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POLICY, URBAN FORM, AND TOOLS FOR MEASURING AND MANAGING GREENHOUSE GAS EMISSIONS: THE NORTH AMERICAN PROBLEM

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The scale of intervention required to reduce and adapt to the effects of climate change will require action at all levels of government and society. International accords and some federal and state governments are beginning to address greenhouse gas reduction targets, but it is at the local level that most decisions about urban form are made. Yet, urban planners and local decision makers generally lack the tools and means needed to make informed choices about the climate change implications of local growth and redevelopment decisions or to measure the effects of their decisions. While a wide spectrum of tools currently exists, few have the capacity to work simultaneously at both the regional and local scale or to capture the multiple consequences of regulatory decisions. They generally lack the capacity to model the land-use–GHG relationship in a way that informs the policy process in real time.

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The Lincoln Institute of Land Policy and the Design Centre for Sustainability at the University of British Columbia have been engaged in surveying existing tools that support land-use policy and decision making in the context of climate change mitigation and urban planning at local and regional levels. To date, two international workshops have been held in Vancouver, an area at the forefront of mitigation policy for GHG emissions. The meetings brought together many of North America's leaders in tool development, policy implementation, and urban development regulation. Patrick M. Condon, Duncan Cavens, and Nicole Miller at UBC draw from those meetings and review the relationship between urban planning and GHG emissions as a key component of climate change. This paper provides characteristics of GHG decision support tools and evaluates the strengths and limitations of a cross section of existing tools using those characteristics.

INTRODUCTION

New state and provincial laws in the United States and Canada are demanding that cities reduce greenhouse gas ("GHG") emissions to specified levels within relatively short time frames. In British Columbia, for example, the Greenhouse Gas Reduction Targets Act requires the reduction of GHG emissions by at least 33 percent below 2007 levels by 2020 and by 80 percent below 2007 levels by 2050.[1] As a result, efforts by local governments are becoming increasingly important in the effort to meet GHG reduction targets. Recent studies commissioned by the province of British Columbia suggest that municipal and regional authorities control and influence over 40 percent of total provincial GHG emissions.[2] With this recognition, a number of city and regional planners are under

1. Greenhouse Gas Reduction Targets Act, 2007 S.B.C., ch. 42 *Can.). *See also* CAL. HEALTH & SAFETY CODE § 38550 (West 2006) (requiring a reduction in GHG emissions to 1990 levels by 2020); WASH. REV. CODE § 70.235.020 (2007) (requiring a reduction in GHG emissions to 1990 levels by 2020, 25 percent below 1990 levels by 2035, and 50 percent below 1990 levels by 2050).

2. JOTHAM PETERS ET AL., A QUANTITATIVE ANALYSIS OF SELECTED CLIMATE POLICIES IN BRITISH COLUMBIA 4 (July 25, 2008), *available at* http://www.llbc.leg.bc.ca/public/.../MKJA_Report_final_July_25_2008.pdf (quantifying the annual emissions reductions from additional policies relating to residential, commercial, and transportation sectors by 2020, based on results from the CIMS model).

new obligations to mitigate GHG emissions and to quantify the GHG impacts of their policy decisions.[3]

Part of the pressure to realize these goals is the increased level of integrated decision making that meeting these targets requires. At the scale of local government, the multiplicity of urban-form-related decisions[4] must be informed by a clear understanding of their contributions to, or competition with, higher level policy; this, unfortunately, is difficult to do and infrequently achieved. Local and regional planning processes must be robust enough to speak to decision makers engaged in various disciplines who manage efforts at different scales and who regulate different elements of public infrastructure or private enterprise (building code regulators, departments of transportation, etc.). This level of coordination in decision making at the policy level is presently uncommon, particularly in the United States where the rights of lower levels of government and private property are highly valued.

Most GHG emissions are linked at the local level to urban-form decisions—how streets, blocks, land uses, buildings, and infrastructure are arranged across regions, cities, and neighborhoods. Most critically, urban form greatly impacts transportation and building energy needs, which are predominantly met by GHG-intensive fuels.[5] Despite numerous studies on the GHG impacts of urban form, academics have not presented the available data in a way in which local governments can use it—that is, in a way that clearly translates land-use and development decisions into effective quantitative or qualitative measurements of GHG implications. As a consequence, future planners will need more information on the types and locations of urban forms they should be planning in order to meet the GHG reduction targets.

The Lincoln Institute of Land Policy has recognized the critical need to measure the influence of urban-form policy on GHG emissions for metropolitan regions in the United States and Canada. To address this issue, the Lincoln Institute, in collaboration with experts and representatives from many of North America's major cities, convened two meetings for policy

3. *See, e.g.*, CAL. HEALTH & SAFETY CODE § 38550; WASH. REV. CODE § 70.235.020; Greenhouse Gas Reduction Targets Act, 2007 S.B.C., ch. 42 (Can.).

4. Examples of urban-form-related decisions include official community plans, development guidelines, development permits, etc.

5. *See* REID EWING ET AL., GROWING COOLER: THE EVIDENCE ON URBAN DEVELOPMENT AND CLIMATE CHANGE 2, 9 (2008), *available at* http://postcarboncities.net/files/SGA_GrowingCooler9-18-07small.pdf.

makers in the Cascadia mega-region, an area that includes the coastal regions of Oregon and Washington and the highly urbanized southwestern corner of British Columbia.[6] At the first event, held in October 2007, leading technical experts and representatives from the three major Cascadia metropolitan areas—Portland, Seattle, and Vancouver—called for new tools and knowledge to support planning decisions and assist municipalities in meeting GHG reduction targets. At the second meeting, held in April 2008, these same experts and representatives began formulating a research agenda to develop such tools.

This Article furthers the conclusions initiated by the Lincoln meeting—that local governments need a new GHG modeling tool to analyze the effects of policy decisions across scales. Section I will review the current state of the policy and decision-making context in North America and discuss the implications of this process for developing GHG tools. Section II will consider the various scales of urban form, their interactions, and their impacts on GHG emissions. Sections III and IV will then examine current modeling approaches and some of the tools that are currently available. This Article will show that these tools have many beneficial characteristics but that they do not yet adequately address the current needs for information in the planning process. Finally, Section V will suggest some aspects of new tools that are desired.

I. POLICY AND THE DECISION-MAKING CONTEXT

Throughout North America, governments are taking action to reduce GHGs. This movement is particularly pronounced in the Cascadia region of the United States and Canada. There, two states and one province have approved legislation aimed at substantially reducing GHGs over the next fifty years.[7] Though these policy changes are impressive, little is known about how these targets are to be met. And even less is known about how the regulations will impact community design. As such, it is necessary to first consider the contextual problems underlying the GHG policy-making process.

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6. This region is currently at the forefront of North American climate change mitigation policy.

7. *See* OR. REV. STAT. § 468A.205 (2007); WASH. REV. CODE § 70.235.020 (2007); Greenhouse Gas Reduction Targets Act, 2007 S.B.C., ch. 42 (Can.).

One initial local government hurdle is that the United States and Canada have not developed a means to equitably distribute GHG reduction targets. How this allocation should proceed is debatable. For example, at two and a half times more GHG per capita consumption of urban dwellers, one might reasonably conclude that suburban communities should shoulder the largest burdens for reductions.[8] On the other hand, one might also argue that since inner city dwellers often have the advantage of transit and other key pieces of infrastructure, they have the greater capacity and responsibility for reductions. Whatever the outcome, this distributional issue is complicated by the challenges and opportunities of high-growth versus low-growth communities, as well as questions of per capita versus total reduction targets. In recognition of these and other problems, British Columbia plans to negotiate the equitable distribution of the GHG compliance burden on a municipality-by-municipality basis.

Outside the distribution problem, policy makers must also determine what capacity exists in communities for GHG reductions and what costs changes would generate—physically, socially, and economically. For example, it would be beneficial to know whether the gradual rebuilding of the suburbs as more complete, transit-friendly communities might eventually overcome car dependency. Policy makers also need to know how much the GHG reductions already achieved in center cities like Portland, Vancouver, and Seattle can be accelerated while also addressing political and economic issues. To answer these questions, a new tool is needed—likely one that builds on the currently available suite of GHG models and related methods. This tool's characteristics are described in the following section.

Little of the key information and data necessary to make sound, locally relevant policy decisions is easily accessible to policy makers or understandable to the public. This absence of information means that decision makers may have little awareness of the potential impacts of policy decisions on GHG emissions and can lead to a breakdown of the political process at the local level. Misunderstandings among the public can lead to political resistance, particularly when policy affects and is perceived to impact current lifestyles, such as the densification of existing neighborhoods. Addressing these challenges

8. Jonathan Norman et al., *Comparing High and Low Residential Density: Life-Cycle Analysis of Energy Use and Greenhouse Gas Emissions*, 132 J. URB. PLAN. & DEV. 10, 17 (2006).

requires understanding the current United States and Canadian policy decision-making processes. Although these socio-political processes are iterative and complex and vary by agency and location, a simplified model of the process, developed by the authors, provides a starting point.[9]

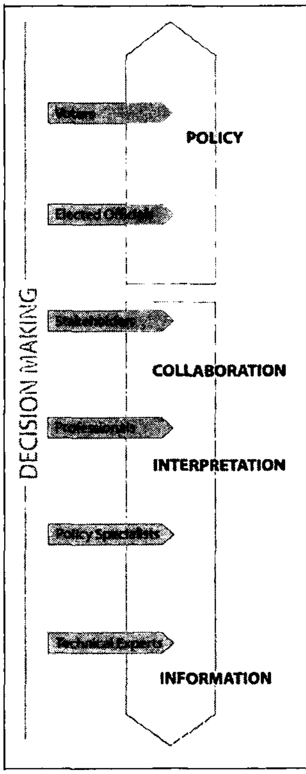
Planning decisions in the United States and Canada undergo a series of stages, moving from information gathering and processing, through interpretation and collaboration facilitated by a variety of experts, and finally to policy and implementation.[10] Diverse players participate and interact in this process, bringing with them a wide spectrum of interests, interpretations, and input. The actors involved in the various stages and scales of decision making often speak discipline-specific languages that create difficulties in communication.

As illustrated in Figure 1, the decision-making process begins with the information stage, where specialists must produce or assemble the data required to make informed decisions. The availability and quality of this data varies widely, particularly in terms of information on how local government planning decisions may impact GHG emissions. Second is the interpretation stage. In this stage, the technical nature of the data requires professional interpretation of the information for various stakeholders, elected officials, and the public. Consequently, limits in technical knowledge among staff, as well as personal or professional biases, may influence these interpretations. The collaboration stage builds on these interpretations—particularly through public processes that allow non-experts who are asked to use interpreted information to comment, and eventually vote, on decisions or decision makers.

9. *See infra* p. 983 fig.1.

10. *Id.*

Figure 1: Stages of Policy Decision Making



Policy: The regulatory and legislative actions made by authorized public officials (appointed or elected).

Collaboration: Decision making methods that bring together multiple parties, scales, jurisdictions, disciplines, and/or stakeholders towards the goal of formulating more integrated strategies and policies.

Interpretation: The analysis and explanation of relationships between information and the various alternative strategies, causes and consequences of decision-making. Interpretations can vary widely depending on available information and means of interpretation.

Information: The assembly of data describing past and present conditions in addition to projections on future conditions and/or the potential impacts of future alternatives or decisions. Availability, quality and consistency of information often varies dramatically.

II. POLICY AND URBAN FORM ACROSS SCALES

Developing effective GHG policies is especially complicated by the interrelationship of multiple governmental scales. Although GHG targets are set at the provincial or regional scale, decisions influencing GHG emissions occur at many scales, ranging from the individual buildings to entire regions. Indeed, most development projects are evaluated and approved at the local scale with very little regulatory recognition of the cumulative impact of these projects. It is important that decision makers consider the implications of individual projects at a variety of scales simultaneously because buildings influence regional GHG emissions not only through their individual characteristics (building type, construction, and the activities of their occupants), but also through their relationship (proximity and accessibility) to one another. Accordingly, the various scales of urban form are inextricably connected.

Urban form and related policy decisions at multiple scales have helped to create steady increases in per capita vehicle miles traveled ("VMT"), along with growing per capita building energy consumption. For example, at the regional scale, funding a new freeway will certainly have some impact on decisions to drive or take transit. At the municipal scale, zoning for high-density development can substantially improve the viability of transit service, district energy systems, and efficient land use. Such zoning locates the greatest number of people near transportation infrastructure while simultaneously providing the appropriate energy mixes and intensities to enhance the economic and technical benefits of local energy supplies. At the neighborhood scale, development guidelines promoting mixed-use communities enable opportunities to walk or cycle to meet daily needs. Finally, at the parcel scale, appropriate building forms and orientation can reduce heating and cooling loads. Recent studies have even concluded that urban-form decisions made at the local scale[11] can impact per capita automobile travel by as much as 40 percent.[12] Higher density building forms, where units share walls, have intrinsic advantages for reducing energy consumption.[13]

These nested scales are each shaped by a variety of policy decisions;[14] however, the interrelation of policies at different scales in both the United States and Canada is often disconnected. Each scale is segregated into "policy silos": building codes and zoning bylaws at the parcel scale, community or local area plans at the neighborhood scale, municipal development plans at the municipal scale, and regional growth strategies at the regional scale. In addition, different groups within individual governments create these policies and, in the case of regions, different governing agencies as well. For example, separate land-use and transportation agencies often share overlapping jurisdiction. The discontinuity of policy between scales of urban form challenges a holistic understanding of urban form. Presently, very little consideration is given to how

11. Examples of urban-form decisions made at the local level include mixed use housing, interconnected streets, higher density, walking distance to services, and jobs.

12. EWING ET AL., *supra* note 5, at 4.

13. *See* Reid Ewing & Fang Rong, *The Impact of Urban Form on U.S. Residential Energy Use*, 19 HOUSING POL'Y DEBATE 1, 8 (2008); Norman et al., *supra* note 8, at 16–18.

14. *See infra* p. 990 tbl.2.

regional decisions may affect neighborhoods or individual parcels and vice versa.

A wide body of research implies that urban form and the options that urban form precludes (or creates) are a main determinant of travel behavior and, in turn, GHG emissions.[15] A comparative analysis indicates how urban forms have affected GHG emissions internationally. In western European countries, automobile trips account for roughly half of all trips; mass transit, walking, and biking capture the rest.[16] In the United States, however, 89 percent of all trips are by car and only 2 percent by mass transit and 6 percent on foot.[17] It does not appear, however, that the tendency for Americans to use their car to the exclusion of all other modes of transportation is a purely national trait. Only 29.1 percent of those who work in the City of New York use their car to get there,[18] a much lower percentage than in Rome, where 57 percent drive to work.[19]

In the United States, the disconnect between land-use and transportation planning has been comparatively extreme. Oregon has the only effective set of overarching land-use goals linked to transportation expenditure.[20] Absent regional controls, the United States interstate highway program became the de facto national planning entity. The program provides an armature for national development that mostly accommodates sprawling, low-density development and urban landscapes hostile to walking and biking.

Canada is at a midpoint between the United States and Europe: Canada has a less aggressive but still substantial metropolitan highway building program. These programs establish a more modest but still robust armature for auto depen-

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15. EWING ET AL., *supra* note 5, at 5–7.

16. John Pucher, *Transportation Trends, Problems, and Policies: An International Perspective*, 33 TRANSP. RES. PART A 493, 500 tbl.7 (1999).

17. *Id.* at 497 tbl.3.

18. United States Census Bureau, American Community Survey 2005–2007: New York-Northern New Jersey-Long Island Metropolitan Statistical Area: Commuting Characteristics by Sex (2008), http://factfinder.census.gov (search "Get a Fact Sheet for Your Community" for "New York City"; select "show more" under "Economic Characteristics").

19. Urban Audit: City Profiles, Roma (2008), http://www.urbanaudit.org/CityProfiles.aspx (select "Italia"; then select "Roma").

20. *See generally* Oregon.gov, Transportation and Growth Management, http://www.oregon.gov/LCD/TGM/grants32306.shtml (last visited September 23, 2009) (providing an overview of Oregon Transportation and Growth Management Grants); Robin Cortright, Or. Dep't Land Conservation & Dev., Land-Use and Transportation Planning in Oregon (Apr. 24, 2008) (briefing for the Transportation and Land-Use Committee and the Oregon Global Warming Commission).

dence: automobile trips account for 81 percent of all trips with a relatively anaemic transit trip share of 10.5 percent.[21] However, this rate is still double that of the United States.[22] Efforts to control regional growth, while more frequent, have waxed and waned as competing parties occupied provincial legislatures, with more or less interest in the topic. Consequently, Vancouver now services its region with only 0.2 meters of freeway per capita while St. Louis, a city of similar size, provides its citizens with five times more freeway lane miles per capita.[23]

III. CURRENT TOOL APPROACHES

The majority of tools that are currently available are measurement tools that can be used to quantify the implications of different strategies and/or scenarios on GHG emissions. Each of these tools operate at a different scale and is the product of very different goals, approaches, methods, and academic disciplines. While this diversity allows the tools to measure different aspects of an urban region's GHG emissions, it is more difficult to integrate them into a comprehensive, easy-to-use tool for informing policy choices. While not exhaustive, many available tools can be categorized along the following parameters.

A. Spatial/Non-Spatial

Even though the spatial arrangement of urban areas (i.e. the proximity of residences to jobs, transit, and commercial services) is a key factor in transportation-related GHGs, many tools (spreadsheet-based tools and scorecard tools in particular) are not sensitive to specific spatial arrangements of urban form. This makes them much less data intensive and quicker to prepare, as they do not require a detailed geographic information systems representation of the urban area. This, however, also means most non-spatial tools are unable to account for certain aspects of emissions dependent on the spatial ar-

21. John Pucher & Ralph Buehler, *Why Canadians Cycle More than Americans: A Comparative Analysis of Bicycling Trends and Policies*, 13 TRANSP. POL'Y 265, 266 (2006).

22. *Id.*

23. PATRICK M. CONDON, CANADIAN CITIES AMERICAN CITIES: OUR DIFFERENCES ARE THE SAME 13–14 (Feb. 2004), *available at* http://www.jtc.sala.ubc.ca/bulletins/Canada%20vs%20US%20FINAL3.pdf.

rangements of specific urban areas, such as regional transportation and solar access at the block or neighborhood scale. They are also less able to consider existing infrastructure, ownership patterns, and history and, in reflection, produce what is actually (as opposed to theoretically) possible in a specific urban area. More complex spatial tools such as MetroQuest, INDEX, and other land-use and transportation simulations explicitly model a city's spatial patterns and use spatial scenarios to drive their analyses. The downside, however, is that spatial tools can be time consuming and expensive to use and, thus, may not be applicable to many day-to-day development choices at the site, block, and even district scales.

B. Top Down/Bottom Up

Metropolitan planning occurs primarily at two scales: approval of specific site-level projects and development of municipal and/or regional plans. Available GHG tools reflect these two approaches: many bottom-up tools focus on the performance of specific buildings or projects[24] while other top-down tools start with regional-level scenarios.[25] Few, if any, tools make an effective link between individual projects and regional performance.

C. Simulation/End-State Assessment

Many tools are designed to assess the end state of scenarios, where users are expected to input information describing a predicted future condition. End-state tools use the data provided for these scenarios to generate performance estimates. Other tools, such as ILUTE and UrbanSim, create simulation models. Users provide the current conditions for a region and a set of land-use/transportation policies, and the tool projects those policies forward to generate how these policies would develop spatially.

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24. Building energy models and RETScreen are examples of bottom-up tools.

25. Land-use and transportation simulations and cell-based models are examples of top-down tools.

D. *Process-Based/Observation-Based Simulation*

Process-based simulation models[26] explore the behavior of and interactions between the individual components that make up the entire system. For instance, in building energy models, users input detailed information (size, orientation and R-value) about every surface in a building and specific room uses and mechanical systems to calculate the heating and cooling load for the entire building. For regional simulation systems like UrbanSim, a detailed behavioral model is used to simulate the effect of individual decisions, such as home and job locations, on urban form. Other tools, such as most of the spreadsheet-based calculators, use empirical data collected from representative buildings and/or regions to summarize various effects as algorithms. The algorithms are then used to generate values based on a number of parameters without simulating underlying individual actions. While the latter is likely to be accurate for known conditions, tools measuring existing conditions are unable to generate results for conditions that are outside of the range of observed data. For instance, if a transportation model was calibrated based on how the transportation mode split for a given suburban environment changes in reaction to increased transit service, it is unlikely to be accurate when extrapolated to much higher levels of service such as those found in a dense urban area.

IV. AVAILABLE TOOLS AND THEIR RELATIONSHIPS TO DECISION MAKING AND SCALES

Understanding the wide variety of tools available, their place in the decision-making process, and the scale or scales at which they are most relevant can help to clarify the current context within which the Lincoln Institute's work is situated. At present, the decision-making process for climate change policy is dominated by incomplete or difficult-to-use tools. Although these tools may be useful in the *information* stage, they have only limited capabilities to support *interpretation* and *collaboration*. For example, these tools often require the guidance of skilled operators, particularly when a project demands even moderate degrees of accuracy. Other tools are easy-to-use but

26. Building energy tools such as ESP-r and urban simulation tools such as UrbanSim are examples of process-based simulation models.

fail to answer the complex, data-intensive questions generated by the need to mitigate climate change. Another difficulty with current tools is that they tend to deal with only one scale of urban form and are unable to consider multiple scales simultaneously.

A majority of existing tools best serve the *information* stage of the policy decision-making process, while fewer tools are available to fully support *interpretation* and *collaboration*. The following matrix describes this condition using an illustrative set of available tools.[27]

The matrix, for reasons of clarity, does not address the additional need for tools that provide education to the public during policy processes or tools at later implementation and monitoring stages. At the moment, there are still only limited resources for developing and translating GHG data, at any scale, into policy-relevant information that evidences the impacts of urban form. Although there are tools available at every scale, few of these tools have the ability to assess or provide information about GHG emissions across scales. As a result, understanding the impact of parcel-or-project scale decisions on the region or region-scale decisions on individual blocks and parcels remains difficult to evaluate. If improved, however, many existing tools have substantial potential for use at the later stages.

27. *See infra* p. 991 fig.2.

Table 2: Scales of Urban Form Impacting GHG Emissions

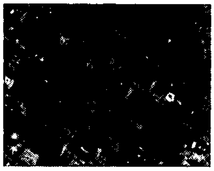
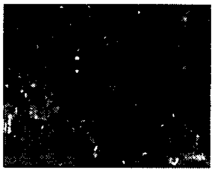
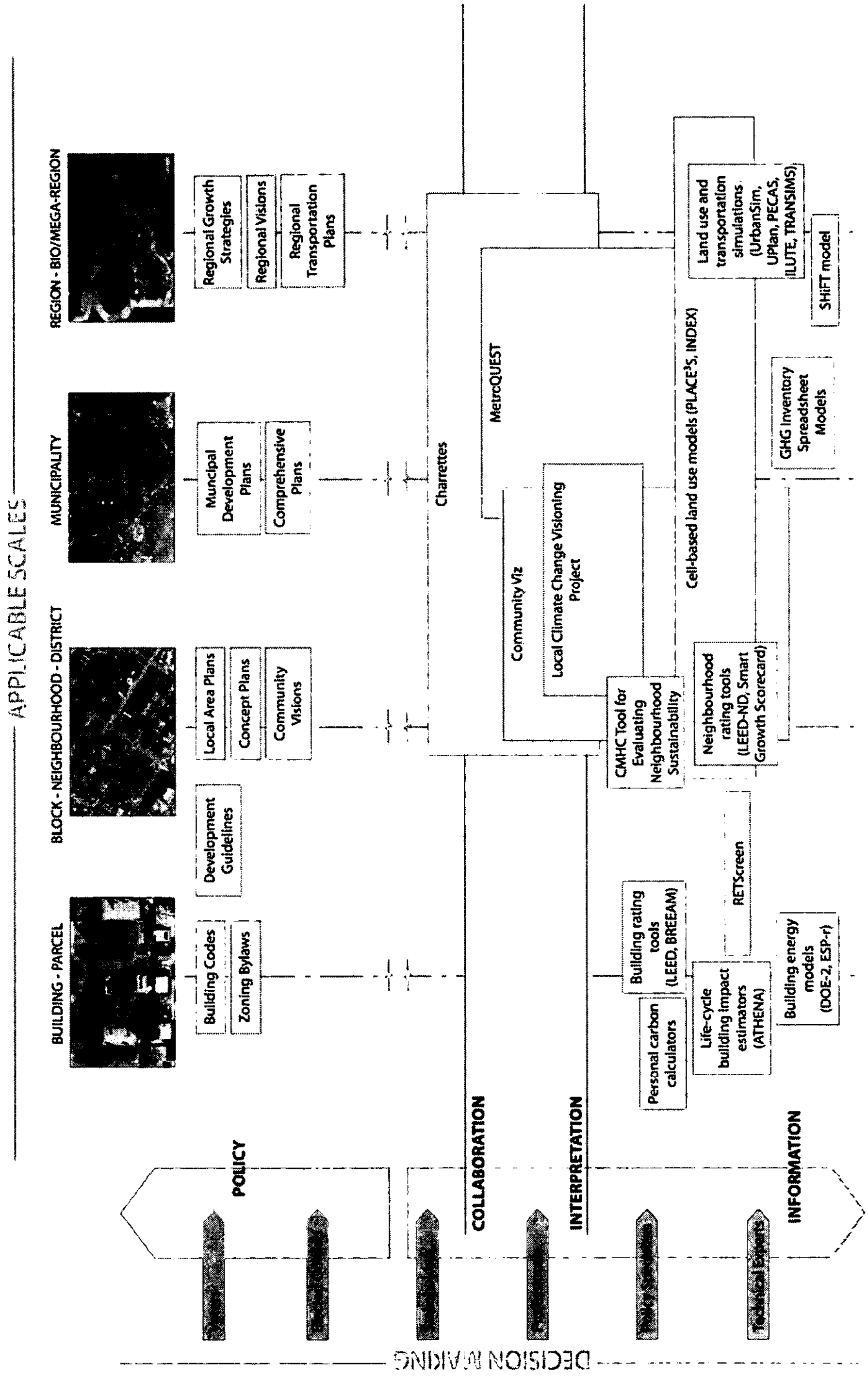
Scales	Building - Parcel		Common policy: building codes, zoning bylaws, development guidelines
	Block - Neighbourhood - District		Common policy: local area plans, concept plans, community visions, development guidelines
	Municipality		Common policy: municipal development plans, comprehensive plans
	Region - Bio/Mega-Region		Common policy: regional growth strategies, regional visions, regional transportation plans

Figure 2


APPLICABLE SCALES
BUILDING - PARCEL
BLOCK - NEIGHBOURHOOD - DISTRICT
MUNICIPALITY
REGION - BIO/MEGA-REGION
Building Codes
Zoning Bylaws
Development Guidelines
Local Area Plans
Concept Plans
Community Visions
Muncipal Development Plans
Comprehensive Plans
Regional Growth Strategies
Regional Visions
Regional Transportation Plans
Charrettes
MetroQUEST
Community Viz
Local Climate Change Visioning Project
CMHC Tool for Evaluating Neighbourhood Sustainability
Cell-based land use models (PLACE³S, INDEX)
Land use and transportation simulations (UrbanSim, UPlan, PECAS, ILUTE, TRANSIMS)
SHIFT model
GHG Inventory Spreadsheet Models
Neighbourhood rating tools (LEED-ND, Smart Growth Scorecard)
Building rating tools (LEED, BREEAM)
RETScreen
Personal carbon calculators
Life-cycle building impact estimators (ATHENA)
Building energy models (DOE-2, ESP-r)
POLICY
COLLABORATION
INTERPRETATION
INFORMATION
DECISION MAKING

V. "PLANNING FOR CLIMATE CHANGE"

At the "Planning for Climate Change" workshop held in Vancouver, British Columbia in April 2008, regional modeling and policy experts were asked to comment on material and to further elaborate their needs for new GHG modeling tools. The Lincoln Institute and its partners would use this information to help create a research agenda. The meeting resulted in the identification of two key needs for local governments previously discussed in this article: first, a GHG target allocation method from the state/provincial level down to cities and regions; and, second, a tool for understanding planning consequences and solutions. Additionally, experts outlined a set of goals and characteristics for a new type of GHG tool and suggested a three-track action plan for forwarding tool development.

A. *A New GHG Tool: Goals and Characteristics*

Based on the discussion above, it seems clear that a new tool or set of tools is needed. While the exact attributes of this tool are unknown, there are several concerns that will dictate its construction. The tool needs to correspond to the policy implementation process; information alone is not enough. The tool also needs to be based on real cities and their real forms; tools will fail if they are blind to the role of block configuration on one end of the scale spectrum or to the influence of regional-scale decisions like freeway construction on the other end. Likewise, the tool must move fluidly between the processes that generate GHG performance data and the policies that might influence this performance; it is not enough to do only one. New tools must also be particularly sensitive to the aggregate effects of site-scale decisions—how building form, shared walls, and orientation influence GHG performance. Finally, the tool must also model the feasibility of neighborhood scale infrastructure such as district heating; it is not enough to generally ascribe a value to such systems absent a cognizance of the neighborhood characteristics necessary to implementation. In addition to these projected requirements, workshop participants also identified seven characteristics necessary for any new tool.

First, a new tool will be iterative, testing scenarios multiple times, ideally in a charrette-like environment. Results generated must be capable of rapid integration into collaborative decision-making processes where participants can collectively suggest and assess the costs and benefits of alternative options.

Second, a new tool will be spatial, generating scenarios based on alternative urban forms. This characteristic is necessary because the urban elements of building, parcel, block, and street network configuration are the essential media for planning decisions and, when assembled into districts and regions, predetermine transportation demands and key aspects of building energy performance. A spatial tool enables more opportunities for visualizations, particularly at the neighborhood scale, allowing decision makers and the public to understand the impacts of policy and other choices "on the ground."

Third, a new tool will be scalable, able to move between small- and large-scale urban-form strategies. Available tools fail to connect large-scale decisions to small-scale consequences and vice versa—for example, decisions on freeway construction pose substantial consequences for local-scale land use and VMT averages. A scalable tool allows the user to understand the relationship between differently scaled decisions, including state/provincial, federal, and global initiatives.

Fourth, a new tool will be synthetic, building on and linking to existing modeling and measuring tools and related applications. A reasonable design for such a tool must take advantage of existing simple tools and have the capacity to connect to more complex, data intensive tools when the situation demands. Technically, this will require the development of a standard "language" among tools, as well as connections to planning process tools, such as design charrettes and other public participation mechanisms.

Fifth, a new tool will be multi-issue, holistic, and able to consider issues beyond building energy and transportation, such as infrastructure. It will be responsive to the impacts of economy, affordability, and liveability, among others.

Sixth, a new tool will be widely accessible to local governments and other decision makers. It must be accessible—both in terms of availability and usability—for the full range of potential users. In addition, it must provide data and results that are understandable to all appropriate audiences and be transparent in terms of assumptions and methods of analysis.

Seventh, a new tool will be economical in terms of the cost, time, and staffing required to achieve the desired results. Ideally, such a tool would be able to provide both quick comparisons within an iterative process, such as a charrette, and also allow "drilling down" to more accurate, absolute values with increased effort and calibration time. With these characteristics in mind, analysts can now determine how to approach the creation of a new tool.

B. *A New Tool Approach*

Given these characteristics, an approach identifying generic and ubiquitous neighborhood types or patterns seems fruitful. It may be possible to characterize a limited number of generic North American neighborhood configurations and their district configurations. Once characterized, their inherent or potential capacity for GHG reductions can be assessed, thus avoiding the necessity of assigning attributes on a much smaller parcel-by-parcel scale. Policy makers can then utilize the patterns to generate regional scenarios.

There are two main reasons why using a form-based methodology founded on neighborhood patterns has the potential to meet the demanding functional requirements as outlined above. First, neighborhood-scale "development patterns" have the potential to simplify the data requirements commonly associated with more data-intensive models. Existing models typically rely on census measures or other comparably detailed data to represent the current condition. These models require similarly detailed data for future scenarios, which can be time consuming to produce and calibrate. A development pattern approach, on the other hand, would enable the assembly of an existing region or future scenario comprised of a few hundred neighborhoods from a smaller palette of neighborhood types. With this method, it would be possible to develop a tool that would simplify data input, analyze scenarios quickly and cheaply, and potentially function in real time in collaborative, public processes.

Second, if a development-pattern-based tool could access existing tools and methods as sub-models to generate GHG measures for regional scenarios, the tool could absorb and translate data from available sub-models into the characterization of neighborhood and regional energy and GHG performance. The most important sub-models to access are those dealing with building energy use (e.g. ESP-r), alternative energy feasibility models (e.g. RETScreen), and travel behavior (regional and neighborhood scale). Ideally, the methods by which information emanating from sub-models is absorbed should be transparent and modifiable as circumstances dictate.

C. *A Way Forward: The Action Plan*

Participants in the April 2008 meeting initially clustered into two opposing viewpoints. Participants with modeling expertise, some with related projects completed or underway, opined more than a single tool was necessary because tool needs and requirements varied significantly. Others felt building a more comprehensive, synthetic "tool suite" or meta-tool from a mosaic of existing tools, supplemented with remodelled and new components, was a more robust and resilient approach.

Generally, participants who adopted the first point of view were interested in collaborative and coordinated efforts to cross geography, scales, and energy sectors. This group would create a tool suite that was based on the best research and experience. The tool would share a common engine of methodological concepts and standards and be open source, scalable, and incrementally developed. Getting the core of this shared effort right, through targeted research and development, was a high priority.

The conclusions of policy representatives, on the other hand, predominantly aligned with the desire to adapt existing tools. Policy representatives were influenced by the rapid emergence of similar policy in all three Cascadia states/provinces, requiring dramatic reductions in GHGs by 2020 and up to 80 percent reductions below current levels by 2050.[28] Among participants, there was a sense of urgency and a shared feeling that efforts to characterize the GHG performance of current municipal and regional forms must begin immediately. State and provincial laws will soon require jurisdictions at various levels to bring their transportation, zoning, building code, and economic development policies into alignment with mandated GHG reduction goals. Workshop participants recognized they have a limited amount of time to provide guidance to policy makers and legislators as new laws increase emphasis on the assessment of GHG performance without a corresponding increased understanding of potential solutions.

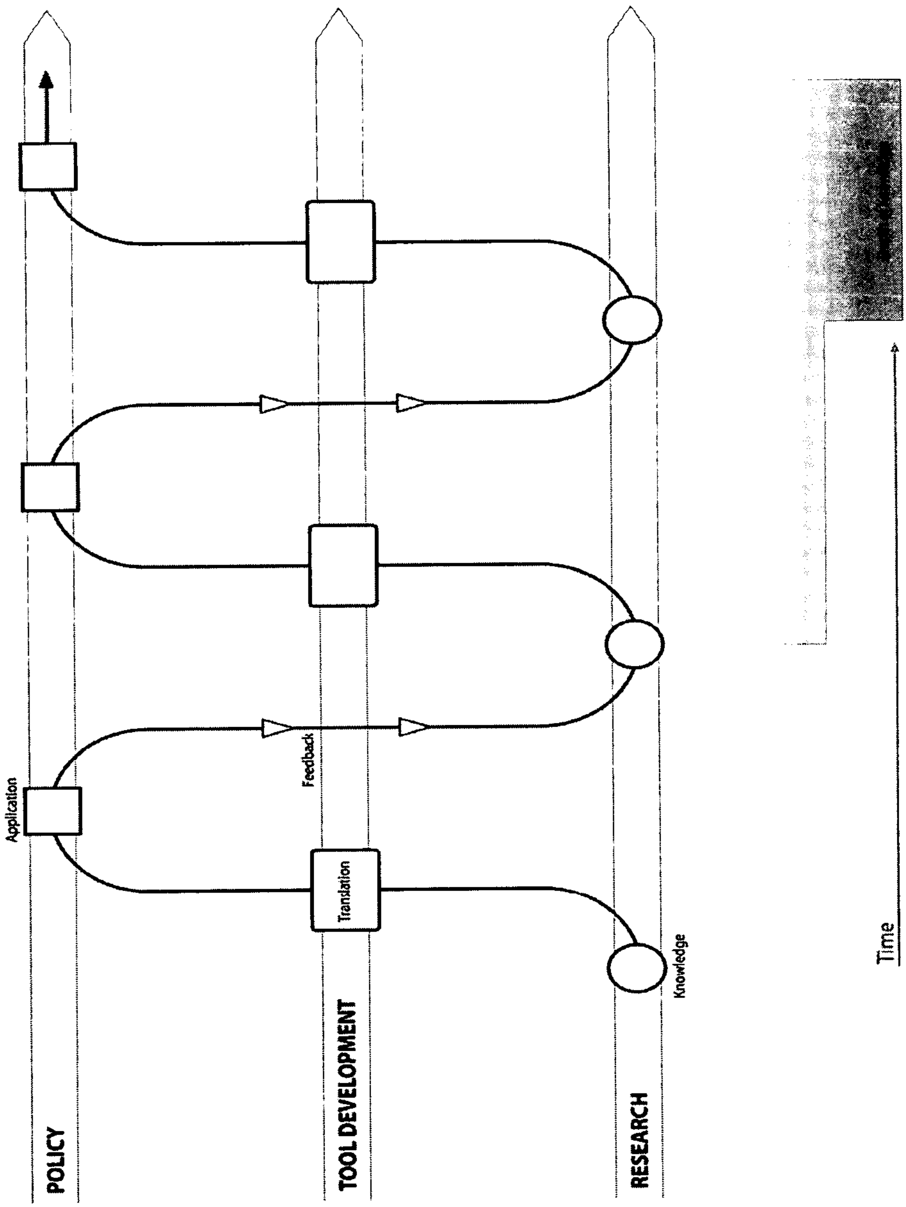
28. *See, e.g.*, WASH. REV. CODE § 70.235.020 (2007); CAL. HEALTH & SAFETY CODE § 38550 (West 2006); Greenhouse Gas Reduction Targets Act, 2007 S.B.C., ch. 42 (Can.).

The action plan for this group would commence trial-run mapping and visioning exercises within the year with the objective of characterizing existing GHG performance for one or more of the three main metro planning areas as well as generating future scenarios for comparison purposes.

After the organizing team considered these comments, they felt the positions, although seemingly contradictory, were nonetheless compatible. Creating a compatible structure would require a three-track process where several parties work in parallel over time.[29] The foundation of this process would be a technical *research* track where specialists would continue working on the models, data collection, calibration, and analysis necessary to develop a sufficiently robust understanding of the impacts of urban form on climate change, increasing in depth and sophistication over time. The central (and critical) track in this process involves experts who will continue work on *tool development*, ensuring that the goals and desired tool characteristics articulated above are achieved over time. The top track, *policy*, involves those policy makers and senior planners who, in order to carry out their responsibilities, require immediate information and action on GHG targets as well as long-term strategies for allocating, implementing, and monitoring climate change policies. This track will necessarily proceed with the best available information for a given point in time. A key objective over the course of tool development in this track should be to provide initial, on-going, and growing capacity to take new research (as it becomes available) and incorporate it in ways accessible to the top track of policy makers. A successful process would mean that policy makers quickly have access to a simple, useable tool utilizing the best available data, with increasingly improved, more complete, and sophisticated versions of the tool and underlying data over the duration of the process.

29. *See infra* p. 997 fig.3.

Figure 3


POLICY
TOOL DEVELOPMENT
RESEARCH
Application
Feedback
Translation
Knowledge
Time

CONCLUSION

The challenge for both Canada and the United States is to find a way to think and act across scales and coordinate many different realms of policy regulation. Coordination of this type is uncommon, and the daunting challenge is made even more intimidating by the absence of tools that explain to citizens and policy makers what benefits such coordination would create.

Therefore, the challenge is to identify an effective point of intervention in this dynamic context. It would seem that participation in the "Tool Development" track would be most fruitful as it is here that the research and policy come together as applied to the questions of future city form. As a starting point, it seems appropriate to initiate testing from one or more of the three Cascadia states/provinces. For example, a second iteration of Vancouver's Sustainability by Design initiative, a fifty-year plan for Portland, Oregon, or a low-carbon vision for King County, Washington could utilize early iterations of a developing tool as a means to explore its potential effectiveness in both top-down and bottom-up policy decision making. If established early, these cases could continue to provide testing grounds and critical feedback over the duration of GHG tool development.

It is by no means clear that the mere existence of such a tool will produce positive policy actions. It is, however, clear that rational policy action is not possible in the absence of such a tool.