takes to run systems and equipment in buildings. Energy efficiency is the amount of energy that these systems and equipment take to produce a unit of service (e.g. heat, lighting, etc.). Energy source is the type and greenhouse gas intensity of fuel that is used to power the systems and equipment. Energy demand combined with energy efficiency equals the total energy use of a building. The combination of all three factors equals the total emissions produced by a building (Pond et al. 2010).

Factors that influence energy demand include climate, building type, building envelope, and building design. Climate affects how much energy a building uses for heating and cooling. For example, a building in New Delhi uses little energy for heating but consumes a lot of power for cooling while energy use in a building located in Prince George would have the opposite pattern. Building use sets different requirements for indoor climate and internal loads (UNEP 2007). For example, energy consumption is dominated by HVAC and lighting in residential and industrial buildings to provide comfortable environments for residents, business owners, and customers; while equipment and machinery might dominate energy consumption in industrial buildings (Centre for Climate and Energy Solutions 2009).

The building envelope plays an important role in shaping energy consumption by determining how much heat transfer occurs between the interior of the building and the outside environment. For example, a very well insulated building can keep warm or cool air inside and minimize the use of HVAC. Building design influences how much lighting, heating, and cooling a building will require. For example, southern orientation can maximize opportunities for daylighting and solar energy. Size and complexity are also part of building design. Larger and more complex buildings generally require more energy for heating, cooling, and lighting.

Energy efficiency depends on the systems and technologies used in buildings. For example, a building that heats water using a natural gas boiler will use more energy and produce more GHGs than a building that uses a solar hot water heater. Energy source depends on what fuels are available in a certain location as well as the capabilities of a building's systems and technologies to use those fuels. For example, a building in BC that uses the same amount of electricity as one located in Alberta would produce significantly fewer emissions, since BC's electricity is mostly generated from hydro while coal and natural gas generate most of Alberta's electricity (ibid).

Technologies for Reducing Building-Related Emissions

There are numerous proven, cost-effective, and accessible technologies for reducing emissions from the building sector and it is beyond the scope of this project to describe all of them. The following section generally describes main technologies, categorized by whether they decrease energy demand, increase energy efficiency, or switch to lower GHG-intensive energy sources. As with factors that influence building energy consumption and GHG emissions, many technologies also interact in complex ways so should not be seen as discrete pieces but rather as integral parts of a system.

Decreasing Energy Demand

Building energy demand can be lowered by improving the building envelope and by designing a building to passively heat, cool, ventilate and light itself to minimize or eliminate the need for those systems.

There are two key components to a building envelope that minimizes heat exchange between the interior of a building and the outdoors: high levels of insulation with minimal thermal bridges and airtight construction. High levels of insulation can be achieved using thick walls, designing junctions in walls, roofs, and floors to avoid thermal bridges, and filling those areas with appropriate insulation material. Installing well insulated windows and doors is also part of improving insulation (UNEP 2007). Existing buildings can be retrofitted for better insulation, though some things (e.g. thicker walls) would be prohibitively expensive and cumbersome; while new construction can design for high levels of insulation.

Airtight construction is important for all parts of the building envelope. The key principle for air tightness is to carefully plan and meticulously build a continuous and uninterrupted envelope that will completely enclose the interior of a building. To apply this principle, the part of each external building component that will form the airtight layer should be specified (e.g. the interior plaster for a brick wall). Secondly, how the ends of those airtight parts are permanently and air-tightly joined should be specified (e.g. interior plaster is used to seal the gap between the window frame and the exterior wall). Thirdly, any necessary interruptions should be minimized and planned (e.g. grouping together necessary interruptions in as few locations as possible). Lastly, these plans need to be well implemented (IPHA 2006). Retrofits to existing buildings can improve the continuity and integrity of the airtight layer while new development can plan and build for airtight construction.

Building design can drastically reduce energy demand by taking advantage of the sun for passive heating, cooling, ventilation, and lighting. This typically involves orienting the building and glazing to maximize collection of solar energy; storing the energy in 'thermal mass', which consists of building materials with high heat capacity; and using design elements or fans, ducts, and blowers to distribute the stored solar energy back into the living space when required (Light House & Wimmers 2009).

To reduce unwanted solar gains in the summer, buildings can also incorporate passive cooling techniques, such as including overhangs for south-facing windows, minimizing windows and wall areas facing east and west, and planting deciduous shade trees and plants to block summer sun. The strategic placement of windows can accomplish passive ventilation and lighting (ibid).

Building shape, type, and size are design elements that also influence energy demand. Simple building shapes that keep corners and joints to a minimum reduce the surface area and thermal bridges through which heat can be lost. Building types that require individual units to share walls (e.g. rowhouses) or floors (e.g. apartments and high-rises) also reduce heat loss and associated space heating demand by reducing the amount of surface area per unit that is exposed. Smaller units and buildings simply have less space that needs to be heated, thereby reducing energy demand (Pond et al. 2010).

While each of these and copious other design strategies can contribute to reducing energy demand in buildings, maximizing the overall potential to reduce demand through design requires an integrated and multi-disciplinary design process that brings architects and engineers together to tackle energy and environmental considerations at an early stage. Hence, incorporating design strategies is easiest and most effective for new buildings, though existing buildings can be adapted to incorporate some elements (UNEP 2007).

The Passive House standard reveals how much energy demand can be reduced through construction and design. The Passive House concept "is based on the goal of reducing heat losses to an absolute minimum" so that a building needs very little or no energy for heating and cooling (Passive House Institute 2012). The requirements for Passive House certification in Canada are maximum space heat demand of 15 kWh/m^2a and maximum total primary energy demand of 120 kWh/m^2a. This is achieved by incorporating design fundamentals such as an integrated planning process, efficient building shape, exploitation of solar exposure, superinsulation, triple glazed and insulated windows, airtight construction, pre-heated ventilation with heat recovery, and thermal bridge-free construction (Canadian Passive House Institute n.d.).

Increasing Energy Efficiency

Reducing building energy use and emissions through energy efficiency primarily involves improving the energy efficiency and, when possible, reducing the numbers and sizes of building systems, equipment, and appliances. The energy efficiency of new products has been steadily increasing. The most efficient products available today use two to five times less energy than the least efficient appliances (IPCC 2007b). Energy efficient equipment and appliances can be installed in new construction from the start and can be retrofitted into existing buildings, often when older equipment already needs to be replaced.

Although new models of individual equipment and appliances are becoming more efficient, planning to use fewer and smaller energy-consuming products is also important to ensure that energy efficiency gains are not lost. While these might be personal or business choices for household appliances and office equipment, buildings can be planned and designed so that the heating, cooling, and electricity needs of a group of buildings can be linked in a district energy system to realize significant efficiencies in energy use.

A district energy system is a neighbourhood- or community-scale network of buried pipes that carry steam, hot water or chilled water to provide heating, cooling, and domestic hot water services to a collection of buildings in a defined geographic area. A system can be designed with a central plant or multiple smaller plants that heat or cool water or steam. Some district energy systems also provide electricity by using cogeneration or combined heat and power (CHP), which captures the waste heat from electricity generation for heating needs (Gilmour & Warren 2008).

District energy can realize energy efficiencies beyond what can be accomplished by optimizing the design of a single building because they aggregate the thermal needs of multiple buildings. This allows individual buildings to use smaller HVAC and hot water systems or forego them altogether. Modeling done by Urban Energy Solutions found that connecting every residential and commercial building in Canada to a natural gas-fired CHP district energy system could produce energy savings of nearly 897 million gigajoules per year as well reductions of more than 57 million tonnes of CO_2 emissions (ibid).

Depending on how the system works, district energy can also enable the collection of waste or surplus heat and distribute it to where it is needed in the network, creating further efficiencies. Both new construction and existing buildings can be connected to district energy systems, though it is often easier to lay out buildings to maximize the technical and financial feasibility of a district energy system and install the necessary hydronic heating systems in new construction than retrofit existing buildings.

Switching to Lower GHG-Intensive Energy Sources

Beyond reducing energy demand and increasing efficiency, switching to lower-carbon energy sources for heating, cooling, and power is a critical part of significant and long-term GHG reductions. In BC, switching to less GHG-intensive energy sources usually means switching to renewable energy, as the primary energy sources used by buildings (i.e. hydroelectricity and natural gas) are already low in emissions compared to jurisdictions that use more fossil fuels. Renewable energy is energy derived from natural sources such as sunlight, wind, rain, tides, biomass, and geothermal heat. It also includes the recovery of waste heat that would otherwise be lost, even if the heat is produced by non-renewable sources (CEA 2008b).

Switching to renewable energy can be accomplished through onsite or offsite generation. Onsite generation produces heat or electricity at the location of the building that uses those services. Technologies for onsite generation of renewables include solar thermal and geo exchange systems and heat pumps to source heat from the air or ground for space conditioning and hot water systems, as well as solar photovoltaic cells, wind turbines, and biomass combustion for electricity generation (ibid). Net zero energy buildings produce as much energy as they consume over a full year by using onsite microgeneration technologies. Buildings may produce more energy in the summer and consume more in the winter. Surplus energy can be stored onsite in batteries or thermal storage or on the electricity grid with net metering. Typically, net zero energy buildings use passive design to minimize energy use requirements then use community-based or on-site renewable and waste energy resources to meet remaining energy needs. The net zero energy concept is a high standard of environmentally responsible construction and is seen as a potential solution to mitigating climate change (UNEP 2007).

Offsite generation usually produces heat or electricity at a central location to service a number of buildings. While this may be as large as the entire electricity grid, switching to renewable energy at a community or neighbourhood scale with a district energy system is more feasible. The centralized production of heating and power in district energy systems makes it easy to switch to renewable sources such as solar power, geothermal, biogass, biomass, waste heat, or a combination. While natural gas and oil are the most common fuel sources for district energy systems, renewable sources are growing in popularity (Gilmour & Warren 2008). Onsite and offsite generation of renewable energy can be used in new construction as well as in existing buildings.

Opportunities for Reducing Emission from the Building Sector

While there are numerous technologies and design approaches to reduce energy use and GHG emissions related to buildings, no single one is the ‘magic bullet’ for reducing emissions from the building sector. The diversity of buildings and their uses require a combination of technologies and designs tailored to the characteristics of specific places. A study by Pond et al (2010) tests different combinations to determine distinct pathways for achieving deep emissions reductions in BC. Their study provides illuminating insights on which technologies and designs are the most effective for the province.

The study examines how existing buildings can be retrofitted and new units constructed to achieve provincial targets for 33% reductions in emissions by 2020 and 80% reductions by 2050. The authors concentrate primarily on the residential sector, as 57% of building-related emissions is attributable to residences (Province of British Columbia 2008a). The study models building-related GHG reductions for three scenarios.

The Current Policy Direction Scenario consists of current practices for energy retrofits in existing buildings and ‘green buildings’ for new construction, promoted and incentivized by government agencies and other organizations. The Intensive Building Scenario attempts to achieve 80% GHG reductions through aggressive retrofits for existing buildings, including significant renovations that are not typically employed in current practice, and Passive House standards for new construction. The Neighbourhood Focused Approach Scenario also aims for 80% emissions reduction but combines more moderate building-scale approaches with neighbourhood-scale strategies such as biomass-based district energy systems for heat and water and the redevelopment of the worst-performing buildings. This scenario also prescribed Passive House standards for new construction.

The three scenarios were applied to three case study neighbourhoods from Delta, Kimberley, and Prince George, to account for climatic differences across BC. The Current Policy Direction Scenario produced GHG reductions of 33-50% between the three case studies. The Intensive Building Retrofits Scenario, which according to the authors “represent substantially more aggressive buildings changes, costs, and lifestyle impacts”, achieved reductions of 55-93% (ibid: iv).

The Neighbourhood Focused Approach Scenario resulted in 80-94% emissions reductions, even with a 54% increase in units for the Prince George case study. The authors comment that this is the only scenario in which “growth in residential units can be accompanied by deep GHG reductions” (ibid: v). The two case studies that employed biomass-based district energy systems achieved the highest emissions reductions and Pond et al note that “[t]he use of the district energy system in [Scenario 3] allows for substantially greater GHG reductions than Scenario 2, with less intensive building retrofits and without increasing total electrical loads” (58).

Pond et al conclude from their study that deep reductions in building-related emissions are possible with currently available technologies. Current policy directions will only achieve the 33% reduction by 2020 but not 80% reduction to meet the 2050 target. The Intensive Building and Neighbourhood Focused Approach Scenarios illustrate that there are different ways to meet an 80% reduction. One of the key findings of the study is that moving to a lower carbon energy supply is essential for making deep cuts to GHG emissions. As well, the authors comment that “the move to shared biomass supplied District Heat Systems… demonstrates that fewer reductions in energy demand may be possible while still achieving [+80%] GHG emissions reductions. As well, increases in residential units are possible while still meeting the 80% GHG reduction target” (69). These conclusions are significant, as all scenarios in the study assumed a retrofit rate of 100%, which is highly unlikely in practice.

Pond et al also point out that each scenario has different policy implications. For the Current Policy Direction and Intensive Building Scenarios, responsibility for implementation lies primarily with individual home-owners and builders to retrofit existing buildings and construct highly efficient new buildings. Municipal, provincial, and federal governments can support implementation through regulatory requirements (e.g. increasing energy efficiency requirements in the Building Code), incentive programs (e.g. grants or discounts for retrofits or energy efficient products), and retrofit financing. In contrast, the shared systems in the Neighbourhood Focused Approach Scenario place responsibility for implementation with local government, with some involvement from home-owners, builders and higher levels of government.

The study reveals some key points on reducing building-related emissions in existing buildings and new construction. For existing buildings, significant retrofits or neighbourhood-scale approaches, namely district energy systems, are needed to achieve deep reductions; the latter is likely easier to achieve and can be implemented by local government. New construction should be built to net-zero or Passive House standards, since it is easier to ‘build green’ from the beginning than retrofit later. These findings provide the key to constructing a climate change mitigation DCC that not only meets the reasonable relationship test but can also stand up to the rational nexus test.

A Climate Change Mitigation Development Cost Charge

Although scholars argue that environmental development cost charges should be subjected to a reasonable relationship standard, it may be possible to construct a DCC for climate change mitigation that can pass the rational nexus test. To pass the two prongs of the test, DCCs must demonstrate (1) a reasonable connection between community growth generated by development and the need for infrastructure and services that the growth creates and (2) the development that pays the DCC must in some way benefit from the fees collected (Nicholas, Nelson & Juergensmeyer 1991).

To address the first prong, a climate change mitigation DCC should specifically fund local government measures that reduce GHG emissions in the building sector. Theoretically, the DCC can fund the broad range of technologies and design approaches available for reducing building-related emissions. However, the convention in BC is to use DCCs for infrastructure needs, as the Local Government Act only permits charges for providing, building, altering, or expanding highways, sewage, water, and drainage, and to acquire and improve parkland. Since the objective of this project is to paint a realistic picture of what a climate change mitigation DCC would look in order to make the case for enabling legislation in BC, the methodology and case study will accordingly follow the infrastructure convention and only fund capital GHG reduction projects.

District energy systems are a good fit with this convention, as they are physical infrastructure that local governments can use to effectively reduce building-related emissions by realizing energy efficiencies across the system and facilitating the move to lower carbon energy supplies. District energy systems can also yield direct cost savings and energy security benefits to the developments that will be paying the fee, meeting the second prong of the test.

A climate change mitigation DCC needs to ensure that fees are proportional to the impact caused by new development. Since the rationale is that new buildings produce emissions and therefore require mitigation by local government, new buildings that produce low emissions should pay reduced fees and fees should be waived for those that produce extremely low to negligible emissions. Structuring the DCC in this way makes it more robust against the rational nexus test.

It also has the added benefit of Nicholas and Juergensmeyer's (2003) suggestion of using market-based regulation to incentivize increased conservation. Developers can build to current building standards and simply pay the fee to fund district energy systems and the associated GHG reduction service for their project; or they can build to higher standards if the cost of improved performance is equal to or less than the fee and/or they can better market their product and increase their sales prices because they built to a higher standard. There is ample research that states that it is easier to 'build green' than to retrofit afterward, so incorporating this into the climate change mitigation DCC can be a powerful way of encouraging the development industry in that direction.

District energy systems can and should be used to reduce emissions in new developments and existing buildings. However, a climate change mitigation DCC should ensure that new developments only pay its fair share of the cost. This will be incorporated into the City Centre case study methodology.

In determining the legality of development cost charges, the courts also review whether local governments have the statutory authority to impose them. Legislative changes will be required to enable local governments to charge DCCs for climate mitigation. The strong action that the Province has taken on climate change mitigation and the connection that Bill 27 made between reducing GHG emissions and DCCs suggest that there is opportunity for such changes if communities can present a strong case for the additional authority. Hence, the following case study aims to help construct a persuasive argument by testing how practical a climate change mitigation DCC is by developing a methodology and applying it to calculate rates for the City Centre case study.

CHAPTER 4: LEVELS OF PERFORMANCE, SURREY CITY CENTRE CASE STUDY AND A METHODOLOGY FOR CALCULATING A CLIMATE CHANGE MITIGATION DEVELOPMENT COST CHARGE

As Chapter 2 states, crafting defensible, robust, and fair development cost charges that meet the rigors of the dual rational nexus test is a complex exercise that involves careful consideration of multiple policy and technical issues. These issues include the establishment of facility standards; integration with broad community planning objectives; synchronization with detailed master servicing plans; geographical extent; time period; net recoverable costs; categories of charges; and units of development. Of these, the challenge is selecting facility standards that ensure that fees for climate change mitigation are proportional to the impact of new buildings on community GHG emissions and are structured logically for the buildings sector and development industry.

This chapter grapples with the facility standard issue, to establish a framework for structuring climate change mitigation development cost charges. Ledman (1993) rightly points out that standards for environmental DCCs are levels of environmental quality or performance rather than levels of service that communities wish to maintain or achieve. Consequentially, more appropriate terms for facility standards related to environmental DCCs are 'levels of environmental quality' or 'levels of environmental performance'. This project will refer to 'levels of performance'. Although the overarching concern underscoring a mitigation DCC is environmental quality (i.e. the level of greenhouse gas emissions and its contribution to climate change), it is effectively concerned with environmental performance (i.e. how buildings perform in terms of energy efficiency and GHG emissions).

The chapter then addresses the other policy and technical considerations listed above in the context of the Surrey City Centre case study; and closes by describing the methodology for calculating mitigation DCC rates. In some ways, this methodology is specific to Surrey City Centre as the case study's real-world parameters present unique opportunities and challenges. These parameters are needed to put the mitigation DCC concept through real-world paces to test how feasible the idea is in practice. However, the broad contours of the methodology are structured to be applicable across jurisdictions.

Levels of Performance

Establishing appropriate levels of performance is crucial for structuring defensible climate change mitigation DCCs because facility standards are integral to fulfilling the first prong of the rational nexus test. Local governments must demonstrate that the need for new or expanded facilities is created by growth rather than existing deficiencies, in order to fairly apportion facility costs between new and current development. Facility standards are the yardstick that communities set for measuring shortfalls in levels of service, whether they are from existing deficiencies or are created by new growth. Levels of performance have a similar function in that they provide the basis for assessing gaps between the ideal level of GHG emissions performance of buildings and the performance of current buildings and future developments.

Chapter 3 proposed that DCCs should be waived for new buildings that produce a minimal level of emissions, as they essentially require almost no mitigation action by local government. In other words, the ideal level of performance is minimal emissions. Developments that build to mandatory standards set by the BC Building Code should pay the full fee. All new construction is required to meet the

Building Code, so these requirements act as a baseline level of performance. Since the Building Code does not yet require zero emissions, the emissions generated by these buildings require mitigation. Buildings that produce fewer emissions by performing better than the Building Code should pay reduced fees, since they would necessitate less mitigation action compared to buildings constructed to, but not beyond Code. There should also be several benchmark levels of performance between the ideal and baseline, to fairly apportion costs as well as recognize developers and builders for achieving higher performance.

This general framework abides by the first prong of the rational nexus test but needs to be technically defined so that it is useful in practice and is coherent and compatible with the vast landscape of existing mandatory and voluntary building standards. It is widely accepted that "it is much simpler, from both the local government's and the developer's perspective, to reference a well-known standard than to try to develop one from scratch" (FBC 2009: 8). Hence, all levels of performance for the mitigation DCC reference common building standards and ratings.

The following sections discuss some general technical considerations for all levels of performance; describe the benefits of adopting minimal emissions as the ideal level of performance and define its technical specifications; give an overview of performance standards set by the BC Building Code; and propose benchmark levels of performance between Code requirements and a minimal-emissions yardstick.

General Technical Considerations

Only emissions and energy use associated with the services that a district energy system will provide can constitute the technical descriptions of levels of performance, to adhere to the principle that the benefiter pays only for infrastructure that they will use and from which they will benefit. As the City Centre case study's DE system will only provide space heating and domestic hot water (DWH), only these thermal components will constitute the technical descriptions of levels of performance given in the following sections. Other DE systems that provide other services such as cooling and electricity can incorporate these components into their technical descriptions of building performance.

It should be noted that a district energy system fueled by renewable energy sources is a supply-side strategy. It reduces greenhouse gas emissions by enabling all connected buildings to switch from conventional fuels (e.g. natural gas, coal-generated electricity, etc.) to mainly renewable sources (e.g. woody biomass, geothermal, etc.). While the system provides some energy efficiency gains to customer buildings, it achieves emissions reductions primarily through fuel switching rather than reducing energy use. In contrast, the building standards and ratings referenced by the levels of performance in the following sections are demand-side strategies. They regulate or challenge buildings to be designed and constructed to use energy efficiently, sometimes to the point of using very little to no energy.

The following sections describe levels of performance in three ways. First, they describe the building standard or rating system that is referenced by the level of performance, in terminology commonly used by the development and construction industries. They then give the energy use intensity that is achieved by meeting the particular standard or rating referenced by a level of performance, so levels can be compared in terms of energy efficiency. Lastly, they give the emission intensity associated with a level of performance, so that levels can be compared with each other in terms of GHG emissions and against the emissions reduction abilities of the district energy system.

Energy use intensity (EUI) is how much energy a building uses per unit area. This project uses equivalent kilowatt-hours per square meter of floor area per year ($kWh_e/m^2{\cdot}a$)[2] as the unit for expressing EUI. Many commonly-used building standards and rating systems do not use energy use intensity to describe building performance. The EUI figures associated with these standards and ratings given in the following sections are drawn from actual energy consumption data. Specific sources are listed below.

Emission intensity (EI) is how much greenhouse gas emissions a building produces per unit area. This project uses equivalent greenhouse gases emitted per square meter of floor area per year ($kgCO_2e/m^2{\cdot}a$)[3] for expressing EI. Very few, if any, standards and ratings yet evaluate building performance in terms of emission intensity. However, given data on energy intensity, it is relatively simple to calculate emission intensity, since energy use is directly related to GHG emissions. The conversion relies on emission factors, which are "average emissions rate[s] of given [greenhouse gases] for a given source, relative to units of activity" (UNFCCC 2012). Appendix A provides an overview of emission factors and the methodology for calculating emissions from energy use. Appendix B provides sample calculations used to calculate the EI figures given below.

A development project must meet both the EUI and the associated EI for the level of performance that it aims to achieve. Meeting the energy use intensity for a level of performance shows that the project meets the standard or rating associated with that level. Meeting the associated emission intensity is necessary, since the objective of the mitigation DCC and the service provided by the DE system is to reduce greenhouse gases.

The Ideal: Minimal GHG Emissions

There is no singular definition for 'minimal GHG emissions'; as global, multi-sectoral research is currently experimenting in many directions with how to construct individual buildings and transform the building sector to produce very low to no emissions and to even offset, sequester, and/or remove emissions from the surrounding environment and adjacent communities (Architecture 2030 2011; American Institute of Architects 2012; Clinton Foundation n.d.).

However, there is wide consensus that buildings can and should be carefully designed to reduce energy demand to as close to zero as possible through passive design and by using high-efficiency lighting and equipment. Minimizing energy use is the current focus of most initiatives that seek to reduce building-related emisisons. The American Institute of Architects (2012) notes that: "**This *must* be the starting point for any carbon neutral design. If the building is not carefully designed to lessen its…energy requirements from the outset, it will not be possible to provide adequate renewable energy to allow the building to operate**" (original emphases). Hence, as the ideal level of performance, minimal to zero energy consumption can be taken as the practical, demand-side definition of minimal emissions.

Setting minimal to zero energy consumption as the ideal performance level makes sense for several reasons. Constructing buildings that use little to no energy makes a considerable dent in addressing

[2] All fuels differ in how much energy they produce per unit of volume. Energy unit conversion factors are used to express how much energy is produced from a particular type and amount of fuel in equivalent kilowatt-hours (kWh_e), where one kWh of electricity equals 1.

[3] All greenhouse gases differ in their strength in trapping heat in the atmosphere. To compare the ability of different GHGs to trap heat or for radiative forcing, the concept of global warming potential (GWP) was development. It equates 1 kg of CO_2 to 1 and measures the GWP of other GHGs relative to CO_2. Hence, the unit carbon dioxide equivalent (CO_2e) can be used to compare and add different quantities of GHGs (Government of BC 2012b).

climate change. According to the United Nations Environment Program, these buildings “are increasingly important in developed countries. They are seen as a potential solution to mitigating global warming and other environmental problems. It is [sic] also an alternative to economic vulnerabilities, such as the dependence on fuel imports of fossil fuels” (2007: 27).

There is a strong case and opportunity for new buildings to aspire to and achieve this ideal. As Pond et al’s 2010 study illustrates, building to net zero energy or Passive House standards is needed to make deep emissions reductions from the building sector as a whole and it is easier to ‘build green’ from the beginning than to retrofit later. This puts new construction in a strong position to lead emissions reductions in the building sector.

While the large stock of existing buildings do require retrofitting or, in some cases, demolition to lower its portion of emissions, this will require considerable time as the actors responsible for implementation are diverse and the role of local government in effecting implementation is limited. In contrast, constructing new buildings to use as little energy as technically and financially possible can be done immediately and local government can play a strong supportive role by providing incentives, awarding density bonusing, and fast-tracking permits.

Setting this ideal level also encourages leaders in the building sector and development industry to be early adopters and stay ahead of the curve. Many mandatory building standards have the long-term aim of net-zero energy. At the global level, several International Energy Agency countries “have adopted a vision of… ‘net zero energy buildings’ (NetZEBs) as the long-term goal of their energy policies” (Ayoub 2008: 1). CanmetENERGY, Natural Resources Canada’s clean energy research and technology development section, is shooting for this milestone (NRCan 2008).

It is possible that BC’s Building Code will move toward net-zero energy buildings in the future. As the U.S. Department of Energy (2010) observes, “[b]uilding energy codes are a baseline of energy efficiency that constantly drive beyond-code programs to improve. As code cycles iterate from one to the next, today’s beyond-code programs become the baseline of tomorrow. Ultimately, the energy codes community will converge on its true goal—buildings with zero energy use.” (25).

As introduced in Chapter 3, there are two well-recognized voluntary standards for zero or close to zero energy buildings: net-zero energy buildings (NetZEBs) and the Passive House standard.

NetZEBs would be conceptually the best match for the ideal level of performance, as they are functionally carbon-neutral buildings, and may well become the standard of the future. However, much more research is required to make affordable net-zero energy buildings a reality. Recent demonstration projects by leading-edge builders show that NetZEBs are technically possible in Canada’s climate (NRCan CanmetENERGY 2011). However, they also reveal that the incremental cost of building to net-zero energy compared to a regular house ranges from $65,000 to $125,000, depending on the technologies, location, and typology (Delisle 2011). It would be unreasonable to set net-zero energy as the highest level of performance, as presently it is financially unachievable given current technologies, energy prices, and markets. When the risk and incremental cost of building NetZEBs are drastically reduced, it would be worthwhile to revisit this approach.

The Passive House standard serves well as the yardstick level of performance for several reasons. It is “the fastest growing [voluntary] energy performance standard in the world”, with over 30,000 buildings constructed according to Passive House principles (Mead & Brylewski 2011: 2); so will be familiar to builders and developers. The standard is the same for residential, commercial, institutional, and industrial buildings.

It is stringent, with a maximum 15 $kWh_e/m^2{\cdot}a$ for space heating demand and a maximum 120 $kWh_e/m^2{\cdot}a$ for total primary energy demand (CaPHI n.d.). Since total primary energy demand is for all appliances, domestic hot water, space heating, and cooling, energy demand for just space heating and DWH should be broken out. The Passive House Institute recommends 35.3 $kWh_e/m^2 \cdot a$ for space heating and hot water (Passive House Insitute n.d.).

This recommendation is based on energy consumption data gathered from 244 units from 18 Passive House projects in Germany, Austria, and Switzerland. The projects differ in terms of building type but are primarily single-family, multi-family, terraced, and semi-detached houses. This figure may therefore not accurately reflect the domestic hot water consumption and thermal energy use intensity of high-rise multi-unit residential buildings and commercial buildings. However, there is no data available for these other building types. Hence, 35.3 $kWh_e/m^2 \cdot a$ is used because it is based on the best available data.

The equivalent emission intensity is 6.3745 $kgCO_2e/m^2 \cdot a$ (see Calculation 1 in Appendix B). This assumes that thermal energy demand is met entirely by natural gas. While Passive House buildings can use other types and combinations of non-renewable and renewable fuels, the emission intensity produced by using only natural gas is the highest. Calculating the EI based on this assumption avoids penalizing developers building to Passive House energy efficiency standards but choosing to meet energy demands entirely with natural gas.

The current incremental cost of building to Passive House standard is much more reasonable at typically 10-15% (CaPHI n.d., Light House & Intep LLC 2012, Paulsen 2012, White 2012). This figure is based on projects built in Europe and residential buildings in North America, which constitute the majority of Passive House buildings constructed to date. It may therefore not accurately reflect the incremental cost of building high-rise residnetial, commercial and industrial buildings to Passive House standards in North America. However, it is the best data currently available.

Incremental costs are generally expected to shrink as fuel prices and building energy standards increase and Passive House-quality building components become more available and cheaper (CaPHI n.d.). If the current incremental cost is comparable to the value of the mitigation DCC, it may incentivize developers and builders to adopt Passive House standards. The 80-90% reduction in annual heating costs for the owner would also be a marketing benefit, especially as the cost of energy is expected to rise in the future (ibid).

The Baseline: Building Energy Codes

The energy efficiency of buildings in British Columbia is regulated by the BC Building Code. As mentioned above, GHG emissions performance metrics are not yet part of building codes in BC and Canada. In general building codes are "a complete set of building regulations that govern all aspects of the design and construction of buildings" (DoE 2010: 5). They include minimum energy efficiency and other performance requirements for the design and construction of building envelopes, systems, and equipment for new and substantial renovations to existing residential, commercial, industrial, and institutional buildings (ibid).

Constitutionally, Canadian provinces and territories regulate the design and construction of new buildings, as well as the maintenance and operation of fire safety systems in existing buildings. The Canadian Commission on Building and Fire Codes develops national Model Construction Codes for buildings, fire, plumbing, and energy that provincial and territorial governments can choose to adopt in whole or in part with variations in content and scope. British Columbia publishes its own Building Code that is based on National Model Construction Codes but with variations and additions (National Research Council 2012).

Part 3 of the BC Building Code and National Model Building Energy Code (NMBEC) pertains to large residential, industrial, commercial, and institutional buildings, and reference standards developed by the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE). Part 9 of the provincial Code and NMBEC applies to housing and small buildings, and references the EnerGuide rating system developed by Natural Resources Canada (NRCan).

As part of its commitment to reduce GHG emissions related to buildings and construction, the Province introduced a new Part 10 to the BC Building Code in 2008 that includes new requirements for energy and water efficiency. The new regulations require Part 3 buildings to meet the ASHRAE 90.1-2004 standard. Part 9 buildings need to either meet new insulation standards or achieve an EnerGuide rating of 77 (City of Surrey 2013a).

ASHRAE 90.1 "Energy Standard for Buildings Except Low-Rise Residential Buildings" is an internationally recognized standard for energy efficiency in large buildings. It was originally developed in the 1970s and is updated regularly by the American Society of Heating, Refrigerating, and Air-conditioning Engineers. The comprehensive, whole-building standard provides minimum energy efficiency requirements for building systems and equipment, the building envelope, heating, ventilation, and air-conditioning (HVAC), service water heating, electric power distribution, and lighting (FBC 2009).

ASHRAE 90.1 is a flexible standard in that it states prescriptive requirements and alternative compliance paths through trade-offs. Pursuing trade-offs between building systems requires computer modeling using the Energy Cost Budget method to substantiate that the overall proposed building energy performance is on par or better than a reference building that follows all the prescriptive requirements. ASRHAE 90.1 is written in code-style language, making it well-suited for easy referencing by governments and regulating authorities (City of Surrey 2013a). Although the BC Building Code currently uses ASHRAE 90.1-2004, the most recent version of the standard is ASHRAE 90.1-2010.

The baseline energy use intensities and emission intensities for Part 3 buildings constructed to ASHRAE 90.1-2004 are summarized in Table 1 below. Data on EUI for all building types except high-rise residential is from consumption data collected in the Lower Mainland and prepared by BC Hydro in 2012 for the City of Surrey. Only EUI for ASHRAE 90.1-2007 and 90.1-2010 was available for all building types except mid-rise residential, so EUI for ASHRAE 90.1-2004 was estimated based on the assumption that the 2007 standard is 10% more energy efficient than the 2004 version. This assumption is based on the fact that EUI figures for ASHRAE 90.1-2010 are roughly 10% more efficient than those for the 2007 standard.

Energy use intensity data for high-rise residential is from a 2011 report by RDH Building Engineering Ltd on 39 multi-unit residential buildings (MURBs) in Metro Vancouver and Victoria built between 1974 and 2002. The report is the first in-depth study on energy use by MURBs in this region and represents the most accurate data available for this building type.

Data on the proportions of total EUI for space heating and domestic hot water are from the RDH (2011) study for Part 3 residential building types and from comprehensive data tables for commercial and institutional buildings prepared by NRCan's Office of Energy Efficiency (2011). Calculation 2 in Appendix B shows how EIs were calculated for buildings, assuming that natural gas is used for space heating and hot water. Again, using this assumption creates a larger EI figure than one calculated from a combination of natural gas, electricity, and/or renewable energy source and avoids penalizing developments that build to Code energy efficiency standards and choose to use natural gas.

EnerGuide is NRCan's energy efficiency rating system for new and existing houses and low-rise multi-family residential buildings (i.e. 3 storeys and under). EnerGuide ratings range from 0 to 100 on a non-linear scale. A rating of 0 represents a house with major air leakage, no insulation, and extremely high energy consumption. A rating of 100 represents a home that is air-tight, well insulated, and does not need purchased energy on an annual basis (e.g. net-zero energy). According to NRCan, a new house with some energy-efficiency measures would score 73-79. An energy efficient new house would rate 80-90, while a house requiring little or no purchased electricity would score 91-100. A rating of 80 and above is considered to be excellent for a new house (NRCan 2010a).

Since the City Centre district energy system will not be connected to single-family homes and townhouses, only the baseline energy use intensity and emission intensity for low-rise multi-unit residential buildings is given at the bottom of Table 1. Information on EUI is froma financial model that the City of Surrey is using to estimate costs for its City Centre district energy system (City of Surrey 2013b). Again, it is assumed that natural gas is used for space heating and hot water.

Table 1:Baseline Energy Use Intensities and Emission Intensities for High, Mid and Low Rise Residential and Commercial Buildings

Building Type	Energy Use Intensity ($kWh_e/m^2/year$)					Emission Intensity ($kgCO_2e/m^2 \bullet a$)
	Total for ASHRAE 90.1-2004	ASHRAE 90.1-2007	% of Total for Space Heat	% of Total for DWH	Baseline (Space Heat and DWH)	
High Rise Residential (18 storey)	213*	195	37%	25%	132.06	23.85
Mid-Rise Residential (5 storey)	191	180	37%	25%	118.42	21.38
Wood Frame Mid-Rise Residential (5 storey)	196**	176	37%	25%	121.24	21.89
Mid-Rise Mixed Use (5 storey residential w/ ground retail)	194**	175	37%	25%	120.56	21.77
Low-Rise Commercial (single storey stand-alone retail)	392**	353	50%***	8%***	225.53	40.73
Mid-Rise Commercial (5 storey infill office)	174**	157	50%***	8%***	100.31	18.11
High Rise Commercial (17 storey office)	177**	159	48%***	8%***	98.40	17.77
Low Rise Residential (3 storeys and under)	-	-	-	-	89.00	16.07

* RDH Building Engineering Ltd. (2011)
** Assuming that ASHRAE 90.1-2007 is 10% more energy efficient than ASHRAE 90.1-2004
***NRCan Office of Energy Efficiency 2011. Tables 7 and 13.

As part of its Greening the BC Building Code initiative, the Province is planning to further increase energy efficiency requirements and introduce other measures over the next several years for reducing the environmental footprint of buildings (City of Surrey 2013a). Although the baseline level of performance could be updated to reference newer versions of the Building Code, it would be more legally defensible for a climate change mitigation DCC scheme to use an absolute baseline level of performance. If the baseline changed with the Building Code, projects that are built to the higher standards of more current versions of the Code, perform better in terms of energy efficiency and GHG emissions, and require less mitigation would be paying the same rates as projects that are built to older editions of the Code, do not perform as well, and require more mitigation.

The Benchmarks

Benchmark levels of service should ideally reward increases in performance with commensurate reductions in the cost charge. Following this reasoning, a simple way to set benchmarks is to measure a project's degree of improvement in energy and emissions performance above the baseline as a percentage of the difference between the baseline and ideal levels of performance; and to reward the same percentage discount on the development cost charge. For example, if a new high-rise MURB is designed to have an EUI of approximately 84 kWh_e/m^2•a for heating and hot water and a resulting EI of about 14 $kgCO_2e/m^2$•a, which is 50% of the difference between the baseline and ideals levels for high-rise MURBs, then the project should only pay 50% of the mitigation DCC.

Sample benchmark levels are given in Table 2 below. This approach adheres to the principle of proportionality and is simple to comprehend. In practice, it would require developers to model the energy and emissions performance of their projects to demonstrate that the buildings will achieve will achieve certain levels of performance.

Surrey City Centre Case Study

Community Planning Objectives

Surrey City Centre is an ideal case study, as much of the community planning related to climate change mitigation and service planning for the City's district energy system is complete or well underway.

In 2010, Surrey City Council adopted interim targets, policies, and actions to reduce greenhouse gas emissions in order to comply with the Local Government (Green Communities) Statutes Amendment Act. The municipality chose to match the provincial targets of reducing emission levels below 2007 levels by 33% by the year 2020 and by 80% by the year 2050, with the exception that community targets are based on per capita emissions. Surrey is projected to be one of the fastest growing municipalities in Metro Vancouver over the next three decades and achieving absolute reductions given such rapid growth will be extremely challenging. Hence, the City decided that per capita targets are more appropriate and achievable (City of Surrey 2010a).

Two major plans that set out detailed policies for addressing climate change will be completed in 2013. Surrey is updating its Official Community Plan to incorporate key policy initiatives since the last major update in 2002, and building an energy-efficient and climate-resilient community will be a significant addition to the Plan. The new OCP will include policies that "support land uses, development options, transportation alternatives, built forms, and infrastructure that reduce energy use and costs, integrate renewable energy sources, and increase energy conservation through efficiency improvements” (City of Surrey 2013c).

Table 2: Baseline, Benchmark and Ideal Energy Use Intensities and Emission Intensities

Building Type	Baseline Level		Sample Benchmark Levels 25%		Sample Benchmark Levels 50%		Sample Benchmark Levels 75%		Ideal Level	
	EUI (kWh_e/m^2•a)	**EI ($kgCO_2e/m^2$•a)**	**EUI (kWh_e/m^2•a)**	**EI ($kgCO_2e/m^2$•a)**	**EUI (kWh_e/m^2•a)**	**EI ($kgCO_2e/m^2$•a)**	**EUI (kWh_e/m^2•a)**	**EI ($kgCO_2e/m^2$•a)**	**EUI (kWh_e/m^2•a)**	**EI ($kgCO_2e/m^2$•a)**
High Rise Residential	132.06	23.85	107.87	18.82	83.68	13.80	59.49	8.77	35.3	3.74
Mid-Rise Residential	118.42	21.38	97.64	16.97	76.86	12.56	56.08	8.15	35.3	3.74
Wood Frame Mid-Rise Residential	121.24	21.89	99.76	17.35	78.27	12.82	56.79	8.28	35.3	3.74
Mid-Rise Mixed Use	120.56	21.77	99.25	17.26	77.93	12.76	56.62	8.25	35.3	3.74
Low-Rise Commercial	225.53	40.73	177.97	31.48	130.42	22.24	82.86	12.99	35.3	3.74
Mid-Rise Commercial	100.31	18.11	84.06	14.52	67.81	10.93	51.55	7.33	35.3	3.74
High Rise Office	98.4	17.77	82.63	14.26	66.85	10.76	51.08	7.25	35.3	3.74
Low Rise Residential	89.00	16.07	75.56	12.99	62.15	9.91	48.73	6.82	35.3	3.74

With regards to district energy, the Official Community Plan supports “the implementation of district energy systems to provide thermal energy to new and existing buildings to improve community energy resilience, facilitate the use of renewable energy sources and reduce GHG emissions” and “[the development of] financial and policy tools to enhance the financial viability of district energy implementation [within designated energy service areas]” (ibid).

The City is also working on a Community Energy and Emissions Plan (CEEP) to guide community-wide action on reducing energy consumption and greenhouse gas emissions. The plan includes detailed strategies for encouraging complete and compact land use; sustainable transportation options; constructing energy efficient new buildings and completing energy retrofits on existing buildings; reducing the amount of solid waste and recovering energy from waste; and establishing sustainable energy supply systems, including district energy infrastructure, through the public and private sectors.

District energy strategies in the CEEP include “establish[ing] and expand[ing the City’s low carbon district energy services in major growth areas” and “facilitat[ing] opportunities for district energy in medium-sized development in greenfield, infill, and industrial parks” (City of Surrey 2013d).

City Centre District Energy Overview

Although the OCP update and the CEEP are relatively recent policy documents, Surrey has been moving forward with district energy for several years. In its 2009-2010 Economic Investment Action Plan, Surrey committed to exploring the feasibility of a district energy system for distributing thermal energy to buildings in City Centre as one of many initiatives to encourage new investment in the area (City of Surrey 2010b).

City Centre is an area approximately 581 hectares in size located in the northwest corner of the municipality (see Figure 1). The SkyTrain's Expo Line, one of the region's rapid transit lines, runs through the area and there are stations located at Gateway, Surrey Central, and King George (indicated on Map 1 by the dark green connected dots). The City intends to develop the area into the main business, cultural and activity centre for Surrey as well as for municipalities south of the Fraser River (City of Surrey 2009).

The vision for City Centre is a dense, easily identifiable, and energetic downtown core located around the Surrey Central SkyTrain station. This core will feature high-density retail and office development, major civic, cultural and institutional facilities, and a central open space for civic celebrations. The rest of City Centre will be made up of distinct neighbourhoods, with a number of high-density residential developments concentrated around all three SkyTrain stations and lower-density residential neighbourhoods outside of these high-density nodes (ibid).

The 1991 Surrey City Centre Plan is currently being updated to reflect the City's vision for the area. An analysis of existing conditions and stakeholder engagement workshops to identify key issues were completed in 2006 and 2007. From 2009 to 2011, the City developed and refined concepts related to land use and density, building height, road network, road width, and parks and open space network with input from public information meetings and engagement events. Staff are currently working on a utility servicing strategy and infrastructure financing plans for sewer, water and drainage to support the land use and density concept (City of Surrey 2011a).

The City Centre Plan's analysis of existing conditions showed that in 2006, the area was home to approximately 23,000 and employed about 14,500. The Plan projects that population will increase to 65,000 and employment will rise to 36,000 by 2030. Substantial high-density residential, office, retail, and institutional development is also expected in the area over the next several decades (City of Surrey, n.d.b). This growth presents a huge opportunity for developing a district energy system as an “efficient and effective means of reducing greenhouse gas emissions by utilizing low GHG emission energy sources”, since DE systems are best suited for implementation in dense urban areas with a diverse mix of land uses (City of Surrey 2010c: 1).

Surrey completed a City Centre District Energy Strategy in 2011 that confirmed that a system is viable given the projected land uses, densities, and energy demands of future buildings. The strategy also confirmed that, when compared to a conventional development model where individual buildings have separate space heating and hot water systems, a district energy system would “stimulate local economic development, provide competitive energy pricing and increase public awareness around the sustainable use of energy” (City of Surrey 2011b: 2).

Figure 1: Surrey City Centre Area
Source: City of Surrey. No date a.

In the same year, Council authorized the establishment of a utility to design, construct, and operate district energy in the City. Surrey City Energy will be operated as a business unit of the Engineering Department. Staff recommended this ownership model and operational structure based on several reasons. The City-owned utility has the flexibility of self regulation as long as it does not cross municipal boundaries. In contrast, private utilities are regulated by the BC Utilities Commission and require approval for establishing customer rates, expanding and replacing infrastructure, extending service, and disposing or transferring assets. As a City-owned entity, the utility can be entirely financed by the City's long-term borrowing rate, which is generally lower than rates that the private sector can obtain (City of Surrey 2011c).

Operating the utility as a business unit allows greater synergies with other City departments than other governance models. Additionally, City staff have experience running utilities such as water, sewage, drainage, and solid waste management as business units within the Engineering Department. Existing staff can also manage the utility in its beginning stages and add positions as necessary rather than hire a complement of new staff. By establishing Surrey City Centre as a municipal entity, the City retains the flexibility to involve the private sector in the future if other arrangements are advantageous (ibid).

In 2012, Council passed the City Centre District Energy System Bylaw and adopted a District Energy Early Adopters Policy to support the implementation of the City Centre DE system. The Bylaw establishes two distinct service areas in City Centre in which developments must be compatible with the DE system. The purpose of the Bylaw is to ensure district energy compatibility in as many new buildings as possible in City Centre, to build a sufficient customer base for the system (City of Surrey 2012b).

Service Area A encompasses lands in City Centre with a Floor Area Ratio (FAR) higher than 3.5 that are designated for high density development (see Figure 2). Development projects in Service Area A that have an FAR of 1.0 or higher must have hydronic hot water, make-up air units, and in-suite heating, to be fully compatible with the DE system. These developments are also required to connect to the system prior to occupancy (ibid).

Service Area B is land in City Centre outside of Service Area A that is primarily designated for low to medium densities at an FAR less than 3.5, with the majority being less than 2.5 FAR (see Figure 2). Developments in this service area may not receive DE service immediately, so projects with an FAR of 1.0 or higher and less than 2.5 will only be required to have hydronic make-up air and hot water systems so that they are partially compatible with district energy. Developments with an FAR of 2.5 or higher in Service Area B will still need to be fully compatible with the DE system (i.e. also incorporate in-suite hydronic heating) (ibid).

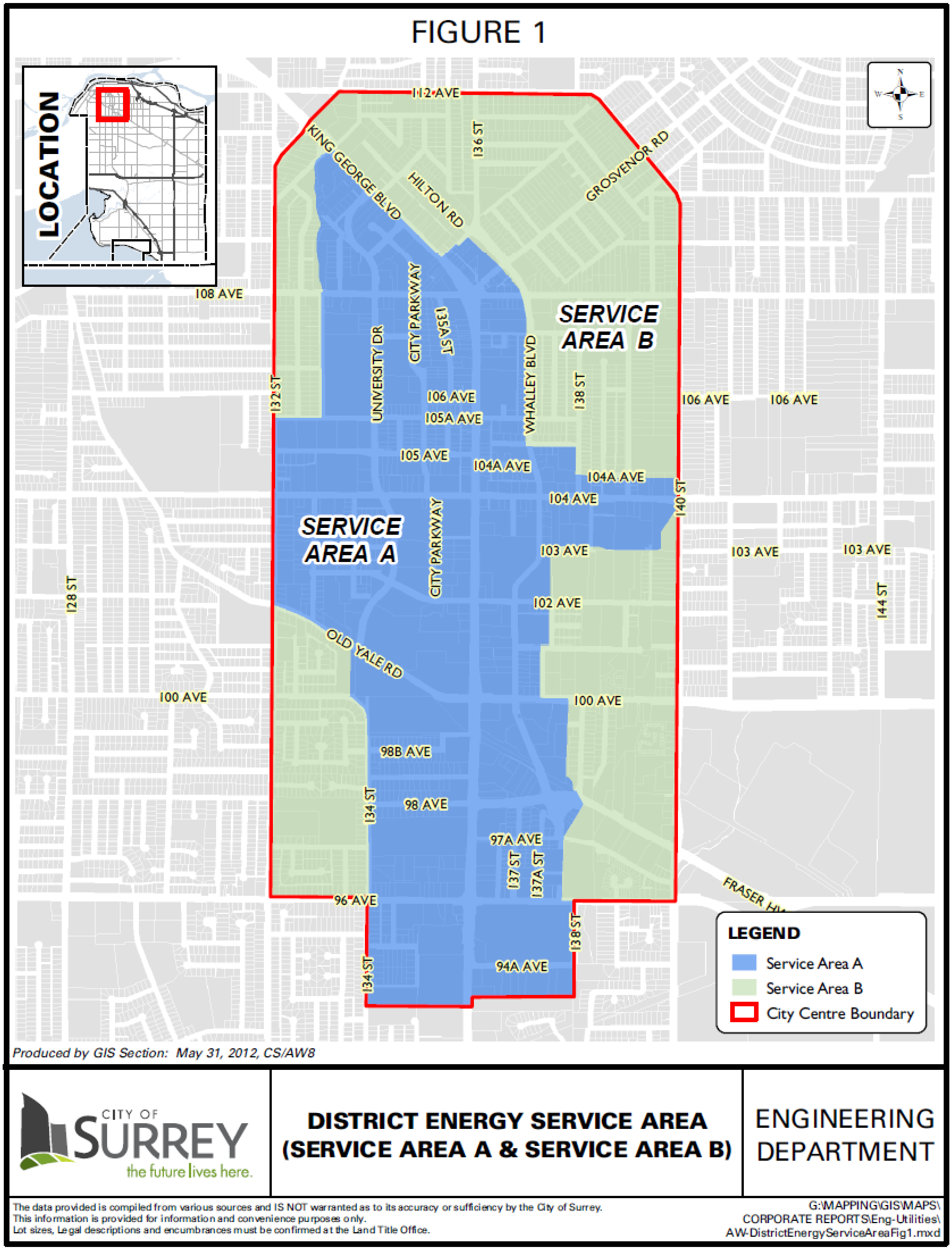
The Early Adopters Policy provides financial assistance for eligible residential developments to help offset some of the costs associated with hydronic systems. Hydronic systems are currently more expensive to install than conventional systems. The initial capital cost for a hydronic heating system is estimated to be $1,500 to $2,100 more per dwelling than for electric resistance baseboard heaters (City of Surrey 2010b).

The Policy will provide eligible projects with up to $1.50 per square foot of dwelling unit area, to a maximum of 50% of the cost premium for installing a hydronic system in comparison to installing electric baseboard heating. Eligible projects are residential developments in Service Area A or B with full hydronic capability that can immediately be connected to the DE system and that will be issued building permits within 3 years of the policy being adopted. It is anticipated that the incentive is only necessary for a limited amount of time until hydronic systems become more common and the cost premium decreases (City of Surrey 2012b).

The incentive will be recovered through the transfer of property tax revenues from participating developments. Half of the property taxes from these projects will be transferred to Surrey City Energy as repayment for the debt incurred from the financial assistance. It is expected that the debt will be fully paid after three years for a typical project. Each project would need to enter into a partnering agreement with the City in order to receive the financial assistance (ibid).

Several next steps for the City include drafting detailed design guidelines for hydronic heating systems and hot water systems; creating an application for service process; designing customer rates; securing financing for capital costs; working on detailed designs of the system; and procuring construction contractors (ibid).

Figure 2: Surrey City Centre District Energy Service Areas A and B
Source: City of Surrey 2012b



City Centre District Energy Technical Description

As described in Chapter 3, a district energy system generates and distributes thermal energy to buildings for heating and/or cooling. Connected buildings are equipped with heat exchangers and heat pumps to gain or give thermal energy from or to the system and generally do not require their own boilers, furnaces, chillers or air conditioning systems. Thermal energy is distributed through a network of underground pipes that carry steam, hot water or chilled water to supply connected buildings.

A large central plant or a network of smaller plants can be used to generate the required services. Various sources and technologies can be used to generate thermal energy. The most common sources are fossil fuels, biomass, and municipal solid waste. Other heating sources include geo-exchange, solar energy, and recovered heat from wastewater. DE systems can just generate heat or use combined heat and power (CHP) co-generation to produce heat and electricity.

The City Centre district energy system will use a hot water distribution piping loop to provide heating and hot water to connected buildings. Customer buildings will be equipped with energy transfer stations, which will consist of heat exchangers used to transfer heat from the distribution piping to the building. Connected developments can be built without individual boilers, resulting in the benefit of lower maintenance costs for building owners and operators (City of Surrey 2010b).

Sufficient demand must be in place to support district energy, so implementation of the City Centre system will roughly follow the location and timing of development in the area by taking a nodal growth pattern and a phased approach. The 2011 City Centre District Energy Strategy proposed establishing the system as separate nodes located at Gateway, Surrey City Central, and King George, since high-density land uses are planned around the stations. These nodes will serve as anchor locations from which three separate systems can be expanded as these areas build out. Eventually, as City Centre approaches build out and the three systems become large enough, the nodes will be connected together to form one system (City of Surrey 2011d).

The strategy identified Surrey Central as the first node for establishing the district energy system, since the City is constructing several large buildings adjacent to the station as part of a new Civic Centre. The 77,000 sq. ft. City Centre library opened in 2011 while the new 180,000 sq. ft. City Hall is scheduled for completion in 2013 and a 400,000 sq. ft. mixed-used residential and hotel high-rise will be built by 2015. All buildings are or will be DE ready. Construction of a closed-loop geoexchange system is already underway and will be operational in 2013. The Civic Centre geoexchange system is the inaugural district energy system in City Centre but will only provide service to the three Civic Centre developments.

The City Centre DE system will be developed in phases. In the first phase, temporary natural gas boiler plants will be built to service areas where there is sufficient development to create demand. This phase is expected to start in 2015 at Surrey Central and is intended to create a critical mass of customers that will produce enough demand to support the second phase; which consists of larger scale permanent centralized heating plants located at each node. The third phase of system development consists of one or more large-scale low-carbon renewable energy plant(s). The most likely fuel source for the first of these plants is biomass from clean waste wood and the City is currently exploring whether it will be a biomass thermal or combined heat and power system.

When the third renewable phase is complete, the centralized biomass plant will provide roughly 80% of the system’s annual energy at 30% of the peak heating load while the natural gas plant will be used to meet the remaining annual energy at peak demand (ibid). Annual energy is the total amount of energy consumed in a year. Peak load or demand is the highest rate of customer energy consumption in a day, month, or year. The system uses this approach in order to match energy demand patterns with appropriate technology.

Energy demand follows predictable daily and seasonal patterns, usually with a large variation in demand over the course of the day and with greater demand for heating in the winter than in the summer. Installed generating capacity needs to be able to meet anticipated peaks in demand. However, peak demand periods are relatively short and do not amount to much energy consumption. The consequence is that some capacity will be under-utilized during the daily and seasonal periods of low demand.

A common approach to minimize under-utilization is to supply a base load or a minimum amount of power at a constant rate using generating plants operating at optimum capacity and to meet peak loads using technologies that can operate efficiently at a range of capacities. For the City Centre system, it is most efficient for the large biomass plant to be consistently running at its maximum capacity while natural gas boilers can be turned on and off fairly efficiently to satisfy periods of higher-than-average or peak demand.

A triple bottom line analysis of the City Centre district energy concept shows that it will provide lower cost energy and significant reductions in greenhouse gas emissions and electricity compared to a business as usual scenario where development projects provide individual heating and hot water systems. Using alternative energy systems for the first phase would lower GHG emissions even further. Several systems were considered, but the analysis concluded that these systems have relatively higher capital costs than gas boilers and would operate less efficiently than gas boilers for meeting peak demand. However, the availability of capital grants could increase the viability of advancing the renewable component of the system to an earlier phase (ibid).

Geographical Extent, Time Period and Case Study Net Capital Costs

Climate change mitigation DCCs should be area-based rather than community-wide charges, since district energy will only be built in and benefit discrete areas in the City that have sufficient demand. The case study only calculates development cost charges for a representative district energy node based on the City Centre system.

Cost estimates for Surrey City Energy and growth projections for City Centre are still being developed and are currently not available for public dissemination. Hence, the case study is based on a fictitious district energy node that represents how one node in City Centre may implement a stand-alone district energy system consisting of a natural gas peaking plant and a biomass plant developed in three phases in an aggressive development scenario. Data for the case study was generated by the City of Surrey's district energy team with the actual financial model used for Surrey City Energy and using representative cost estimates and development projections.

The case study only calculates DCCs for one representative node rather than for a fictitious system based on the final City Centre system with three interconnected nodes because the City will likely develop future district energy in other parts of Surrey as self-contained nodes. City Centre is unique in that the high-density development expected at the three Skytrain stations allow for the creation of three nodes that are close enough to possibly be connected at some point. Future systems will likely occur in discrete nodes as sufficient demand grows in areas through development and/or the retrofitting of existing buildings; so developing a DCC methodology for nodal district energy implementation will be more useful.

Climate change mitigation DCCs should be calculated based on a build out program rather than a revolving program of five to 10 years. This is because capital expenditures associated with developing district energy systems are typically distributed unevenly throughout the asset life of the system and calculating DCCs in five or ten year increments would result in some development projects shouldering the majority of costs for the DE infrastructure.

All district energy projects require significant up-front capital costs, as energy generation and distribution infrastructure must be in place before customers can connect. The costs of installing infrastructure for energy distribution occur steadily through the construction of the system, since new piping and energy transfer stations can be added incrementally as new customer developments are built. The cost of energy generation infrastructure, however, is necessarily ‘lumpy’, as it is financially unviable and technologically inefficient to build plants half or one MW at a time. Renewable energy components, such as the City Centre system’s biomass plant, are often the most capital intensive portion of district energy systems and are usually the largest one-time cost (Comeault 2011).

The ideal approach to capital deployment is to develop the system in phases so that the energy demand from development is matched with a slightly greater energy supply as the service area builds out. Surrey employs this approach by building small temporary natural gas boiler plants to serve growing demand before building larger permanent gas peaking plants followed by low-carbon renewable energy capacity to meet the growing demand.

The implementation of these phases will depend on the timing of development in the area, but it is estimated that the first natural gas peaking plant will be built during the first 3-5 years of the system and that the biomass plant will be constructed around 2020 (City of Surrey 2013c). However, build out of the area is expected to take approximately 30 years. If the mitigation cost charge were calculated on a five or 10 year basis, developments that are built in the first 10 years of the DE system will pay considerably more than those built later. Hence, calculating for a build-out program is fairer as it spreads the costs more evenly among all benefiting developments.

The net present value (NPV) cost of constructing the representative district energy node at full build out of the system from 2015 to 2045 is estimated to be approximately $45,500,000. This includes costs for engineering design, land acquisition, equipment purchase, construction, contract administration, and contingencies (see Table 3 below for a more detailed breakdown; figures are rounded to the nearest $100,000 for simplicity and contingencies are factored into each cost component). It does not include costs for planning, public consultation, legal costs, and interim financing; all of which are recoverable through development cost charges.

Costs are expressed in terms of net present value to take into account the time value of money. The NPV method applies a discount rate to future cash flows and costs to express future amounts in today's dollars; based on the premise that a dolla received today is more valuable than a dollar received in the future, since the dollar received today can be invested and generate a return whereas a future dollar cannot earn a return in the current year. It is a useful practice for calculating development cost charges, as developers have to pay charges for benefits that will not appear until infrastructure is built in the future. The appropriate discount rate for calculating net present value is the cost or interest rate of borrowing money. The case study uses a discount rate of 5%, as this is the interest rate for the City Centre district energy system.

Table 3: Net Present Value Capital Costs for the Case Study District Energy Node 2015-2045

Cost Component	Nominal Cost ($)
Energy plants (natural gas and biomass)	$27,800,000
Buildings for housing energy plants	$4,000,000
Land (for locating biomass plant)	$1,700,000
Distribution piping network (for distributing hot water)	$7,000,000
Energy transfer stations in customer buildings	$5,100,000
Total	$45,600,000

The net cost for the representative node can be determined by subtracting grants, external funding, the proportion of costs applicable to current development, the municipal assist factor, and existing DCC reserve monies from the total capital cost. To date, the City has not received grants or external funding for the district energy system. The City plans to apply for Green Municipal Fund grants from the Federation of Canadian Municipalities to help offset some infrastructure costs (J. Owen, personal communication, 7 May 2013). If and when these grants are confirmed, they should be subtracted from the total capital cost before DCCs are calculated.

Construction of the district energy system would not proceed if there was no new development in representative node, so none of the costs should be paid by existing users. A handful of existing buildings in the area may be retrofitted for connection to the actual City Centre system (City of Surrey 2013c). However, this is not modeled in the representative node and, in reality, the vast majority of buildings that will benefit from the City Centre district energy system will be new developments.

The municipal assist factor is a reflection of a community's financial support towards the financing of services for development. It can be used strategically to lighten the DCC burden on development if City Council and/or staff feel that the fees determined through best practice calculations are too high. Rather than arbitrarily determining a percentage prior to calculating mitigation DCCs for the case study, the following chapter discusses how the municipal assist factor might be used to lessen the impact of the mitigation cost charge on development pro formas or increase its acceptability to the development community; depending on how comparable the mitigation DCC is to other DCCs, the impact it may have on development, and expert opinions on how it may be received by the development community.

There are no reserve monies that should be subtracted from total capital costs, as mitigation DCCs are a new concept. Hence, the net capital cost of the representative node is $45,500,000.

Categories of Charges, Units of Development, and Case Study Development Projections

The City of Surrey takes the common approach of charging DCCs based on land use categories. It charges DCCs on one acre, half acre, mobile home, and single family zoned land on a per lot basis. Townhouses and low-rise and high-rise apartments are charged by per square foot of developed area, to better reflect the impact of multi-family residential land uses. The City sets a maximum charge for each multi-family land use based on maximum developed area, to ensure equity between the single family per unit charge and the multi-family per square footage charge. Commercial, industrial, and institutional developments are also charged by square foot of developed building area (City of Surrey 2010d).

Since different land uses generate different levels of demand for facilities, the City uses impact ratios to calculate development cost charges in order to reflect the relative impact of each land use type.

The method for determining impact ratios varies between different types of cost charges and is based on how different land uses and different sizes of developed area impact the specific infrastructure. For example, impact ratios for road DCCs are based on the average number of trips per unit while those for storm drainage DCCs are based on the average percentage of a site that is impervious.

For all cost charges, the impact ratio of a single family residence is equal to one and the impact of all other land uses is measured in comparison to the impact of a single family house. For example, if a single family house generates an average of 1.01 vehicle trips per unit and a high rise apartment produces 0.40 trips per unit on average, then the impact ratio of high rise apartment buildings would be 0.36. Development cost charges for each land use type are calculated by multiplying the specific impact ratio by the charge of a single-family residence (ibid).

The case study uses simpler land use categories than the City's DCC bylaw, which calculates different impact fees for different zones. The four categories used for the case study are low-rise residential, mid- and high-rise residential, office, and commercial. This is because the district energy financial model that the City is developing to estimate costs and calculate utility rates only includes development projections for these four categories (City of Surrey 2013c). When development projections used by the financial model are more refined, these categories of charges can be refined accordingly.

These categories are broader than those used for giving levels of performance. However, the reductions in DCCs can still be applied since the broad categories of charges encompass all the more specific categories used for levels of performance. For example, mid- and high-rise residential buildings in this case study have the same DCC rate but the reduction in charge can still be assessed according to the more specific level of performance categories.

The case study follows Surrey's approach of charging DCCs by square foot of developed area. This sliding scale approach more accurately reflects the impact of development than the per lot approach, as larger buildings will consume more energy than smaller buildings of the same land use type. Additionally, the City Centre DE system's customer base is not expected to include single-family homes and townhouses.

Impact ratios will not be used in the case study. The impact of different building types on the district energy system does vary by peak demand for space heat and domestic hot water, as the energy transfer system and distribution piping needs to be sized larger for higher peak demands. However, the peak demand assumptions used by the City's financial model varies marginally between different building types, so the variation in impact is negligible (City of Surrey 2013c). The extent to which the cost of connecting customer buildings varies with peak demand is also limited (J. Owen, Personal communication, 7 May 2013), so impact ratios are not necessary for the case study.

The development projections for the case study representative node are detailed in Table 4 below. Floorspace figures are rounded to the closest hundred for simplicity and are only for above-ground indoor space and may include some non-habitable floorspace. Actual development cost charges should be based on habitable floorspace. However, the figures are the best projections currently available. Almost all district energy customers will be new development projects. A handful of existing buildings may be retrofitted for connection to the system. The floorspace of these buildings are not included in Table 4, as DCCs only apply to new developments.

Table 4: Development Projections for the Case Study District Energy Node 2015-2045

Building Type	Floor Space (m^2)	Floor Space (sq. ft.)
Low-Rise Residential	170,500	1,835,200
Mid- and High-Rise Residential	663,400	7,141,000
Office	70,300	756,200
Commercial	509,800	5,486,900
Total	1,413,900	15,219,300

Methodology for Calculating a Climate Change Mitigation Development Cost Charge

The methodology for determining development cost charges is simple once all policy and technical issues have been resolved: the net capital infrastructure cost generated by new development in a specified time period and geographical area is divided by the number of developments that will be built in that same time period and geographical area.

The City of Surrey adds an additional step to its DCC calculations by multiplying the number of development units for each land use by the impact ratio of that land use to determine total equivalent development units, which is used as the denominator for calculating the base charge per equivalent unit. The base charge is then multiplied by impact ratios to determine the cost charge rates for different land uses. This extra step is to account for the relative impacts of different land uses on DCC calculations (City of Surrey 2010d). Since impact ratios are not use in this case study, this step is not necessary.

The methodology for calculating climate change mitigation development cost charges for the case study representative node is as follows:

$$\text{Charge per square foot} = \frac{\text{NPV net capital cost of case study node}}{\text{Total projected connected floor space for case study}}$$

$$= \$45{,}600{,}000 / 1{,}413{,}900\text{m}^2 \text{ or } \$45{,}600{,}000 / 15{,}219{,}300 \text{ sq. ft.}$$

$$= \$32.25/\text{m}^2 \text{ or } \$3.00/\text{sq. ft.}$$

CHAPTER 5: DISCUSSION

Albert Einstein once said, “In theory, theory and practice are the same. In practice, they are not”. For the climate change mitigation development cost charge to succeed in practice, it is essential to assess its effectiveness in achieving its goals, understand its implications, and identify opportunities and barriers for implementing the concept.

This chapter evaluates the potential of the mitigation DCC to reduce building sector emissions, possible effects on development, and alternative ways to apply the concept. It closes by suggesting next steps for implementation and further research.

Comparison With Other DCCs

It is important to assess how the mitigation DCC compares with the other cost charges to gauge its impact on development and how acceptable it may be to the development community. Charges for multi-unit residential developments in City Centre and commercial developments across the City from the City of Surrey’s 2011(e) DCC Bylaw are detailed in Table 5. At $3.00/sq.ft., the mitigation DCC would be comparable to the higher end of the City’s existing charges.

It is difficult to definitively determine whether the charge is excessive or would dampen development. Studies suggest that at least some portion of development cost charges are passed on to homebuyers; so the effect of the DCC on development depends on a combination of housing prices, land prices, and the economics of individual development projects. The addition of a mitigation DCC may not slow or deter development if demand creates housing prices that are sufficient to cover all the costs of development and still generate enough profit to warrant the risk of developing. Additionally, the predictability of a mitigation DCC would allow developers to factor the additional cost into project pro formas and negotiate cheaper land prices if necessary.

Practically speaking, the development community will likely not be enthusiastic about a new charge, as it would increase total development cost charges for City Centre projects. Reducing the amount of the charge may make the mitigation DCC more acceptable as a concept to consider if acceptability is an issue. There are two ways to adjust the charge: including fewer costs when calculating the fee and applying a generous municipal assist factor.

Any of the costs associated with the case study node can be excluded from DCC calculations. However, since the objective of the charge is to assist with reducing GHG emissions, it would make the most sense to base the mitigation DCC only on capital costs associated with the bioenergy plant, the component of the system that delivers emissions reduction services. The net present value cost for the biomass plant for the case study is $25,100,000 (City of Surrey 2013c). This results in a mitigation DCC of $1.65/sq.ft., which is more comparable to the middle range of Surrey’s current cost charges.

Taking this approach to calculating the mitigation DCC would, in addition to lowering the charge, strengthen the nexus between the impact of development and the service provided to address the impact. The main function of the district energy system is to supply customers with heat and hot water and it is only the biomass plant that provides emission reduction services. However, the entire system is necessary for the biomass plant to be effective so there is still a case for including all costs in the calculation of mitigation DCCs. Both approaches are legally and technically defensible, so it may be through consultation with stakeholders in the event that this concept is seriously considered that an approach is selected.

Table 5: City of Surrey (2011e) Development Cost Charges for Multi-Unit Residential and Commercial Buildings

Zones and Land Uses	Water	Sewer	Arterial Roads	Major Collector Roads	Drainage	Parkland Acquisition	Total	Units
Low Rise Multi-Unit Residential Buildings in City Centre (RM-30)	$1.06	$1.12	$3.67	$0.90	$1.32	$2.95	$11.02	/sq.ft. of dwelling unit
Mid- and High-Rise Residential Buildings in City Centre (RM-45 and RM -70)	$1.13	$1.20	$3.03	$0.75	$0.85	$3.16	$10.12	/sq.ft. of dwelling unit
High-Rise Residential and Multi-Use Buildings in City Centre (RM-135, RMC-135, and RMC-150)	$1.07	$1.13	$2.20	$0.54	$0.30	$2.99	$8.24	/sq.ft. of dwelling unit
Ground Floor Commercial	$567	$600	$3,696	$912	$2,211	$0	$7,985	/1,000 sq.ft. of building area
Non-Ground Floor Commercial	$567	$600	$2,407	$594	$442	$0	$4,609	/1,000 sq.ft. of building area

Surrey applies a municipal assist factor (MAF) of 10% for all utilities (sewer, water, and drainage) and 5% for arterial roads, collector roads, and parkland acquisition (City of Surrey 2010d). With an assist factor of 10%, the mitigation DCC would be $2.70/sq.ft if all costs are included and $1.49/sq.ft. if only costs for the renewable component is included. A local government can set the municipal assist factor to as high a percentage as it deems necessary for supporting development and can also impose different assist factors for different types of infrastructure; so a greater municipal factor can be applied to the mitigation DCC if needed to make it more acceptable to the development community. Municipalities typically fund MAF contributions from general revenue sources drawn from the existing tax base. In the case of the mitigation DCC, MAF contributions should be funded through higher utility rates since the system only benefits a specific area in the City.

GHG Reduction Potential

The objective of the climate change mitigation development cost charge is to reduce GHG emissions from the building sector, either by connecting buildings that pay the fee to the low-carbon district energy system or by incenting developers to construct highly energy-efficient buildings. It is important to assess how successful it is in meeting this objective by confirming that the district energy system provides comparable or lower emissions reductions to the highest level of performance set by the mitigation DCC framework and by gauging how strong of a market mechanism the cost charge would be in motivating the development community to build greener.

The district energy system must provide equivalent or greater emissions reductions to the ideal level of performance for it to be an effective climate change mitigation measure. According to analysis conducted by the City of Surrey, the representative node is expected to produce

110,310 tonnes of CO_2e during the 30-year build-out period for the mitigation DCC. Biomass is assumed to be carbon neutral. Hence, the annual emission intensity of buildings connected to the system would be:

$$EI = \frac{110{,}310 \text{ tonnes } CO_2e \times 1{,}000 \text{ kg/tonne}}{30 \text{ years} \times 1{,}413{,}900 m^2} = 2.6 \text{ kg } CO_2e/m^2a$$

This is much lower than the ideal emission intensity of 6.37 CO_2e/m^2a, confirming that the district energy system is an effective measure for reducing emissions

A mitigation DCC could encourage developers to build greener if the cost of the charge is equal to or greater than the incremental costs of building to higher levels of energy efficiency. Table 6 below compares the incremental costs of building to the ideal level of performance with the full cost of the mitigation fee at both $2.70/sq.ft. and $1.49/sq.ft. For all building types except for high-rise residential, data for average cost of construction for medium-quality construction to current standards (i.e. ASHRAE 90.1-2004) in Surrey is from Butterfield Development Consultants Ltd. (2013)[4] and percentage incremental cost for Passive House is from the Canadian Passive House Institute (no date). Data on low-rise residential buildings was not available. Data for high-rise residential is from a study on a carbon neutral framework for high-rise MURBs that included a financial analysis on the cost of constructing residential towers to achieve a target of < 50 kWh/m^2a for space heat and DWH (Light House & Intep LLC 2012). While the study's target energy use intensity is above the ideal EUI level, it may reflect a more realistic target for MURBs in the region as contemporary designs for this building type pose challenges for improving energy efficiency (RDH 2011). Based on the best data available, it appears that it would currently be considerably more expensive to build to the highest level of performance than to pay the full mitigation cost charge at $2.70/sq.ft. and $1.49/sq.ft. This is unsurprising, as the development industry is still relatively unfamiliar with low-emissions building design and construction. As expertise builds and equipment and materials become commonplace, the cost premium over conventional practice will shrink and the mitigation DCC will act as a stronger incentive for building to Passive House standards.

The mitigation cost charge may still incent better performance in new construction, since the DCC framework rewards multiple levels of energy efficiency between the baseline and ideal levels and the incremental costs of achieving certain levels may be lower than the associated discounted fee. Table 7 below compares the incremental cost of building to ASHRAE 90.1-2010 standards with the commensurate discounted cost charge for achieving the associated benchmark level of performance. Data on incremental cost per square foot for high-rise residential are from the Light House and Intep LLC 2012 study. Data on incremental costs per square foot for all other building types as well as data on energy use intensity for ASHRAE 90.1-2010 are from BC Hydro (2012). Data was unavailable on low-rise residential buildings. It appears that even a mitigation DCC of $1.49/sq.ft. is a strong incentive to build to ASHRAE 90.1-2010 for all building types except for high-rise MURBs. Although incremental costs likely do not increase in linear fashion with energy efficiency, the large differences between additional cost for achieving ASHRAE 90.1-2010 and associated fee reductions suggest that the mitigation DCC would motivate energy performance beyond ASHRAE 90.10-2010 in new construction. This is a positive finding, especially as the Province of BC is adopting the 2010 version of ASHRAE 90.1 in 2014 (Government of BC 2013).

[4] Building types used by Butterfield Development Consultants did not exactly match the building types used in this study, so the closest representative building types from Butterfield Development Consultants were used.

Table 6: Comparing the Incremental Cost of Building to Passive House Standard to the Commensurate Climate Change Mitigation DCC Discount for Achieving the Ideal Level of Performance

Building Type	Size	ASHRAE 90.1-2004 Cost of Construction	Passive House Incremental Cost of Construction		Reduction in Mitigation DCC	
			Rate	Total	At $2.70/sq.ft	At $1.49/sq.ft
High Rise Residential (20 storey)	147,000 sq.ft	$221.00	$32/sq.ft	$4,704,000	$396,900	$219,030
Mid-Rise Residential (5 storey)	50,000 sq.ft	$223.10/sq.ft.	10-15%	$1,116,000 - $1,673,000	$135,000	$74,500
Wood Frame Mid-Rise Residential (5 Storey)	50,000 sq.ft	$157.14/sq.ft.	10-15%	$786,000 - 1,176,000	$135,000	$74,500
Mid-Rise Mixed Use (5 storey residential w/ ground retail)	50,000 sq.ft	$161.02/sq.ft	10-15%	$805,000 - 1,208,000	$135,000	$74,500
Low-Rise Commercial (single storey stand alone retail)	18,000 sq.ft	$174.60/sq.ft	10-15%	$314,000 - $471,000	$48,600	$26,820
Mid-Rise Commercial (5 Storey infill office)	50,000 sq.ft	$194.00/sq.ft	10-15%	$970,000 - 1,455,000	$135,000	$74,500
High Rise Office (17 storey office)	170,000 sq.ft	$261.90/sq.ft.	10-15%	$4,452,000 - 6,678,000	$459,000	$253,300

Table 7: Comparing the Incremental Cost of Building to ASHRAE 90.1-2010 to the Commensurate Climate Change Mitigation DCC Discount for Achieving Associated Benchmark Levels of Performance

Building Type	Size	ASHRAE 90.1-2010 Incremental Cost		Energy Use Intensity for AHSRAE 90.1-2010	Benchmark Level	Reduction in Mitigation DCC	
		Rate	Total			At $2.70/sq.ft	At $1.49/sq.ft
High Rise Residential (20 storey)	147,000 sq.ft	$8.00/sq.ft	$1,176,000	113 kWh_e/m^2a	20%	$78,839	$43,507
Mid-Rise Residential (5 storey)	50,000 sq.ft	$0.07/sq.ft	$3,500	107 kWh_e/m^2a	14%	$19,133	$10,558
Wood Frame Mid-Rise Residential (5 Storey)	50,000 sq.ft	$0.07/sq.ft	$3,500	102 kWh_e/m^2a	17%	$23,023	$12,705
Mid-Rise Mixed Use (5 storey residential w/ ground retail)	50,000 sq.ft	$0.09/sq.ft	$4,500	107 kWh_e/m^2a	22%	$29,752	$16,419
Low-Rise Commercial (single storey stand alone retail)	18,000 sq.ft	$0.30/sq.ft	$5,400	95.7 kWh_e/m^2a	68%	$33,169	$18,304
Mid-Rise Commercial (5 Storey infill office)	50,000 sq.ft	$0.32/sq.ft	$16,000	76 kWh_e/m^2a	37%	$50,524	$27,882
High Rise Office (17 storey office)	170,000 sq.ft	$0.20/sq.ft	$34,000	75 kWh_e/m^2a	37%	$169,925	$93,773

Implications for District Energy Systems

If legal, a climate change mitigation DCC could provide an additional source of funding for municipally built district energy systems and would likely affect utility rates.

Currently, the City Centre system will be entirely debt-financed through internal loans. The City of Surrey plans to pursue funding for the design and construction of the system from the provincial and federal governments, the BC Hydro Power Smart Program, and from the Federation of Canadian Municipalities' Green Municipal Fund. If funding from these sources is secured, the internal loan amount will be reduced accordingly. The debt will be paid back over the 30-year asset life of the system through customer fees. Similar to a private energy utility, all utility costs - including capital, operation, maintenance, debt, repayment, debt servicing, and managing costs – will be accounted for in the rate structure (City of Surrey 2011e).

The approach that Surrey is using to set the rate structure for Surrey City Energy broadly follows the approach taken by the City of Vancouver for the Southeast False Creek Neighbourhood Energy Utility (NEU). Surrey has not finalized its rate structure, so the following description is based on the NEU's project economics.

Similar to the Southeast False Creek utility, Surrey City Energy will use a combined fixed and variable rate structure. The fixed rate portion or capital levy is based on the floor area of each building and goes toward recovering the fixed costs of constructing and operating the utility. The variable rate component or energy use charge is tied to actual energy use and is meant to cover the variable costs of natural gas and electricity needed for the utility. Vancouver's NEU uses a 60/40 fixed vs. variable rate split, to encourage ratepayers to conserve energy (Comeault 2011).

Rates for Surrey City Energy customers will be set so that the costs of heating and hot water consumption will be comparable to those incurred by typical residential and commercial heating systems. To achieve this, City Centre Energy will use a linear levelized rate recovery approach that under-recovers capital costs early in the utility's amortization period and over-recovers toward the end of the amortization period. This approach spreads out the 'lumpy' capital costs required early in the amortization period to build the district energy system, so that utility rates remain competitive and do not fluctuate widely. The deficit during the under-recovery period will be paid for using a reserve fund modeled after the NEU's Rate Stabilization Reserve (RSR). The RSR acts as a revolving line of credit that the NEU uses to top up shortfalls in the NEU's early years (ibid).

A climate change mitigation DCC would reduce the need for a rate stabilization reserve as monies from the cost charge would be used to cover all or some of the capital costs, depending on whether the mitigation fee includes all capital costs associated with district energy or just those of the renewable energy component. Municipalities may still need to front-end some capital costs. District energy infrastructure must be constructed before buildings are collected but development cost charges for multi-family and non-residential land uses are usually collected at the building permit stage rather than at subdivision approval, allowing less time for funds to accumulate in the development process (Government of BC 2006). However, the Rate Stabilization Reserve would be smaller, as capital costs would paid off sooner with the mitigation DCC than they would be from rates alone.

Rates for district energy customers would be lower with a climate change mitigation DCC, as they would not include a capital levy or include a smaller capital levy. This would be a benefit to customers, especially as energy prices are forecasted to increase in coming decades. Utility rates without a capital levy or with a smaller capital level may also have the additional benefit of incenting increased energy conservation behavior; as all or a larger portion of customers' utility bills would be tied to actual consumption, creating a stronger linkage between energy use and cost to consumers.

Study Limitations and Areas for Further Research

State and provincial governments would need to legislatively enable local governments to levy a development cost charge for climate change mitigation for this concept to be put into practice. There is a strong case for the additional authority: it is imperative to reduce greenhouse gas emissions, development generates additional emissions and should bear some of the costs of their mitigation, and local governments can effectively lower these emissions. There are several issues that provincial and state governments should take into account when considering cost charges for climate change mitigation.

This project proposed using cost charge monies to fund district energy systems because it chose to work within the requirements of the rational nexus test and BC's convention to use DCC funding strictly for physical infrastructure. While district energy is a highly effective greenhouse gas reduction technology, it is economically feasible mainly in dense, mixed-use, urban areas. Suburban and rural areas do not usually support district energy because of the low density of heat demand, distance between heat demands, and the tendency for demand across buildings to have the same profile.

Hence, a climate change mitigation DCC that can only fund district energy systems would be useful predominantly within the urban cores of larger communities. This would limit the potential of a mitigation DCC, given the large numbers of suburban developments and small communities in British Columbia and across North America.

There are numerous ways for local governments to influence emissions and a mitigation cost charge that can fund a broader range of initiatives and programs would have a wider impact. Using mitigation DCC monies for expanding existing and building new transit and active transportation infrastructure could be one option. Many local governments would be able to use mitigation DCCs for this purpose and transportation accounts for a substantial portion of emissions in most communities. In British Columbia, transportation accounts for the largest share of provincial GHG emissions (Government of BC 2008a). Additionally, development cost charges for roads are already commonplace. The challenge would be to establish a strong nexus between development, transportation-related emissions, and the ability of local government to mitigate those emissions. This is an interesting area for further research.

Another limitation of the mitigation DCC is that it can only be used to address emissions from new construction. Existing buildings and transportation patterns account for the bulk of a community's emissions but it would be inequitable to use development cost charges for mitigation actions that target these emissions. A more effective funding mechanism to assist local governments in their climate change mitigation efforts would be grants from a provincial or state carbon tax. Unlike development cost charges, local governments would have discretion to use these funds for any emission-reduction actions deemed appropriate by the grant.

BC currently has a conditional grant program that provides funding to local governments that have signed onto the BC Climate Action Charter. The program allocates grants that are equal to 100 percent of the carbon tax that eligible local governments paid as a direct expenditure in the previous year. While this is along the right lines, an expanded grant program funded by general carbon tax revenue could have greater impact. This is possible fiscally, as BC's revenue-neutral carbon tax is currently only being allocated to reducing other taxes. It may also be politically possible. A recent survey commissioned by the Pacific Institute for Climate Solutions and Pembina Institute showed that British Columbians are supportive of increasing the carbon tax if revenue were spent on projects to reduce emissions such as public transit or more energy efficient buildings (Horne, Sauve & Pederson 2012).

It is possible for many local governments to use development cost charges to address GHG emissions without having the power to charge a fee for climate change mitigation. If designed appropriately, DCCs can be used as fiscal instruments to support growth management and more compact urban development. Academics theorize that area-specific pricing - charging different DCC rates for different areas rather than averaging the costs of all development within a community - can incentivize more efficient development. Urban areas with existing infrastructure should have lower area-specific charges that encourage intensification and redevelopment; while suburban and rural areas that are farther from existing infrastructure and need more extensive service provision should have higher charges (Nicholas, Nelson & Juergensmeyer 1991; Skaburskis 2003; Tomalty & Skaburskis 2003).

A study prepared by Coriolis Consulting (2003) for West Coast Environmental Law supports the use of development cost charges to encourage smart growth and greener building design. The study reviewed existing DCC bylaws in a number of BC municipalities and found that almost every municipality set different rates for single-family and multi-family residential units but only a few vary single-family charges and commercial and industrial charges by density. Some municipalities used area-specific pricing but many do not and none took green building design features into account, even though the report estimated that compact urban growth and high performance design could save over $5,000 in infrastructure costs per residential unit in many communities.

The report concluded that local governments should increase the use of varying residential charges by density as well as the use of different DCC rates for different locations and consider charging lower rates for green buildings that place lower demands on municipal infrastructure. These are fruitful areas that local governments can and should easily implement and explore without the need for legislative changes.

Next Steps and Conclusion

This project presents a creative look at how development cost charges may be used to support local government efforts to address climate change. It forges a clear proposal of how a climate change mitigation DCC may work in practice by working within the demands of the rational nexus test and the guidance of best practices for calculating cost charges. The details of the proposal will hopefully generate lively discussion and debate among practitioners that like to ask 'what if...?' More importantly, this project will have accomplished its purpose if it sparks a conversation among planners and local governments in British Columbia and beyond about how we can do more with the tools in our toolbox and find new ways to use those tools to create more sustainable futures for our communities.

"Creativity is contagious, pass it on". Albert Einstein

REFERENCES

Altshuler, A.A., & Gómez-Ibáñez, J.A. (1993). *Regulations for revenue: The political economy of land use exactions*. Washington, DC: The Brookings Institution.

Altus Group. (2009). *Long-term housing demand in Canada*. Prepared for Canadian Home Builders' Association. Toronto, Canada: Altus Group Economic Consulting. Retrieved September 13, 2012 from http://www.chba.ca/uploads/policy%20archive/2009/housing_demand_in_canada-jul09.pdf.

Architecture 2030. (2011). The 2030 Challenge [webpage]. Retrieved February 7, 2013 from http://architecture2030.org/2030_challenge/the_2030_challenge.

American Institute of Architects. (2012). The Carbon Neutral Design Project [webpage]. Retrieved February 7, 2013 from http://www.tboake.com/carbon-aia/index.html.

Ayoub, J. (2008). 'Towards Net Zero Energy Solar Buildings IEA SHC/ECBCS Project Factsheet'. Natural Resources Canada, CanmetENERGY. Retrieved from: http://canmetenergy.nrcan.gc.ca/sites/canmetenergy.nrcan.gc.ca/files/files/pubs/2011-118_PM-FAC_411-IEAT40_ayoub_e.pdf. Last accessed 08 January 2013.

Betsill, M. (2001). Mitigating climate change in US Cities: opportunities and obstacles. *Local Environment,* 6(4): 393-406.

BOMA BESt. (2011). BOMA BESt = Building Environmental Standards [webpage]. Retrieved March 4, 2013 from http://www.bomabest.com/about-boma-best/.

Government of British Columbia. Ministry of Environment. (2008a). *Climate Action Plan*. Victoria, Canada: Government of British Columbia. Retrieved September 13, 2012 from http://www.gov.bc.ca/premier/attachments/climate_action_plan.pdf.

Government of British Columbia. Ministry of Environment. (2008b). *Meeting British Columbia's Targets*. Victoria, Canada: Government of British Columbia. Retrieved September 13, 2012 from http://www.env.gov.bc.ca/cas/mitigation/pdfs/CAT_FINAL_REPORT_July_23_2008.pdf.

Government of BC. Ministry of Environment. (2012a). *Making Progress on B.C.'s Climate Action Plan*. Victoria, Canada: Government of BC. Retrieved January 23, 2013 from http://www.env.gov.bc.ca/cas/pdfs/2012-Progress-to-Targets.pdf.

Government of British Columbia. Ministry of Environment. (2012b). *B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions Including Guidance for Public Sector Organizations, Local Governments, and Community Emissions*. Victoria, Canada: Government of British Columbia. Retrieved October 23, 2012 from http://www.env.gov.bc.ca/cas/mitigation/pdfs/BC-Best-Practices-Methodology-for-Quantifying-Greenhouse-Gas-Emissions.pdf.

Government of British Columbia. Ministry of Energy, Mines and Natural Gas. (2013). *Information Bulletin: New Energy Requirements*. Victoria, Canada: Government of British Columbia.

BC Hydro. (2012). Energy use intensities and incremental costs [data tables]. Unpublished data.

British Columbia Statistics (BC Stats). (2012, June). *British Columbia – Level Population Projections*. Retrieved September 13, 2012 from http://www.bcstats.gov.bc.ca/StatisticsBySubject/Demography/PopulationProjections.aspx.

Butterfield Development Consultants Ltd. (2013). Cost Index Calculator [database]. Retrieved May 21, 2013 from http://www.bdconsultants.com/tools/costindex.

Canadian Housing Mortgage Corporation (CMHC). (2005). *Research Highlight: Uses of Development Cost Charges*. Ottawa, Canada: CMHC. Retrieved April 13, 2012 from https://www03.cmhc-schl.gc.ca/catalog/productDetail.cfm?cat=44&itm=44&lang=en&fr=1327615841216.

Canadian Passive House Institute. (No date). Passive house requirements. Retrieved October 20, 2012 from http://www.passivehouse.ca/requirements/.

Centre for Climate and Energy Solutions. (2009). *Climate Techbook Buildings Overview*. Arlington, Virginia: Centre for Climate and Energy Solutions. Retrieved September 13, 2012 from http://www.c2es.org/technology/overview/buildings.

Circo, C.J. (2009). Should owners and developers of low-performance buildings pay impact or mitigation fees to finance green building incentive programs and other sustainable development initiatives?. *William and Mary Environmental Law and Policy Review* 34: 55-120.

Clinton Foundation. (No date.) Climate Positive Development Program [webpage]. Retrieved February 7, 2013 from http://www.clintonfoundation.org/main/our-work/by-initiative/clinton-climate-initiative/programs/c40-cci-cities/climate-positive-development-program.html.

Collier, U. (1997). Local authorities and climate protection in the European union: Putting subsidiarity into practice?. *Local Environment* 2(1): 39-57.

Comeault, C. (2011). *Integrated Community Energy System Business Case Study Southeast False Creek Neighbourhood Energy Utility*. Report prepared by ISIS Sauder School of Business for Quality Urban Energy Systems of Tomorrow. Retrieved February 2, 2013 from http://www.sauder.ubc.ca/Faculty/Research_Centres/ISIS/Resources/~/media/AEE7D705491345178C4568992FB87658.ashx.

Community Energy Association (CEA). (2008a). *Community Energy and Emissions Planning. A Guide for BC Local Governments.* Vancouver, Canada: Community Energy Association. Retrieved August 28, 2012 from http://www.communityenergy.bc.ca/sites/default/files/CEA_PlanningGuide_LR_v3.pdf.

Community Energy Association (CEA). (2008b). *Powering Our Communities*. Vancouver, Canada: Community Energy Association. Retrieved October 10, 2012 from http://www.communityenergy.bc.ca/sites/default/files/Powering%20Our%20Communities.pdf.

Community Energy Association (CEA). (2010). *Build to Zero Local Government Survey*. Vancouver, Canada: Community Energy Association. Retrieved October 12, 2012 from http://www.communityenergy.bc.ca/community-energy-association-connecting-community-sustainability-and-energy/build-to-zero-local-government-survey-report.

Connerly, C.E. (1988). The social implications of impact fees. *Journal of the American Planning Association* 54(1): 75-78.

Coriolis Consulting Corp. (2003). *Do Development Cost Charges Encourage Smart Growth and High Performance Building Design?*. Report prepared for West Coast Environmental Law. Vancouver, BC: West Coast Environmental Law. Retrieved September 10, 2012 from http://wcel.org/resources/publication/do-development-cost-charges-encourage-smart-growth-and-high-performance-buildi.

Curran, D. (2010). *Green Building Leaders: Jurisdiction Options for Energy Efficiency and Renewable Energy in Buildings Discussion Paper*. Report prepared for the Pembina Institute. Vancouver, Canada: Pembina Institute. Retrieved December 13, 2012 from http://www.greenbuildingleaders.ca/publications.

Delaney, C.J., & Smith, M.T. (1989). Pricing implications of development exactions on existing housing stock. *Growth and Change* 20: 1-12.

Delisle, V. (2011). Net-zero energy homes: Solar photovoltaic electricity scenario analysis based on current and future costs. Retrieved January 8, 2013 from the Natural Resources Canada website: http://canmetenergy.nrcan.gc.ca/sites/canmetenergy.nrcan.gc.ca/files/files/2011-040.pdf.

Dowall, D.E. (1980). Methods for assessing land price effects of local public policies and actions. In Black, J.T., & Hoben, J.E. (Eds). *Urban Land Markets* (Pp. 161-83). Washington, D.C.: Urban Land Institute.

Ellickson, R.C. (1977). Suburban growth controls: An economic and legal analysis. *Yale Law Journal* 86(3): 384-442.

Evans-Cowley, J. (2006). Development exactions: process and planning issues. Working Paper for the Lincoln Institute of Land Policy. Cambridge, Massachusetts: Lincoln Institute of Land Policy. Retrieved September 24, 2012 from: http://www.lincolninst.edu/subcenters/teaching-fiscal-dimensions-of-planning/materials/evans-cowley-planning.pdf.

Federation of Canadian Municipalities. (2009). *Act Locally The Municipal Role in Fighting Climate Change*. Ottawa, Canada: Federation of Canadian Municipalities. Retrieved August 28, 2012 from http://www.fcm.ca/Documents/reports/Act_Locally_The_Municipal_Role_in_Fighting_Climate_Change_EN.pdf.

Federation of Canadian Municipalities. (2011). *Partners for Climate Protection National Measures Report 2011*. Ottawa, Canada: Federation of Canadian Municipalities. Retrieved August 28, 2012 from: http://www.fcm.ca/Documents/reports/PCP/2011_Partners_for_Climate_Protection_Measures_Report_EN.pdf.

Fraser Basin Council. (2009). *Energy Efficiency & Buildings: A Resource for BC's Local Governments*. In partnership with the Community Energy Association. Vancouver, Canada: Fraser Basin Council. Retrieved October 23, 2012 from: http://www.communityenergy.bc.ca/sites/default/files/EnergyEfficiencyOnlineGuide2009.pdf.

Gilmour, B., & Warren, J. (2008). *The New District Energy: Building Blocks for Sustainable Community Development*. Toronto, Canada: Canadian District Energy Association. Retrieved October 11, 2012 from https://www.cdea.ca/resources/new-district-energy-building-blocks-sustainable-community-development.

Government of British Columbia. Ministry of Community, Sport & Cultural Development. (2005). *Development Cost Charges Best Practices Guide* 3rd edition. Victoria, Canada: Government of British Columbia. Retrieved July 12, 2012 from http://www.cscd.gov.bc.ca/lgd/intergov_relations/library/DCC_Best_Practice_Guide_2005.pdf.

Gowder, J., Andrew, W., Winter, & Bryan, W. (2010). Recent developments in exactions and impact fees: who pays for new schools, fair housing, and clean air? *Urban Lawyer* 42(3): 615-622.

Home, M., Sauve, K., & Pederen, T. (2012) *British Columbians' Perspectives on Global Warming and the Carbon Tax*. Victoria, Canada: Pembina Institute. Retrieved June 10, 2013 from http://www.pembina.org/pub/2376.

Huffman, F. et al. (1988). Who bears the burden of development impact fees? *Journal of the American Planning Association* 54(1): 49-55.

Ihlanfeldt, K.R., & Shaughnessy, T.M. (2004). An empirical investigation of the effects of impact fees on housing and land markets. *Regional Science and Urban Economics* 34: 639-661.

Intergovernmental Panel on Climate Change. (2007a). *Climate Change 2007: Synthesis Report.* Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. [Core Writing Team, Pachauri, R.K. and Reisinger, A. (eds)]. Cambridge, UK: Cambridge University Press

Intergovernmental Panel on Climate Change. (2007b). *Climate Change 2007: Mitigation of Climate Change*. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. [Core Writing Team, Metz, B., Davidson, O.R., Bosch, P.R., Dave, R., & Meyer, L.A. (eds)]. Cambridge, UK: Cambridge University Press.

International Passive House Association (IPHA). (2006). General principles for improving airtightness. Darmstadt, Germany: Passive House Institute. Retrieved November 2, 2012 from: http://passipedia.passiv.de/passipedia_en/planning/airtight_construction/general_principles/principles_for_improving_airtightness.

Jepson, E. (2011). Could impact fees be used for CO_2 mitigation?. *Journal of Urban Planning and Development* 137(2): 204-206.

Kingsley, B. (2008). Making it easy to be green: Using impact fees to encourage green building. *New York University Law Review* 83: 532-567.

Ledman, T.W. (1993). Local government environmental mitigation fees: Development exactions, the next generation. *Florida Law Review* 45: 835-871.

Levine, J.C. (1994). Equity in infrastructure finance: When are impact fees justified?. *Land Economics* 70(2): 210-222.

Light House Sustainable Building Centre & Intep LLC. (2012). *Towards Carbon Neutral Buildings in BC*. Vancouver, Canada: Light House Sustainable Building Centre Society. Retrieved October 18, 2012 from http://www.sustainablebuildingcentre.com/wp-content/uploads/2012/06/TowardsCarbonNeutralBuildingsInBC-Final.pdf.

Light House Sustainable Building Centre & Wimmers, G. (2009). *Passive Design Toolkit for Homes.* Report prepared for the City of Vancouver. Retrieved October 20, 2012 from https://vancouver.ca/files/cov/passive-home-design.pdf.

Lindseth, G. (2004). The Cities for Climate Protection Campaign (CCPC) and the framing of local climate policy. *Local Environment* 9(4): 325-336.

Local Government Act, Revised Statutes of BC (1996m c. 323). Retrieved August 3, 2012 from the BC Laws website: http://www.bclaws.ca/EPLibraries/bclaws_new/document/LOC/freeside/--%20L%20--/Local%20Government%20Act%20RSBC%201996%20c.%20323/00_Act/96323_30.xml#part26_division10.

Mead, K., & Brylewski, R. (2011). *Passivehaus primer: Introduction*. Hertfordshire, UK: BRE Trust. Retrieved December 24, 2012 from http://www.passivhaus.org.uk/podpage.jsp?id=72.

Mudge, A.E. (1992). Impact fees for conversion of agricultural land: a resource-based development policy for California's cities and counties. *Ecology Law Quarterly* 19(1): 63-96.

Muth, R.F. (1960). The demand for non-farm housing. In Harberger, A.C. (ed), *The Demand for Durable Goods* (pp . 29-75). Chicago, USA: University of Chicago Press.

National Research Council. 2012. Model code adoption across Canada [website]. Retrieved January 25, 2013 from http://www.nationalcodes.nrc.gc.ca/eng/code_adoption.shtml.

Natural Resources Canada. CanmetENERGY. (2008). Housing | Net Zero Energy (NZE) Housing [webpage]. Retrieved January 8, 2013 from http://canmetenergy.nrcan.gc.ca/buildings-communities/housing/2335.

Natural Resources Canada. CanmetENERGY. (2011). Housing | Affordable Net Zero Energy Homes [webpage]. Retrieved January 8, 2013 from http://canmetenergy.nrcan.gc.ca/buildings-communities/housing/853.

Natural Resources Canada. Office of Energy Efficiency. (2010a). What is the EnerGuide Rating System? [webpage]. Retrieved December 21, 2012 from http://oee.nrcan.gc.ca/residential/new-homes/upgrade-packages/4998.

Natural Resources Canada. Office of Energy Efficiency. (2010b). The R-2000 Standard [webpage]. Retrieved December 24, 2012 from http://oee.nrcan.gc.ca/residential/builders-renovators-trades/4350.

Natural Resources Canada. Office of Energy Efficiency. (2011). *Commercial/Institutional Sector – British Columbia and Territories, Comprehensive Energy Use Database*. Retrieved October 25, 2012 from http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/comprehensive_tables/list.cfm?attr=0.

Nelson, A.C. (1988). Introduction: Development impact fee symposium. *Journal of the American Planning Association* 54 (1): 3-6.

Nelson, A.C., Frank, J.E., & Nicholas, J.C. (1992). Positive influence of impact-fee in urban planning and development. *Journal of Urban Planning and* Development 118: 59-64.

Nelson, A.C., Nicholas, J.C., & Marsh, L.L. (1992). New-fangled impact fees. *Journal of the American Planning Association* 58: 20-24.

Nicholas, J.C., & Juergensmeyer, J.C. (2003). Market based approaches to environmental preservation: To environmental mitigation fees and beyond. *Natural Resources Journal* 43(3): 837-863.

Nicholas, J., Nelson, A.C., & Juergensmeyer, J. (1991). *A Practitioner's Guide to Development Impact Fees*. Chicago, USA: Planner's Press, American Planning Association.

Nicholas, J.C., & Nelson, A.C. (1988). Determining the appropriate development impact fee using the rational nexus test. *Journal of the American Planning Association* 54(1): 56-66.

Nicholas, J.C. (1987). Impact exactions: Economic theory, practice and incidence. *Law and Contemporary Problems* 50(1): 85-100.

Nicholas, J.C. (1992). On the progression of impact fees. *Journal of the American Planning Association* 58(4): 517-524.

Passive House Institute. (2012). About passive house – what is a passive house? [webpage]. Retrieved November 2, 2012 from the Passive House Institute website: http://passiv.de/en/02_informations/01_whatisapassivehouse/01_whatisapassivehouse.htm.

Passive House Institute. (No date). Passive House heating systems in practice – Results and experiences gained from field measurements. Retrieved February 8, 2013 from http://www.passipedia.passiv.de/passipedia_en/planning/building_services/heating_and_dhw/heating/passive_house_heating_systems_in_practice?s[]=domestic&s[]=hot&s[]=water.

Paulsen, M. (2012, June). High performance homes. *Canadian Geographic*. Retrieved January 7, 2013 from http://www.canadiangeographic.ca/magazine/jun12/sustainable_homes.asp.

Pond, E. et al. (2010). Re-thinking existing residential neighbourhoods for deep greenhouse gas reductions. Vancouver, Canada: The Collaborative for Advanced Landscape Planning. Retrieved April 2, 2012 from http://www.calp.forestry.ubc.ca/wp-content/uploads/2010/02/CALP_REIBC_Retrofit-Challenge_Final_Report.pdf.

Porter, D.R. (1988). Will developers pay to play? *Journal of the American Planning Association* 54(1): 72-75.

Ross, D.H., & Thorpe, S.I. (1992). Impact fees: Practical guide for calculation and implementation. *Journal of Urban Planning and Development* 18(3): 106-118.

Singell, L.D., & Lillydahl, J.H. (1990). An empirical examination of the effect of impact fees on the housing market. *Land Economics* 66: 82-92.

Skaburskis, A. (2003). Pricing city form: Development cost charges and simulated markets. *Planning, Practice & Research* 18(2-3): 197-211.

Skaburskis, A., & Qadeer, M. (1992). An empirical estimation of the price effects of development impact fees. *Urban Studies* 29(4):653-657.

Skidmore, M., & Peddle, M. (1998). Do development impact fees reduce the rate of residential development?. *Growth and Change* 29(4): 383-400.

Snyder, T.P., & Stegman, M.A. (1986). *Paying for Growth: Using Development Fees to Finance Infrastructure*. Washington, DC: Urban Land Institute.

Tomalty, R., & Skaburskis, A. (2003). The politics of average versus marginal cost pricing of development charges: a Canadian case study. In Ennis, F. (ed). *Infrastructure Provision and the Negotiating Process*. Hamshire, UK: Ashgate.

City of Surrey. (2009). *Surrey City Centre Plan Update – Phase II, Stage 1*. Retrieved April 15, 2013 from http://www.surrey.ca/bylawsandcouncillibrary/C001-F24A.pdf.

City of Surrey. (2010a). *Official Community Plan Amendment – Targets for the Reduction of Greenhouse Gas Emissions*. Retrieved March 3, 203 from http://www.surrey.ca/bylawsandcouncillibrary/R096-7992.pdf.

City of Surrey. (2010b). *Economic Investment Action Plan – Phase 2*. Retrieved March 3, 2013 from https://www.surrey.ca/city-government/3046.aspx.

City of Surrey. (2010c). *District Energy Heating System – Surrey City Centre*. Retrieved April 15, 2013 from http://www.surrey.ca/bylawsandcouncillibrary/R109-B5E8.pdf.

City of Surrey. (2010d). *Development Cost Charge By-law Supporting Documentation*. Retrieved April 15, 2013 from http://www.surrey.ca/files/2011DCCReportWEB.pdf.

City of Surrey. (2011a). *Surrey City Centre Plan Update – Stage 2 – Status Report*. Retrieved April 15, 2013 from http://www.surrey.ca/bylawsandcouncillibrary/CR_2011_R151.pdf.

City of Surrey. (2011b). *District Energy System – City Centre Area*. Retrieved April 15, 2013 from http://www.surrey.ca/bylawsandcouncillibrary/CR_2011_R013.pdf.

City of Surrey. (2011c). *Surrey District Energy System Utility – Governance and Branding*. Retrieved April 15, 2013 from http://www.surrey.ca/bylawsandcouncillibrary/CR_2011_R069.pdf.

City of Surrey. (2011d). *Surrey Central District Energy Feasibility Study.* Retrieved April 15, 2013 from http://www.surrey.ca/community/3475.aspx.

City of Surrey. (2011e). *City of Surrey By-Law No. 15973*. Retrieved April 15, 2013 from http://www.surrey.ca/bylawsandcouncillibrary/BYL_reg_15973.pdf.

City of Surrey. (2012a). Community ENERGYShift: Surrey's Energy and Emissions Plan [webpage]. Retrieved April 16, 2012 from: http://www.surrey.ca/energyshift/9466.aspx.

City of Surrey. (2012b). *City Centre District Energy System By-Law and Related Financial Assistance Policy*. Retrieved April 15, 2013 from http://www.surrey.ca/bylawsandcouncillibrary/CR_2012-R123.pdf.

City of Surrey. (2013a). *Energy efficiency 2012 BC Building Code Part 10 of Division B*. Retrieved February 20, 2013 from http://www.surrey.ca/files/EnergyEfficiency.pdf.

City of Surrey. (2013b). City Centre Energy Rate Setting Tool. [Unpublished data].

City of Surrey. (2013c). *Official Community Plan.* [Document in preparation].

City of Surrey (2013d). *Community Energy and Emissions Plan.* [Document in preparation].

City of Surrey. (No date a). Surrey City Centre Area [map]. Retrieved April 15, 2013 from http://www.surrey.ca/city-services/772.aspx.

City of Surrey. (No date b). Surrey City Centre [webpage]. Retrieved April 15, 2013 from http://www.surrey.ca/city-services/1343.aspx.

Taylor, B. (2010). *Development Cost Charges*. Paper for the Continuing Legal Education Society of British Columbia. Vancouver, Canada: Continuing Legal Education Society of British Columbia.

United Nations Environment Programme (UNEP). (2007). *Buildings and Climate Change Status, Challenges and Opportunities.* Oslo, Norway: United Nations Environment Programme. Retrieved April 12, 2012 from http://www.unep.fr/scp/publications/details.asp?id=DTI/0916/PA.

United Nations Framework Convention on Climate Change (UNFCCC). (2012). Greenhouse gas inventory data – definitions [webpage]. Retrieved January 31, 2013 from http://unfccc.int/ghg_data/online_help/definitions/items/3817.php.

U.S. Department of Energy. (2010). *Building Energy Codes 101 An Introduction*. Washington, DC: Department of Energy. Retrieved December 19, 2012 from https://www.ashrae.org/File%20Library/docLib/Public/20100301_std901_codes_101.pdf.

Weitz, S. (1984). Funding infrastructure for growth. In National Association of Home Builders (ed), *Impact Fees: A Developer's Manual*. (Appendix B). Washington, DC: National Association of Home Builders.

White, A. (2012, March 18). Passive House commercial buildings find economic sweet spot. RENX.ca Real Estate News Exchange. Retrieved January 8, 2013 from http://www.renx.ca/Detailed/Commercial/Passive_House_Commercial_Buildings_Find_Economic_Sweet_Spot_24853.html.

Yinger, J. (1998). The incidence of development fees and special assessments. *National Tax Journal* 51(1): 23-41.

APPENDIX A
Emission Factors and Methodology

The emission factors used for the following calculations are sourced from the BC Ministry of Environment's *2012 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions* guide. The guide's emissions factors and estimation methods are based on the following principles:

1. If BC-specific information was available, the guide provides BC-specific emission factors, to improve the accuracy of GHG accounting.
2. When BC-specific information was not available, standardized emission factors from recognized national and international data sources are given.
3. Simplified methods for estimating emissions are given if GHG measuring and reporting in certain cases is too burdensome or costly.
4. Simplified estimation methods err on the side of overestimating rather than underestimating emissions to adhere to the principle of conservativeness.

Emission factors are expressed in kilograms of GHG emissions per unit of consumption activity. The Province measures six groups of greenhouse gases: carbon dioxide (CO_2); methane (CH_2); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); sulphur hexafluoride (SF_6); and perfluorocarbons (PFCs). International rules also require the separate reporting of biogenic emissions from biomass combustion (e.g. wood, wood waste, ethanol, biodiesel, and biomethane).

Direct emissions from stationary fuel combustion in BC buildings typically result from several different fossil fuels: natural gas, propane, light fuel oil, kerosene, marine diesel, diesel fuel, and gasoline. Buildings in Metro Vancouver typically use natural gas, so calculations below will only use the energy conversion factor and emission factors for natural gas, given below in Table 1. The energy conversion factor is used to convert volume (m^3) of natural gas into energy (GJ or kWh)[5].

To calculate tonnes of CO_2e for natural gas, the amount of energy from natural gas combustion is multiplied separately by the emission factors for CO_2, CH_4, and N_2O. The emission for CH_4 and N_2O are multiplied by the Global Warming Potential for each gas (given below in Table 1) to calculate the CO_2 equivalent for each gas. The tonnes of CO_2e are then added together for the total emissions resulting from natural gas combustion. If the volume of natural gas is given, then that is first multiplied by the energy conversion factor to convert volume into energy.

Equation 1: Calculating CO_2e Emissions of Natural Gas

$$\begin{array}{c}CO_2e\\ \text{Emissions of}\\ \text{Natural Gas}\end{array} = \text{Sum of} \begin{cases} \begin{array}{c}\text{Volume of}\\ \text{Natural Gas}\end{array} \times \begin{array}{c}\text{Energy}\\ \text{Conversion}\\ \text{Factor}\end{array} \times \begin{array}{c}CO_2\\ \text{Emission}\\ \text{Factor}\end{array} \\ \begin{array}{c}\text{Volume of}\\ \text{Natural Gas}\end{array} \times \begin{array}{c}\text{Energy}\\ \text{Conversion}\\ \text{Factor}\end{array} \times \begin{array}{c}CH_4\\ \text{Emission}\\ \text{Factor}\end{array} \times \begin{array}{c}CH_4\\ \text{GWP}\end{array} \\ \begin{array}{c}\text{Volume of}\\ \text{Natural Gas}\end{array} \times \begin{array}{c}\text{Energy}\\ \text{Conversion}\\ \text{Factor}\end{array} \times \begin{array}{c}NO_2\\ \text{Emission}\\ \text{Factor}\end{array} \times \begin{array}{c}NO_2\\ \text{GWP}\end{array} \end{cases}$$

[5] The *Best Practices Methodology* guide gives the energy conversion factor in gigajoules. Since this project uses kilowatt-hours, the energy conversion factor and emission factors are also given in both GJ and kWh, based on 1 GJ = 277.78 kWh

Indirect emissions in buildings result from electricity consumption. The GHG emissions from BC's hydroelectric power system can fluctuate widely from year to year because of variations in water supply conditions and reservoir levels. Emissions also differ between electric utilities due to the different proportions of hydro and thermal power in each utility's supply mix. Buildings in Metro Vancouver are typically supplied by BC Hydro, so the emission factor for electricity is based on a rolling three-year average of BC Hydro's reported domestic supply GHG intensity, to partially account for annual fluctuations, given below in Table 2.

Equation 2: Calculating CO_2e Emissions of Electricity

$$\text{CO}_2\text{e Emissions of Electricity} = \text{kWh of Electricity Consumed} \times \text{Electricity Emission Factor}$$

Common unit conversions are given in Table 3 below.

Table A: Emission Factor for Natural Gas

Fuel Type	Energy Conversion Factor	Emission Factors Global Warming Potential (GWP)		
		CO_2	CH_4	N_2O
Natural Gas	0.03843 GJ/ m^3 10.675 kWh/m^3	49.86 kg/GJ 0.1795 kg/kWh GWP: 1	0.0010 kg/GJ 3.600×10^{-6} kg/kWh GWP: 21	0.0009 kg/GJ 3.2400×10^{-6} kg/kWh GWP: 310

Table B: Emission Factor for Purchased Electricity from BC Hydro

Public Utility	Emission Factor	Emission Factor[2]
BC Hydro	25 tCO_2e/GWh 2.5×10^{-2} kgCO_2e/kWh	6.9 kg/GJ 2.484×10^{-3} kg/kWh

Table C: Common Unit Conversions

Unit 1	Unit 2
1 GJ =	277.78 kWh
1 GWh =	1×10^6 kWh
1 MWh =	1,000 kWh
1 tonne =	1,000 kg

APPENDIX B
Emission Intensity Calculations

Calculation 1: Emission Intensity of Passive House Standard

$$= \Sigma \begin{cases} 35.3 \text{ kWh/m}^2\cdot\text{a} \times 1.795 \times 10^{-1} \text{ kg/kWh} = 3.6434 \text{ kgCO}_2\text{e/m}^2\cdot\text{a} \\ 35.3 \text{ kWh/m}^2\cdot\text{a} \times 3.600 \times 10^{-6} \text{ kg/kWh} \times 21 = 1.5347 \times 10^{-3} \text{ kgCO}_2\text{e/m}^2\cdot\text{a} \\ 35.3 \text{ kWh/m}^2\cdot\text{a} \times 3.2400 \times 10^{-6} \text{ kg/kWh} \times 310 = 2.0389 \times 10^{-2} \text{ kgCO}_2\text{e/m}^2\cdot\text{a} \end{cases}$$

$$= 6.3745 \text{ kgCO}_2\text{e/m}^2\cdot\text{a}$$

Calculation 2: Emission Intensities of Part 3 Buildings

Sample Calculation for Energy Use intensities of Space Heating and DWH for High Rise Residential Building (20 storey)

$$= \Sigma \begin{cases} 213 \text{ kWh/m}^2\cdot\text{a} \times (0.37 + 0.25) \times 1.795 \times 10^{-1} \text{ kg CO}_2\text{e/kWh} \\ 213 \text{ kWh/m}^2\cdot\text{a} \times (0.37 + 0.25) \times 3.600 \times 10^{-6} \text{ kg CO}_2\text{e /kWh} \times 21 \\ 213 \text{ kWh/m}^2\cdot\text{a} \times (0.37 + 0.25) \times 3.2400 \times 10^{-6} \text{ kg CO}_2\text{e /kWh} \times 310 \end{cases}$$

$$= \Sigma \begin{cases} 132.06\text{kWh/m2}\cdot\text{a} \times 1.795 \times 10\text{-}1 \text{ kg CO}_2\text{e/kWh} \\ 132.06\text{kWh/m2}\cdot\text{a} \times 0.0000756 \text{ kg CO}_2\text{e/kWh} \\ 132.06\text{kWh/m2}\cdot\text{a} \times 0.0010044 \text{ kg CO}_2\text{e/kWh} \end{cases}$$

$$= 132.06 \text{ kWh/m2}\cdot\text{a} \times (0.1795 + 0.0000756 + 0.0010044) \text{ kg CO}_2\text{e/kWh}$$
$$= 132.06 \text{ kWh/m2}\cdot\text{a} \times 0.18058 \text{ kg CO}_2\text{e/kWh}$$
$$= 23.85 \text{ kg CO}_2\text{e/m2}\cdot\text{a}$$