Policy, Urban Form and Tools for Measuring and Managing Greenhouse Gas Emissions

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INTRODUCTION

The Lincoln Institute of Land Policy, in collaboration with planning experts and planning directors from many of North America's major cities, has identified a critical need to measure the influence of urban form on greenhouse gas emissions. To address this issue, the Lincoln Institute convened two meetings for policy makers in the Cascadia mega-region, a region currently at the forefront of climate change mitigation policy. At the first event, held in October, 2007, representatives from the three major Cascadia metropolitan areas – Portland, Seattle and Vancouver, BC, joined by leading technical experts, identified the need for new tools and knowledge to support planning decisions and assist municipalities in meeting greenhouse gas (GHG) reduction targets. At the second meeting, held in April, 2008, these same representatives began formulating a research agenda to develop such tools.

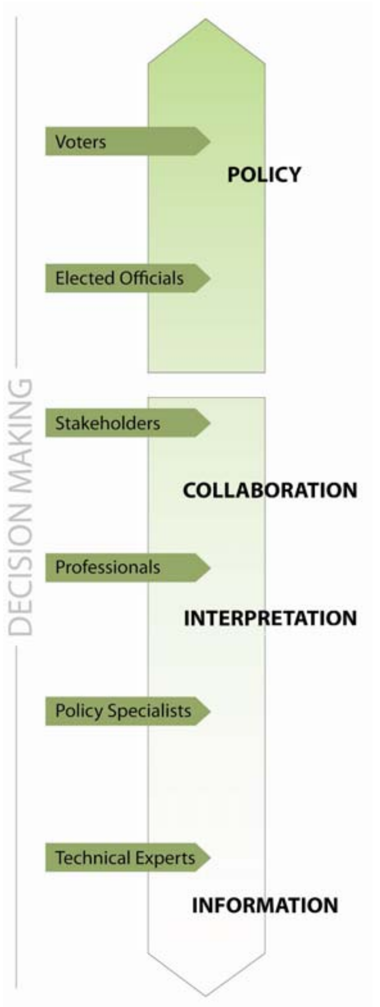
Workshop participants agreed that achieving challenging GHG reduction targets, such as those recently adopted by governments in the Cascadia region, will require new levels of integrated decision making. New tools supporting these processes must be robust enough to speak to decision makers engaged in 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 suggests a presently uncommon level of coordination in decision making at the policy level, which would include both elected and appointed officials in many branches of government.

POLICY AND THE DECISION MAKING CONTEXT

Increasingly, new laws and policies are demanding that cities reduce GHG emissions to specified levels in relatively short amounts of time. City and regional planners are under new obligations to meet these reduction targets and to provide quantitative evidence on the impacts of their policy decisions. For example, a bill recently passed in Washington state calls for emission reductions of 25% below 1990 levels by 2035 and 50% by 2050 with mandatory reporting and statewide annual VMT (vehicle miles traveled) reduction goals (SSB 6516 2008). The California Global Warming Emissions Cap established a statewide GHG cap for 2020 based on 1990 emissions levels and has adopted mandatory reporting rules effective in 2008 (AB 32 2006). In British Columbia, the Greenhouse Gas Reduction Targets Act requires the reduction of GHG emissions by at least 33% below 2007 levels by 2020, and 80% below 2007 levels by 2050 (Bill 44 2007).

Recent calculations done within the province of British Columbia suggest that at least 43% of total provincial GHG emissions are under the control or influence of local governments. A significant majority of these emissions can be linked to urban form, particularly in terms of transportation and building energy consumption. At the scale of local government, the multiplicity of urban form-related decisions (official community plans, development guidelines, development permits, etc.) should be informed by a clear understanding of their contributions to, or competition with, higher level policy; however, this is most often not the case. Particularly in terms of climate change and GHG emissions, there is a lack of spatial, real-word data, and some of the key information and data necessary to make sound, locally-relevant policy decisions is not easily accessible to policy makers or understandable and meaningful for the public.

Addressing these challenges requires understanding the current policy decision-making process. In reality, such processes are iterative and complex social-political processes that vary among agencies and locations; however, a simplified model of the process provides a starting point. At present, the process through which decisions are made regarding climate change and GHG reduction strategies can be described as a series of stages, moving from *information* gathering and processing, though *interpretation* and *collaboration* facilitated by a variety of experts, and finally to *policy* and implementation (Table 1). Participating in this process is a diverse set of players, interacting at specific stages and bringing with them a diverse spectrum of (sometimes disparate) interests, interpretations, and inputs towards eventual policy decisions. Actors involved in the various stages and scales of decision-making often speak arcane languages that create difficulties for communication, collaboration, and consensus. This breakdown in the process means that decisions are often being made in the absence of good, applicable evidence regarding the potential impacts of policy decisions on GHG emissions.

<table>
<tr><th colspan="2">Table 1: Stages of Policy Decision Making</th></tr>
<tr><td rowspan="4">
</td>
<td>Policy: The regulatory and legislative actions made by authorized public officials (appointed or elected).</td></tr>
<tr><td>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.</td></tr>
<tr><td>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.</td></tr>
<tr><td>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.</td></tr>
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POLICY AND URBAN FORM ACROSS SCALES

Developing effective GHG policies is complicated by the fact that GHG emissions are influenced by decisions made at a variety of scales. While targets are being set at the provincial or regional scale, the decisions that impact GHG emissions are spread across many scales, ranging from the building-level to the region. The increasing recognition that cities, and the relationship between land use and transportation, are significant drivers of GHG emissions implies that urban form – the streets, blocks, land uses, buildings and infrastructure that shape regions, cities and neighbourhoods – must be understood at a variety of scales in order to fully access its capacity to mitigate climate change. Much like the relationship between cell and body, the various scales of urban form are inextricably connected.

Steady increases in per capita VMT, along with growing per capita building energy consumption, are attributable in large part to urban form and related policy at several scales. For example, at the regional scale, these conditions are impacted by growth and transportation strategies that shape major infrastructural investments that impact decisions to drive or take transit. At the municipal scale, comprehensive development plans establish density targets that greatly impact the viability of transit service, district energy systems and efficient land use. At the neighbourhood scale, development guidelines promoting mixed-use communities enable opportunities to walk or cycle to meet daily needs, and at the parcel scale, appropriate building forms and orientation reduce heating and cooling loads. Recent studies have concluded that urban form can impact per capita automobile travel by as much as 40% (Ewing et al. 2007). Higher density building forms, where units share walls, have intrinsic advantages for reducing energy consumption (Ewing 2008, Norman et al. 2006).

These nested scales are each shaped by a variety of policy decisions (Table 2); however, related policies are often disconnected, segregated into “policy silos” such as building codes and zoning bylaws at the parcel scale, community or local area plans at the neighbourhood scale, municipal development plans at the municipal scale and regional growth strategies at the regional scale, among others. In addition, these policies are often created by different groups and, in the case of regions, by different governing agencies. The discontinuity of policy between scales of urban form imposes challenges on understanding urban form holistically. Presently very little consideration is given to how regional decisions may affect neighbourhoods or individual parcels and vice versa.

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, limiting their abilities to support the processes of *interpretation* and *collaboration*. Often these tools require the guidance of skilled operators, particularly when even moderate degrees of accuracy are demanded. Other tools are designed primarily to be easy-to-use and thus influential but fail to answer the complex, data intensive questions generated by the need to mitigate climate change. At the same time, tools tend to deal with only one scale of urban form, without the ability 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 (albeit incomplete) set of available tools (Figure 1). 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. It should be noted, however, that many existing tools have substantial potential to support these areas with improved usability. In other words, 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. In addition, although there are at least some tools available at every scale, few of these tools have the ability to assess or provide information about GHG emissions across scales, meaning that understanding the impact of parcel or project scale decisions on the region and region scale decisions on individual blocks and parcels is still a challenge to be addressed.

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

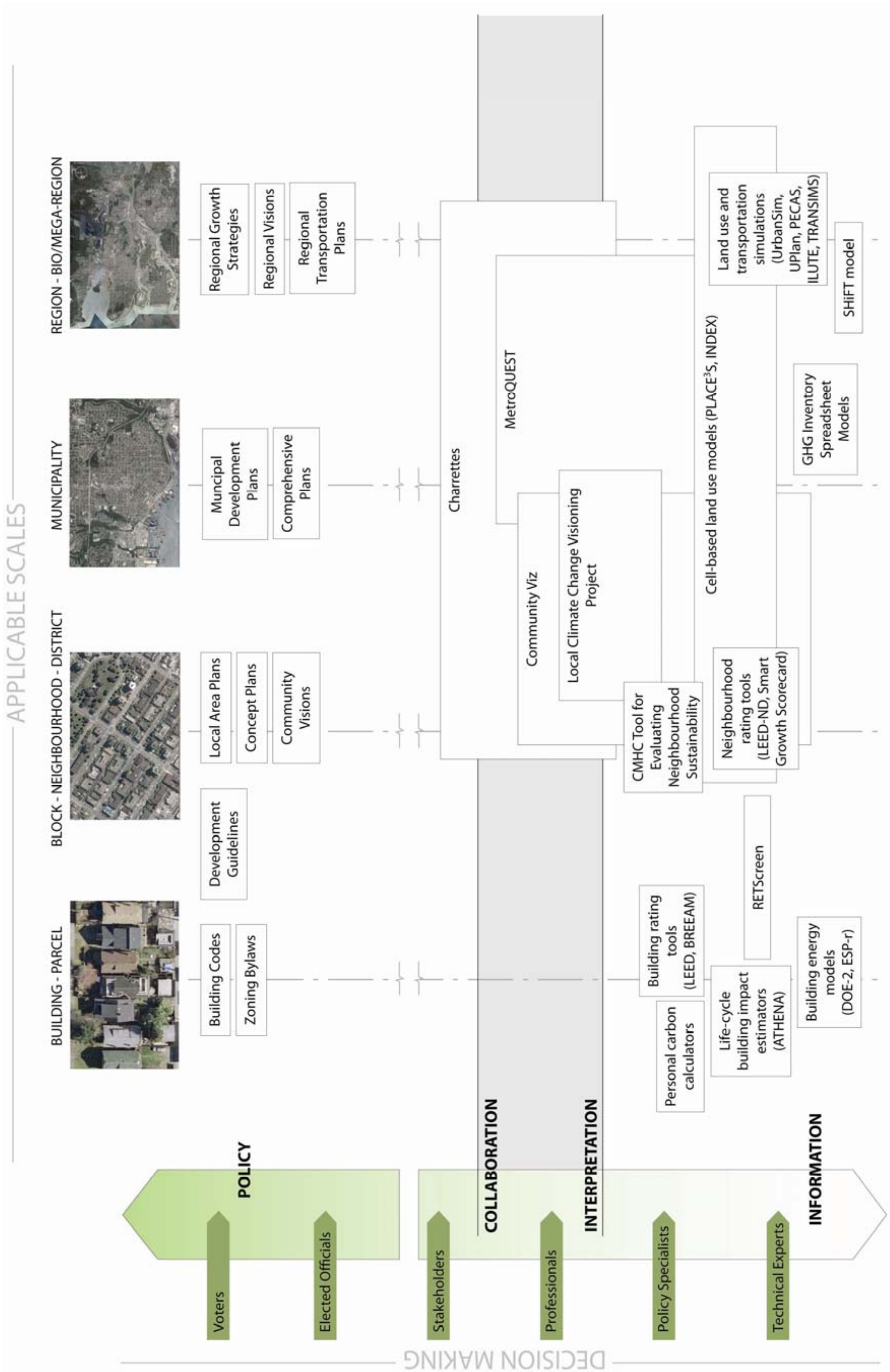
APPLICABLE SCALES
BUILDING - PARCEL
BLOCK - NEIGHBOURHOOD - DISTRICT
MUNICIPALITY
REGION - BIO/MEGA-REGION
Building Codes
Zoning Bylaws
Development Guidelines
Local Area Plans
Concept Plans
Community Visions
Muncipal Development Plans
Comprehensive Plans
Regional Growth Strategies
Regional Visions
Regional 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)
RETScreen
Building rating tools (LEED, BREEAM)
Personal carbon calculators
Life-cycle building impact estimators (ATHENA)
Building energy models (DOE-2, ESP-r)
POLICY
COLLABORATION
INTERPRETATION
INFORMATION
Voters
Elected Officials
Stakeholders
Professionals
Policy Specialists
Technical Experts
DECISION MAKING

Figure 1

CURRENT TOOL APPROACHES

The majority of tools in Figure 1 are measurement tools that can be used to quantify the implications of different strategies and/or scenarios on GHG emissions. Each of these tools work at different scales, and are the products of very different goals, approaches, methods and academic disciplines. While this allows them to measure different aspects of an urban region's GHG emissions, it means that it is more difficult to integrate them into a comprehensive, easy-to-use tool for informing policy choices.

While not exhaustive, the following pairs of parameters can be used to categorize many available tools:

- **Spatial/non-spatial**: Even though the spatial arrangement of urban areas (i.e. proximity of residences to jobs, transit, and commercial services) is a key driver of transportation-related GHGs, many tools (spreadsheet-based tools and scorecard tools in particular) are not sensitive to the specific spatial arrangement of scenarios. This makes them much less data-intensive and quick to prepare, as they do not require a detailed GIS representation of the urban area, but also means that they are not able to represent spatial arrangements of specific urban areas, which can have a large impact on transportation GHGs, especially at the regional scale. They are also less able to reflect what is actually (as opposed to theoretically) possible in a specific urban area given existing infrastructure, ownership patterns and history. More complex 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 down side is that such tools can be time consuming and expensive to use, and thus may not be applicable for many day to day development choices at the site, block and even district scales.
- **Top down/bottom up**: Planning in metropolitan areas is done primarily at two scales: approvals of specific site-level projects and the 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 (building energy models, RETScreen), while other, top-down tools start with regional-level scenarios (land use and transportation simulations, cell-based models). Few, if any, tools make an effective link between individual projects and regional performance.
- **Simulation/end state assessment**: Many tools are designed to assess the end-state of scenarios, where users are expected to provide as inputs the information that describes a predicted future condition. Tools use the data provided for these scenarios to generate performance estimates. Other tools, (ILUTE, UrbanSim) are simulation models. Users provide the current conditions for a region and a set of land-use/transportation policies, and a tool projects selected policies forward to generate a scenario of how these policies would develop spatially.
- **Process-based/observation-based**: Process-based simulation models (i.e. building energy tools such as ESP-r and urban simulation tools such as UrbanSim) represent and explore the behaviour of and interactions between the individual components that make up the entire system. For instance, in building energy models, detailed information (size, orientation and R-value) of every surface in a building is used, in conjunction with information about 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 behavioural model is used to simulate how each individual makes decisions, such as the location of their homes and jobs, to represent effects 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. These can be 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 based on measurements of existing conditions are not able to generate results for conditions that are outside of the range of their observed data. For instance, if a transportation model was calibrated based on how mode splits in a suburban environment change 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.

"PLANNING FOR CLIMATE CHANGE"

The preceding information was presented to participants at the "Planning for Climate Change" workshop held in Vancouver, British Columbia in April, 2008. At this workshop, regional modeling and policy experts were asked to comment on material and to further elaborate their needs for new GHG modeling tools towards the creation of a research agenda for the Lincoln Institute and its partners. Three major findings arose from this meeting:

1) Two key needs for local governments: a GHG target allocation method from the state/provincial level down to cities and regions, and a tool for understanding planning consequences and solutions
2) Goals and characteristics for a new type of GHG tool
3) A three-track action plan for forwarding tool development

Key needs

Throughout North America, governments are taking action to reduce GHGs. This movement is particularly pronounced in the Cascadia region where two states and one province have approved legislation aimed at reducing GHGs substantially over the next 50 years (SSB 6516, HB 3543, Bill 44). Despite impressive policy changes, little is known about how these targets are to be met. Even less is known about how regulations will impact the building and retrofitting of communities. Under these conditions, participants identified two key needs for meaningfully moving forward with GHG reduction goals.

First, no methodology for determining an equitable distribution of high-level GHG reduction targets has been established. For example, one could determine that it would be more equitable to require suburban communities to shoulder the largest burdens for reductions, as suburban dwellers have been shown to produce up to three times more GHGs per capita than inner city dwellers (Center for Neighborhood Technology 2006). Conversely, one could 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. Such issues are complicated further by considering the challenges and opportunities of high-growth versus low-growth communities, as well as questions of per capita versus total reduction targets. In the case of British Columbia, the Province plans to negotiate with local governments with the intention of arriving at an equitable allocation on a municipality by municipality basis.

Second, policy makers need to know what capacity exists in communities for GHG reductions and what costs related changes would generate – physically, socially and economically – before they can act. Policy makers need to know, for example, how the gradual rebuilding of the suburbs as more complete, transit friendly communities might overcome, in time, 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 addressing market forces and therefore political and economic issues. To answer these questions, a new tool– likely building on and accessing the available suite of GHG models and related methods – is needed. The characteristics of such a tool are described in the following section.

A new GHG tool: goals and characteristics

Based on the above, it seems clear that a new tool or set of tools is needed. While the exact attributes of such a tool and its performance are not yet known, a few things can be said. The tool needs to be relevant to the way policy is made and implemented; information by itself is not enough. It needs to be based on real cities and their real forms; tools that are blind to the role of block configuration on one end of the scale spectrum or the influence of regional scale decisions like freeway construction on the other will fail. The tool must move fluidly between processes that generate GHG performance data and the policies that might influence this performance; it's not enough to do only one and expect the tool to be used. New tools must also be particularly sensitive to the aggregate effects of site scale decisions - how building form, shared walls, and orientation, for example, influence GHG performance, not at the site scale only, but in the aggregate, at the district and regional scale. Finally, the tool must also model the feasibility of district 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 implement them practically.

Feedback from workshop participants on their goals for a new GHG tool (or tools) for policy makers reflects the diverse challenges and questions facing city planners today. When asked what a new tool or suite of tools for GHG policy planning would look like, planners and technical experts responded with comments that can be summarized as seven key characteristics:

- *Iterative:* A new tool will have the capacity to iteratively test scenarios, ideally in a charrette-like environment. Results generated by any modeling tool 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.
- *Spatial:* A new tool will generate scenarios based on alternative urban forms. 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 form-based tool enables opportunities for visualizations, particularly at the neighbourhood scale, allowing decision makers and the public to understand the impacts of policy and other choices "on the ground."
- *Scaleable:* A new tool will move between small and large scale policies in order to understand the relationship between differently scaled decisions, including state/provincial, federal and global initiatives. Available tools fail to connect large scale decisions to small scale consequences and vice versa - for example, decisions on freeway construction have substantial consequences on local scale land use and VKT averages.
- *Synthetic:* A new tool will build on and link to existing modeling and measuring tools and related applications. A reasonable design for such a tool must take advantage of existing simple tools and also have the capacity to connect to more complex and data intensive tools when the situation or scale 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.
- *Multi-issue:* A new tool will be holistic and able to consider issues beyond building energy and transportation, such as infrastructure, and be responsive to the impacts of economy, affordability, and livability, among others.
- *Accessible:* A new tool will be widely accessible to local governments and other decision makers in terms of both availability and usability for the full range of potential users. A new tool must also be accessible by providing data and results that are understandable to all appropriate audiences and should be transparent (i.e. not a "black box") in terms of assumptions and methods of analysis.
- *Economical:* A new tool will be economical in terms of cost, time, and staffing required to achieve 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.

A new tool approach

Given these characteristics, an approach where generic and ubiquitous neighbourhood types or patterns are identified seems fruitful. It may be possible to characterize a limited number of generic North American neighborhood configurations, and the related district configurations into which they assemble. Once characterized, their inherent or potential capacity for GHG reductions could be assessed, thus avoiding the necessity of assigning attributes on a much smaller parcel by parcel scale. Once assembled, these patterns could then be used to generate regional scenarios.

There are a number of reasons why using a form-based methodology grounded in neighbourhood patterns has the potential to meet demanding functional requirements. Neighbourhood scale "development patterns" have the potential to simplify the data requirements commonly associated with more data intensive models. Existing models typically rely on detailed, measured data (i.e. census measures) to represent the current condition. This results in a model that requires similarly detailed data for future scenarios, which can be very 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 neighbourhoods from a smaller palette of neighborhood types and base computations on that limited set of inputs. 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.

Accessing existing tools and methods as sub-models to generate GHG measures for regional scenarios, a development pattern-based tool could absorb and translate data from available models into the characterization of neighbourhood and regional scale energy and GHG performance. Key sub-models would include building energy use (e.g. ESP-r), alternative energy feasibility models (e.g. RETScreen), and travel behaviour (regional and neighborhood scale). Ideally, the methods by which information emanating from sub-models is absorbed should be transparent and modifiable as circumstances dictate.

A way forward: the action plan

Conclusions from the April 2008 meeting on a course of action for developing a new GHG tool varied. Participants with modeling expertise, some with related projects completed or underway, were of the opinion that tool needs and requirements varied significantly and that more than a single tool was necessary. Building a more comprehensive, synthetic "tool suite" or meta-tool from a mosaic of existing tools, supplemented with remodeled and new components was considered the more robust and resilient approach. Generally, these participants were interested in a collaborative and coordinated effort able to cross geography, scales and energy sectors. The resulting suite of tools would be rationalized through a consensus around best research and experience, and would share a common engine of methodological concepts and standards, be open-source, scaleable and incrementally developed. Getting the core of this shared effort "right" was a high priority.

Conclusions forwarded by policy representatives, on the other hand, 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% reductions below current levels by 2050. 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 that 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 and the mitigation of GHGs through planning actions in the absence of a complete understanding of potential solutions. The action plan for this group would have trial-run mapping and visioning exercises commence 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 consideration of these comments by the organizing team, it was felt that these positions, while seemingly contradictory, can be compatible. Compatibility is structured by conceptualizing a "three track" process where several parties work in parallel over time (Figure 2). At the base of this process, a technical *research* track involves specialists who 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 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. The central (and critical) track in this process involves experts who will continue work on *tool development*, insuring that the goals and desired tool characteristics articulated above are achieved over 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 using the best available data and increasingly improved, more complete and sophisticated versions of the tool and underlying data over the duration of the process.

CONCLUSION

The challenge for the Lincoln *Planning for Climate Change* project 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 that test cases from one or more of the three Cascadia states/provinces (for example Vancouver’s Sustainability by Design initiative, a fifty year plan for Portland, or a low-carbon vision for King County, Washington) could utilize the earliest iterations of a developing tool as a means to explore its potential effectiveness in both top down (regional scale effects on neighbourhoods) and bottom up (neighbourhood level effects on regions) policy decision making. Established early, these cases could then continue to provide testing grounds and critical feedback over the duration of GHG tool development. Lincoln will continue to play a strategic role, bringing together the necessary experts and organizations in support of this process.

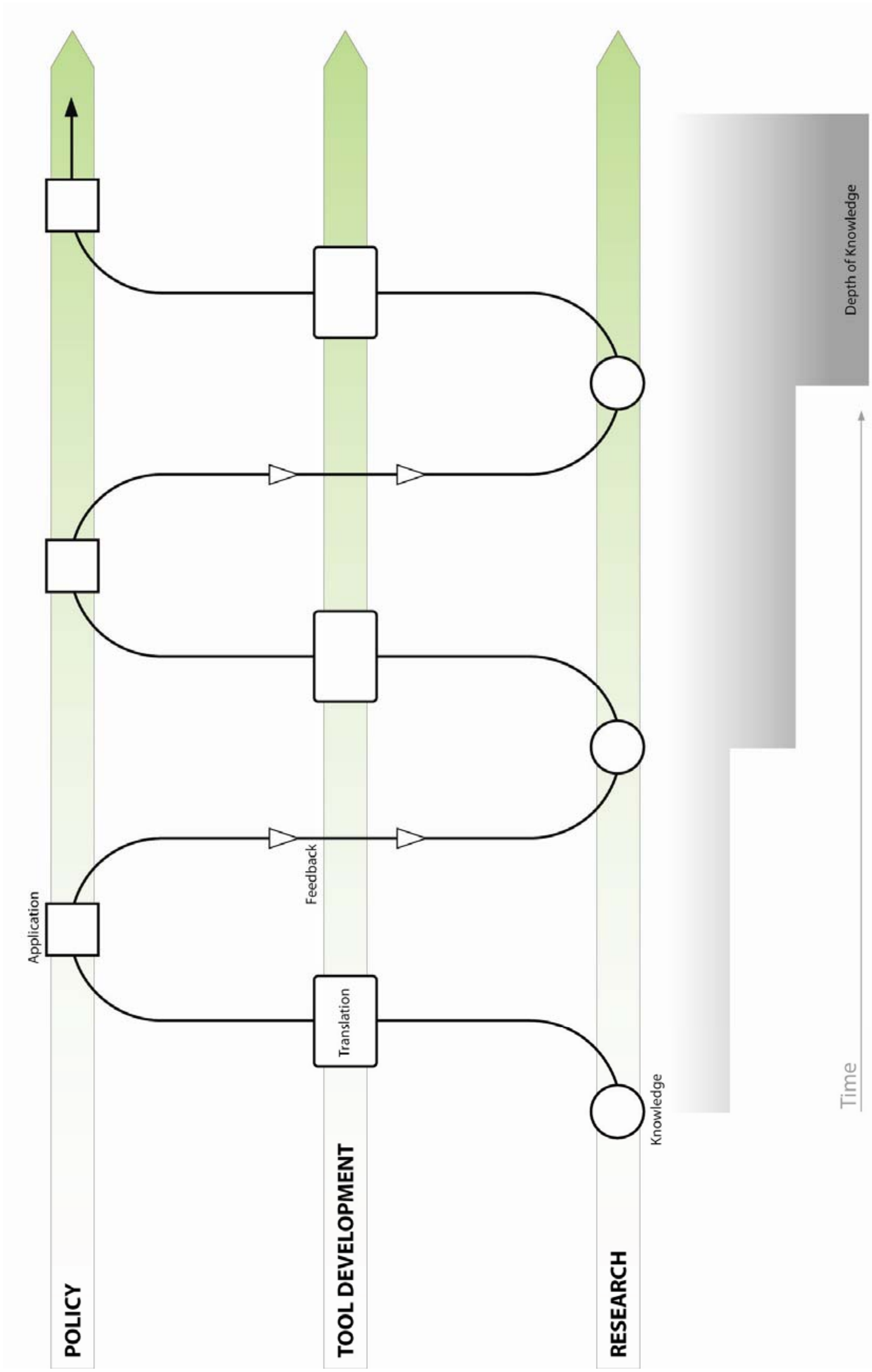
POLICY
TOOL DEVELOPMENT
RESEARCH
Application
Feedback
Translation
Knowledge
Time
Depth of Knowledge

Figure 2

SOURCES

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