CANADIAN PLANNING AND POLICY

Aménagement et politique au Canada

SPECIAL ISSUE — COMMUNITY ENERGY PLANNING IN CANADA:
INSIGHTS AT THE NEXUS OF RESEARCH AND PRACTICE

SPECIAL ISSUE EDITOR

Kirby Calvert

Co-Mapping Solutions Inc.

CPP-APC ASSOCIATE EDITOR

Thomas Gunton

Simon Fraser University

TABLE OF CONTENTS

EDITORIAL INTRODUCTION

1. [The emergence and evolution of community energy planning in Canada: Introduction to a special issue](#) 1-10
Kirby Calvert, Abhilash Kantamneni, and Ian McVey

ARTICLES

2. [Why is there an implementation gap in community energy planning?](#) 11-34
Rose Murphy, Aaron Pardy, Morgan Bragiewicz, Brett Zuehlke, and Mark Jaccard
3. [Enabling community energy planning? Polycentricity, governance frameworks, and community energy planning in Canada](#) 35-54
Mark Winfield, Scott Harbinson, Susan Morrissey Wyse, and Colleen Kaiser
4. [The CEP Crosswalk: A community energy planning tool for interdepartmental alignment and stakeholder engagement](#) 55-68
Cody Walter, Michelle Adams, and Alexander L. MacDonald
5. [Social and municipal influences on intention to purchase electric and hybrid electric vehicles in London Ontario, CA](#) 69-88
Jordan Michael Fuller, Jamie Baxter, and Jamie Skimming
6. [Participatory mapping and spatial planning for renewable energy development: The case of ground-mount solar in rural Ontario](#) 89-100
Kirby Calvert and Rebecca Jahns

Social Sciences and
Humanities Research
Council of Canada

Canada

Conseil de recherches
en sciences humaines
du Canada

Publication of this special issue was partially funded by the Social Sciences and Humanities Research Council, The Canadian Institute of Planners, and the Association of Canadian University Planning Programs, but views expressed are the personal views of the author(s).

WHY IS THERE AN IMPLEMENTATION GAP IN COMMUNITY ENERGY PLANNING?

Rose Murphy^a , Aaron Pardy^a , Morgan Braglewicz^a, Brett Zuehlke^a, and Mark Jaccard^a
^aSimon Fraser University

Résumé

Dans la planification énergétique communautaire, on note un écart persistant entre les objectifs et les plans annoncés par les gouvernements locaux et l'application des politiques efficaces pour réduire la consommation d'énergie et les émissions de gaz à effet de serre (GES). Pour explorer cette lacune dans la mise en œuvre, on utilise deux méthodes. Premièrement, on applique des outils de modélisation d'économie-énergie au niveau urbain pour évaluer l'efficacité des diverses options politiques disponibles aux gouvernements locaux. Pour ces exercices, l'étude de cas est la juridiction de Vancouver, en Colombie-Britannique. Deuxièmement, on rapporte et analyse les résultats d'une enquête qu'on a administré auprès des acteurs dans le domaine d'énergie communautaire au Canada. Les résultats de la modélisation indiquent que les limites juridictionnelles contribuent de façon importante à la lacune dans la mise en œuvre. Selon nos conclusions, bien que Vancouver puisse réaliser des progrès considérables en mettant en œuvre les politiques qui relèvent clairement de sa juridiction, c'est peu probable que la ville atteigne ses cibles ambitieuses en matière d'énergie renouvelable et émissions de GES sans le soutien des gouvernements supérieurs. Les réponses à l'enquête indiquent que les limites de capacité des gouvernements locaux jouent également un rôle dans la perpétuation de la lacune dans la mise en œuvre.

Mots-clés: modèle énergie-économie, émissions de gaz à effet de serre, modèle de l'aménagement du territoire, énergie renouvelable

Abstract

In community energy planning, a persistent disconnect has been observed between the targets and plans announced by local governments and the application of effective policy to reduce energy consumption and greenhouse gas (GHG) emissions. We use two methods to explore this implementation gap. First, we apply energy-economy modelling tools at the urban level to evaluate the effectiveness of various policy options available to local governments. Our case study for these exercises is the leading jurisdiction of Vancouver, British Columbia. Second, we report and analyze the results of a survey we administered to community energy practitioners in Canada. The modelling results point to jurisdictional reach as an important contributor to the implementation gap. We find that, while Vancouver can make significant progress by implementing policies that are clearly within its jurisdiction, the city is unlikely to meet its ambitious renewable energy and GHG emissions targets without the support of higher levels of government. The survey responses suggest that capacity limitations of local government also have a role in perpetuating the implementation gap.

Keywords: energy-economy model, greenhouse gas emissions, land-use model, renewable energy

Canadian Planning and Policy / Aménagement et politique au Canada, Volume 2021, Special issue: Community Energy Planning in Canada, pages 11-34.

This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/).

ISSN 2562-122X

DOI 10.24908/cpp-apc.v2021i2.13956

CIP-ICU & ACUPP-APUCU

11

Canadian Planning and Policy 2021

1. INTRODUCTION

Community energy planning (CEP), or management, is a way of focusing energy-based policy at the local level by integrating it with typical municipal policies and planning practices (Jaccard et al., 1997). It is within this framework that a growing number of city governments have set ambitious mid-century targets for reduced greenhouse gas (GHG) emissions and increased reliance on renewable energy. However, the concept of CEP pre-dates much of the GHG reduction rhetoric that has increased in popularity at the local level over the last few years. For instance, the use of district energy and combined heat and power has been widespread in Europe for decades, especially in Scandinavian countries such as Denmark and Sweden. Early work suggesting that CEP, as a formal planning framework, has the potential to affect local energy use and help communities achieve GHG reduction targets dates to the 1980s.

For almost as long as CEP has been formally established as a planning framework to achieve GHG emissions reductions, the challenges and limits to implementing effective policy at the local level have been acknowledged. For instance, many of the recommendations in Jaccard et al. (1997) involve cooperation between different entities, such as utilities and transportation planning authorities, as well as changes to legislation governing land-use planning. A decade after this work, scholars continued to observe a “stubborn gap between the rhetoric and reality of local climate policy” (Betsill & Bulkeley, 2007, p. 448). Today, there is still a gap between the increasing interest and enthusiasm shown by cities in setting GHG reduction targets and their understanding of the dynamics involved in urban policy and how to go beyond target-setting to implement effective emissions measures (Hughes, 2017; Ryan, 2015).

In recent years, the number of local and regional governments around the world pursuing ambitious emissions reduction and renewable energy targets has grown considerably (Bloomberg Philanthropies, 2018). This trend includes a growing list of prominent metropolises on every continent (except

Antarctica) as well as hundreds of smaller cities in Europe and North America (Agar & Renner, 2016; Sierra Club, 2018). Common targets among these local governments include 80 percent emissions reduction, carbon neutrality, and/or 100 percent renewable energy or electricity, typically by the year 2050. In Canada, Guelph, Halifax, Hamilton, Montréal, Toronto, and Vancouver have recently set carbon neutral by 2050 goals (Government of Canada, 2020). One hundred percent renewable energy is being pursued by Vancouver, Victoria, Nelson, Saanich, Guelph, Regina, and Oxford County, and hundreds of other local governments have developed community energy plans (Littlejohn & Laszlo, 2015).

Adopting climate targets is an inexpensive and relatively uncontroversial way for cities to demonstrate concern for climate change, but targets on their own do not guarantee local implementation of policies that lead to significant emissions reductions (Sharp et al., 2011). For instance, one study found that 20 percent of municipalities in Indiana had a clearly articulated GHG reduction target, but only five percent had performed a GHG inventory, developed a dedicated plan, or allocated money to emissions reduction initiatives (Krause, 2011).

The legal authority of local governments to enact GHG and energy policy is limited in many jurisdictions. Whereas national and sub-national governments typically have the authority to regulate or price virtually all GHG emissions, local governments tend only to have an indirect and limited ability to regulate or control activities that produce emissions. Additionally, the ability of cities to regulate these activities is often complicated by the scope of their authority and competing jurisdiction of more senior levels of government. Local governments generally can influence emissions from buildings, transportation, and waste. However, it is usually only sub-national and national governments that have the authority to implement multi-sectoral, price-based policies such as a carbon tax or cap-and-trade system. Cities also tend to have negligible authority to regulate the sale

Why is there an implementation gap in community energy planning?

of the technologies (home heating systems, vehicles) and energy forms (gasoline, natural gas) that cause most urban GHG emissions.

The CEP policy and planning tools available to municipalities include land-use planning and zoning, building and development permitting, parking access and pricing, local road management, electric vehicle charger deployment, district energy system and community electric utility company development and management, and public transit and active transportation network design. These powers are exercised by cities in their typical planning and development processes. As cities pursue aggressive GHG reduction objectives, they will need to find ways to apply these powers in a new context to influence emission-producing activities, land uses, and energy choices of individuals, institutions, and businesses.

Thus far, city-level policy discussions have often emphasized policies that might influence energy efficiency and energy demand through modified building and site designs, urban form changes, increased uptake of energy efficient technologies, and a mode shift away from private vehicles to public transit and active mobility (Corfee-Morlot et al., 2009). However, there is conflicting evidence on the ability of some of these actions to substantially reduce GHG emissions, and this could help to explain the implementation gap in CEP. Some studies suggest that approaches such as higher density neighbourhood designs and a greater mix of land uses can impact vehicle ownership and use, whereas other studies find the link between these actions and car use to be quite limited (Badoe & Miller, 2000). Additionally, the widely accepted urban planning notion that rezoning for higher density land use is a key policy pathway to less private vehicle use has been challenged by studies that suggest that densification in itself may have only a modest impact on transportation mode choice for most mobility needs (Hachem, 2016). Therefore, cities that have announced or are considering ambitious targets must better understand the likely effect of these types of actions and policies. Similarly, national and sub-national governments

need to better understand these effects so that they can accurately predict the contributions of local government policy to their national, provincial, or state emissions targets.

In this article, we use two methods to investigate the often observed disconnect between energy and emissions targets/plans and the deployment of effective policy at the local level. First, we use urban energy-economy-emissions modelling tools to assess the effectiveness of policy options that local governments can use to reach their GHG reduction and renewable energy targets. We apply these tools to the City of Vancouver, British Columbia as a case study for this exercise. The second way in which we address the implementation gap is by reporting and analysing the results of a survey administered to community energy practitioners in Canada. We developed this survey as a preliminary test of some ideas about the role of additional factors – beyond the jurisdictional and policy effectiveness issues discussed so far – in perpetuating the gap. We used the survey to explore factors such as municipal government expertise, policy development and implementation capacity, and political will. We hypothesize that these factors may also compromise the ability of local governments to implement effective policies within their jurisdiction.

This paper is organized as follows. In section 2, we describe the CIMS energy-economy model used to carry out the quantitative policy assessments reported here. A spatially explicit version of the model, CIMS-Urban, combines a city-level version of CIMS with a land-use and infrastructure model, allowing for the simulation of municipal energy and emissions policies. In the first part of section 3, we briefly summarize work by Jaccard et al. (2019) using CIMS-Urban to evaluate the impact of a zero-emissions buildings policy and transit-oriented development in the City of Vancouver. Under the Jaccard et al. scenarios, Vancouver does not meet its mid-century GHG emissions and energy targets. Therefore, in the second part of section 3, we analyze an additional scenario that pushes the stringency of the city's available policy levers to the

Why is there an implementation gap in community energy planning?

limits of political, economic, and legal feasibility. In section 4, we use CIMS to assess the emissions outcomes of alternative densification scenarios for Vancouver's low-density neighbourhoods. We then focus on the survey of Canadian community energy practitioners in section 5. We establish the context for the survey, explain the methods, and provide an overview of the results. Finally, in section 6, we discuss insights from our research into the factors contributing to the implementation gap and implications for the roles of different levels of government in deep decarbonization and the renewable energy transition.

2. THE CIMS ENERGY-ECONOMY MODEL

CIMS is an integrated set of dynamic energy-economy models that simulates the evolution of capital stocks in an economy through retirements, retrofits, and new purchases (Jaccard et al., 2003). The model is technologically explicit, meaning it keeps track of vintages of capital stocks of different efficiencies as well as other vintage-specific characteristics. It is also behaviourally realistic in that it incorporates consumer preferences based on empirical research to better simulate how households and firms may respond to GHG and energy policies. Behavioural parameters within the model are estimated from a combination of market research into past technology choices (revealed preferences) and discrete choice surveys of possible future technology choices (stated preferences) (Rivers & Jaccard, 2006). The CIMS energy-economy model is described in more detail in Jaccard (2009) and Murphy and Jaccard (2011).

CIMS simulates the turnover of infrastructure, factories, equipment, buildings, vehicles, and appliances over time through retirements, retrofits, and new acquisitions. In each 5-year period, a portion of the existing capital stocks are retired according to an age-dependent function, although accelerated retirement and retrofit are possible if warranted by economic conditions. As new capital stocks are required, technologies compete for market share based on a comparison of their lifecycle costs. The technology competition algorithm is applied at several levels of decision-

making. For example, at one level there is competition among different private vehicle technologies, which is nested inside a higher-level competition between modes of transport, the mode options being private vehicles, public transit, cycling, and walking.

The CIMS technology competition algorithm is given in Equation 1. The market share (*MS*) of the new capital stock captured by technology *j* is dependent on its lifecycle cost relative to the lifecycle costs of all other technologies (*K*) available to provide the energy service in question (e.g., heated indoor floor space, person-kilometres travelled). The financial costs of a technology are comprised of its capital cost (*CC*), its annual maintenance and operation cost (*MC*), and its annual energy cost (*EC*), which depends on energy prices and energy consumption.

$$MS_j = \frac{[CC_j * \frac{r}{1-(1+r)^{-n_j}} + MC_j + EC_j + i_j]^{-v}}{\sum_{k=1}^K [CC_k * \frac{r}{1-(1+r)^{-n_k}} + MC_k + EC_k + i_k]^{-v}} \quad (1)$$

In

addition to these standard financial costs, the market share algorithm includes three behavioural parameters, each of which characterizes a different aspect of firm and household decision-making. First, a time preference parameter (*r*) represents the trade-off between present and future costs for the technologies in the competition (e.g., higher upfront cost versus lower operating cost). This parameter is used to annualize the capital cost, along with the average lifespan (*n_j*) of the technology in question. Second, a parameter (*v*) denotes the heterogeneity of decision-makers – different individuals may choose different technologies when presented with identical options. The market heterogeneity parameter influences the relationship between technology lifecycle costs and market share. Finally, an (annual) intangible cost parameter (*i*) reflects technology- or mode-specific preferences, relative to a baseline. An example of this last parameter is the intangible cost value for public transit in the personal mobility mode share competition, which is based on revealed and stated preference research

Why is there an implementation gap in community energy planning?

showing that a significant share of consumers attribute an intangible, non-financial cost to public transportation to reflect their perceptions of its lower convenience, status, and comfort relative to the private vehicle. The inconvenience and/or perceived risks of adopting a new technology, such as a ground-source heat pump or an ultra-efficient building shell, are also represented by intangible costs in CIMS.

CIMS includes two functions for simulating endogenous change in the real and perceived characteristics of technologies that are new to the market: a declining capital cost function and a declining intangible cost function. These functions are especially important for modelling policies that pursue technological transformation of the energy system over the next few decades.

While energy-economy models such as CIMS can have considerable regional detail, they generally lack urban-level detail on land use. However, many of the actions targeted by municipal energy and emissions policy have a spatial dimension. Urban planners and policymakers tend to focus on land-use zoning and the coordination of urban development (density, mixed uses) with mobility infrastructure (roads, public transit, cycling routes, pedestrian features) and perhaps energy infrastructure (district heating).

Land-use models, on the other hand, do not tend to use sophisticated methods to account for energy consumption and GHG emissions. For example, when it comes to the personal transportation sector, any tracking of energy and emissions in these models is generally based on a simplistic representation of the vehicle technology mix that is not responsive to changes in financial costs and other factors that are known to influence how people make vehicle purchase decisions. These factors can change over time and across scenarios, affecting the market shares of vehicles that have different efficiency levels and use different energy sources, including gasoline, electricity, biofuels, and hydrogen. In turn, these changes in market shares can influence energy and emissions in ways that

would not be picked up by a conventional land-use model.

A spatially explicit version of CIMS, called CIMS-Urban, consists of an energy-economy model linked to a GIS land-use model (Jaccard et al., 2019). It thereby combines the strengths of both model types. CIMS-Urban accounts for energy consumption and GHG emissions based on an explicit representation of the technology mix, realistically simulates human behavior with respect to technology selection as well as travel mode selection, captures key spatial relationships, and offers the ability to simulate interactions with federal and provincial government policies.

In CIMS-Urban, the CIMS energy-economy model is linked to a GIS model that tracks changes in land use (establishment of high-density nodes, a shift to mixed uses, overall increases in density) and the development of mobility infrastructure in an urban setting. These changes, in turn, affect the intangible cost values in the CIMS technology market share algorithm. Thus, for example, a mixed-use, higher density development can decrease the distance of many residents to a commercial area, thereby reducing the intangible cost in CIMS of the personal mobility choice of walking for some types of mobility needs.

3. MODELLING ZERO-EMISSIONS BUILDINGS AND TRANSIT-ORIENTED DEVELOPMENT

In this section, we describe the use of CIMS-Urban to assess whether the policies available to the local government of the City of Vancouver are enough to meet its ambitious energy and emissions targets. In North America, Vancouver is at the forefront of local government efforts in this regard. The city announced in 2015 that it would use 100 percent renewable energy and reduce GHG emissions by 80 percent by 2050 as part of its *Renewable City Strategy*. These are the specific targets we analyze in this paper. Since 2015, Vancouver has increased its 2050 commitment to carbon neutrality; has implemented policies aimed at reducing emissions in buildings, transportation, and waste; and has announced plans and programs for future policy

Why is there an implementation gap in community energy planning?

(City of Vancouver, 2017, 2020). Although Vancouver is a leading jurisdiction for climate-energy policy, it too has experienced the CEP implementation gap. The city is expected to miss its 2020 emissions target (set before the adoption of the *Renewable City Strategy*) of a 33 percent reduction below 2007 levels. As of 2018, the city's emissions were only 12 percent lower than their 2007 baseline (City of Vancouver, 2019).

Three key modelling assumptions are worth describing up-front, as they provide context for the scenario descriptions and results that follow in sub-sections 3.1 and 3.2. First, we assumed only a limited development of district heating systems in nodes of high density in the urban core and near public transit stations where they could be economically justified. Elsewhere in the city, our analysis found the high capital costs of expanding district energy systems to be a challenge, given that Vancouver has access to low-cost hydropower. Second, our supply curve for biomethane rises steeply, making it difficult for this energy source to achieve a high penetration once all the potential supply from municipal solid waste has been exploited. Electricity from low-cost hydropower therefore plays an ever-greater role in space heating and cooling, and even in water heating, as GHG policies increase in stringency. Third, the source of renewable electricity remains primarily external to Vancouver, namely the major hydropower facilities of British Columbia, which are augmented in the next few decades by new large and small hydropower facilities, wind turbines, wood waste burning thermal plants, geothermal developments, and some solar photovoltaic farms in the sunny interior of the province. While there will be some development of rooftop solar in Vancouver, our analysis found uptake of this option to be limited due to the low cost of the non-urban renewable electricity resources and Vancouver's relatively low solar incidence in winter when electricity demand is highest.

3.1. CURRENT POLICY AND RENEWABLE CITY STRATEGY SCENARIOS

Jaccard et al. (2019) evaluate the impact of zero-emissions buildings policy and transit-oriented development. Here we report results from two of the policy scenarios tested in that study: a current policy scenario and a scenario based on the City of Vancouver's *Renewable City Strategy* (2015). The first scenario, *CurrentPol*, includes Vancouver and senior government policies at their announced design and stringency levels as of 2016. This scenario serves as a reference for how GHG emissions and energy would be expected to evolve to 2050 in the absence of additional policy, given projected population and economic growth for the city. Population growth in CIMS-Urban was based on projections by B.C. Statistics for Vancouver until the year 2040 (BC Stats, 2016). For the years 2040 to 2050, the same population growth rate was assumed as in the previous decade.

The second scenario, *VanRen*, simulates the *Renewable City Strategy* that was designed to shift Vancouver onto a trajectory that would achieve its GHG and energy targets. This scenario includes full implementation of the *Zero Emissions Building Plan* (City of Vancouver, 2016) that applies to both residential and commercial buildings, requiring that all new buildings be zero-emissions by 2030. The *VanRen* scenario also includes transportation network improvements, mixed-use pedestrian-oriented developments along major public transit routes, and more high-density development nodes centered on rapid transit stations.

In Figure 1, we show the GHG emissions and energy use results of the CIMS-Urban simulations of *CurrentPol* and *VanRen* to 2050 and compare these to levels in 2015 (also shown is a third scenario, *100RE*, that is discussed in sub-section 3.2). Although the CIMS model system can be used to assess upstream emissions from energy production, only emissions from end-use fossil fuel consumption within Vancouver are reported here (electricity consumed in the city is almost exclusively from near-zero-emissions hydropower). For *CurrentPol*, the model forecasts that total

Why is there an implementation gap in community energy planning?

Figure 1. Energy use and GHG emissions in Vancouver in 2015 and for policy scenarios in 2050.
(Source: Adapted from Jaccard et al. (2019), Fig. 3.)

energy use in Vancouver will rise to 13 percent above the 2015 level in 2050. GHG emissions rise by only seven percent due to a slight shift from fossil fuels to renewable energy. In this scenario, the share of renewable energy is up four percentage points from 2015 in 2050, reaching 39 percent of total energy use. Under the *VanRen* scenario, GHG emissions fall 25 percent from 2015 levels, while total energy use remains essentially unchanged and renewable energy reaches 50 percent of the total. Although these results represent significant progress, the scenario falls far short of achieving the city's GHG and renewable energy targets for 2050.

A closer look at the results for buildings and transportation reveals why Vancouver's targets are not met under the *VanRen* scenario. For residential buildings, code changes improve energy efficiency relative to *CurrentPol*, and there is also a requirement for new buildings to be zero-emissions by 2030. However, existing buildings continue to use natural gas, producing substantial emissions. Likewise, natural gas represents a significant portion of commercial, institutional, and light industrial energy use, even by the end of the simulation period.

For personal transportation, infrastructure investments and changes to urban form that support walking, cycling, and public transit result in

network quality improvements for these modes of mobility, decreasing the intangible costs associated with them in CIMS-Urban. This increases the shares of person-kilometres captured by alternative modes in the *VanRen* simulation, which in turn helps to accommodate travel demand from a growing population without increasing the use of private vehicles.

Although the CIMS-Urban forecast indicates that energy consumption and GHG emissions from personal transportation will be reduced markedly to 2050 under *VanRen*, emissions remain significant. There are at least two reasons for this. First, even with a loss of mode share relative to 2015, private vehicles still provide a considerable share of personal mobility demand (person-kilometres) in 2050. Second, the acquisition of gasoline and diesel vehicles continues throughout the simulations, despite existing subsidies for the purchase of zero-emissions vehicles and expanding installations of electric vehicle recharging stations. Without forceful regulations or substantially rising carbon prices, low long-run oil prices are expected to sustain the attraction of gasoline-powered vehicles for many consumers. The city policies that were simulated have little relevance to the freight transportation sector, as the actions they induce predominantly relate to personal mobility mode shifting.

3.2. 100 PERCENT RENEWABLE ENERGY SCENARIO

Because the simulation of *VanRen* in Jaccard et al. (2019) failed to achieve Vancouver's mid-century GHG and renewable energy targets, we provide results for an additional scenario here. This scenario, *100RE*, increases the strength of policies within the *VanRen* scenario and adds new policies, pushing the limits of political, economic, and legal feasibility to achieve the city's targets without additional senior government support.¹ For residential buildings, fossil-fuel-burning hot water heaters and furnaces are not permitted under Vancouver's building code after 2030, either in new buildings or as replacement equipment in existing

¹ More detail on the set-up and results of the *100RE* scenario is provided by Zuehlke (2017) and Zuehlke et al. (2017).

Why is there an implementation gap in community energy planning?

buildings. Likewise, in new or existing institutional, light industrial, and commercial buildings, new fossil fuel burning heating, ventilation, and air conditioning systems are not allowed to be installed after 2030. Natural gas can still be consumed for a few specific uses, such as cogeneration and cooking, but an increasing percentage of biomethane replaces conventional natural gas. To promote energy switching in personal transportation in the *100RE* scenario, city-controlled parking spaces for gasoline and diesel vehicles are gradually reduced such that by 2050 there are none available. With freight vehicles, the policy challenge is greater given the predominant jurisdictional authority of senior government. We nonetheless assumed that Vancouver requires businesses operating within the city to demonstrate the exclusive use of renewable-powered vehicles to qualify for a business license after 2030.

In the *100RE* scenario, fossil fuels are virtually phased out by the end of the simulation and GHG emissions are below the 80 percent reduction target level (Figure 1). Most remaining emissions are landfill gas from the decomposition of organic material in municipal solid waste. Despite the dramatic reduction in GHG emissions, energy use is down only 25 percent from 2015. A key observation from the results is that, while reduced energy consumption through lower energy service demands and improvements in energy efficiency plays a significant role in GHG emissions reduction, the switch to renewables increases in importance as the GHG reduction policies increase in stringency. The simulations with CIMS-Urban suggest that Vancouver's inhabitants will continue to use considerable energy in buildings and for mobility, with a significant amount of the latter consumed in private vehicles and freight trucks.

While the *100RE* scenario results demonstrate that Vancouver can theoretically achieve its ambitious renewable energy and GHG targets acting alone, this is based on the presumption that the city can enact aggressive, all-encompassing policies that effectively ban the use of natural gas in buildings and gasoline and diesel in vehicles. With respect to

buildings, we assumed that Vancouver can regulate the type of energy used by new and existing buildings. In the case of existing buildings, this assumption is legally and politically uncertain. However, Vancouver appears to be moving towards this policy direction: with the recent passing of the *Climate Emergency Action Plan*, city staff have been directed to begin investigating policy options for regulating existing building emissions. The design of this policy, particularly to which buildings it will be applied and how its stringency will increase over time, is ill-defined (City of Vancouver, 2020). However, this potentially novel policy development should be closely watched by researchers and practitioners in the coming years.

For personal transportation, we assumed that restricting city-controlled parking spaces to zero-emissions vehicles will be sufficient to cause a wholesale shift from gasoline and diesel to electric and biofuel vehicles, which is likely optimistic. Because Vancouver lacks the authority to regulate vehicle energy choices, acting alone to achieve its ambitious renewables and GHG targets requires implausible urban policies that somehow prohibit gasoline and diesel vehicles within city boundaries. In the case of freight transportation, the political and legal challenge is equal or greater. Given these caveats, it is likely that for Vancouver to achieve its GHG and energy targets, the city will require either stronger legislative authority or greater assistance from senior government than it appears to have at present.

4. MODELLING PATHWAYS FOR INCREASING URBAN DENSITY

The simulations described in the previous section did not evaluate alternative densification pathways in Vancouver, leaving uncertainty as to how densifying low-density neighborhoods could influence energy use and emissions in the context of the city's targets. Popular planning theories such as Smart Growth, New Urbanism, and Transit-Oriented Development champion density as an essential component for achieving sustainability, livability, and affordability goals (Grant, 2009; Knaap & Talen, 2005). However, the relationship

Why is there an implementation gap in community energy planning?

between densification on the one hand and energy use and emissions on the other is nuanced. Many studies have found evidence of negative correlations between urban density — the number of inhabitants per unit land area — and per capita energy use and emissions in buildings and personal transportation (Ewing & Rong, 2008; Larivière & LaFrance, 1999; Lee & Lee, 2014; Liu et al., 2017; Norman et al., 2006; Mindali et al., 2004). However, the strengths of these interactions are still subject to much debate (Gudipudi et al., 2016). These relationships appear to be highly context-specific, and the effects of densification—the process of increasing density over time—are not well understood, particularly in low-density suburban neighbourhoods. Density alone does not tend to have large personal transportation energy use and emissions effects (Kim & Brownstone, 2013). Instead, research finds that increases in density needs to be paired with mixed-use development and improved public transit and active transportation infrastructure for meaningful reductions in energy use and emissions to result.

In June 2018, Vancouver brought forward its *Making Room* Housing Program, a strategy for densifying low-density residential neighbourhoods within its borders. Although the city is well-known for its high-density, transit-friendly urban core, over 50 percent of its land area is comprised of low-density single-family detached home neighbourhoods. *Making Room* aims to change the composition of these neighbourhoods by fostering medium-density housing options within the city, including triplexes, quadplexes, sixplexes, row houses, and low-rise apartments, among others (City of Vancouver, 2018). Although Vancouver's rationale for *Making Room* is firmly rooted in housing availability and affordability, if the program's vision is met, the resultant change in urban density could have implications for the city's renewable energy and emissions reduction targets.

4.1. DENSIFICATION SCENARIO DEVELOPMENT

To explore the influence of residential densification on energy use and GHG emissions in Vancouver, we used an urban-level version of the CIMS energy-economy model to evaluate three hypothetical densification scenarios to 2050. These scenarios are intended to be illustrative rather than predictive and were chosen to show the effects of varying degrees of single-family neighbourhood densification. The densification scenarios differ in terms of what is built to replace a single-family detached home during stock turnover (i.e., when it is demolished).² In the first scenario, *Detached*, we assumed Vancouver's residential neighbourhoods will continue to evolve as they have over the past decade — when detached homes are demolished, they are predominantly replaced with detached homes. In the second and third scenarios, *Triplex* and *Sixplex*, these demolished homes are instead replaced with triplexes (three dwellings) and sixplexes (six dwellings) respectively.³ The rest of the sectors in the model, including the residential sector outside of Vancouver's single-family detached housing stock, evolve over time based on City of Vancouver, Metro Vancouver, and provincial and federal government growth projections. Across all three scenarios, Vancouver, Metro Vancouver, and senior government policies were included at their announced design and stringency levels as of 2018. We modelled implementation of only the first phase of Vancouver's *Zero Emissions Building Plan*, as full implementation was uncertain.

The *Triplex* and *Sixplex* scenarios are characterized by increased dwelling numbers and, therefore, increased population size relative to the *Detached* scenario. Using average dwelling occupancy data for Vancouver derived from Statistics Canada (2016), when a triplex replaces a detached home in the model, population increases according to the average occupancy of three triplex units minus the average occupancy of a detached home (and a

² For additional data and assumptions used to inform the densification scenarios, see Pardy (2018). This source also documents inputs and assumptions that are common across all scenarios.

³ Most single-family homes in Vancouver were built at a floor area ratio (FAR) of 0.6. In the *Triplex* scenario it is assumed new triplexes are built to maximize a 0.9 FAR, and in the *Sixplex* scenario it is assumed new sixplexes are built to maximize a 1.5 FAR.

Why is there an implementation gap in community energy planning?

secondary suite when applicable). Population increases in a similar manner for new sixplexes. In 2050, relative to *Detached*, *Triplex* has a population 10 percent larger and *Sixplex* has a population 34 percent larger. This population effect increases city-wide population density from 77 people per hectare in *Detached* to 85 people per hectare in *Triplex* and 103 people per hectare in *Sixplex*. In the model, population growth influences growth in three other sectors: commercial buildings, light and medium freight transportation, and personal transportation. Activity in these sectors grows proportionally to population, except for personal transportation activity, which grows slightly slower than population to account for constrained traffic growth within a land-constrained city.

4.2. THE INFLUENCE OF DENSIFICATION ON CITY-WIDE ENERGY USE AND EMISSIONS

In Figure 2, we present GHG emissions in Vancouver under the densification scenarios (also

Figure 2. GHG emissions in Vancouver under densification scenarios with and without additional policies and actions to promote transportation mode shifting (MS = ModeShift)

(Source: Adapted from Pardy (2018), Figure 7.)

Note: The analysis presented here differs somewhat in terms of coverage and assumptions from the one presented in section 3. To avoid confusion resulting from different reference case trajectories, results for the other densification scenarios are therefore presented relative to *Detached* in the figure.

shown are the results of adding a transportation mode shift sub-scenario +*ModeShift*, as discussed in sub-section 4.3). The greater numbers of dwellings and higher populations in the *Triplex* and *Sixplex* scenarios drive up energy consumption and GHG emissions in the model over time relative to the *Detached* scenario.⁴ This occurs as population growth drives greater demand for energy services in transportation and buildings, leading to greater energy use. By 2050, emissions in *Triplex* are seven percent higher than *Detached* and emissions in *Sixplex* are 24 percent higher. Emissions rise through increased gasoline and diesel consumption to supply higher levels of personal and freight transportation and increased natural gas consumption to supply higher levels of residential and commercial energy services. While new triplexes and sixplexes are more efficient than new detached homes, they do not lead to significant energy switching under the reference case, which in this analysis includes only the first phase of Vancouver's *Zero Emissions Building Plan*. In the model, the relatively low retail price of natural gas combined with the higher financial and intangible costs of electric heating systems lead to natural gas continuing to dominate the home heating market, regardless of building form. Because energy switching is not a factor, emissions per unit of energy consumption changes very little in *Triplex* and *Sixplex* relative to *Detached*.

The denser neighbourhoods modelled in the *Triplex* and *Sixplex* scenarios contain more dwellings per unit land area, increasing residential sector energy use. Although the denser building forms in the *Triplex* and *Sixplex* scenarios have improved thermal performance (due to shared walls) relative to their *Detached* counterparts, these efficiency gains are not enough to overcome the increase in total residential floor space per lot. While triplexes and sixplexes have less floor space than detached homes on a per dwelling basis, triplex and sixplex buildings have significantly higher floor space than detached homes. The energy required to light and

⁴ As in the analysis presented in section 3, we report only emissions from end-use fossil fuel consumption within Vancouver.

Why is there an implementation gap in community energy planning?

heat these additional square metres counteracts the efficiency gains of these denser building forms.

4.3. TRANSPORTATION MODE SHIFT SUB-SCENARIO

The *Triplex* and *Sixplex* scenarios represent densification without any coordinated mixed-use development, public transit and active transportation network improvements, or accelerated road congestion feedbacks. In the densification scenarios, the increase in residential density relative to *Detached* therefore has no influence on per capita personal travel demand and mode shares. While this basis for the scenarios is likely not realistic, it demonstrates densification's effect on building energy use and emissions and provides a conservative baseline for densification's effect on city-wide energy use and emissions.

Population growth and the densifying of an area, however, can provide the impetus for improved transportation networks and new commercial areas by stimulating demand and helping local governments fund such development. It is likely that densification under *Making Room* would be paired with transportation improvements and additional commercial areas along corridors, although the degree to which is uncertain. To evaluate emissions and energy use under a scenario where densification does influence mode shifting, we applied a transportation mode shift sub-scenario (*+ModeShift*) to the *Triplex* and *Sixplex* scenarios. In this sub-scenario, transportation mode shares shift over time to meet Vancouver's *Transportation 2040* target of two-thirds of trips by transit, cycling, or walking by 2040 (City of Vancouver, 2012).⁵ As of 2017, slightly over 50 percent of trips in the city were by foot, bike, or transit (City of Vancouver, 2017).

The shift in travel demand towards public transit, cycling, and walking leads to substantially lower total emissions in *+ModeShift* scenarios (Figure 2) than in their density-only counterparts. Much of Vancouver's transit system runs on electricity, so shifts to transit result in reductions in fossil fuel use.

The results suggest that, if residential densification occurs as modelled in this study and key assumptions about densification's effect on other sectors hold true, density alone will not help Vancouver meet its 80 percent emissions reduction by 2050 target. However, if densification is paired with the transportation policies and actions simulated in *+ModeShift*, the simulations indicate that by 2050 Vancouver will be able to accommodate 90,000 additional people in the *Triplex* scenario, while producing slightly fewer total emissions than under the *Detached* scenario. Similarly, Vancouver would be able to accommodate 301,000 additional people in *Sixplex* while producing emissions slightly higher than the non-mode shift *Triplex* scenario. Thus, to help overcome the CEP implementation gap, local governments should not rely on densification alone to drive emissions reduction. Instead, this lever should be coordinated with improvements in zero-emissions public transit, cycling networks, and walkability to commercial areas. It is important to note that, if electric and plug-in hybrid electric vehicles gain higher market shares than modelled in this study, the emissions reduction effects of mode shifting would be less prominent.

5. SURVEY OF COMMUNITY ENERGY PRACTITIONERS

The modelling exercises described above suggest that cities may not have the jurisdictional authority to implement the policies necessary to reach their ambitious energy and GHG emissions targets. Here we describe a survey administered through the Community Energy Knowledge Action Partnership (CEKAP) to explore other factors that may be contributing to the implementation gap including municipal government expertise, policy development and implementation capacity, and political will.

CEKAP is a project that aims to explore the challenges to and opportunities of CEP in Canada. At its core is a network of partners consisting of academic groups, governments, civil society groups, and other community energy practitioners. The

⁵ The specific assumptions used to simulate the *+ModeShift* sub-scenario are provided by Pardy (2018).

Why is there an implementation gap in community energy planning?

research group that we are affiliated with is one of the academic partners on this project. In the fall of 2017, CEKAP hosted a series of half-day workshops across Canada to explore the use of analytical tools for CEP, including energy-economy models, Geographic Information Systems (GIS), and cost benefit analysis tools. The goal was to share expertise across the partnership, while engaging in conversation about how analytical tools might be improved to support decision-making in the CEP process from target-setting to implementation.

We followed up the workshops with a Canada-wide survey targeted at community energy practitioners. The survey focused on practitioners' use of analytical tools in their field. While 'analytical tool' is a term that can be applied very broadly, in this case we use it to describe a process or method that can be used to perform an evaluation of a policy option. In administering the survey, our objective was to explore if and how such tools are currently used and understood. Our survey questions did not describe specific policies or programs related to community energy, nor did they presume that some of these policies perform better than others.

5.1. SURVEY METHODS

The survey consisted of 25 questions regarding respondents' use and perception of analytical tools in their professional experience. The questions were developed intuitively based on our expertise and that of a subgroup of the CEKAP project leads to explore ideas about the role of other factors besides jurisdictional limitations in perpetuating the implementation gap. Rather than being a strictly academic exercise, our intent was also to provide information that would be of interest and/or value to practitioners themselves.

The survey contained a mix of close- and open-ended questions. The latter allowed for detailed qualitative responses. Given the exploratory nature of the survey, these open-ended questions were appropriate as a means of gathering information from a highly specialized pool of respondents. The close-ended questions were designed to capture

general trends and levels of knowledge of the respondents before delving deeper into specific areas. Generally, each close-ended question or grouping of themed close-ended questions was accompanied by an open-ended question allowing respondents to expand on their answers. A copy of the survey questionnaire is included as Appendix A.

The target sample was community energy practitioners in Canada, with an emphasis on those working at or with local governments. For the purposes of this study, we have defined a community energy practitioner as someone who is professionally involved with local level energy policy. By limiting the sample to this group, we aimed to provide high quality observations that are reflective of those working in CEP. Respondents were recruited through the CEKAP network via an email that solicited voluntary participants, who were offered a copy of the results report as an incentive to complete the survey.

The survey was administered over a period of about seven weeks. It was hosted online through the Qualtrix platform, with a web link circulated to participants. The invitation to complete the survey was sent to approximately 100 partners. The survey itself was initiated by 27 people and 15 of them completed all the questions. The 15 complete sets of responses is a small but meaningful sample, as the pool of Canadian community energy practitioners who have experience with analytical tools is fairly small. Eight of the 15 respondents who completed all the questions were community energy practitioners who worked at local governments, overwhelmingly in Ontario. Considering the low number of respondents in this category, all 15 complete sets of responses were analyzed. The other respondents included one individual who worked at each of the following: a consultancy, a non-profit, an environmental group, a university, a conservation authority, and a not-for-profit. There was also one respondent who identified as an independent. Given the small set of responses, the data is best suited for exploratory analysis.

Why is there an implementation gap in community energy planning?

5.2. KEY SURVEY RESULTS

In our discussion below, we provide quantitative results for the close-ended questions and qualitative summaries of the responses to the open-ended questions.⁶ In some cases, we also highlight specific examples of responses to the open-ended questions. We selected these responses to illustrate a trend we identified in the results or to communicate a unique insight. Given the small sample size, we did not undertake any coding, categorization, or other detailed qualitative analysis of the open-ended questions.

Experience with analytical tools

Experience with analytical tools was addressed in the survey as follows:

An analytical tool can be anything (a method, a type of software) used to perform analysis. Examples of tools commonly used in community energy planning include energy-economy models (e.g. CIMS), spatial tools (e.g. GIS), and cost benefit analysis. Please keep this in mind as you complete the survey.

*Have you or the organization that you work for used an analytical tool to **measure or evaluate** the performance of policies or programs related to community energy?*

☐ Yes, I/we have used the following tool(s):

☐ No

Over half of the respondents had no experience with analytical tools as defined above, with only 45 percent reporting that they have used an analytical tool to measure or evaluate the performance of policies or programs related to community energy. Of those that responded they had used tools for this purpose, GIS tools were most reported as being used (55 percent of those who had used tools). Other types of tools used by respondents include

spreadsheets tracking energy consumption or used to create inventories of GHG emissions, cost-based tools, and simulation or forecasting tools. Twenty-five percent of all respondents reported having used energy-economy models such as CIMS. Given the limited sample, these numbers are not necessarily representative of all community energy practitioners in Canada, but they do provide some context for responses to the rest of the survey questions.

Factors influencing use of results from analytical tools

We asked respondents to identify factors that influence whether the results of an analytical evaluation of a community energy policy or program are likely to affect future decisions on community energy initiatives. Respondents were given a list of potential factors, of which they could select more than one. They were also given the opportunity to add to the list and to elaborate on their answer in the accompanying open-ended question. Financial resources and political context were identified as influencing factors by most respondents, though there was quite a variety in the factors that respondents selected (Figure 3).

Figure 3. Number of respondents that selected the above factors as influencing whether the results of an evaluation of a community energy policy or program are likely to affect future decisions on community energy initiatives in their jurisdiction. (Source: Braglewicz (2018), Figure 10.)

⁶ Braglewicz (2018) contains a detailed discussion of the survey results.

Why is there an implementation gap in community energy planning?

Detailed responses to the open-ended question show that while tools bring capacity to the planning process, they do relatively little to fill the capacity deficit in implementation. Results of analytical tools are only one factor, albeit an important one, in shaping CEP outcomes and implementation. As one respondent noted, “It often seems that political and time constraint factors are more important than the quality of results.” Another suggested that:

Moving beyond awareness raising and communications activities requires a lot of time and money, both of which are in short supply within municipal government. The analysis tells us what we need to do, but there is a lack of resources to actually implement policies to achieve what the analysis suggests.

Level of trust in analytical tools

In spite of their limited experience with tools, respondents generally indicated a trusting or neutral attitude towards the results of analytical processes. When asked how respondents would rate their level of trust in these results, 40 percent indicated “Somewhat high” and 40 percent indicated “Neutral” (20 percent were not sure). No one responded that they have “Very high,” “Somewhat low” or “Very low” trust in results from tools. In a similar format to the question described in the previous sub-section on use of results, respondents were then provided with a list of factors that could influence their level of trust in the use of analytical tools and asked to select those that apply. According to the responses, key factors influencing levels of trust were previous experience, the respondent’s level of knowledge, and the person or organization that uses the tools (Figure 4). Respondents also indicated that the assumptions or data informing the tool affects their level of trust.

Although no respondents indicated that they distrust analytical tools outright, qualitative explanations given in response to the accompanying open-ended question suggest that trust is dependent on the specific situation or case. For instance, one respondent indicated that “an analytical tool or model is only as good as the assumptions that go

into it,” echoing a common sentiment that model results can be challenged in terms of the strength of the model itself but also in terms of the strength of the presumptions made by the model builders and the modellers. This view was shared by another respondent, who expressed that their concerns regarding the use of tools “is less about the tools, and more about the operators.”

Figure 4: Number of respondents that selected the above factors as influencing their level of trust in analytical tools.

(Source: Braglewicz (2018), Figure 11.)

Perceived usefulness of tools

All respondents found tools to be “Always or almost always useful,” or “Sometimes useful” in garnering council support. This indicates the high political value of analytical tools. The perceived usefulness of tools in garnering public support or communicating internally was not as strong, though the majority (73 percent) found them to be “Sometimes useful” or “Always or almost always useful.”

According to many respondents, the results of analyses can provide a solid starting point for discussion. One noted that “Being able to “show your math” . . . sets a high standard for discourse on topics.” Another also weighed in on this theme:

Council participation in a workshop enables long term support for the plan in addition to understanding the potential impacts of actions. While communities are often disappointed in

Why is there an implementation gap in community energy planning?

the low impact of the 'easier' actions, it serves the purpose of capacity building for key players and allows them to get started on achieving and reporting on their GHG emission reduction targets that they were required by the province to include in . . . their community plans.

However, other respondents identified limits to how useful tools may be. One noted that political and social challenges are often left unanswered through an analytical process using a tool:

In my (limited) experience, the analytical tools tell us what the long-term game is, but don't help us answer the near-term questions of how we overcome the political and public resistance to changing the status quo. So, the analysis tells us that it is technically possible to achieve low emissions, etc., but provides no intelligence on the social/political pathway to actually realizing it. That isn't a concern with analytical tools per se, but just a limitation in terms of their usefulness.

Respondents also noted that the usefulness of tools varies depending on the audience. One observed that "The results of analytical tools are most helpful in communicating to staff and other technical experts. Politicians and general public are much more likely to reject analytics if the information presented differs from their philosophies and perceptions of the issue." This comment was reflected by another participant, who responded that "If a tool and its output is [sic] complicated, councils and the public will not understand. Case studies work better (what another, similar community has experienced)." These responses suggest that the effective communication of results from policy evaluations is critical in determining the impact that such studies can have.

5.3. INSIGHTS FROM THE SURVEY

The survey results provide a glimpse into the challenges facing community energy practitioners. On the one hand, respondents acknowledged the usefulness and, in some cases, the necessity of using

analytical tools to create a solid foundation for discussing policies to achieve community energy goals. On the other hand, practitioners expressed that the results of using a tool to evaluate policies are often not enough, on their own, to drive the required changes. This challenge relates to the implementation gap and suggests that, while policy evaluation exercises such as the ones we reported on in previous sections are necessary, they are also insufficient for the successful execution of community energy policy.

The responses point to some potential issues in using the results of energy and GHG analytical tools in a municipal context. The generally high or neutral level of trust in and perceived usefulness of these tools is encouraging. However, if combined with low staff expertise and capacity, these factors could lead to acceptance of results even in cases where the methods are questionable. Additional research might provide more definitive information on the relationship between trust, perceived usefulness, and interpretation of policy evaluation results.

Many respondents indicated a healthy skepticism of modelling assumptions and inputs, which could help to avoid the problem described above. However, it is challenging for non-experts to clearly identify specific issues and their implications for the results of a policy evaluation. Therefore, it is important that modellers are effective in delivering the key messages of their analyses while also making clear the assumptions and limitations of their work. At the same time, they must strike the right balance between communicating uncertainty and undermining confidence in the results.

The findings from our survey suggest that there are substantial barriers to implementing effective energy and GHG policy at the city level. While some of these barriers face other levels of government as well – rapidly changing political priorities and difficulty in implementing unpopular policies, for example – others are either unique to local governments or present a somewhat different challenge. Resource constraints such as time, money, and capacity to interpret and communicate

Why is there an implementation gap in community energy planning?

results were all identified as factors affecting the implementation of policy recommendations generated through the application of an analytical tool. Given the smaller support staff of cities compared to provincial or federal government departments, these constraints would likely affect local governments the most. Further research that explores how internal capacity limitations and political barriers affect local governments as compared to provincial and federal governments could provide valuable insights.

6. CONCLUSIONS

In this article, we have described three strands of research that probe the implementation gap in CEP by exploring the potential for cities to achieve ambitious GHG emissions reduction and renewable energy targets. The findings from all three point to one conclusion. While cities may have an important role in achieving such targets, the jurisdictional and capacity limitations of local governments mean that other levels of government should also be involved to make success possible. Cities that wish to be a catalyst for deep decarbonization may be most effective if they partner with or seek support from senior levels of government. They may also be instrumental in increasing political pressure on senior government to provide greater policy support in areas that are beyond the jurisdictional reach of cities.

We used CIMS-Urban – an urban-level energy-economy model with spatial capabilities – to examine the potential for the City of Vancouver to meet its targets of 100 percent renewable energy and an 80 percent reduction in GHG emissions by 2050. CIMS-Urban is unique in that it portrays how spatial relationships affect human behaviour within a framework that allows for simulation of the interactions between policies implemented at different levels of government. Subsequent versions of the model will see improvements in two key areas: 1) the ability of the model to capture the spatial impacts of increasing population density and mixed-use development on transportation demand and mode choice, and 2) the empirical basis for its behavioural parameters. However, based on

sensitivity analyses that we have conducted during the work reported here, as well as other projects, these changes are not expected to alter the broad conclusions discussed below.

The CIMS-Urban simulations for Vancouver reported in this article indicate that the city can make significant progress towards its aggressive targets by implementing policies that are clearly within its jurisdiction. However, Vancouver will need to be both creative and jurisdictionally aggressive if it is to make a credible effort to achieve the announced targets, and it is unlikely to succeed without additional support from higher levels of government. These findings suggest that jurisdictional reach is an important contributor to the implementation gap. Cities that do not share Vancouver's track record of environmental leadership, supportive electorate, access to zero-emissions electricity, and sufficient population density to make public transit viable face additional challenges. While it may be theoretically possible for some cities to achieve deep GHG emissions reductions and a switch to renewable energy on their own, this appears to be unlikely. Therefore, senior levels of government must also enact stringent GHG policies if the ambitious, mid-century targets announced by cities are to be achieved.

Increasing population density is often recommended to enhance the social and environmental performance of urban areas. Higher density development is believed to reduce per capita energy consumption and GHG emissions in both the residential and personal transportation sectors. And policies that promote urban density tend to be within the jurisdiction of municipal governments. However, in an application of the CIMS model to the City of Vancouver, we found that – in the absence of significant mode shifting in personal transportation – the increased population we assumed would accompany higher density overwhelms per capita reductions in energy and emissions, making it more difficult for the city to reach its targets. We expect that this impact of densification would be counteracted by reduced

Why is there an implementation gap in community energy planning?

population growth and urban sprawl in the surrounding suburbs. However, accounting for such interactions would require analysis and target setting at the regional level, again suggesting that involvement of higher levels of government may be necessary.

Our finding that densification accompanied by a corresponding increase in population can lead to higher GHG emissions is relevant to other cities in Canada and beyond, except in cases where GHGs from buildings and transportation are already being driven to very low levels by senior government policy, such as zero-emissions building and vehicle regulations. In such cases, densification would likely not be pursued to reduce GHGs, but could be attractive for other reasons, such as preserving green space and achieving health benefits. It is important to note that, unlike Vancouver, most local governments in Canada do not have jurisdiction over their building codes, which instead fall under provincial jurisdiction, and that cities (including Vancouver) tend to lack the authority to regulate vehicle energy choices.

Our survey of community energy practitioners looks beyond the jurisdictional limitations of local governments to examine other factors contributing to the implementation gap. Though the survey results are exploratory in nature due to the limited sample size, they suggest that even when legitimate policy evaluation exercises point to the policies that are most likely to help cities achieve their objectives, substantial barriers to implementing these policies remain. While some of these challenges are faced by senior levels of government as well, others are either unique to local governments or present a different angle at the municipal level. Resource constraints such as time, money, and capacity to interpret and communicate results were all identified as factors affecting the implementation of policy recommendations.

ACKNOWLEDGMENTS

We are grateful to Dr. Kirby Calvert (President, Co-Mapping Solutions Inc) and Ian McVey (Manager of Sustainability, Region of Durham) for assistance in survey design and administration. We are also thankful to Michael Wolinetz (Partner, Navius Research) for research support and to Bradford Griffin (Executive Director, CEEDC, SFU) for feedback during model development, simulation, and analysis.

Financial support for the conduct of the research described in this article and for the preparation of the article itself was provided by the Pacific Institute for Climate Solutions (PICS; grant number 36170-50280), the Social Sciences and Humanities Research Council (SSHRC; individual funding for A. Pardy, M. Braglewicz, and B. Zuehlke), the Community Energy Knowledge - Action Partnership (CEKAP; funded through SSHRC [grant number 890-2015-0008]), and Simon Fraser University (SFU).

NOTE ON CONTRIBUTIONS

Rose Murphy holds a PhD from the School of Resource and Environmental Management at SFU, where she is currently a senior research associate.

Aaron Pardy is a PhD student in the School of Resource and Environmental Management at SFU. In his PhD, Aaron is assessing policies aimed at decarbonizing buildings and personal transportation.

Morgan Braglewicz holds a Masters in Resource Management from SFU and is currently a senior climate change policy and planning analyst at the Metro Vancouver Regional District.

Brett Zeuhlke holds a Masters in Resource Management from SFU and works as a climate policy researcher at Navius Research in Vancouver

Mark Jaccard is Distinguished Professor and Director of the School of Resource and Environmental Management at SFU, and a member of the Royal Society of Canada.

Why is there an implementation gap in community energy planning?

CORRESPONDING AUTHOR

Rose Murphy
School of Resource and Environmental
Management
Simon Fraser University
8888 University Drive, Burnaby, BC V5A 1S6
Email: remurphy@sfu.ca

REFERENCES

- Agar, B., & Renner, M. (2016). Is 100 Percent Renewable Energy in Cities Possible? In *State of the World: Can a City Be Sustainable?* (pp. 161–170). Washington, DC: Island Press. https://doi.org/10.5822/978-1-61091-756-8_13
- Badoe, D. A., & Miller, E. J. (2000). Transportation–land-use interaction: Empirical findings in North America, and their implications for modeling. *Transportation Research Part D: Transport and Environment*, 5(4), 235–263. [https://doi.org/10.1016/S1361-9209\(99\)00036-X](https://doi.org/10.1016/S1361-9209(99)00036-X)
- BC Stats. (2016). [Population Projections](#).
- Betsill, M., & Bulkeley, H. (2007). Looking Back and Thinking Ahead: A Decade of Cities and Climate Change Research. *Local Environment*, 12(5), 447–456. <https://doi.org/10.1080/13549830701659683>
- Bloomberg Philanthropies. (2018). [Sustainable Cities](#).
- Braglewicz, M. (2018). *Policy Makers or Policy Takers: How Can Cities Contribute to Reducing Greenhouse Gas Emissions?* (Unpublished Master's Project). Simon Fraser University, Burnaby, BC.
- City of Vancouver. (2012). [Transportation 2040](#). Vancouver, BC: City of Vancouver.
- City of Vancouver. (2015). [Renewable City Strategy](#). Vancouver, BC: City of Vancouver.
- City of Vancouver. (2016). [Zero Emissions Building Plan](#) (Policy Report No. RTS 1195). Vancouver, BC: City of Vancouver.
- City of Vancouver. (2017). *Renewable City Action Plan*. Vancouver, BC: City of Vancouver.
- City of Vancouver. (2018). *Making Room Housing Program*. Vancouver, BC: City of Vancouver.
- City of Vancouver. (2019). [Greenest City 2020 Action Plan: 2018-2019 Implementation Update](#). Vancouver, BC: City of Vancouver.
- City of Vancouver. (2020). [Climate Emergency Action Plan](#) (Report to Council No. RTS 13199). Vancouver, BC.
- Corfee-Morlot, J., Kamal-Chaoui, L., Donovan, M. G., Cochran, I., Robert, A., & Teasdale, P.-J. (2009). *Cities, Climate Change and Multilevel Governance*. OECD Environmental Working Papers 14. Paris: OECD Publishing. <https://doi.org/10.1787/220062444715>
- Ewing, R., & Rong, F. (2008). The impact of urban form on U.S. residential energy use. *Housing Policy Debate*, 19(1), 1–30. <https://doi.org/10.1080/10511482.2008.9521624>
- Government of Canada. (2020, November 19). [Net-zero Emissions by 2050](#).
- Grant, J. L. (2009). Theory and Practice in Planning the Suburbs: Challenges to Implementing New Urbanism, Smart Growth, and Sustainability Principles. *Planning Theory & Practice*, 10(1), 11–33. <https://doi.org/10.1080/14649350802661683>
- Gudipudi, R., Fluschnik, T., Ros, A. G. C., Walther, C., & Kropp, J. P. (2016). City density and CO2 efficiency. *Energy Policy*, 91, 352–361. <https://doi.org/10.1016/j.enpol.2016.01.015>
- Hachem, C. (2016). Impact of neighborhood design on energy performance and GHG emissions. *Applied Energy*, 177, 422–434. <https://doi.org/10.1016/j.apenergy.2016.05.117>
- Hughes, S. (2017). The Politics of Urban Climate Change Policy: Toward a Research Agenda. *Urban Affairs Review*, 53(2), 362–380. <https://doi.org/10.1177/1078087416649756>
- Jaccard, M. (2009). Combining Top Down and Bottom Up in Energy Economy Models. In J. Evans & L. C. Hunt (Eds.), *International Handbook on the Economics of Energy* (pp. 311–331). Cheltenham, UK: Edward Elgar. Retrieved from https://ideas.repec.org/h/elg/eechap/12764_13.html
- Jaccard, M., Failing, L., & Berry, T. (1997). From equipment to infrastructure: Community energy management and greenhouse gas emission reduction. *Energy Policy*, 25(13), 1065–1074. [https://doi.org/10.1016/S0301-4215\(97\)00091-8](https://doi.org/10.1016/S0301-4215(97)00091-8)
- Jaccard, M., Murphy, R., Zuehlke, B., & Braglewicz, M. (2019). Cities and greenhouse gas reduction: Policy makers or policy takers? *Energy Policy*, 134, 110875. <https://doi.org/10.1016/j.enpol.2019.07.011>
- Jaccard, M., Nyboer, J., Bataille, C., & Sadownik, B. (2003). Modeling the Cost of Climate Policy: Distinguishing Between Alternative Cost Definitions and Long-Run Cost Dynamics. *The Energy Journal*, 24(1). <https://doi.org/10.5547/ISSN0195-6574-EJ-Vol24-No1-3>
- Kim, J., & Brownstone, D. (2013). The impact of residential density on vehicle usage and fuel consumption: Evidence from national samples. *Energy Economics*, 40, 196–206. <https://doi.org/10.1016/j.eneco.2013.06.012>
- Knaap, G., & Talen, E. (2005). New Urbanism and Smart

Why is there an implementation gap in community energy planning?

- Growth: A Few Words from the Academy. *International Regional Science Review*, 28(2), 107–118. <https://doi.org/10.1177/0160017604273621>
- Krause, R. M. (2011). Symbolic or Substantive Policy? Measuring the Extent of Local Commitment to Climate Protection. *Environment and Planning C: Government and Policy*, 29(1), 46–62. <https://doi.org/10.1068/c09185>
- Larivière, I., & Lafrance, G. (1999). Modelling the electricity consumption of cities: Effect of urban density. *Energy Economics*, 21(1), 53–66. [https://doi.org/10.1016/S0140-9883\(98\)00007-3](https://doi.org/10.1016/S0140-9883(98)00007-3)
- Lee, S., & Lee, B. (2014). The influence of urban form on GHG emissions in the U.S. household sector. *Energy Policy*, 68, 534–549. <https://doi.org/10.1016/j.enpol.2014.01.024>
- Littlejohn, D., & Laszlo, R. (2015). *National report on community energy plan implementation*. QUEST Canada.
- Liu, Y., Gao, C., & Lu, Y. (2017). The impact of urbanization on GHG emissions in China: The role of population density. *Journal of Cleaner Production*, 157, 299–309. <https://doi.org/10.1016/j.jclepro.2017.04.138>
- Mindali, O., Raveh, A., & Salomon, I. (2004). Urban density and energy consumption: A new look at old statistics. *Transportation Research Part A: Policy and Practice*, 38(2), 143–162. <https://doi.org/10.1016/j.tra.2003.10.004>
- Murphy, R., & Jaccard, M. (2011). Energy efficiency and the cost of GHG abatement: A comparison of bottom-up and hybrid models for the US. *Energy Policy*, 39(11), 7146–7155. <https://doi.org/10.1016/j.enpol.2011.08.033>
- Norman, J., MacLean, H. L., & Kennedy, C. A. (2006). Comparing High and Low Residential Density: Life-Cycle Analysis of Energy Use and Greenhouse Gas Emissions. *Journal of Urban Planning and Development*, 132(1), 10–21. [https://doi.org/10.1061/\(ASCE\)0733-9488\(2006\)132:1\(10\)](https://doi.org/10.1061/(ASCE)0733-9488(2006)132:1(10))
- Pardy, A. (2018). *Densification of Vancouver's Neighbourhoods: Energy Use, Emissions, and Affordability* (Unpublished Master's Project). Simon Fraser University, Burnaby, BC.
- Rivers, N., & Jaccard, M. (2006). Useful models for simulating policies to induce technological change. *Energy Policy*, 34(15), 2038–2047. <https://doi.org/10.1016/j.enpol.2005.02.003>
- Ryan, D. (2015). From commitment to action: A literature review on climate policy implementation at city level. *Climatic Change*, 131(4), 519–529. <https://doi.org/10.1007/s10584-015-1402-6>
- Sharp, E. B., Daley, D. M., & Lynch, M. S. (2011). Understanding Local Adoption and Implementation of Climate Change Mitigation Policy. *Urban Affairs Review*, 47(3), 433–457. <https://doi.org/10.1177/1078087410392348>
- Sierra Club. (2018). *2018 Case Study Report: Cities are Ready for 100% Clean Energy*. Oakland, CA: Sierra Club National.
- Statistics Canada. (2016). *Structural Type of Dwelling (10) and Household Size (8) for Occupied Private Dwellings of Canada, Provinces and Territories, Census Metropolitan Areas and Census Agglomerations, 2016 Census—100% Data*.
- Zuehlke, B. (2017). *Vancouver's Renewable City Strategy: Economic and Policy Analysis* (Unpublished Master's Project). Simon Fraser University, Burnaby, BC.
- Zuehlke, B., Jaccard, M., & Murphy, R. (2017). *Can Cities Really Make a Difference? Case of Vancouver's Renewable City Strategy*. Burnaby, BC: Energy & Materials Research Group, Simon Fraser University.

Why is there an implementation gap in community energy planning?

APPENDIX A: SURVEY QUESTIONNAIRE

CEKAP: Retooling Community Energy Survey

Start of Block: Welcome

Q1 Welcome to our survey, 'Retooling Community Energy.' The purpose of this survey is to get information on how professionals working in the field of community energy use analytical tools. With this information, we hope to gain some insight in to how tools have been used, and how tools could be better designed to meet the needs of professionals. We plan to share the results of this survey with those who respond so that those in working in the field can benefit from this information.

The Community Energy Knowledge Action Partnership (CEKAP) is administering this survey through the Energy and Materials Research Group (EMRG) at Simon Fraser University as part of a three-year project that aims to remove the barriers to and improve implementation of community energy policy and programs in Canada. This survey focuses on the use of analytical tools to improve implementation.

For more information on CEKAP and EMRG, please follow the links below:

CEKAP: www.cekap.ca

EMRG: www.emrg.sfu.ca

End of Block: Welcome

Start of Block: Consent Page

Q2 Survey Consent Form Retooling Community Energy in Canada: Survey

Who is conducting this survey? This survey is being administered by Morgan Braglewicz, a graduate researcher at Simon Fraser University. The survey is part of the Community Energy Knowledge Action Partnership, a three-year research project that aims to remove barriers to the implementation of community energy initiatives in Canada funded by the Social Sciences and Humanities Research Council of Canada.

This survey consists of five sections of questions on the use of analytical tools in community energy planning, and should take roughly 20 - 30 minutes to complete.

Why should you complete this survey? As part of the project, we will be using the results of this survey to produce a report on the use of analytical tools in community energy planning in Canada. The report will help disseminate information on the use of analytical tools across Canada, benefiting community energy professionals by expanding their knowledge base.

This report will be shared with CEKAP project partners and survey participants. This report or others may also be shared externally with a wider audience, either as a semi-public report or publication in an academic journal, or in a master's thesis.

How will the results be stored and used? The survey results will be uploaded to SFU Radar, an online repository, and maintained indefinitely. The information uploaded to the repository will be anonymized, with all identifying information removed. The full set of responses with consent information will be kept in a secure digital location for two years, only accessible to CEKAP project researchers via password protected computers. After two years, consent information with identifying details will be destroyed. Results will be shared outside of project leadership in the form of a report or thesis as mentioned above. As part of the survey, we will collect your name and contact information so that we can share the results of the survey with you. However, the results communicated in any reports will be anonymized and not attributed to a specific respondent (e.g. responses will be attributed to 'CEP Practitioner C' rather than to the name or workplace of an individual).

Consent to Participate Taking part in this study is entirely up to you. You have the right to refuse to participate in this study. If you decide to take part, you may choose to pull out of the study at any time without giving a reason and without any negative impact. In proceeding with this survey, your consent to the terms outlined above is implied. If at any point you wish to withdraw from the study, you may end your session. If you wish to remove your survey responses from the study, please contact the principle

Why is there an implementation gap in community energy planning?

investigator for the survey. Previously collected data will be destroyed unless it has already been released or published, or you give consent to continue to use your data. You may also request to view your own responses to the survey.

Q3 By clicking the box below and completing the survey, you are providing your consent to the terms outlined above.

- ☐ I consent to participate in this survey (1)

End of Block: Consent Page

Start of Block: Introductory Questions

Q4 Do you work for a municipal or local government?

- ☐ Yes (1)
- ☐ No, I work at: (2) _____

Q5 What is your role in the community energy planning process?

- ☐ Manager (1)
- ☐ Planner (2)
- ☐ Municipal analyst working on community energy planning (3)
- ☐ Consultant (4)
- ☐ Other (please specify) (5) _____

Q6 Please provide your contact information (e-mail address) so that we may share the results of the study with you:

End of Block: Introductory Questions

Start of Block: Analytical Tools for Evaluation

Q7 An analytical tool can be anything (a method, a type of software) used to perform analysis. Examples of tools commonly used in community energy planning include energy-economy models (e.g. CIMS), spatial tools (e.g. GIS), and cost benefit analysis. Please keep this in mind as you complete the survey.

Q8 Have you or the organization that you work for used an analytical tool to **measure or evaluate** the performance of policies or programs related to community energy?

- ☐ Yes, I/we have used the following tool(s): (1) _____
- ☐ No (2)

Q9 Have you or the organization that you work for used an energy-economy tool (e.g. CIMS, CityInSight, GHG Proof, etc.) to **measure or evaluate** the performance of policies or programs related to community energy?

- ☐ Yes, I/we have used the following tool(s): (1) _____
- ☐ No (2)

Display This Question:

If Have you or the organization that you work for used an analytical tool to measure or evaluate the... = Yes, I/we have used the following tool(s):

Q10 Please give at least one example of a case in which the results of using an analytical tool helped your organization **measure or evaluate** the outcome of an initiative, such as a policy or program, related to community energy. In your answer, please consider:

- What tool was used?
- What type of study or report has been completed?
- What types of results were produced?

Why is there an implementation gap in community energy planning?

- Who completed this work (e.g. was it completed in house or contracted out?)
- How were the results used?

Display This Question:

If Have you or the organization that you work for used an analytical tool to measure or evaluate the... = Yes, I/we have used the following tool(s):

Q11 Which of the following factors help to explain why the use of the tool **was** helpful in the example that you have provided? You may select more than one answer. Please feel free to add to the list.

- ☐ Time constraints (1)
- ☐ Financial resources (2)
- ☐ Knowledge (3)
- ☐ Political context (4)
- ☐ Ability to understand results (5)
- ☐ Ability to communicate results (6)
- ☐ Other factor(s): (7) _____

Display This Question:

If Have you or the organization that you work for used an analytical tool to measure or evaluate the... = Yes, I/we have used the following tool(s):

Q12 Which of the following factors help to explain why the use of the tool **was not** helpful in the example that you have provided? You may select more than one answer. Please feel free to add to the list.

- ☐ Time constraints (1)
- ☐ Financial resources (2)
- ☐ Knowledge/expertise (3)
- ☐ Political context (4)
- ☐ Ability to understand results (5)
- ☐ Ability to communicate results (6)
- ☐ Other factor(s): (7) _____

Display This Question:

If Have you or the organization that you work for used an analytical tool to measure or evaluate the... = Yes, I/we have used the following tool(s):

Q13 Please elaborate on how these factors affected the outcome of using the tool in your example.

Page Break

Why is there an implementation gap in community energy planning?

Q14 Which of the following factors influence whether or not the results of an evaluation of a community energy policy or program are likely to affect **future** decisions on community energy initiatives in your jurisdiction? You may select more than one answer. Please feel free to add to the list.

- ☐ Time constraints (1)
- ☐ Financial resources (2)
- ☐ Knowledge (3)
- ☐ Political context (4)
- ☐ Ability to understand results (5)
- ☐ Ability to communicate results (6)
- ☐ Other factor(s): (7) _____

Q15 Please elaborate.

End of Block: Analytical Tools for Evaluation

Start of Block: Trust in Tools

Q16 How would you rate your level of trust in results generated by an analytical tool?

Page Break

	Very high (1)	Somewhat high (2)	Neutral (3)	Somewhat low (4)	Very low (5)	I'm not sure (6)
I would rate my level of trust as: (1)	☐	☐	☐	☐	☐	☐

Q17 Which of the following factors influence your level of trust in the use of analytical tools, as you've indicated in the previous question? You may select more than one answer. Please feel free to add to the list.

- ☐ Previous experience (1)
- ☐ My level of knowledge (2)
- ☐ Political context (3)
- ☐ The person or organization who uses the tool (4)
- ☐ Other(s): (5) _____

Q18 Please elaborate on how the factors you have indicated in the previous question affect your level of trust in analytical tools.

Page Break

Why is there an implementation gap in community energy planning?

Q19 In your experience, to what extent are the results of using analytical tools useful in terms of:

	Always or almost always useful (1)	Sometimes useful (2)	Neither useful nor useless (3)	More often than not, they are not useful (4)	I never find them useful (5)	I don't have any experience with this (6)
Garnering council support (1)	☐	☐	☐	☐	☐	☐
Garnering public support (2)	☐	☐	☐	☐	☐	☐
Communicating with staff / other departments (3)	☐	☐	☐	☐	☐	☐

Q20 If you'd like to elaborate on any of your answers to the question above, please use this space to provide an explanation:

End of Block: Trust in Tools

Start of Block: Block 3

Q21 Have you encountered any questions/issues that you think should be answered through the use of a tool, but haven't been?

- ☐ Yes (1)
- ☐ No (2)

Display This Question:

If Have you encountered any questions/issues that you think should be answered through the use of a... = Yes

Q22 Please explain these questions/issues and how you think a tool might help address this gap.

Page Break

Q23 Have you observed any problems in the way that analytical tools are used or applied in the practice of community energy planning?

- ☐ Yes (1)
- ☐ No (2)

Display This Question:

If Have you observed any problems in the way that analytical tools are used or applied in the practi... = Yes

Q24 Please describe the problem(s) in the way that analytical tools are used or applied in the practice of community energy planning that you have encountered.

Page Break

Q25 In general, what concerns do you have regarding the use of analytical tools in community energy planning?

End of Block: Block 3