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Data Issues and Promising Practices for Integrated Community Energy Mapping

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Executive Summary

Municipalities, utilities, and the public can use energy mapping to make informed decisions on energy end use and renewable supply options in the built environment. Integrated community energy mapping (ICEM) is an emerging mapping and modelling approach that leverages existing and new datasets and available building and technology energy modelling software in combination with geographic information systems (GIS) to provide scalable spatial decision support to energy and emissions planning, policy, and program development, and their implementation and verification. Applications include energy and emissions inventories for municipalities, and utility conservation demand management and demand-side management program planning, implementation, and identification of smart energy network opportunities.

ICEM is a key component of a consistent methodology for characterizing energy and emissions in communities. Outcomes include achieving energy conservation and greenhouse gas reduction targets, offsetting energy infrastructure renewal costs, and realizing energy cost savings for residents, businesses, and organizations.

Similar Issues Observed Across Energy Mapping Projects

Natural Resources Canada has led and supported ICEM research projects since 2008. The projects faced similar data challenges.

This report outlines municipal and utility user needs for energy mapping, providing the basis for a detailed investigation of common technical barriers and knowledge gaps in working with ICEM data inputs. The datasets required to map and model baseline and future energy, emissions, and costs scenarios for the housing and building stock are explored.

Two case studies describe collaborative and data issues: the Integrated Energy Mapping for Ontario Communities (IEMOC) project and the Spatial Community Energy Carbon and Cost Characterization ($SCEC^3$) model for Prince George, BC. For each dataset and distinct data integration activity, specific issues are described. Themes that emerge include access, structure, level of geography, and consistency. Importantly, the protection of personal and commercially sensitive information is not an issue but rather a prerequisite to be addressed for datasets individually and when integrated.

The data issues encountered in energy mapping projects to date are typically larger than can be tackled by individual proponents on a project basis. They are of concern because they translate into quality issues that impact the reliability, replicability, accuracy, and cost effectiveness of energy mapping initiatives and, by extension, the policy, planning and programs being designed, implemented and monitored. This paper aims to identify and describe the data issues so they may be resolved systematically by organizations working collaboratively to implement promising practices to advance community energy planning and utility conservation and infrastructure planning.

Best and Promising Practices

A number of best and promising practices for ICEM were used successfully in the IEMOC and SCEC[3] projects to respond to data issues; a third case study, the Tract and Neighbourhood Data Modelling (TaNDM) project, offers new methods for data integration and aggregation. The best and promising practices cover the themes of collaboration, access, consistency, structure, and level of geography. Guidance from these three projects is augmented in this discussion with information from NRCan's Canadian Geospatial Data Infrastructure (CGDI).

Best organizational practices enabling data access for clearly defined purposes include commitment to collaboration and continuous improvement, conducting user needs assessments, developing use cases, defining scopes, and gathering data requirements. Data should be evaluated to determine sensitivities and shared to enable further research and development of authoritative and useful data products. Requirements around privacy and the commercial value of data must be respected and managed appropriately; privacy impact assessments, privacy protection principles, non-disclosure agreements, and data licenses are useful mechanisms.

Obtaining data closest to the source is another best practice that, although organizational in nature, will reduce project risk by accessing the most relevant and authoritative data. Seeking clarification on structural and consistency issues from data custodians is also recommended. Although not all datasets needed for energy mapping are yet accessible via open data, this best practice shows how governments can make administrative datasets more readily available.

Best practices to improve data consistency include developing authoritative parcel fabrics and civic addressing on a provincial basis, although this may be precluded in some jurisdictions for commercial reasons. Further best practice guidance is required on greenhouse gas emissions factors, capital costs, and the use of modelled energy data. All of these datasets and associated best practice guidance will provide a strong foundation for energy mapping when openly accessible in all jurisdictions.

Promising practices to improve consistency include assessing the data to determine its highest and best use for energy modelling and mapping, identifying standard building categories across collaborating organizations, and developing standard building information reports.

To tackle issues relating to level of geography, sharing data (under prescribed conditions as defined by non-disclosure agreements and/or data licenses) at the finest spatial resolution—at the level of the parcel, building, and energy meter — is recommended. Data integration at this scale is considered a promising practice as it enables the data integration to be done once; if maintained, this integrated dataset can serve multiple purposes. Linking all data to a unique numeric identifier, maintaining direct database/geodatabase linkages, and additional data tables to link building and unit attributes are promising practices for data matching, including for complex parcel-building-unit cases. Establishing a common method for municipalities to assign identification numbers and link parcel and building data for multi-unit residential buildings and other complex building types is also advised.

Data aggregation by building type or category to defined levels of geography and privacy thresholds are promising practices that generate robust energy and GHG emissions information by building type in a privacy-compliant manner. Energy use intensity and energy use per capita are key energy-related indicators that can be produced at various levels of geography through this approach.

In further ICEM research and development, to ensure the integrity and authoritativeness of data products as well as ensuring a positive stakeholder experience, it is important that quality assurance and quality control be performed at various stages in the ICEM development process. The Canadian Geospatial Data Infrastructure can provide numerous examples of best practices in other domains as well as data standards that can be leveraged by ICEM initiatives on a going-forward basis.

Future Directions

Leveraging geospatial standards and web services, visualization and information design, and energy analysis at finer temporal resolutions are all potential future directions that can enable and derive additional value from integrated spatial datasets. The ubiquity of sensors and the rapid evolution of the type and quantity of data will support enhanced model calibration, monitoring, and verification.

Given the ability of GIS to integrate multiple complex datasets in a spatial manner that stakeholders can see and understand, ICEM is a transformative innovation that has the potential to contribute to improved economic productivity, environmental protection, and quality of life for Canadians. This depends, however, on enabling access to authoritative data and fostering a community of practice for its use.

Summary of Data Issues and Promising Practices

Table 1: Summary of data issues and promising practices by theme.

Theme	Data Issue	Promising Practices
Collaboration	• Improper assumptions made about datasets originally collected and maintained for purposes other than energy mapping • Business models of organizations not designed to interact with each other • No prior business case for use of each other's data	• Collaboration and continuous improvement • Build a roundtable of data custodians and users • Engage broad range skill sets to assess data issues and means of their resolution (e.g., business strategy and policy, geomatics and IT, building energy, legal, etc.) • Hold workshops to build trust and to identify barriers, business needs, data requirements, and use cases • Use project management and business analysis best practices • Hold multi-stakeholder meetings to develop, promote common understanding of, and seek clarification on the methodology and data models under development
Access	• Users: Accessing data through ad hoc requests • Providers: Receiving multiple inconsistent data requests • Datasets for future modelling (e.g., future growth, utility rates) may not be accessible	• Establish scope defining acceptable use cases • Assess level of sensitivity of datasets or data products • Develop standard reports • Elicit assumptions for future scenarios from those with local/domain knowledge • Implement organization geomatics policies

Consistency	• Data gaps for specific attributes consistently, or individual records randomly • Lack of complete civic address • Lack of clarity on modelling methods • Lack of standard assumptions for baseline emissions factors, energy prices, and capital costs	• Identify potential causes of data gaps; develop methods to address limitations and approaches for filling data gaps • Develop authoritative civic address information • Use building and housing archetype modelling files according to provincial Building Code or National Energy Code for Buildings (NECB) • Provide guidance on standard assumptions for baseline and projected GHG emissions factors, energy prices and capital costs on a provincial, regional or community basis
Structure	• Data originally collected and maintained for other purposes (e.g., property assessment) • Building types or categories defined differently by different organizations • Multiple parcel-building-unit configurations • Data maintained in different database types (e.g., relational or geodatabase) with different data linkages	• Assess existing data to determine highest and best use for energy modelling and mapping purposes • Identify standard building categories across assessment authorities, utilities, municipalities, and NRCan • Link standard building categories, census tract and municipal identifiers to each building to enable aggregation • Link all data to a unique numeric identifier such as the parcel identifier (this may vary by jurisdiction) • Establish direct database linkages for simple cases (e.g., one parcel to one single-family unit) and maintain data tables to link building and unit attributes for more complex cases (e.g., multiple parcels to mixed-use unit) • Engage a third party to provide quality control, quality assurance review of data models, standard reports, new data products, etc.

Level of Geography	• Obtaining utility data at the individual building level • Significant undertaking of linking parcel-building-meter data • Aggregation of energy data by postal code	• Establish data-sharing agreements • Integrate data at the parcel-building-energy meter scale • Build data relationships once and maintain them • Aggregate utility data by standard building category and levels of geography to privacy thresholds

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1. Introduction

In 2008, legislated requirements newly introduced in British Columbia (BC) and Ontario began generating demand for improved measurement and modelling of energy and greenhouse gas emissions in communities. In BC, changes to the Local Government Act required municipalities and regional districts to include emissions policies, targets and actions in their Official Community Plans and Regional Growth Strategies. In Ontario, the Ontario Power Authority (OPA) introduced requirements for Local Distribution Companies (LDCs) to meet Conservation and Demand Management (CDM) targets. Increasingly, natural gas utilities across the country have been introducing Demand-Side Management (DSM) programs. Municipal sustainability and local economic development goals are also drivers of energy planning.

In 2009 Natural Resources Canada's (NRCan) CanmetENERGY hosted a symposium entitled *Community Energy Planning in Canada: the Value of Energy Mapping*. [1] Attended by members of the federal government, municipal governments, non-governmental organizations, and industry and academic representatives, the symposium's purpose was to assess potential for the application of energy mapping and to encourage knowledge exchange about the role of the federal government in deploying energy mapping across Canada.

Responding to the need for more research and development in the area, from 2009 to 2012 CanmetENERGY supported or led a number of energy mapping initiatives, including those in: Calgary, Alberta; Prince George and Vancouver, BC; Guelph, Hamilton, Barrie and London, Ontario; and the Strait-Highlands Regional District, Nova Scotia. Similar technical barriers and knowledge gaps about data access, structure and integration were identified by data users and providers across all of these initiatives.

Based on project experience and interviews with community energy planning practitioners, this discussion paper characterizes these data issues and identifies promising practices for their resolution.

1.1 Integrated Community Energy Mapping

Integrated community energy mapping (ICEM)[1] is designed to support cost savings and greenhouse gas (GHG) emissions reduction measures. It achieves this by quantifying energy conservation, energy efficiency, and opportunities for district and renewable energy technologies in communities.

ICEM is a decision support approach that offers municipalities and utilities a powerful new means of integrating data, conducting scenario analysis, and visualizing energy,

[1] Common language is a central challenge for any new technology or discipline. This paper will use "ICEM" and "energy mapping" interchangeably. A glossary of terms and acronyms are found in Appendix A and Appendix B.

GHG and costing information. It can be used to develop inventories and in target-setting and prioritization exercises to advance the implementation of integrated community energy solutions (ICES). [2]

Using a basic level of technology, hands-on mapping exercises are effective for stakeholder engagement. Using a higher level of technology, data-rich map-based digital applications can be developed by overlaying geospatial datasets on buildings, along with measured and modelled energy-use data. Geographic information systems (GIS) as well as other database and design software are used for data analysis and visualization. Data may be presented at different levels of geography depending on the planning purpose and privacy requirements associated with the data (Figure 1, Figure 2).

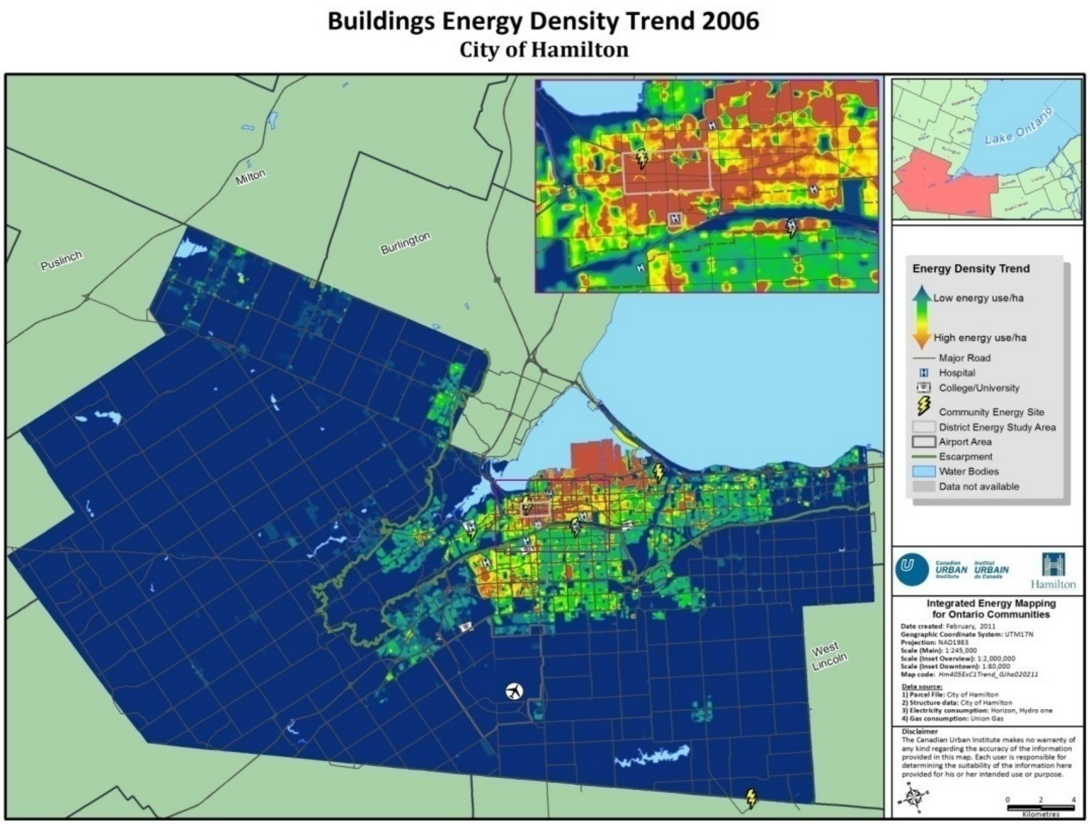

Figure 1: Energy density map: building energy use spatialized by hectare in Hamilton, Ontario. Integrated Energy Mapping for Ontario Communities (IEMOC) initiative.

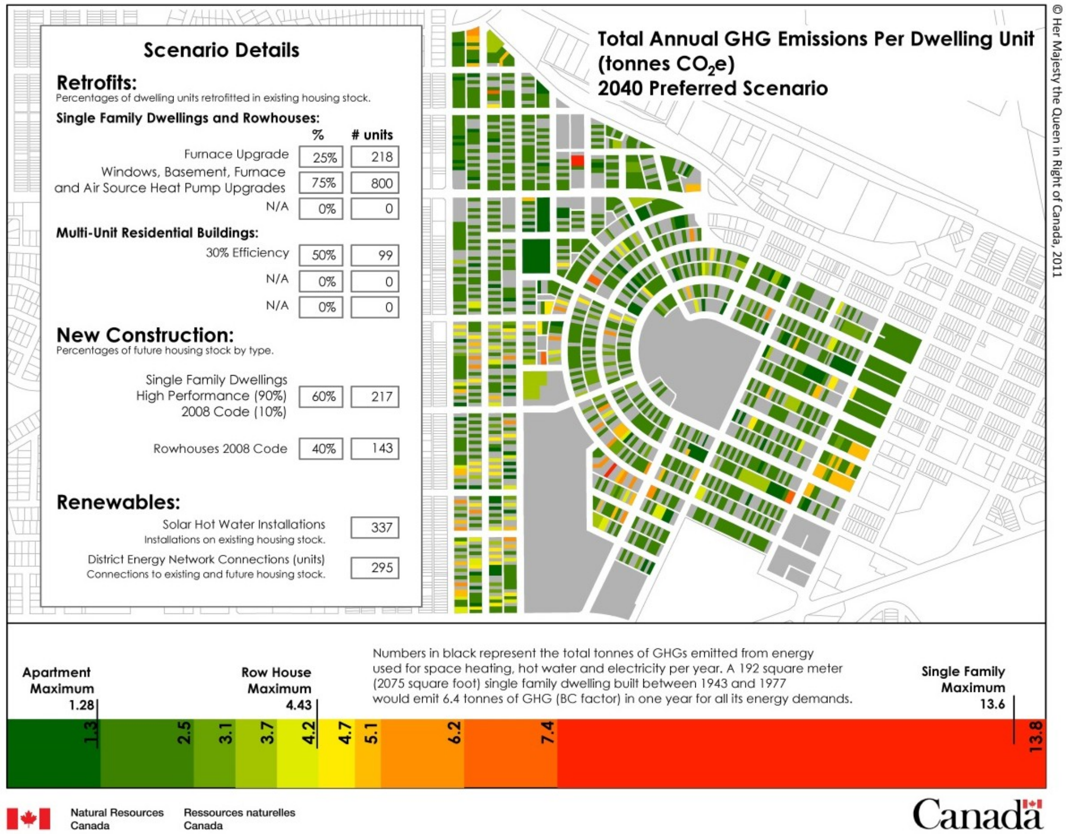

Figure 2: Average GHG emissions (based on modelled energy use) at the level of the housing unit, attributed to the parcel, in the Crescents neighbourhood, Prince George, BC. Spatial Community Energy Carbon and Cost Characterization (SCEC3) model.

1.2 User Needs and Use Cases

Municipalities and utilities are organizations served and engaged by energy mapping projects. Common decisions that benefit from energy mapping include: energy and GHG target setting and evaluation; energy efficiency and conservation in housing, buildings, land use and transportation; infrastructure and capital planning; and district and renewable energy potential assessment. These areas of common interest support greater utility-government collaboration and data sharing.

1.2.1 Energy and GHG Targets

Municipalities can use mapping assessments to evaluate the potential to meet established energy or emissions reduction targets or for setting new targets. To assess how actions contribute to an overall community target, mapping and modelling is required across a range of sectors. For example, the City of Calgary has used energy mapping to visualize the energy impacts of different levels of energy efficiency and alternative energy technology improvements. Using a cost-benefit approach, staff determined actions necessary to achieve Calgary's target of 50% reduction below 2005 levels by 2050. [3]

Since 2008, British Columbia's Local Government Act has required local governments and regional districts to include GHG targets, policies and actions in their Official Community Plans (OCPs). [4] This links energy and GHG emissions to the land use planning process, creating a "technology pull" for energy mapping.

Some municipalities have sector-specific targets in addition to community-wide targets. [5] For example, energy conservation or GHG reduction targets may be included in community energy plans for municipal buildings or residential housing stock.

In Ontario, electric local distribution companies (LDCs) are now required by the Ontario Energy Board (OEB) to meet specific CDM targets. [6] Natural gas LDCs propose DSM targets, which are then approved by the OEB. [7] Mapping is an underutilized tool for assisting utilities to prioritize projects that will meet or exceed their targets.

1.2.2 Land Use and Transportation

Transportation energy end use typically accounts for the highest proportion of GHG emissions in a community. Mapping can be used to visualize and quantify the transportation energy and emissions implications of development patterns. Electric utilities are also interested in the impact of electric vehicles on electricity demand.

1.2.3 Energy Efficiency and Conservation in Houses and Buildings

Mapping can help target building types and neighbourhoods for energy efficiency and conservation measures. It supports quantification of estimated energy and GHG emissions savings of measures applied to existing buildings. Although mapping is not required to simply calculate the energy impact of new buildings built to the Building Code or better, it can support the integrated assessment of energy, emissions, and cost implications of future scenarios that consider both existing and new buildings, in relation to zoning and Development Permit Areas. Mapping helps to answer the critical planning question: "How many buildings, of which type and floor area, will be built where and what are the energy, GHG emissions, and cost implications?"

Utilities are anticipating that information derived from mapping will inform CDM and DSM planning and programs. For example, Horizon Utilities, an electric LDC, is evaluating the use of energy maps to direct CDM resources to where they will achieve the largest reductions in electricity use. [8] Increasingly, gas utilities are also introducing DSM programs.

1.2.4 Infrastructure and Capital Planning

Mapping provides utilities with a more detailed and nuanced understanding of municipal growth patterns, potentially leading to better-informed infrastructure decisions and capital cost deferrals. For example, a transmission planner could benefit from a holistic picture of the sources of alternative supply and demand in relation to transmission infrastructure. Similarly, integrated land use, energy use, and infrastructure information can allow a regulator to consider a utility's plans based not only on historical growth patterns but also on anticipated growth patterns driven by market demand and government policy.

1.2.5 District and Renewable Energy Potential Assessment

In Vancouver, mapping heating demand revealed neighbourhoods suitable for district energy pre-feasibility studies and district energy (DE) policy development. [9] In Calgary, the aforementioned energy mapping study showed where solar thermal hot water installations could support meeting local demand. [10]

Spatial analysis is commonly used to calculate renewable energy resource potentials and assess site suitability for renewable technologies in the pre-feasibility phase.

1.2.6 Education and Awareness

The energy mapping process is a powerful means of collaboration and communication. Using maps to engage stakeholders and solicit local knowledge of energy opportunities helps to develop a comprehensive picture of the many potential actions that can reduce energy and GHG emissions in a community. Maps convey abstract and complex issues in a holistic and visual manner to which people can relate. Community engagement in energy planning processes is important for enabling stakeholders to voice their ideas and concerns, contribute to a common understanding and solution that everyone can live with, and increase the likelihood of successful project implementation. Mapping is a key tool in any community engagement toolkit.

1.2.7 Municipal and Utility Collaboration

Mapping is seen as a way to create bridges between utilities and municipal governments. Horizon Utilities, the electric LDC for Hamilton and St. Catharines, Ontario, discovered that the mapping process can create a common cause for action and a platform for partnership and collaboration with municipalities and other local agencies.

BC Hydro has initiated a collaborative energy management agenda, which started with partial funding for Community Energy Managers to work as members of local government staff. Energy maps are often included in community energy assessments.

1.3 Approach

This paper focuses on the data required to develop digital ICEM applications in order to analyse building stock for policy and program development and assist municipalities and utilities with implementation.

Three research projects are reviewed:

1. Integrated Energy Mapping for Ontario Communities (IEMOC) initiative
2. Spatial Community Energy Carbon and Cost Characterization ($SCEC^3$) model
3. Tract and Neighbourhood Data Modelling (TaNDM) project

Drawing on these three research projects and practitioner interviews, this paper discusses:

- Current and emerging user needs
- Data requirements
- Issues with data accessibility, consistency, structure, and level of geography
- Promising, good and best practices for resolving data issues

1.3.1 Research Projects and Sources

The IEMOC initiative used energy mapping to inform long-range planning in Guelph, Hamilton, Barrie and London, Ontario to reduce energy demand within the built environment and encourage use of renewable energy sources while enabling population and employment growth. IEMOC was led by the Canadian Urban Institute (CUI) and supported by the (OPA), Natural Resources Canada's CanmetENERGY Ottawa and the Ontario Centres of Excellence (OCE). Utilities participated as data providers. There was interest among utilities in energy mapping applied to CDM and DSM planning; however, this was not an objective or activity of the IEMOC initiative.[2]

The $SCEC^3$ model was developed to provide decision support for residential community energy and emission reduction planning in Prince George, BC and to research a consistent method for characterizing energy and emissions in communities. It was developed from 2009 to 2012 by NRCan and Vive le Monde Mapping in collaboration with the City of Prince George, non-government organizations, and academic and private sector partners.

The TaNDM project provided an opportunity to refine the thinking about user needs and data issues and further develop promising practices. Its purpose was to pilot the development of Community Energy and Emissions Inventory (CEEI) reports at the neighbourhood or census tract scale, specifically by improving the quality, structure and level of geography of the data. TaNDM was a research initiative of the Province of BC, supported by NRCan through the Clean Energy Fund and the ecoENERGY Innovation Initiative.

[2] Horizon Electric Utility's project, Energy Mapping for Delivery of Conservation and Demand Management (CDM) Programs, was a separate initiative inspired by IEMOC and funded by the Ontario Power Authority.

Data issues and promising practices identified and developed in the research projects were confirmed through interviews with practitioners. Additional guidance was sought from Canadian Geospatial Data Infrastructure, [11] *A Guide to the Business Analysis Body of Knowledge*, [12] and *The DAMA Guide to the Data Management Body of Knowledge*. [13]

2. Data Requirements

Datasets used in the three projects reviewed here are listed in Table 2. Repurposing existing datasets originally collected and maintained for other purposes is a common practice in energy mapping.

Table 2: Data used in ICEM projects.

Data	Contains	Source		
		IEMOC	SCEC[3]	TaNDM
Parcel fabric	Legal lot boundaries, referred to as parcels	Teranet via participating municipalities	ICIS	ICIS
Property assessment	Building attributes such as building type, age, floor area, number of units	MPAC via municipalities	BCA	BCA
Future building growth projections	New construction by building type, floor area, and neighbourhood	Developed by municipal long-range planners	Demographic consultants, refined by municipal long-range planners	n/a
Measured electricity use	Annual measured electricity consumption	LDCs	BC Hydro via CEEI	BC Hydro
Measured natural gas use	Annual measured natural gas consumption	LDCs	FortisBC via CEEI	FortisBC
Housing energy retrofit audits	Detailed data on building attributes; a record of envelope and mechanical system retrofits	NRCan	NRCan	n/a
Modelled housing and building energy use	Simulations for a variety of building types, vintages, and locations; simulation of alternative energy technologies	HOT2000 Screening Tool for New Building Design	HOT2000 Screening Tool for New Building Design	n/a

LiDAR	3D point cloud and digital elevation model describing rooftops and vegetation for assessing solar and biomass general technical potential	n/a	City of Prince George	n/a
Solar photovoltaic and solar hot water potentials	Modelled general technical potential of solar energy resource for photovoltaic (PV) and domestic hot water (DHW)	RET Screen	University of British Columbia	n/a
GHG emissions factors	Factors to convert energy end use by source to equivalent tonnes or carbon dioxide	US EPA, IPCC, Mobile 6C, local and provincial data	BC Ministry of Environment	n/a
Operating energy costs	Energy prices for baseline and future scenarios	LDCs	BC Hydro and FortisBC	n/a
Capital costs	Capital costs for building retrofits, higher building standards, and renewable technologies	Cost consultant	Cost consultant	n/a
Market segments	Demographics, social values, preferred media channels for research, map and program design	Environics Analytics	Environics Analytics	n/a

3. Data Issues

Each dataset used in the IEMOC and SCEC[3] projects is described, and the issues encountered in the course of the projects are explored. The TaNDM project, which took place after IEMOC and SCEC[3] and addressed many of the previous issues raised, is described in section 6, Best and Promising Practices.

Data issues are generally either organizational or technical in nature. Organizational issues (3.1) stem from the new energy and GHG emissions planning requirements, and the theme of most of these issues is one of collaboration. Technical issues (3.2 to 3.11) embody four additional themes: access, consistency, structure, and level of geography. For some of the datasets described, the issue or challenge that needed to be overcome may not be readily apparent. This generally relates to datasets for which access posed the greatest challenge. As was the case with housing and building modelled energy data, renewable energy technology assessment, and GHG, energy price and cost factors, significant efforts were required to obtain raw data, analysis, or informed estimates by subject matter experts.

Collectively, these issues all affect the quality of the datasets individually, and the accuracy, consistency, replicability, and reliability of information products developed through analysis when datasets are combined.

Identifying and proactively resolving these issues by implementing promising, good and best practices is important for deriving the best value from energy mapping initiatives. Because many of the issues are beyond what can be addressed on an individual project basis, they are described to enable senior governments, utility regulators, provincial associations or others to resolve them systematically.

Protection of personal information and commercially sensitive data is not an issue per se, but rather a prerequisite to be managed. Whether datasets or attributes are considered personal or commercially sensitive information is touched upon for each dataset reviewed. This topic is further elaborated in section 5, Protection of Personal and Business Information.

3.1 Organizational Issues

The business models for organizations such as provincial government departments, municipalities, tax authorities, and utilities are not designed to interact with each other to respond to the new energy and GHG requirements. Specifically, there is no precedent for the use of each other's data for community energy and utility conservation program planning purposes.

Many of the required datasets were originally created and maintained for different purposes (e.g., customer billing or asset maintenance). Organizations such as utilities and property assessment authorities receive inconsistent data requests to access this information. Allocating staff time and resources to respond to these requests presents operational issues. Increased collaboration is required to achieve service quality and operational efficiencies while adhering to legislative and policy requirements, and new geospatial policies may need to be developed.

3.2 Parcel Fabric

The parcel fabric, or cadastre, is a digital geospatial dataset of legal lot boundaries known as parcels. The parcel fabric is created from survey plans, site plans, and area plans. Each parcel is described by its geospatial location and boundaries and is identified with a unique alphanumeric identifier known as a parcel identification number (PIN) in Ontario and a parcel identifier (PID) in BC for privately owned parcels (PINs are also used in BC to identify parcels of Crown Land). The parcel is the level of geography to which municipalities assign zoning and building types, number of units, and other information. The parcel fabric is updated when properties are subdivided or combined.

In Ontario, the Ontario Parcel database was initially developed and is now maintained and licensed to municipalities by Teranet. Ontario Parcel aligns the geometry of ownership, assessment, and crown land parcels and contains both PINs and assessment roll numbers. This integrated dataset is not always accessed by all organizations, however.

In BC, the parcel fabric is updated by local governments and a common authoritative version is maintained by the Integrated Cadastral Information Society (ICIS).

The parcel fabric is not considered personal information. In both the IEMOC and SCEC[3] projects, the parcel fabric was obtained from city staff.

IEMOC

In Ontario, parcel fabric data issues may be attributed to:

- Out-of-date parcel fabric, owing to the length of time between when a parcel changes on the ground and when the parcel fabric is updated.
- Different parcel fabric versions maintained by different municipal departments. For example: residential and commercial properties maintained by one department and green space by another.

The IEMOC project team referreddiscrepancies back to the municipality for investigation and manual update; in some cases this involved digitizing an original site survey. Guelph improved the accuracy of its parcel fabric when out-of-date parcels were identified during the energy mapping process. An unanticipated project benefit was identification of unassessed properties.

SCEC[3]

In BC, fewer issues relating to missing PIDs were observed, possibly because most municipalities provide parcel fabric updates toICIS within a month and some within a week of a property or land title change. However, different issues relating to data structure have been identified. These include:

- Crown land parcels not assigned PIDs and sometimes not having PINs.
- Different approaches for assigning PIDs to strata or condo plans in the assessment roll compared to parcel boundaries in the municipal GIS. Sometimes PIDs are assigned to a part of a parcel, sometimes to a building, and sometimes to a unit within a building. Municipalities typically devise their own method of linking information on stratas or condos to the parcel fabric.

3.3 Property Assessment Data

Having a relatively complete and comprehensive picture of the building stock is a central requirement for developing functional, accurate, and useful energy mapping applications. Property assessment databases contain building attributes or characteristics collected and maintained to support municipal taxation. Property assessment data describes the building stock as a whole, in a general way. Appropriate use of assessment data requires an understanding of valuation terminology. Building energy knowledge helps to determine whether attributes collected for tax assessment purposes are reliable for energy modelling.

In Ontario, property assessment data is maintained in by the Municipal Property Assessment Corporation (MPAC). In BC, property assessment data is maintained by BC Assessment (BCA).

IEMOC

Participating municipalities provided assessment data to the project team. For some properties, the required building attributes were found to be missing. These were highlighted and sent back to city staff to be updated manually; if this was not possible, approximate values were assumed.

In the case of a missing building structure code, the property code (describing the type of buildings that could be developed on the property) was used as a proxy. If total floor area was missing, a building's footprint was multiplied by number of storeys.

In some cases, floor area data for institutions—large energy users such as hospitals or universities—were missing. These buildings were located in Google Earth and floor area estimated using GIS.

Assessment data in Ontario is maintained by MPAC and certain details are provided to Ontario municipalities under license. Building attribute or structure information accessible by municipalities is limited in scope and designed for planning and taxation purposes. While energy planning for municipalities is likely a consistent planning purpose under the municipal license, attributes currently accessible by municipalities are incomplete for comprehensive energy modelling of the building stock.

SCEC^3

Building attribute completeness can be thought of as the availability of a given attribute across all buildings of a type in a specified geographic area (e.g., the province). In the development of the SCEC^3 model for Prince George, building characteristics or attributes, including manual class codes and actual use codes (to describe building type and use) and year built, were readily available from BCA. In addition, custom requests were made to BCA to acquire building floor area, number of storeys, and number of dwelling units within each building. BCA data was found to be largely complete for the main building attributes needed to define single-family dwellings, row houses and apartments. Table 3 lists the building attributes used in the SCEC^3 model.

The presence or absence of a particular attribute across all buildings of a type may be explained by the valuation approach. For example, residential assessments require floor area as a key indicator of value. In contrast, floor area data might be missing for institutional buildings where floor area may not be a factor in calculating assessment value or are exempt from taxation. Some floor areas captured are the gross building area while others are the net unit area (e.g., the interior space of a retail shop). Other valuation methods focus on the number of units instead of floor area.

When attributes are missing for individual buildings in a dataset but the attribute data is otherwise available, the problem may be unsatisfactory data management.

A data structure issue relating to floor area is that the area recorded for valuation purposes may include or exclude areas for energy modelling purposes, such as unheated basements or parking garages, and high energy consuming areas such as swimming pools. Floor area required for energy modelling typically excludes unheated areas and would treat areas with high consumption as separate zones. Although modelling and planning at larger spatio-temporal scales is tolerant of larger margins of error, what is included in floor area data should be well understood and considered approximate.

As a part of the TaNDM project, a Privacy Impact Assessment (PIA) was conducted by the Province of BC and BC Assessment to identify and mitigate risks to privacy. This best practice is described further in section 6.4.

Table 3: BCA building attributes used in the SCEC^{3}model for Prince George, BC.

BCA Building Attribute	Use
Actual use code	Identifies building use
Manual class code	Refines building use in certain residential and education facilities when actual use code is insufficient
Number of storeys	Identifies archetype and floor area calculation if floor area is missing
Year built	Identifies building age
Effective year	Reflects upgrades or improvements made to the structure (but cannot be reliably associated with an improvement in energy efficiency)
Number of suites	Calculates energy use per suite in apartments
Total floor area	Calculates building energy intensity
Building finished area	Refines building energy intensity calculation in residential buildings with basements
Jurisdiction	Identifies location; matches data
Roll number	
Parcel ID	
Civic address	
Legal description	
Income ID	Identifies building types on parcels with more than one building or buildings with more than one use
Occupancy ID	
Tenant description	
Occupancy (rent categorization)	
Unit of measure	
Lot size	Assesses building and consumption density
Assessed value	Assists with policy analysis for Ministry of Energy and Mines
Building footprint	Assists with building characterization in creating archetypes
Main building	Sorts out duplicate information for some duplexes

3.4 Remotely Sensed Data

Three main types of remote sensing data are relevant for energy mapping: satellite imagery, LiDAR, and thermal imagery.

Satellite imagery uses a variety of space-based sensors to collect radiation reflected from earth. Types of sensors include visible infrared, synthetic aperture radar, and hyperspectral; each collects distinct information on the earth's surface. [14] For energy mapping purposes, satellite imagery is used to verify building footprints, determine location and type of vegetation, and as a base map layer for visualization purposes.

Light Detection and Ranging (LiDAR) is active remote sensing technology.[3] When processed, LiDAR data produces detailed topographical information in the form of a point cloud that describes elevation and three dimensional characteristics of buildings and vegetation. The LiDAR data most useful for energy mapping is that collected using an aircraft. Stationary and vehicle-mounted applications are also common. [15]

Thermography or thermal imaging detects radiation in the infrared range of the electromagnetic spectrum and converts the data into colour based on warmth. Applications in energy management include detecting heat loss in houses and buildings and overheated components in electrical systems. Thermal imagery does not depict energy use, but rather the emissivity or thermal radiation from objects.

Aerial thermal imagery is collected by mounting a thermographic camera to an aircraft or satellite. Either approach enables production of a map depicting heat loss in the form of temperatures from objects on the earth's surface. This type of data has successfully been used in projects assessing the urban heat island effect [16] and is commonly used to identify grow-ops.

A semantic issue and potential source of confusion is that thematic maps depicting whole house or building energy end use are sometimes called hot spot maps. Although accurate from a cartographic perspective, map authors and users should endeavour to clearly communicate whether a given map depicts whole building energy use (measured or modelled) or thermal imagery (heat loss).

Users should also carefully investigate any claims made regarding the ability to identify specific energy efficiency opportunities relying mostly on aerial thermal imagery. [17] Aerial thermal imagery must be calibrated to measured and modelled housing or building energy data to make specific recommendations concerning retrofits and expected performance improvements and cost savings on an individual house level. Furthermore, the privacy implications of using remotely sensed thermal imagery for energy mapping and planning purposes have also not been fully explored. [18] Further technical research and policy analysis on aerial thermal imagery is required to identify good practices for its use in ICEM.

[3] Examples of passive remote sensing technologies include aerial and ortho-photography.

IEMOC

Thermal and satellite imagery and LiDAR were not used in the IEMOC project.

SCEC[3]

LiDAR data was used by the University of British Columbia to calculate total rooftop area suitable for solar panel placement by calculating rooftop area, orientation, and slope. The LiDAR data obtained from Prince George's Engineering Department was originally collected in 2009 to evaluate flood risk and develop flood control solutions.

Accessing expertise to perform LiDAR data analysis may be an issue for some energy mapping projects.

3.5 Measured Electricity and Natural Gas Data

Measured electricity and natural gas data is required to develop community energy and emissions inventories, monitor energy use over time, and validate modelling results at the building and community-wide scales.

Electricity and natural gas consumption data is collected and maintained by utilities or LDCs for load management and billing purposes. Usage is recorded on a monthly, daily, hourly, or 15-minute basis. Electricity meters are typically installed for each unit. Natural gas meters are commonly installed on a whole-building basis, a practice referred to as bulk metering. Customers are assigned a rate class according to peak monthly demand and billed according to usage. Utilities are receiving an increasing number of data requests from government, the private sector, and non-profit and academic organizations for reporting, planning, and research purposes.

In both Ontario and BC, residential energy use is considered personal information that utilities are required to protect under the federal Personal Information Protection and Electronic Documents Act (PIPEDA). [19] Commercial customers, on an individual basis, may find their commercial and industrial energy use data to be sensitive for commercial purposes. Energy use data as a whole may also be considered sensitive for utilities' own business purposes. Accordingly, utilities have developed policies and protocols for aggregating energy use data before sharing it with external organizations. A common approach is to group customer accounts by three-digit postal code or Forward Sortation Area (FSA).

Distinct approaches were taken in Ontario and BC to make utility data available to the research projects described in this paper. Neither involved obtaining data for individual households and businesses with their individual written consent, as this is a long and tedious process.

IEMOC

In Ontario, energy use data was provided in different formats and levels of aggregation depending largely on the relationship between the local utility and the municipality. In some cases data was provided at a very high level—aggregated by building type across the entire city, for example. In these cases building floor area was combined with energy use intensity factors (EUIs) by the project team to disaggregate and spatially allocate energy use. In other cases, utilities were able to provide energy use data at the address level under Non-Disclosure Agreements (NDAs) between LDCs, municipalities, and the Canadian Urban Institute. This method significantly reduced the generalizations and errors associated with building energy modelling and screening tools, allowing the project team to undertake analyses and make recommendations based on actual, historical measured data. When energy use for a given building was missing, inaccurate, or incomplete, the building's floor area (provided by the municipality) was multiplied by a regional building-type-specific EUI estimate.

A third strategy for data sharing employed a method of aggregation known as the "5 and 25 rule." It was developed by Enbridge Gas Distribution to enable privacy-compliant data sharing. This protocol stipulates that customer natural gas usage data can be shared, grouped by six-digit postal codes, unless either of the following is the case (which will break the rule):

- There are fewer than 5 buildings in the postal code
- Any one building consumes more than 25% of the aggregated natural gas total

If the "5 and 25 rule" is broken at the six-digit postal code level—that is, if there are fewer than five buildings or one building consumes more than 25% of the total—then the last digit of the postal code is removed and customer accounts with the resulting five-digit postal code are grouped together. The test is repeated at the five-digit postal code level and so on until the rule is not broken; energy use data is summed for customer accounts at whichever level the rule is unbroken. In this way, energy data for a city is provided for analysis aggregated to either six, five, four, or three-digit postal codes. Although a legitimate approach from a privacy-compliance perspective, the "5 and 25" aggregation method and resulting data structure was a known source of error in the final energy maps.

Significant time was spent by the IEMOC project team attempting overcome the structural limitations of data provided according to the "5 and 25 rule." Data for some areas was suppressed entirely, meaning that energy use reported at the community scale was usually not complete. To disaggregate the data, assumptions had to be made about which energy data belonged to which building. Data structure issues affecting data quality include:

- A six-digit postal code overlapping a five-digit postal code
- Incomplete address data causing energy use to be assigned to the wrong postal code
- Postal codes crossing municipal boundaries
- Utility rate classes not always corresponding with assessment authority structure codes or Screening Tool archetypes (a separate issue described further in section 4.2)

Postal codes were originally developed for delivering the mail. Energy data aggregation by postal code is problematic for reasons of data structure and level of geography. The structural issue is that postal codes cannot be reliably associated with building type. The level of geography issue is due to postal codes being assigned to different geographies, sometimes crossing municipal boundaries. For example, in urban areas one six-digit postal code may be assigned to all buildings on one side of a block or all buildings on a university campus. One postal code may be assigned to a whole subdivision, a linear rural route, or entire (remote) town. For these reasons, postal codes are not the best mechanism for aggregating and disaggregating measured energy use data, particularly for commercial, industrial, and mixed-use neighbourhoods. Utilities use postal codes because it is a georeferenced attribute already integrated in their datasets for billing purposes. Currently, most utilities are not set up to query data by other geographic boundary systems that may be more useful or appropriate for energy mapping.

Postal codes should, however, be maintained as a building attribute associated with the civic address. Postal codes have value for linking market segments containing demographic and social values information, as discussed in section 3.11.

SCEC^3

In BC, BC Hydro generates and distributes the majority of electricity. FortisBC is the main supplier of natural gas. For the SCEC^3 model, energy use data was obtained for the residential sector at the community scale from the Community Energy and Emissions Inventory (CEEI).

Utility data is made available via the provincial CEEI reports at the community scale but not at the parcel scale. Utilities do not distribute energy use information for individual customers. The rule of thumb applied to the sharing and distribution of utility energy use data is that when any one user consumes more than 50% of energy use within a zone aggregation—such as a postal code—energy use for all users of the same sub-sector, such as industrial, are not shown in that aggregation zone.

3.6 Modelled Housing and Building Energy Data

An ideal energy mapping project has access to both measured and modelled energy data. Measured energy data is needed to develop inventories and monitor energy use over time. Modelling outputs are required to support "what if" analysis to estimate the energy savings potential of retrofits to existing buildings, or the additional consumption to be anticipated from new construction.

Housing and building energy modelling estimates energy performance based on a reference building or archetype. Changes in energy performance are calculated resulting from changes to orientation, geometry, thermal mass, mechanical systems, lighting, and appliances. Assumptions (either standard or community-specific) are used for occupancy, temperature set points, and weather. Energy use is output by source or carrier (electricity, natural gas, renewable sources) and end use (hot water, space heat, and electricity for lighting and appliances). From these results, GHG emissions and operating energy costs can be calculated. Capital costs for retrofit measures or incremental energy improvements to new construction are typically calculated by cost consultants.

Housing and building energy models are used to inform design processes, determine Building Code compliance, and secure grants and incentives.

Although outputs were used differently, both the IEMOC and SCEC[3] projects used HOT2000 and the NRCan Screening Tool for New Building Design. These tools and their outputs are briefly reviewed here. It should be noted these are not the only tools available for this purpose. [20]

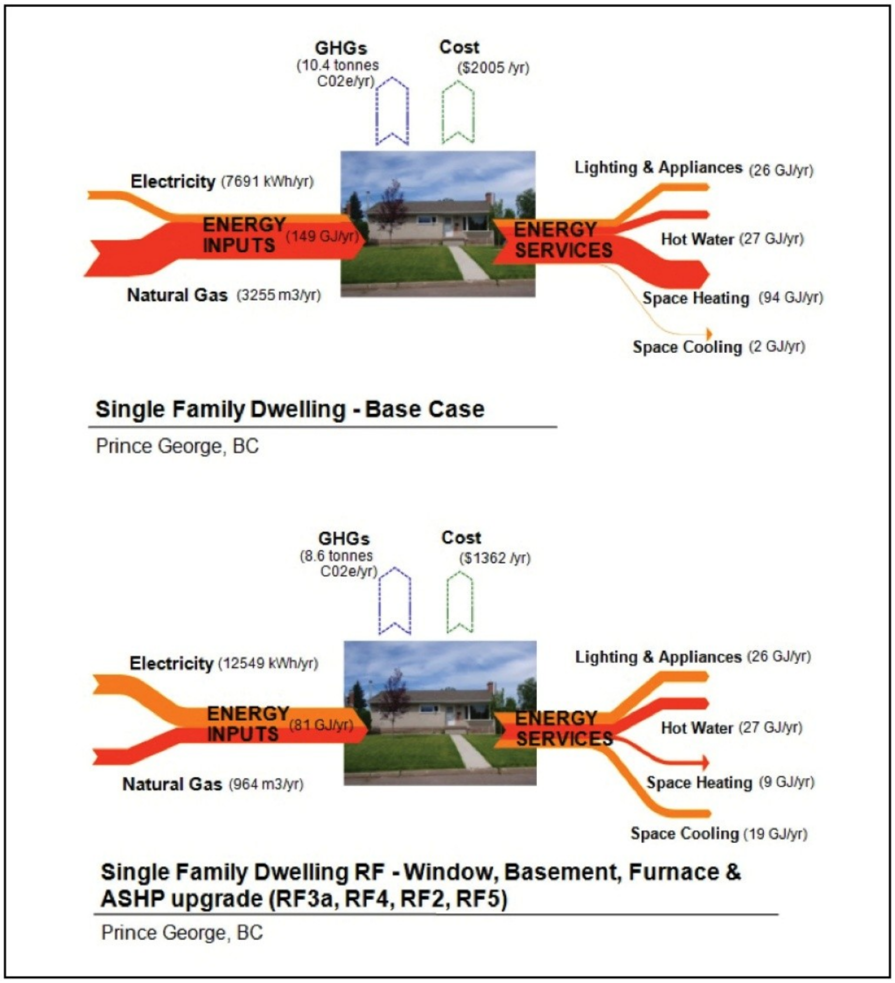

Figure 3: Building modelling estimates of energy, emissions, and costs for baseline and retrofit scenarios.

3.6.1 EnerGuide Home Evaluation Records and HOT2000

The EnerGuide home evaluation records, which include results from all homes evaluated using NRCan's EnerGuide Rating System (ERS), are an important dataset consisting of housing energy modelling outputs using a consistent approach to evaluating energy performance in single-family, duplex, row house, and mobile dwellings. Included in this dataset are the records from the former ecoENERGY Retrofit – Homes incentive program.

Generated using the HOT2000 simulation software and following the ERS standard, there are more than one million home energy evaluation records describing the Canadian residential housing stock. Data has been collected from site visits to individual houses by trained energy advisors who evaluate the home from the attic to the basement and complete a test to measure air leakage. This large and comprehensive dataset, managed by NRCan's Office of Energy Efficiency (OEE), reflects numerous housing types and weather regions and offers important insights into the energy performance of a community's housing stock. Individual records contain detailed building attribute information and estimated energy performance by source and end use. They are also a good source of data for the types and number of retrofits conducted on a community's housing stock.

Using the EnerGuide home evaluation records for community energy mapping and planning is a new purpose distinct from the professional energy efficiency recommendations for homeowners, which they were originally collected to facilitate. As such, there are limitations when using this data. Specifically, limitations arise because:

- It is a self-selected sample; a subset of the housing stock within a community.
- Certain housing types and vintages, neighbourhoods, and demographic segments are better represented than others.
- The dataset does not reflect all retrofits completed in a community. Program participants may not have had a post-retrofit audit conducted and those doing retrofits may not have participated in the program.
- The set of standard operating conditions used in the ERS rating is designed to assess the efficiency of the house itself and does not include information on the behaviour impacts of occupants. Space heating is estimated based on building characteristics, while electricity for lighting, appliances, and other plug loads is assumed.
- Records contain personal information including names, phone numbers, and street addresses.

The EnerGuide home evaluationrecords are an administrative dataset subject to the Privacy Act. A Privacy Impact Assessment has not been completed to assess the risks and mitigation measures for making this dataset available for community energy planning purposes. When data requests are made, the protocol involves removing names, phone numbers, and the street address, and truncating postal codes to the three-digit level. Unless the EnerGuide home evaluation records are used to create a set of archetypes, there is difficulty in using the data for energy planning.

3.6.2 Screening Tool

Apartments, commercial, and institutional buildings were modelled at a high level using NRCan's Screening Tool for New Building Design. [21] The Screening Tool enables calculation of whole-building energy performance by modifying a building archetype—a reference building—located in a weather region. A user must provide basic information including heating system type, building envelope characteristics, mechanical systems, lighting, auxiliary fans and pumps, as well as process loads. The building archetype modelling files meet the provisions of the Model National Energy Code for Buildings (MNECB) 1997.

Some assumptions contained in the tool are not exposed. Additionally, 30-year historical weather data is used. Screening Tool outputs should therefore be understood as quick, general estimates of building energy use.

IEMOC

In the IEMOC project, measured utility data provided by FSA was disaggregated to lower levels of geography and distributed across various building archetypes, guided by energy intensity factors output from the Screening Tool. Because this involved integration of two datasets, this is described in greater detail in section 4.3.

Building energy modelling was provided by a third party consultant engineering firm. Although the numeric values were developed as outputs, the underlying methodology was not fully described in the IEMOC Lessons Learned report, preventing a reliable assessment of the use of modelled energy data in the context of the project.

SCEC^3

Recalling that individual dwellings described in the property assessment data were grouped into archetypes, energy use intensity factors modelled in HOT2000 were multiplied by the floor areas of individual dwellings corresponding to a given archetype. More specifically, the energy use intensity factors were broken down by energy source by end use (e.g., natural gas for space heating) prior to multiplication by either floor area or standard occupancy. Energy uses driven by occupancy (e.g., hot water) were calculated in modelling tools based on average occupancy from the 2006 Census. Modelled energy for these occupancy-driven uses was assigned to the dwelling unit, not multiplied by floor area.

In the case of multi-unit buildings, whole-building energy simulations were developed in the Screening Tool. Whole-building results were divided by the number of units in the building to enable comparison of energy use per apartment unit with that of single-family residential buildings; common areas were divided and attributed equally among apartment units.

Future changes to the Building Code and the energy, carbon, and cost implications were calculated by simulating homes with higher energy performance. In Prince George, the energy performance of next-generation R-2000 single-family dwellings were modelled and applied to a percentage of new dwellings in high-energy-performance scenarios.

The development of the $SCEC^3$ model was led by CanmetENERGY, the NRCan division also responsible for the development of HOT2000 and the Screening Tool. An effort was made to be transparent about the underlying assumptions and limitations associated with these tools.

3.7 Renewable Energy Technical Potential

Renewable energy technical potential is estimated by assessing characteristics of the resource, the technology, the economy, and the market. While Excel-based decision support software such as RETScreen is common for site-specific analysis, mapping can support the assessment of spatial aspects of resource and technical potential at the site and larger geographic scale. This facilitates wide-scale implementation of renewable energy technologies such as rooftop solar photovoltaic (PV), solar thermal, and wind energy.In the United States, the National Renewable Energy Laboratory has created a national assessment of renewable energy technical potentials using GIS-based methods. [22]

IEMOC

In the IEMOC project,values for renewable energy contributions were generated using RETScreen. [23]

While valid for site-specific considerations, spatial analysis could provide added capacity to refine general renewable energy technical potential assessments, in particular when attempting to estimate contributions from renewable energy sources and technologies over larger areas of geography.

$SCEC^3$

The $SCEC^3$ model enables assessment of three renewable energy technologies: solar domestic hot water (DHW), PV, and biomass district energy. From 2011 to 2012, a method for assessing geothermal energy opportunities was explored but not undertaken due to lack of data and time.

Following the identification of suitable roof areas for solar placement as described in section 3.4 and using established system specifications, estimates of general technical potential for electricity generation from PV systems and thermal generation from solar DHW systems were calculated at a pre-feasibility level in RETScreen. For example, for solar thermal DHW, assumptions were made for daily DHW demand and delivery temperature.

The main issue for other projects could be with access to datasets required to perform the spatial renewable energy technology potential assessments.

3.8 Future Growth Projections

To develop energy maps that support future scenario analysis, future growth projections of the building stock are required. For new construction, the number, building type, total floor area, and location of new residential and non-residential units, as well as approximately when they will be built, is required. The number, type, floor area, approximate location, and timeframe in which old buildings are to be demolished should also be estimated.

IEMOC

Population and employment projections (i.e., number of new residents and new jobs) were converted, in cooperation with municipal staff, to the anticipated number of new units, type, and average floor area for residential; for non-residential, floor area per job was calculated. The estimated number of new units and their floor areas were then distributed in areas identified for new construction through growth strategies such as vacant parcels, nodes and transportation corridors and planning districts. Floor area per building and building type was calculated in each neighbourhood accordingly.

SCEC^3

To develop the SCEC^3 model, the number and location of new residential units was derived from a growth management options analysis prepared for Prince George's 2010–2011 Official Community Plan (OCP) review process known as myPG. [24] Based on zoning requirements for each neighbourhood, the number of potential new units was calculated and assigned based on current OCP residential growth strategies, preferred growth patterns identified in myPG and from the community energy charrette process, and input from planners.

In BC and Ontario, future growth projections are based on the number of new residents and jobs rather than the number of building units per type and corresponding floor area. In the IEMOC project, community planners developed the required information, but in the SCEC^3 project, although the growth projection study existed for the whole community, the location and type of each new unit still needed to be assigned to neighbourhoods by municipal planners. In both instances, this was a necessary but time- and resource-intensive exercise.

Future growth projections may be not readily accessible because they can be considered sensitive for commercial purposes. If disclosed at a low level of geography, future growth projections may impact public participation in planning processes and land values. This information was seen as more sensitive in Ontario than in Prince George, possibly due to differences in growth rates.

3.9 Greenhouse Gas Emission Factors

Energy mapping projects are often driven by or linked with community energy and emissions planning processes. Baseline and projected GHG emissions estimates are therefore an essential output. Emissions factors are needed to calculate equivalent tonnes of carbon dioxide (CO_2e) emitted through energy end use activities.

The emissions factor for natural gas is 1.90 $kgCO_2e/m^3$. NRCan's Fuel Focus website [25] contains the factors for a variety of transportation fuels.

GHG emissions factors for electricity vary according to the fuel mix of the provincial electricity grids. However, for both Ontario and BC, provincial emissions factors are not updated on an annual basis. In particular for electricity, given the changes in the generation mix and associated emissions, timely authoritative information is not always readily accessible.

IEMOC

In Ontario, GHG emissions factors for electricity (tonnes CO_2 per kWh) were prepared by experts familiar with the provincial fuel mix, compiled from sources including the US Environmental Protection Agency, Intergovernmental Panel on Climate Change, Mobile6, and local and provincial data. In some cases, this information was readily available from utilities.

Although natural gas and transportation fuel emissions factors are readily accessible, annual updates of electricity emissions factors on a provincial basis are not. In both projects, these were either sought out from utilities or procured from private sector consultants familiar with the provincial grids and associated emissions factors. For example, Independent Electricity System Operator provides information on grid supply mix in Ontario. [26]

SCEC^3

In BC, electricity emissions factors are established by the Province, published in the *Technical Methods and Guidance Document 2007-2010 Reports*. [27] In the SCEC^3 model, GHG emissions were calculated by multiplying energy use outputs from HOT2000. Default emissions factors contained in HOT2000 are national averages not necessarily reflective of provincial electrical grids.

3.10 Cost Factors

Current and future energy prices and utility rate structures are required to calculate operating energy costs. Estimated capital costs are required to calculate the cost of building retrofits, the incremental costs of higher energy performance in new construction and renewable technologies. Operating energy and capital costs are used to calculate cost savings and simple payback.

IEMOC

In Ontario, baseline operating energy costs were calculated using the rate structure, established according to customer classes and total usage. The structure of rate components such as debt retirement charges and transmission and distribution charges introduced some calculation difficulties.

In both projects energy cost and rate structures for baseline and future projections were not readily available and had to be requested from the utilities. Rate structures, in particular for commercial and industrial sectors, also presented challenges for reliable quantification. Estimated capital costs for retrofit and renewable energy technology measures were researched and calculated by cost consultants.

Energy prices and utility rate structures are for the service area or whole province served by a utility. Geography may pose a challenge for easily accessing capital cost factors. Costing information for many types of construction project components are available for major city centres in costing manual RSMeans. [28] Expertise is required to assemble the cost components (parts and labour) into an overall figure and to recommend adjustments for communities or regions not listed in RSMeans.

SCEC^3

For the SCEC^3 model, baseline electricity and natural gas rates were compiled based on input from FortisBC and BC Hydro. Short- and medium-term rates were available for natural gas. Medium-term electricity rates were available to 2015 but long-term projections were not available. From 2015 to 2040 an increase was assumed mirroring the increase in FortisBC rates. Potential savings from demand management were not calculated.

3.11 Geodemographic Data

Geodemographic analysis is the use of small-geographic-area data to make inferences about populations when data are not available directly on the populations of interest. Analysis typically includes the following datasets either as actual data or direct estimates for a large number of small areas, or as propensity scores based on clusters:

- Census data
- Current-year demographic estimates and projections for future years
- Daytime population
- Household expenditures
- Wealth
- Vehicle registrations
- Clusters
- Broad consumer purchase data
- Health data
- Interests/leisure activities
- Media use
- Attitudes/values
- Voting behaviours

There are generally two types of inferences made:

1. Attribution of data (e.g., demographics, expenditures, wealth, and vehicle registrations) for small areas to individuals who reside in that area).
2. Prediction of the propensity of an individual or household to engage in some behaviour based on assignment to a sociodemographic segment or “cluster” that is created by statistically classifying small areas into similar types based on demographic and other small-area data. The data used to observe propensity can either come from actual observations from participant or customer databases, or from sample surveys linked to these cluster systems.

IEMOC

In the City of Hamilton, building upon the work done in IEMOC, Horizon Utilities worked with Canadian Urban Institute and Environics Analytics to use market segmentation to target high energy users.

SCEC^3

In Prince George, it was planned to use geodemographic data, specifically market segments of ecoENERGY Retrofit program participants, to inform the design and messaging of a residential energy efficiency website based on the SCEC^3 model. Upon review, this project component was deemed as outreach and education and therefore outside of CanmetENERGY’s research mandate.

No issues were encountered with geodemographic data in either of the two projects reviewed here.

4. Data Integration

The IEMOC and SCEC[3] projects took the general approach of accessing, preparing, and linking required datasets in one common geodatabase or integrated community energy map. Issues identified included:

1. Multiplicity of parcel-building-unit configurations
2. Building types defined differently by different organizations

The two projects took separate approaches to the integration of measured and modelled building energy use. The first approach, developed in IEMOC in response to utilities providing aggregated energy data, is to disaggregate measured energy data using modelled values and assigning average values to individual houses and buildings. The second approach, pioneered using modelled data in the SCEC[3] model and then applied to measured data in the TaNDM project, is to match energy use at the lot-building and energy meter scale and then aggregate the energy data by building type to different levels of geography.

Structure issues associated with the disaggregation of measured energy data using modelled energy use and aggregations of modelled data to match a community-wide inventory are also described.

4.1 Matching Building Attribute Data to the Parcel

For both IEMOC and SCEC[3], building attributes were connected to the parcel fabric via the PIN (Ontario) and PID (BC). Figure 4 illustrates the most common and simplest configuration: one single-family dwelling on one parcel. In BC, there is typically a direct or one-to-one relationship between one BCA jurisdictional roll number and one PID.

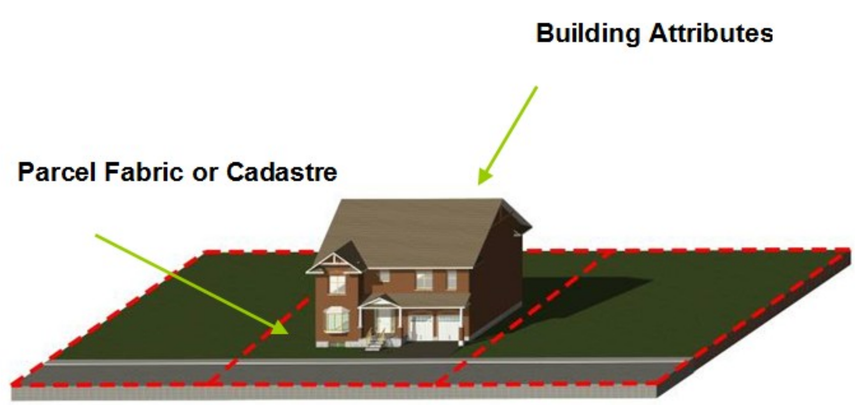

Figure 4: Linking parcel fabric and building attributes.

Issues relating to data structure arose in sorting through the “one-to-many-relationships-in-both-directions” occurring between one or more parcels, buildings, and units, particularly in medium- and high-density neighbourhoods. In these cases, building attribute information was consolidated and linked to the parcel in a consistent manner via a unique numeric identifier: the parcel ID (PID). Examples of these interactions are illustrated in Figure 5.

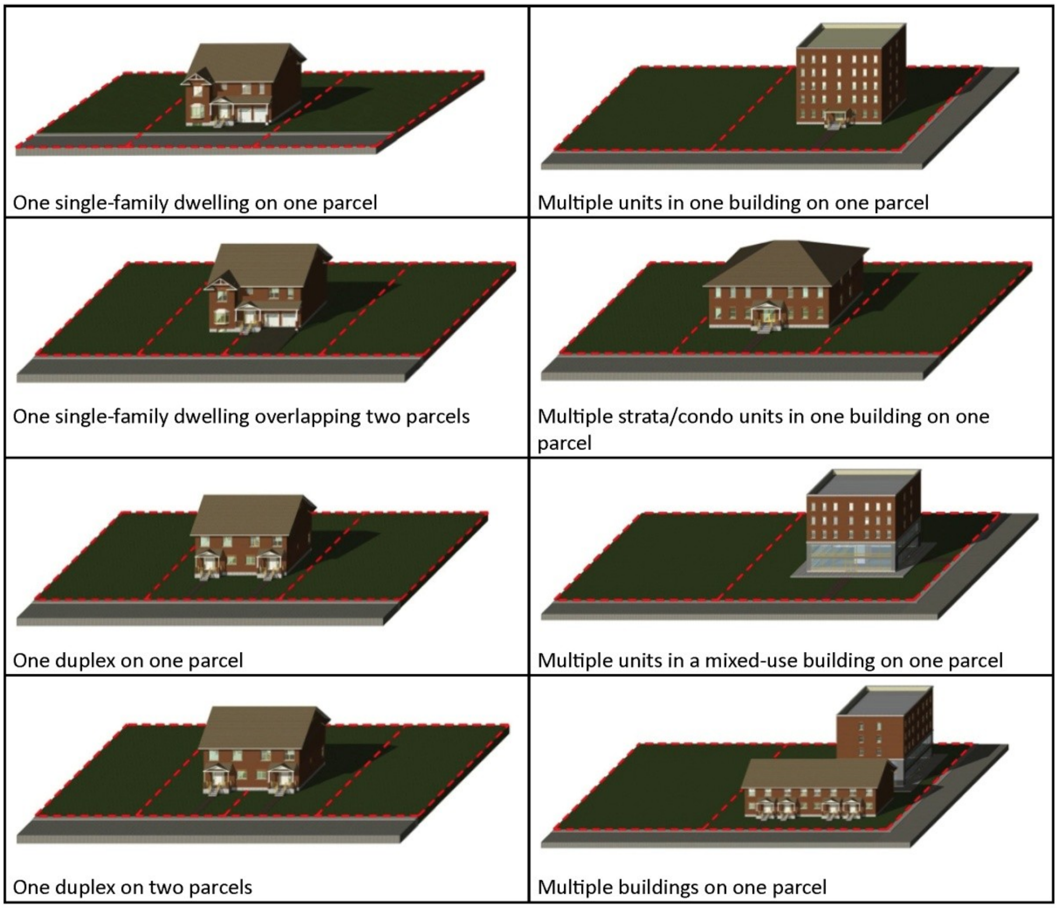

Figure 5: Examples of different parcel-building-unit configurations.

IEMOC

In the IEMOC project, the connection between the parcel fabric and the property assessment was established in the data provided by participating municipalities. These were previously established linkages for municipal planning purposes, not necessarily what was required for energy mapping. In cases where the linkage was not present, it was established by the IEMOC project team. When parcel fabric and property assessment data were matched numerically, inconsistencies observed include:

- Missing PINs
    - PINs contained in the parcel fabric were not found in property assessment data

    - PINs found in the assessment data did were not found in the parcel fabric
- Inaccurate or unclear spatial relationships were identified visually when geospatial data layers were combined in an overlay process

In the Municipal Property Assessment Corporation (MPAC) database, when a property contains more than one structure such as a house, garage, shed, or swimming pool, each structure is given the same identifier, the assessment roll number (ARN). However, property records can have multiple structure codes. MPAC maintains each structure in its database separately to distinguish components such as a detached garage or basement apartment. In Ontario, each condo unit has an ARN.

The IEMOC project team referred to entries with multiple structures with the same ARN as "duplicates." Before building information in the assessment roll was matched to the parcel fabric, duplicates were consolidated into a single entry. First, all non-energy-using structures such as garages and sheds were removed. Next, the floor area of energy-using buildings was summed and assigned to an archetype corresponding to the structure with the largest floor area. Duplicate entries were consolidated using a combination of sorting, filtering, pivoting, and look-up functions in Microsoft Excel. Significant time and computing resources were needed for this task.

Many of the issues encountered by the IEMOC project team can be attributed to the having obtained the data from the municipalities and not via MPAC directly. Although MPAC did provide clarification and information support in some instances, it was not able to provide more complete support as there was no contractual relationship between Canadian Urban Institute and MPAC for the purpose of the project; the cost of purchasing comprehensive data suited to energy mapping for the four municipalities from MPAC directly was not feasible within the IEMOC project budget.

SCEC[3]

Each property valued in BC has an assessment roll number. They are only unique if coupled with the jurisdiction code of the jurisdiction in which the property is located. For example, a property may have a roll number of 12345.678. Because there are roll numbers 12345.678 in Victoria (jur code 234), Quesnel (jur code 470) and Vancouver (jur code 200), the three-digit jurisdiction code is added to create a unique identifier. Thus it becomes 23412345678 for Victoria, 47012345678 for Quesnel, and 20012345678 for Vancouver. This unique numeric identifier for each property, comprised of the jurisdiction code and assessment roll number, is referred to as the jurisdiction and roll (jur-roll) number.

Custom data queries, analysis, and preparation were required to clarify and consolidate the number of units and floor area for duplexes, row houses, and apartments in BC. Data queries, filters, searches for duplicates, mismatches, and confirmation of final results were completed in Microsoft Access.

In the case of single-family dwellings, a direct relationship was made between BCA jurisdiction and roll (jur-roll) information via PID to the parcel polygon in GIS. Entries appearing to be duplicates were found most often to describe two identical units in a duplex. Two attributes can be used to clarify duplicate attributes: main building ID and/or predominant building.

For more complex building types, the main challenge was that building attribute information has a different unique identifier other than the PID. BCA stores building attributes linked to the jur-roll number. The jur-roll is different from the PID and there can be more than one connected to each PID. Likewise, there can be more than one PID connected to one jur-roll number. This many-to-many relationship between PIDs and jur-roll numbers is maintained and updated by BCA.

Purpose-built rental apartments have one jur-roll number, which contains attributes identifying either the whole building or parts of the building with a number of similar units. Sometimes these similar units will be grouped into sets within the jur-roll, possibly due to differences in floor area or other attributes.

When a strata or condo unit is created it is assigned its own PID. For this reason, strata units appear as multiple PIDs in one building. The parcel is not divided into the same number of PIDs as units in the building and is identified by yet a different PID. Each local government uses its own method to link strata or condo units to the parcel fabric. One approach is to enter the strata plan number in the PID attribute field in the municipal GIS and BCA attribute table and use this strata plan number as a link to the multiple PIDs that are part of that strata plan.

In mixed-use buildings, commercial businesses on the ground floor can be distinguished from the residential units above by the actual use code in the jur-roll or an income ID and tenant description.

When there are more than one records containing building attribute information associated with a jur-roll, and more than one of these records per parcel, these attributes are first grouped to describe the different uses within a whole building or different uses of multiple buildings and then linked to the parcel via the PID. The resulting housing data table was not aggregated to the parcel level until energy use had been calculated for each type of use. Energy use was first calculated by building type at the building level and then all energy use for different building types on the PID were summed to the parcel level.

4.2 Different Organizations Define Building Types Differently

An issue hampering the reliable matching of building types and attributes with associated energy use is inconsistent building types identified across organizations. The different words used to refer to building types provide an indication: they may be called archetypes or building categories, or be defined by customer classes. Manual class and actual use codes describe building form and function.

Utilities, which bill customers on the basis of consumption, maintain customer classes for billing purposes. For example, a customer account is usually associated with a residential, commercial, or industrial rate class related to peak demand. These categories may not align between gas and electric utilities. Traditionally, utilities maintained little additional information on building attributes. This is changing, however, with additional data being collected, purchased, or obtained from property assessment authorities and other sources to support a variety of utility analytics.

In contrast to the limited number of customer classes maintained by utilities, property assessment authorities maintain a much longer list of property codes that describe the land and buildings by structure and current use. For example, MPAC maintains two types of classifications: “Property Type” is at a high-level class like residential, farm, commercial, or industrial; “Property Code” is more granular and depicts the predominant use of the property such as single-family detached, freehold townhouse, restaurant – fast food, etc. BCA maintains 480 manual class codes to describe building structure or type for main buildings, outbuildings, and manufactured homes.

The result is that an individual building may be classified differently by different organizations. For example, a warehouse may be described as “industrial” by the assessment authority and as “commercial (General > 50 kW)” by a utility. Another example: the land use for both golf courses and shopping malls is designated as commercial. These discrepancies often require detailed and individual examination of the data prior to analysis, creating challenges for matching building attribute and energy data maintained by different organizations and introducing a potential source of error in ICEM applications.

NRCan uses yet another approach to defining building types. Instead of customer classes and property codes, it uses representative housing and building archetypes to develop energy models. Originally developed to assist with determining eligibility of houses and buildings for incentive programs and compliance of building designs with national and provincial building energy codes, archetypes are also essential for energy mapping.

IEMOC

In Ontario, building types listed on the assessment roll were grouped into eight building archetypes. For example, row housing and walk-up apartments were assigned to the “residential medium density” archetype.

Table 4 lists, for Ontario, customer classes used by natural gas and electric LDCs, selected property codes maintained by MPAC, and building archetypes that can be modelled in NRCan’s Screening Tool.

Table 4: Different building-type classifications in Ontario as observed in the IEMOC project.

Natural Gas Customer Class	Electricity Utility Customer Class	NRCan Screening Tool Building Archetypes	MPAC Property Codes (examples)
Residential	Residential	n/a	301 Single Family Detached
Residential Apartments	General < 50 kW	Multi-unit residential	330 Walk-up Apt, up to 6 Units
		Extended care facility	610 Nursing Retirement Home
Commercial		Hotel	
		Retail, strip mall	473 Office Walk-up, Med and Dental
			760 Police Station
		Retail, big box	442 Restaurant, Freestanding
		Suburban mall	430 Neighbourhood Shopping Centre
		School	605 School, Elementary or Secondary
		Office, large	402 Large Office Building
		Office, small	400 Small Office Building
	General > 50 kW	Hospital	621 Hospital, Public or Private
Industrial	Large > 5 MW	Warehouse	522 General Purpose Industrial
n/a	Unmetered Load	n/a	n/a
	Sentinel Lighting		
	Street Lighting		
	Cogeneration		

SCEC[3]

In Prince George, housing types described by manual class and actual use codes in the BCA data were grouped into eight archetypes, further refined by number of stories and vintage. These groupings were compared with housing types in the ecoENERGY Retrofit audit records (which also contain additional attribute data). The proposed housing archetypes were confirmed by municipal planners.

For buildings, three major rate classes are represented in the provincial CEEI reports: residential, commercial/small industrial, and industrial. These rate classes are broken down into finer categories with finer details for the building types. The residential category, for example, contains eight building types.

National statistical surveys such as the Household and Environment Survey or the census collect a general list of building types or categories. Because census dissemination area is the lowest level of geography at which this data is released this survey sample data, while representative, cannot be reliably associated with individual houses or buildings for the purpose of linking datasets to the parcel-building and meter scale.

Table 5: Comparison of IEMOC archetypes with those developed for the SCEC^{3}model.

IEMOC Building Archetypes	SCEC^3 Housing Archetypes
Residential low density	Existing single family 1 – 1 storey (1943–1977)
	Existing single family 2 – 1 storey (1978–1996)
	Existing single family 3 – 2 storey (1978–1996)
	Future single family – 2008 Building Code
	Future single family – Next–gen R2000
	Existing row house (1963 – 1992)
	Future row house 2008 Building Code
	Existing mobile home
Residential medium density	Existing apartment < 5 storeys
Residential high density	Existing apartment > 5 storeys
Commercial office	n/a
Institutional low energy use	n/a
Institutional high energy use	n/a
Commercial retail	n/a
Industrial	n/a

4.3 Matching Electric and Natural Gas Data to Parcel Fabric and Building Attributes

Two distinct approaches were taken to electric and natural gas data integration. In Ontario, utility data aggregated by postal code was provided directly to CUI. The SCEC^3 model compared modelled energy use to measured energy use at the municipal or city-wide scale, as described in the CEEI reports.

IEMOC

In cases where electricity data was provided for individual customers or buildings, it was first matched to the parcel fabric using the customer’s civic or street address. This process was not perfect due to inconsistencies in civic or street addresses in the assessment roll and utility datasets. Electricity and natural gas maps were prepared separately for London, Barrie, and Hamilton. To conceal address-level data, heat maps were created that averaged the consumption over a specified radius, allowing identification of areas with very high or low consumption.

For properties containing multiple energy-using buildings, the attributes of the largest building were assigned to the total floor area of all energy-using buildings. Using this assumption, a small commercial building could be described as a large residential building. Although the best available approach for the project, it decreased the accuracy of the resulting energy maps. It should be noted that there were not many instances of mixed-use commercial and mixed-use residential areas in participating municipalities.

In cases when data was provided for the whole city, energy simulation models were used to calculate energy intensity or total building energy use for all services on an annual basis per floor area as gigajoules per meter squared (GJ/m^2). This energy intensity value was used to disaggregate type-specific building space from the assessment roll. Utility rate classes were then used to disaggregate the energy data from the city-wide to the parcel level. The total energy shown on a map is consistent with the measured city-wide total; having been distributed using simulations it is not reflective of measured energy use at specific locations. In cases where utility data was shared at the six-digit postal code level, the same method was used: energy use in buildings in the assessment roll was aggregated to the city-wide level.

SCEC^3

In the SCEC^3 model, consumption data from the utilities was not matched directly to assessment roll information at the parcel level. Instead, energy simulations were conducted for representative housing and building archetypes based on property assessment data and ecoENERGY Retrofit audit data. By attributing modelled energy intensity factors via housing and building type to the floor areas of similar buildings across the city, totals were calculated per housing archetype. These totals were then summarized for the city as a whole according to the residential categories found in the CEEI and compared with the CEEI report.

Similar to the IEMOC project, errors were found in addresses and locations: some addresses were not linked to a postal code, others had no geographic coordinates, and multi-unit buildings may have one or several meters.

In addition to energy consumption data, utilities have approximate geographic locations of their customers through a civic or street address, sometimes with unit numbers. They also have topology information showing what transformer each account connects to, what distribution line serves that transformer, and the substation that supplies the distribution line. Coordinates (x,y) of smart meters are another spatial attribute maintained by utilities that can be used to link measured energy data to building attributes. All of this data may be maintained differently by different utilities; customer information system data may or may not be spatialized or linked to other databases.

5. Protection of Personal and Business Information

The need to protect personally and commercially sensitive data is not viewed as a data issue but rather as a requirement to be proactively managed and built into organizational policy and technical procedures. This section looks at some of the legislation governing personal and commercial information.

5.1 Personal Information and the Right to Privacy

A number of pieces of privacy legislation govern the collection, use and disclosure of personal information. The common theme across all legislation is that individuals decide what and how much personal information is given to whom and for what purpose.

Personal information is defined similarly throughout all privacy legislation as information about an identifiable individual in a personal capacity. However, different pieces of legislation define what constitutes personal information differently. The Freedom of Information and Protection of Privacy Act (FIPPA) and Municipal Freedom of Information and Protection of Privacy Act (MFIPPA) provide non-exhaustive definitions of personal information that include the address or telephone number of the individual, or any identifying number, symbol, or other particular assigned to the individual. As noted by the Ontario Court of Appeal, information is personal if there is a reasonable expectation that the individual can be identified from that information. Whether such a reasonable expectation exists is determined on a balance of probabilities having considered the circumstances of the case and the particular issues arising in it. [29]

Similarly, the Geospatial Privacy Awareness and Risk Management for Federal Agencies states: "…no clearly defined rule or standard can be applied to easily determine the point at which geospatial information becomes personal information. Rather, each dataset or data element must be construed in its particular setting and circumstances so as to determine whether it contains the necessary elements to attain, or avoid, personal status." [30]

Datasets required for energy mapping and planning, and the organizations that hold these datasets, are subject to different legislative and regulatory schemes. The federal Privacy Act pertains to information collected and held by federal government departments and agencies. In Ontario and BC, FIPPA pertains to provincial agencies and public sector entities including utilities. In Ontario MFIPPA applies to municipalities. In BC, the Personal Information Protection Act contains additional requirements for collection, maintenance and disposal of personal information collected and maintained by any organization. [31]

The Personal Information Protection and Electronic Documents Act (PIPEDA) is federal legislation that applies to organizations that collect, use, or disclose personal information in the course of commercial activities. PIPEDA applies to all organizations in Ontario not otherwise covered by other privacy statutes that collect, use, or disclose personal information for commercial purposes.

Organizations routinely collect personal information to conduct business and provide public services. Consent must be obtained for a specific use of the personal information collected. The nature of the purpose and the consent originally obtained is important when determining whether a new use is consistent with the nature of the consent originally provided.

The proper treatment of personal information occurs along a continuum, from its collection and use through to retention, disclosure, and disposal. Privacy must therefore be taken into consideration throughout the energy mapping processes from data acquisition through to analysis, use, and disposal.

Integrating multiple datasets introduces the risk of re-identifying personal information. When two or more datasets are combined, practitioners must evaluate whether the combination makes it possible to identify an individual and his or her activities.

5.2 Sensitive Commercial Data and the Protection of Commercial Interests

Privacy is often cited as the reason for restricting access to data. However, there is a distinction between personal information and information collected from organizations that is not personal but has business value. For example, energy use data is considered sensitive information for commercial and industrial businesses individually, as it can be used by those familiar with a given industry to back-calculate industrial processes or production and therefore profit.

Data collected by a utility has value for the utility itself. If the information has value arising from the fact that it is confidential and measures are taken to ensure its ongoing confidentiality, confidential information can be protected under common or civil law. Pragmatic approaches to protecting data disclosed by a utility or property assessment organization to another organization are to use either Non-Disclosure Agreements (NDA) or data licenses. For the purpose of maintaining the business value of the data, either of these types of agreements can be used to define the acceptable and non-acceptable uses of the data and ways in which it can and cannot be disclosed to third parties or the public. [32]

Because there are limits to the protection of confidential data, property-based protection may be sought for data under the Copyright Act. This can protect the data itself as well as reproductions of the data such as that found in reports, tables, and maps. Copyright arises automatically upon the creation of the work and applies nationally.Various actions that will assist users to comply with these requirements may be found in the promising practices in section 6.

6. Best and Promising Practices

For the purpose of this paper, best practices are those tested and verified in other domains that are equally applicable to the practice of energy mapping. Promising practices are those that have been defined in the context of ICEM research to date that appear from initial research to be robust organizational and technical approaches for resolving the data issues encountered.

From the IEMOC, SCEC[3] and TaNDM projects, several collaborative, technical, and legal approaches can be identified as promising practices to support data sharing, improve data quality, and protect privacy and commercial interests to enable energy mapping and its use by municipalities and utilities. Common themes of collaboration, access, consistency, structure, and level of geography are highlighted within the practices.

6.1 Commit to Collaboration and Continuous Improvement

Best practices for promoting collaboration and building trust to work through the complex issues associated with data sharing and integration between organizations:

- State a clearly defined project purpose.
- Establish a roundtable of data custodians and users.
- Ensure broad participation reflective of roles and skill sets required for energy mapping (including business strategy and policy, engineering, spatial analysis, information technology and law).
- Hold face-to-face meetings or “requirements workshops” to build trust and identify barriers. and common value potentially derived from integrated data.
- Establish a scope that identifies specific acceptable and non-acceptable uses of shared data
- Use project management and business analysis best practices.
- Hold multi-stakeholder collaborative meetings to develop, promote common understanding of, and seek clarification on the methodology and data models under development.

6.2 Conduct User Needs Assessments and Develop Use Cases

A user needs assessment of specific decision-making scenarios or “use cases” is a good practice for identifying required data, modelling, and visualization and numeric outputs. A variety of elicitation techniques are used to gather input from stakeholders to help develop data requirements and assess and validate the proposed technical and organizational solution. These techniques, some of which were used in the IEMOC, SCEC[3] and TaNDM projects, include:

- Data dictionary and glossary
- Data flow diagrams
- Data modelling
- Document analysis
- Interviews
- Metrics and key performance indicators
- Organizational modelling
- Prototyping
- Requirements workshops

Further information on these techniques can be found in business analysis resources [33] and in the GeoConnections publication *Understanding Users' Needs and User-Centered Design*. [34]

6.3 Evaluate and Share the Data

A best practice is to work collaboratively with data custodians and users to review datasets to determine their attributes and suitability for energy mapping purposes, remembering the key point that many of the datasets may originally have been collected and maintained for other purposes. Information resources such as glossaries [35] or procedures [36] may guide understanding of existing datasets.

It is best practice for data custodians to share data closest to the source to ensure users get the most up-to-date and accurate data. This decreases effort and costs to prepare and integrate the information while improving accuracy for decision-making purposes.

The sensitivity of each dataset should be carefully evaluated. Basic principles for assessing data sensitivity include:

- Unless the dataset is classified as sensitive, it can be provided free of restrictions.
- Information cannot be considered sensitive if it is readily available from other sources or if it is not unique.
- The data custodian is the only agency that can determine whether a geospatial dataset is to be classified as sensitive.
- Data consumers of sensitive geospatial datasets must honour the restrictions accompanying the information in the form of an agreement (see 5.2)
- Organizations should document and openly publish their process, criteria, and decisions.

As AMEC Earth & Environmental notes, “At its core, the successful long term sharing of sensitive geospatial information is about trust, risk management, the credibility of the participating organizations and their overriding desire to disseminate information.”[37]

6.4 Respect and Manage Privacy and Commercial Value

As discussed, datasets must be evaluated for risks to privacy and means of mitigating those risks must be identified. This must be done on the basis of individual datasets, when the datasets are integrated, the information products that are developed from those integrated datasets, and the intended uses. Privacy Impact Assessments, privacy principles, use cases and work flows, non-disclosure agreements and data licenses are all best practices for achieving privacy-compliant ICEM design and dissemination.

6.4.1 Conduct Privacy Impact Assessments

PIAs are a best practice for identifying privacy risks and the means of eliminating or reducing those risks. In the TaNDM project, a PIA was conducted on the attributes in the building information report from property assessment authorities. As a result of this review, the attribute “number of rooms” was deemed to be potentially personal information. To mitigate any privacy risk, this attribute was removed from the final building information report. The omission of this particular variable did not negatively impact the TaNDM methodology.

6.4.2 Adhere to Privacy by Design

Another best practice is Ontario’s Privacy by Design principles. [38] They are:

1. *Proactive* not Reactive: *Preventative* not Remedial
2. Privacy as the *Default Setting*
3. Privacy *Embedded* into Design
4. Full Functionality – *Positive-Sum*, not Zero-Sum
5. End-to-End Security – *Full Lifecycle Protection*
6. *Visibility and Transparency* – Keep it Open
7. *Respect* for User Privacy – Keep it *User-Centric*

These are intended to guide the design of compliant technical protocols. However, simply referencing the Privacy by Design principles does not mean that a proposed technical solution in fact protects privacy. The Ontario Privacy Commissioner has developed further guidance however specific to smart grid app developers. [39]

6.4.3 Seven “Cs” of Geospatial Privacy

Another resource that can assist organizations in developing privacy protection protocols is the *Geospatial Privacy Awareness and Risk Management Guide for Federal*

Agencies. The guide defines key terms of relevance to privacy in a geospatial context in Canada and explores the meaning of personal information at law in Canada to identify the points at which geospatial information becomes personal. It also offers guidelines, referred to as the *Seven "Cs" of Geospatial Privacy,* for "...identifying and mitigating privacy-related risks and issues arising from the collection, use, retention, disclosure and disposition of personally identifiable geospatial information. The Seven "Cs" are:

- Characterization: The characterization of data as personal information or non-personal information is key to its proper treatment in a privacy law context.
- Context: The context within which information occurs has a direct and important impact upon its interface with privacy law and policy.
- Consultation: When in doubt—and sometimes even when not in doubt—consult!
- Consistency: Each federal organization should make a concerted effort to ensure that it adopts a consistent approach to dealings with potentially identifiable geospatial information.
- Cumulative: Geospatial data elements that are not identifiable when considered individually may become identifiable when combined with other data elements.
- Caution: Issues surrounding privacy are complex and that caution should be exercised in cases where doubt exists.
- Constraint: When disseminating either identifiable or de-identified information to third parties, be sure to consider the merits of restricting the data recipient's rights via contract."[40]

6.4.4 Use Cases and Workflows

The use cases discussed in section 6.2 are not only a means of clearly defining the scope, data needs, and permissible uses of integrated datasets; they are also an important means by which to ensure privacy requirements are met and commercial value of data is preserved. Data sharing and handling workflows as well as intended final public information products should be evaluated for privacy compliance during ICEM design and development.

6.4.5 Non-Disclosure Agreements and Data Licenses

A non-disclosure agreement (NDA) is a legal contract between at least two parties that outlines confidential knowledge the parties wish to share for specific purposes but restrict from generalized use. By signing an NDA, the parties agree not to disclose information covered by the agreement. [41] It can protect non-public information of various types including data that contains personal or commercially sensitive information. These may be appropriate in the context of research projects or in the development stage of an ICEM initiative.

Broader than NDAs, data or information sharing agreements can include protocols on data handling, security, and the scale at which results of integrated analysis can be made publicly available in such a way as to protect personal or commercially valuable information. Data sharing agreements may be used in the context of projects where one organization is providing data analysis services to support planning or program development by another organization. The Treasury Board provides some useful guidance for federal agencies on preparing information sharing agreements involving personal information. [42]

Data licenses may either be used when data is shared openly under an open data license or the data is a product being sold for a specific, clearly defined purpose. For example, property assessment authorities will provide data licenses along with any property assessment data purchased by utilities for energy mapping purposes. In this case, data licenses are an important mechanism to protect the commercial value of the dataset by stipulating the terms and conditions of its use.

NDAs, data sharing agreements, and data licenses are a few examples of geospatial operational policies discussed in section.

6.5 Open Data

It is a best practice to make data available unless it is deemed sensitive. The federal government and most provinces, especially Ontario and BC, have open data initiatives and websites. [43][44][45] Almost 97% of the data on the federal open data portal is geospatial data. NRCan's GeoGratis makes geospatial datasets held by government and other organizations available for use by Canadians under open data licenses.

Framework datasets are used to create base maps for a variety of purposes. Although not used in the projects reviewed here, datasets available through GeoGratis relevant for energy mapping include:

- Digital elevation data
- Geodetic network
- Geographical names database
- Administrative boundaries
- National hydro network – inland surface waters of Canada
- National road network – centerline of all non-restricted use roads
- National transmission network
- Satellite orthoimagery

Stakeholder groups and users can propose new themes be added.[46]

A new initiative on the part of the Government of Canada is the Federal Geospatial Platform (FGP), [47] which seeks to "…manage geospatial information assets in an efficient and coordinated way by using a common platform of technical infrastructure, policies standards and governance." Other federally held datasets relevant for energy mapping may be released via the FGP in the future.

6.6 Maintain an Authoritative Parcel Fabric

Linking building and energy data to the parcel is a promising practice identified in the SCEC[3] and TaNDM projects. Maintaining an authoritative parcel fabric is a best practice that can facilitate energy mapping. Both the Integrated Cadastral Information Society (ICIS) in BC and Teranet in Ontario are examples of provincial-level organizations maintaining parcel fabric. The case has been made previously for a nationally consistent parcel fabric framework data layer to serve other decision-making needs. [48] If such an initiative were to be pursued, it would provide a key dataset to enable energy mapping. In absence of a national parcel fabric initiative, energy mapping practitioners should seek out organizations maintaining authoritative parcel fabric data on a provincial basis.

6.7 Maintain Authoritative Civic Addressing

The civic address is another attribute that refers to a specific geographic location. Authoritative civic addressing is useful for initiatives such as emergency response management. Authoritative civic addressing is a best practice with the potential to greatly simplify data integration for energy mapping.

Although not available at the time of either the SCEC[3] or TaNDM project, ICIS's Address BC (ABC) initiative is rapidly expanding to provide authoritative civic addresses across BC. In Nova Scotia, GeoNOVA, through creation of the Nova Scotia Civic Address File (NSCAF), is creating an authoritative source for civic address information for the province. [49]

6.8 Develop Standard Building Categories

A promising practice identified by the TaNDM project is the use of consistent housing and building categories or types among municipalities, property assessment authorities, and utilities within a province. Standard building categories would result in fewer mismatches when buildings and energy datasets are integrated. They would also support privacy-compliant energy data reporting by enabling data aggregation from the parcel-building-meter scale to higher levels of geography.

Standard building categories would enable communication of building energy information to planners, utility managers, decision makers and the general public, and support program and policy design, implementation, and monitoring.

6.9 Develop Standard Building Information Reports

Creating a standard building information report based on property assessment data is a promising practice piloted in the TaNDM project in BC and by MPAC working with Horizon Utilities in Ontario. It involves evaluation of property assessment data by stakeholders (i.e., utilities, NRCan) and assessment experts to create a standard report of buildings and their attributes for energy modelling and mapping purposes. Questions for evaluating the data for the purpose of developing a standard building information report include:

- What valuation method was used?
- Are the individual attributes appropriate for building energy modelling? Are there any limitations of which energy practitioners should be aware?
- Has a given attribute been collected consistently across building types? Over time? Over what geographic areas?
- Is a given attribute personal information that must be protected?

For example, a known limitation requiring additional research and best practice guidance is which floor area types are included or excluded in local valuation approaches and municipal or regional bylaws. A clear understanding of the rationale behind floor area calculations can enable the adjustment of floor area to best align with energy use.

Arising from the TaNDM project, the Building Information Report is composed of four data products:

1. Building attributes for every building in the province, in tabular format
2. Building attributes with standard building categories assigned to each building, in tabular format
3. Building attributes with standard building categories and census tract and/or neighbourhood characteristics assigned to each building, in a spatial format
4. Electricity and natural gas data linked at the building scale and reported out on an aggregated basis, typically by sector at the census tract or building sub-category at the community scale

Though building attributes are available for each building in BC, assigning building categories and spatializing the data is being organized by the Province of BC Ministry of Environment, Climate Change Secretariat on a municipality-by-municipality basis. The reports are created to reflect the building stock in a given year.

It appears that developing the standard building information reports on a provincial basis is effective for both the property assessment authority and data users. BCA views the BCA Building Information Report (BIR) as a success in terms of data stewardship and operational efficiency. It benefits local governments who may request it at no cost. The data is consistent from one request to the next and across jurisdictions. It positions local governments to better review the data internally and analyze changes as related to their own policy changes across the years.

The BCA BIR can serve as a model for other provinces. Property assessment authorities are the data custodians and retain the right to decide how to disseminate the data for what purposes and whether to charge any fees. In most jurisdictions, there is a charge for this data and restrictions are imposed on its use and reuse to maintain the value of the data. There may be merit in exploring potential changes to legislation and comprehensive data purchase initiatives that would allow unrestricted access to the data for specific, clearly defined energy analysis purposes by municipalities and utilities.

6.10 Guidance on Provincial GHG Emissions Factors

It is a best practice to provide guidance on appropriate GHG emissions factors for each province. An example is the GHG modelling guidance document issued by the Province of BC. [50] In addition to saving valuable staff time, this would support consistency in modelling by different organizations, increasing the reliability and comparability of outputs. This information could be coordinated on a federal or provincial basis by a central authority such as a senior level of government or a utility regulator.

Until such a time as this guidance is available, modellers should be aware that default emissions factors contained in housing and building modelling tools may not necessarily be reflective of provincial electrical grids.

6.11 Guidance on Cost Factors

Another best practice is to provide a resource of appropriate cost factors. For instance costing databases for utility rates to provide estimates of potential capital cost expenditures and associated energy cost savings associated with retrofits. For example, under its Open Energy Initiative (OpenEI) the National Renewable Energy Laboratory (NREL) makes available a utility rate database. [51]

6.12 Guidance on Modelled Energy Data

Some guidance on the use of modelled energy data may be found in the final report on the SCEC[3] model for Prince George. [52] Further best practice guidance is required on the use of modelled energy data for energy mapping purposes. This could include information on common building archetypes and their characteristics, the use of weather files and variables held constant to achieve standardized ratings such as occupancy, and standard operating conditions such as temperature set points. Although this type of information is common knowledge for building energy practitioners, it is critically important to document the assumptions and methods made at the building scale for robustness and accuracy when aggregated to represent energy use and opportunities over larger areas of geography. It will also be useful to express that margins of error may be wider when using an archetyping approach and modelled data to represent energy consumption of multiple buildings than those observed in the models of individual buildings.

6.13 Guidance on Data Matching

Several promising practices can be identified to facilitate data matching. These include:

- Connect building attribute and utility data for current and future scenarios at the parcel, building and meter scale.
- Obtain data closest to the source and engage data custodians often to seek clarification on structural and consistency issues.
- Establish a common method to assign identification numbers and link parcel and building data for multi-unit residential buildings and other complex building types.
- Agree upon a unique numeric identifier (existing or new) to which all other data will be linked for energy mapping purposes within a jurisdiction.

A promising practice arising from the SCEC[3] and TaNDM projects is connecting building attribute and utility data for current and future scenarios at the parcel, building, and energy meter scale. Although a significant undertaking for whichever entity chooses to take it on, the approach of building the data relationships once and maintaining them is recommended. It is anticipated that this integrated data will prove useful to multiple utility analytics and government program and policy functions and, despite the up-front costs, yield cost savings for utilities, governments, residents and businesses in time. The "build it once and maintain it" approach implies the creation of a new aggregate database to which all of the other sources are mapped, in terms of their respective semantic models, so that refresh for the original sources can happen regularly. The use of the resulting product must be legally permissible for the intended use case.

To address the issue of many parcel-building-unit configurations, direct database linkages should be established for simple cases (e.g., one parcel to one single-family dwelling). For more complex cases (e.g., one or more parcels to one or more mixed-use or multi-unit residential buildings) database connections should be established between the designated unique numeric identifier and the primary building. Additional data tables linking information on additional buildings and unit attributes may be developed and maintained as required. The approach taken will vary from jurisdiction to jurisdiction, depending on the data model. To every standard there will always be exceptions, even within a single jurisdiction. It will be necessary to map from each model to the standard model; flexibility to implement further changes will be required as new exceptions are discovered.

The issue of municipalities using different approaches to link multi-unit residential buildings, condos, or strata building attributes and units to the parcel can be resolved by establishing a common method to be used consistently by municipalities in each province. This would reduce the complexity of managing data associated with this increasingly common building type.

In Ontario, it is possible that accessing the PIN and ARN linkages maintained in the Ontario Parcel database by Ternaet is a potential area for efficiencies in future data integration and energy mapping initiatives.

In the TaNDM project, BC Hydro and FortisBC linked BCA building attribute data to their customer data behind their respective firewalls. This approach addressed privacy requirements as only results summarized at the census tract and community scales were provided to the Province and municipalities.

A key recommendation is to have a unique numeric identifier to which all data can be linked. TaNDM identified that different approaches may be required for developing data linkages at the parcel level, depending on how customer information is maintained by the utility. When customer information is retained in a relational database that has not been spatialized (mapped), energy use may be linked to the building data via the civic address or numeric parcel identifier.

For utilities where meter locations, associated energy use and customer accounts have not been mapped, a common approach is to match the energy use and buildings data using a relational database and the civic address as the unique numeric identifier. For utilities where meter locations and associated energy use have been mapped, parcel and building attribute information may be matched using GIS via the spatial parcel polygon and meter x-y locations. The experience gained in the TaNDM project suggests that this approach is significantly faster and yields higher match rates than matching addresses using a relational database. [53] For either approach, utilities may leverage the land use knowledge of municipal GIS staff to assist in identifying buildings not matched to customer accounts or accounts with energy use not linked to buildings.

It may be necessary to define which unique numeric identifier will be used on a jurisdiction-by-jurisdiction basis depending on the databases and attributes maintained by different organizations. Anticipating the need for updates, in terms of addition, modification and deletion of points, lines or polygons, it may be necessary to run the changes in the sequence in which they happened or the source and target databases will not remain in sync. This may be a difficult process to automate.

6.14 Establish Data Aggregation Thresholds

Establishing thresholds, or the minimum number of individual records that must be grouped together to ensure protection of privacy and commercial information, is a promising practice to enable sharing of aggregated data. In TaNDM, BC Hydro established aggregation thresholds at not fewer than 3 commercial accounts and not fewer than 20 residential accounts per geographic area.

To date, data aggregation thresholds have been established on an organizational basis. For consistency and comparability it would be preferable for a group of experts (lawyers, statisticians, engineers, IT/GIS analysts, and business analysts) to more precisely define the issue and develop best practice guidance or a standard to mitigate risks to privacy and business interests. Ideally, these thresholds should be established on a national or provincial basis.

6.15 Aggregate to Consistent Levels of Geography

Another promising practice to enable data sharing is aggregating data to levels of geography that are relatively consistent and stable over time. In the TaNDM project, it was found that municipalities and regional districts did not necessarily maintain spatial data layers of neighbourhoods. If these layers were maintained, neighbourhood boundaries might be changed to serve different planning processes. It was therefore decided to use the census tract, a level of geography for which GIS shape files are available consistently across municipalities. Although there are challenges with census tracts—they change over time and do not always align to parcel boundaries or to municipal boundaries—they are an authoritative dataset maintained by Elections Canada.

Similarly, municipal boundaries do not change frequently and are an appropriate level of geography to which data may be aggregated to serve municipal planning purposes. An approach for census tract boundaries that do not align is to perform a non-spatial association for analysis purposes and later display the geometry associated with the result.

Utility distribution or service areas, often larger than and overlapping individual municipalities, were not explored in the context of these projects but may also be a useful level of geography to guide decision making by utilities.

6.16 Aggregate Energy Use Data by Building Type and Geography

A promising practice developed in the TaNDM project is to assign standard building categories, census tract and municipality to each individual building record to aggregate energy use associated with individual customer accounts by building type. The aggregation thresholds, or minimum number of records that could be grouped together for privacy and commercial protection reasons, dictate the level of geography to which a number of customer accounts must be aggregated. Figure 6 illustrates the decision tree developed for the TaNDM project to enable measured energy use to be aggregated by building type and level of geography.

The principle of releasing complete and consistent data should supersede the quest for data at smaller levels of geography. Importantly, if data for one small area is suppressed for privacy or commercially sensitive reasons, the data for that level of geography should be suppressed for all other areas of that same geography. For example, if data is suppressed for one census tract, the data must only be presented for the entire municipality. This is a data-aggregation privacy and commercial-sensitivity risk mitigation measure that will prevent back calculation of the missing values for one census tract if all others have been released.

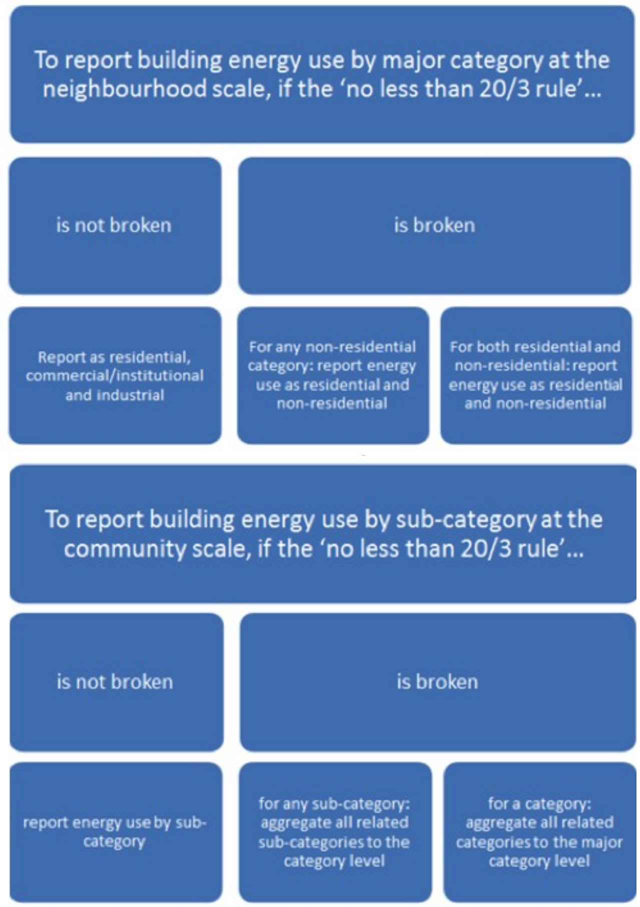

Figure 6: TaNDM data aggregation decision tree.

6.17 Conduct Quality Control and Assurance

Prior to the release of any measured energy data, such as in the form of community energy and emissions inventories, it is a best practice to conduct thorough quality control and quality assurance (QAQC). The importance of this cannot be overemphasized. Not only does it protect the integrity of sensitive utility data, it also serves to maintain authoritativeness and ease of use with provincial and municipal governments and private, non-profit and academic sector organizations providing technical services using the data. Spot checking random data samples and confirming values of key indicators are two specific QAQC methods that may be employed.

6.18 Use Energy Use Intensity and Energy Use per Capita as Key Indicators

Energy use intensity and energy use per capita are key indicators the development of which can be considered a best practice. By linking energy use, building attribute, building category, and census tract data at the building scale, calculations may be made for average energy use intensity for both electricity and natural gas by building type. Residential population information derived from the census can also be used to create average energy use per capita. This could create an indicator of average residential energy use per capita, or in larger metropolitan areas possibly energy use per capita per building type.

6.19 Leverage the Canadian Geospatial Data Infrastructure

NRCan's GeoConnections program develops and promotes the Canadian Geospatial Data Infrastructure (CGDI). "The CGDI is an on-line resource that improves the sharing, access and use of geospatial information—information tied to geographic locations in Canada. It helps decision-makers from all levels of government, the private sector, non-government organizations and academia make better decisions on social, economic and environmental priorities. The infrastructure itself consists of data, standards, policies, technologies and partnerships that are in place to allow the sharing and visualization of information on the Internet." [54]

ICEM projects to date have accessed datasets for one-off projects to develop energy maps on desktop computers. Given that many of the datasets of interest are maintained at the provincial rather than the national level, data is perhaps the least relevant aspect of the CGDI at this time.

More timely for the emergent strategic energy planning decision support needs of municipalities and utilities are the best practices used in other domains, which can be instructive by way of analogy. [55] [56] Standard agreements or data standards may also be adapted and used as needed.

6.20 Develop and Maintain Geospatial Operational Policies

The CGDI describes geospatial operational policies as "…a broad range of practical instruments such as guidelines, best practices, directives, procedures and manuals that address topics related to the lifecycle of geospatial information (i.e., collection, management, dissemination and use) and help facilitate access to and use of location-based information."[57] While many technical barriers to data sharing, integration, and use have been eliminated in recent years, the operational policies of organizations have not always changed to reflect new needs and technical capabilities. This is the case for energy mapping.

The CGDI identifies policy topics and technology trends around which it is considered a best practice to develop organizational policies. Understanding the interorganizational nature of energy mapping, it is recommended that geospatial policies be developed via collaboration across federal and provincial governments, utilities, municipalities, private sector and other organizations to enable data to be shared and used for acceptable purposes described through use cases.

Some of the legal and administrative areas and technological trends for development of operational policies can be found in Table 6.

Table 6: Legal, administrative, and technological areas for development of geospatial operational policies.

Legal and Administrative	Technological and Trending
• Ethical legal practices • Confidential, secure, and sensitive information • Privacy • Intellectual property • Licensing • Data Sharing • Liability • Archiving and preservation • Data quality	• Open data • Volunteered geographic information (VGI) • Open source software • Web 2.0 and the Geoweb • Cloud computing • Mobile and location-based services • High-resolution imagery • Mass market geomatics • Data integration

7. Future Directions

ICEM is a highly ambitious undertaking. To achieve successful decision support for municipal and utility policies, plans and programs requires a specific, detailed, and limited-focus project. The project will develop, implement, and maintain a database required to perform the first and subsequent analyses. This will probably take the form of working with data held at the provincial level or to get a single operating picture to which all required data is regularly contributed, and then mapping this to a standard model designed to meet user needs in a replicable manner.

Leveraging geospatial standards, focusing on visualization and information design and energy analysis at finer temporal resolutions are all potential future directions that can enable and derive additional value from integrated datasets.

7.1 Geospatial Standards

A potential future for energy mapping could involve organizations, governed by data-sharing agreements, accessing open data dynamically over the Internet enabled by web-interoperability standards. The infrastructure to enable the sharing and visualization of geospatial information on the Internet, including for mapping of energy opportunities in communities, already exists.

Web mapping standards can enable data sharing, integration, and representation. Data accessible via CGDI-endorsed standards enable data from one provider to be layered or used with those from another dynamically over the internet. CGDI-endorsed standards are international standards, developed by organizations including the International Standards Organization (ISO) and the Open Geospatial Consortium (OGC). [58] Table 7 lists CGDI-endorsed standards. [59]

Table 7: Geospatial standards relevant for energy mapping.

Standard	Applicability
Semantics	
North American Profile (NAP) of the ISO 19115: Geographic Information – Metadata	Meet specific geographic needs of data producers and users in Canada and the US
Syntax and Encodings	
Geography Markup Language (GML)	XML application that provides a vocabulary and standard means of representing geographic data
GeoRSS	Enables encoding of location in RSS and Atom feeds and enables users to perform geographic searches on feeds or map information found in feeds
Keyhole Markup Language (KML)	XML language for geographic annotation and visualization within Internet-based two-dimensional maps (e.g., Google Maps) and three-dimensional earth browsers (e.g., Google Earth).
Styled Layer Descriptor (SLD)	Provides a map-styling protocol for communicating with an OGC® Web Map Service (WMS) about the appearance of map layers
Symbology Encoding (SE)	Specifies the format of a map-styling language that can be applied to digital feature and coverage data to produce geo-referenced maps with user-defined styling
Services	
Web Map Service (WMS)	Allows interactive mapping through request for information over the Internet
Web Feature Service (WFS)	Allows a client to manipulate data on geographic features at a detailed level

Web Processing Service (WPS)	Enables access to calculations or models that can be applied to geographic data
Catalogue Services for the Web (CSW)	Provides a registry service to support the ability to publish and search collections of descriptive information (metadata) for data, services, and related information objects
Table Joining Service (TJS)	Describes and exchanges tabular data describing geographic data
Web Map Context (WMC)	Specifies how a grouping of one or more maps coming from one or more Web Map Services servers can be described in a portable, platform-independent format for storage in a repository or for transmission between clients
Web Map Tiled Service (WTMS)	Allows access to maps of georeferenced data
Web Coverage Service (WCS)	A standard interface and operations that allow interoperable access to raw geospatial data
Filter Encoding Standard	Provides XML and KVP encoding of a system-neutral syntax for expressing projection, selection and sorting clauses, collectively called a query (or filter) expression
Gazetteer	An online dictionary of geospatial words or terms, with or without applicable feature geometries; Open Geospatial Consortium's Gazetteer Service can be used to relate place names to stored geometry

Currently, the vast majority of systems rely on proprietary services, notably ArcGIS for Server Standard Data Services. Data standards either for individual data features or for data-sharing policies and practices will most likely be adopted and applied on a jurisdictional and not a universal basis, given differences in the nature of the systems and legislation already in place.

7.2 Visualization and Information Design

Improved communication can be achieved through information visualization and the design of dashboards, infographics, and other information products presenting a wide range of information for decision makers. It should be anticipated that these information products will be consumed on a wide range of platforms including smart phones and tablets, large-format touch tables, or in large group or webinar presentations. Examples of these applications have already been developed by the University of British Columbia's Centre for Interactive Research on Sustainability. [60]

7.3 Analysis at Finer Temporal Resolutions

Another future direction sees community energy modelling being performed at finer temporal resolutions. While much of the work to demonstrate energy mapping as applied to municipal decision making has been conducted on an annual basis, analysis of energy demand on an hourly or sub-hourly basis can support utility analytics for demand response, load following, and optimizing purchase of on-peak electricity on the spot market.

Analysis at finer temporal resolutions may be supported by the increasing ubiquity of sensors, causing rapid evolution of the type and quantity of data available to support enhanced model calibration, monitoring, and verification.

Appendix A: Glossary

Term	Definition
Attribute	Descriptive information relating to geographic features such as parcels or buildings. Stored in attribute tables they form the basis for the geodatabase within a geographic information system and can also be imported into other applications.
Building	Structure designed for habitation, shelter, storage, trade, manufacture, religion, business, education, and the like. A structure or edifice inclosing a space within its walls, and usually, but not necessarily, covered with a roof. [61]
Cadastre	A public record, survey, or map of the value, extent, and ownership of land as a basis of taxation. [62]
Data	Distinct pieces of information, especially information organized for analysis or used for decision making. Data are usually formatted in a special way, and exist in a variety of formats. Data in the CGDI includes maps, satellite images, publications, and other geospatial data provided by Canadian and international organizations.
Dataset	A grouping of data by subject topic or type.
Database	A system to organize, store, and retrieve large amounts of data easily, typically in digital form.
Building energy intensity	Whole building energy use per floor area, expressed in either gigajoules per square meter (GJ/m^2) or kilowatt hours per square meter (kWh/m^2). GJ/m^2 is commonly used to describe energy use in residential dwellings whereas kWh/m^2 is more commonly used to describe commercial and institutional building energy use.
Emission factors	Factors to calculate the global warming potential of energy sources according to the supply mix and greenhouse gases and associated global warming potential expressed in equivalent tonnes of carbon dioxide.
Energy map	See Integrated Community Energy Mapping

Forward sortation area (FSA)	A geographic area in which all postal codes start with the same three characters (e.g., M4W).
Geographic information system	A computer system used for collecting, storing, analyzing, and displaying data related to geographical positions on the earth's surface.
Geospatial information	Information that describes geography, such as legal surveys, property cadastre, aerial photography, satellite imagery, aeronautical and nautical charts, as well as various types of maps. Geospatial data may include attribute data that describe features found in a dataset.
Geomatics	The science, technology, and art of gathering, analyzing, interpreting, distributing, and using geospatial data. Geomatics encompasses a broad range of disciplines including surveying, global positioning systems, mapping, remote sensing, and cartography.
Georeferencing	Coordinates to relate an object to its geographical location, as defined by a standard geodetic reference system.
Geographic features	Representations of the natural and built environment located on or near the surface of the earth, typically represented as points, lines, or polygons (areas).
Gigajoule (GJ)	A unit of measure of energy use. One GJ is equivalent to the amount of energy available from 277.8 kWh of electricity, or 26.1 m^3 of natural gas, or 25.8 litres of heating oil. It is often used to describe energy in multiple forms from a variety of sources. In energy mapping, GJs are used to represent a total amount of energy consumed by energy types associated with a house.
Gigajoule per square meter per year (GJ/m^2)	Referred to as building energy intensity,GJ/m^2 describes whole-building energy use per square meter on the basis of the building's total floor area. For community energy planning purposes, this information is most often modelled on a yearly basis.
Gigajoule per hectare (GJ/ha)	In the IEMOC project, *energy density* (GJ/ha) describes energy demand by area of land (not building floor area).
Gigajoule per capita (GJ/capita):	Energy use on a per capita basis. It is useful for land use planning where population growth projections are available and for national/international benchmarking.

Gross building area (GBA)	The total constructed area of a building. This area is computed by measuring to the outside finished surface of a building's permanent outer walls. It includes all enclosed floor areas of the building including basements, mechanical rooms, etc. GBA is only quoted by landlords and property managers when an entire building is leased to a single tenant. [63]
Gross leasable areas (GLA)	The rentable floor area in income earning properties, defined according to industrial, retail and office building types. [64]
Integrated Community Energy Mapping	An emerging mapping and modelling approach that leverages existing and new datasets and available building and technology energy modelling software in combination with geographic information systems (GIS) to provide scalable spatial decision support to energy and emissions planning, policy and program development, implementation and verification.
Identifier	A unique expression in written format either by a code and/or numbers to distinguish variations among a class of substances, items, or objects.
Layers	Information in data themes describing the (spatial) distribution of a phenomenon.
Line	On a map, a shape defined by a connected series of unique x,y coordinate pairs. A line may be straight or curved. [65]
Map	A spatial representation, usually a graphic on a flat surface, representing spatial phenomena.
Metadata	Information about data. Metadata describes how and when and by whom a particular set of data was collected, and how the data are formatted. Metadata is essential for understanding information stored in data warehouses.
Non-disclosure agreement	A legal agreement between two parties, governing information disclosed and received for the purpose of carrying out a specified business function. The non-disclosure agreement requires the receiving party to hold any information received in strict confidence.
Open data	Government data made available in machine-readable formats to enable citizens, the private sector, and non-government organizations to leverage it in innovative and value-added ways.

Parcel	A lot, block, or other area in which real property is held or into which real property is subdivided; includes the right or interest of an occupier of Crown land but does not include a highway or portion of a highway. [66]
Point	A geometric element defined by a pair of x,y coordinates. [67]
Polygon	An enclosed area representing the shape and location of homogenous features such as parcels and land-use zones.
Sensitive	Refers to all geospatial data that may be considered restricted for purposes of dissemination and therefore requires some form of safeguarding.
User	An individual who uses a computer, program, network, or related service.
Zoning bylaw	A legal document describing the permitted uses for land. Zoning is the public regulation of the character and extent of real estate use relating to improvements, structure heights, areas, bulk, density of population, and other limitations on the use and development of private property. [68]

Appendix B: Acronyms

ABC	Address BC
ARN	Assessment Roll Number
BCA	BC Assessment
CEEM	Community Energy and Emissions Modelling
CDM	Conservation and Demand Management
CGDI	Canadian Geospatial Data Infrastructure
CUI	Canadian Urban Institute
DHW	domestic hot water
DPA	Development Permit Area
DSM	Demand Side Management
ERS	EnerGuide Rating System
EUI	Energy Use Intensity
FIPPA	Freedom of Information and Protection of Privacy Act
FSA	Forward Sortation Area
GHG	greenhouse gas
GIS	geographic information systems
ICES	Integrated Community Energy Solutions
IEMOC	Integrated Energy Mapping for Ontario Communities
ICIS	Integrated Cadastral Information Society
LDC	Local Distribution Company
MPAC	Municipal Property Assessment Corporation
MURB	Multi-Unit Residential Building
NDA	Non-Disclosure Agreement

NECB	National Energy Code for Buildings
NRCan	Natural Resources Canada
OCP	Official Community Plan
OEB	Ontario Energy Board
OPA	Ontario Power Authority
PIA	Privacy Impact Assessment
PID	Parcel Identifier
PIN	Parcel Identification Number
PIPDA	Personal Information and Electronic Documents Act
QAQC	Quality Control and Quality Assurance
RGS	Regional Growth Strategies
$SCEC^3$	Spatial Community Energy Carbon and Cost Characterization model
TaNDM	Tract and Neighbourhood Data Modelling project

References

[1] Natural Resources Canada.2012. Community Energy Planning in Canada: the value of energy mapping symposium report. [Online –summary only] http://www.nrcan.gc.ca/energy/efficiency/communities-infrastructure/research/4381(accessed Jan. 2015).

[2] Natural Resources Canada. 2009. Integrated Community Energy Solutions – A Roadmap for Action. [Online] http://www.nrcan.gc.ca/energy/publications/efficiency/cem-cme/6541 (accessed Mar. 2015).

[3] Canadian Urban Institute. 2008. Energy Mapping Study. Prepared for the City of Calgary. [Online] http://www.calgary.ca/PDA/pd/Documents/Publications/plan-it-energy-map-study.pdf (accessed Mar. 2015).

[4] Province of British Columbia. Local Government Act [RSBC 1996] Chapter 323 Part 26 — Planning and Land Use Management. [Online] http://www.bclaws.ca/Recon/document/ID/freeside/96323_30 (accessed Mar. 2015).

[5] Community Energy Association. 2013. Community Energy and Emissions Plan Research: General Summary of Findings. [Online] http://communityenergy.bc.ca/download/327/ (accessed Jan. 2015).

[6] Ontario Energy Board. Electricity Conservation and Demand Management Targets (EB-2010-0216). [Online] http://www.ontarioenergyboard.ca/oeb/Industry/Regulatory%20Proceedings/Policy%20Initiatives%20and%20Consultations/Conservation%20and%20Demand%20Management%20%28CDM%29/CDM%20Management%20Targets (accessed Jan. 2015).

[7] Ontario Energy Board. 2014. Demand Side Management Framework for Natural Gas Distributors (2015 -2020). EB-2014-0134. [Online] http://www.ontarioenergyboard.ca/oeb/_Documents/EB-2014-0134/Report_Demand_Side_Management_Framework_20141222.pdf (accessed Mar. 2015).

[8] Ontario Power Authority. 2013. Cutting Edge: Horizon Utilities Uses Energy Mapping to Improve Conservation Marketing. [Online] http://www.horizonutilities.com/Conservation/Documents/HorizonUtilities_OPA_CaseStudy_2013_June20_2013.pdf (accessed Mar. 2015).

[9] City of Vancouver. Vancouver Neighbourhood Energy Strategy and Energy Centre Guidelines. Report to Standing Committee on Planning, Transportation and Environment. [Online] http://former.vancouver.ca/ctyclerk/cclerk/20121003/documents/ptec1.pdf (accessed Mar. 2015).

[10]Canadian Urban Institute. 2008. Ibid.

[11]Natural Resources Canada. CGDI Resource Centre.[Online] http://www.nrcan.gc.ca/earth-sciences/geomatics/canadas-spatial-data-infrastructure/8904 (accessed Mar. 2015).

[12]International Institute of Business Analysis. 2009. A Guide to the Business Analysis Body of Knowledge Guide. Version 2.0. Toronto.

[13]The Data Management Association.2009.The DAMA Guide to the Data Management Body of Knowledge, 1st Ed. Bradley Beach, NJ.

[14] NRCan. Sensors and Methods. [Online] http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/sensors-methods/10817 (accessed Mar. 2015).

[15]Christen, Andreas, et al. 2010. A LiDAR-based urban metabolism approach to neighbourhood scale energy and carbon emissions modelling. University of British Columbia. [Online] https://circle.ubc.ca/handle/2429/42442 (accessed Mar. 2015).

[16]CMHC. Urban Heat Island Mitigation Measures and Regulations in Montréal and Toronto. 2014. Research Highlight. Technical Series 14-100. [Online] http://www.cmhc.ca/odpub/pdf/68124.pdf (accessed Mar. 2015).

[17] Hay, G.J. HEAT. [Online] http://www.saveheat.co/ (accessed Mar. 2015).

[18]Keenan, Tom. Radio interview on CBC's the Current. November 6th, 2014. [Online] http://www.cbc.ca/thecurrent/episode/2014/11/06/techno-creep-technologies-privacy/ (accessed Feb. 2015).

[19] Government of Canada. Justice Laws Website. Personal Information Protection and Electronic Documents Act (S.C. 200, c.5) [Online] http://laws-lois.justice.gc.ca/eng/acts/P-8.6/index.html (accessed Mar. 2015).

[20]U.S. Department of Energy. Building Energy Software Tools Directory. [Online] http://apps1.eere.energy.gov/buildings/tools_directory/alpha_list.cfm (accessed Mar. 2015).

[21] Natural Resources Canada. Screening Tool for New Building Design. [Online] http://www.screeningtool.ca/ (accessed Mar. 2015).

[22]Lopez, A., B. Roberts, D. Heimiller, N.Blair, and G. Porro. 2012. U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis. National Renewable Energy Laboratory Technical Report. NREL/TP-6A20-51946. [Online] http://www.nrel.gov/docs/fy12osti/51946.pdf (accessed Mar. 2015).

[23]Natural Resources Canada. Renewable Energy Screening Tool. [Online] http://www.retscreen.net/ (accessed Mar. 2015).

[24]City of Prince George. myPG in Action. [Online] http://www.mypg.ca/ (accessed Mar. 2015).

[25]Natural Resources Canada. Fuel Focus.[Online] http://www.nrcan.gc.ca/energy/fuel-prices/4593 (accessed Mar. 2015).

[26]Independent Electricity System Operator. [Online] http://www.ieso.ca/ (accessed Mar. 2015).

[27]British Columbia Ministry of Environment. 2014. Technical Methods and Guidance Document 2007- 2010 Reports: Community Energy and Emissions Inventory (CEEI) Initiative [Online] http://www2.gov.bc.ca/gov/DownloadAsset?assetId=31055DDB5EF346FCB7EC3265ECFFE71E&filename=ceei_techmethods_guidance_final.pdf (accessed Mar. 2015).

[28]The Gordian Group. RSMeans. [Online] http://www.rsmeans.com/ (accessed Mar. 2015).

[29]Siegel, Arianne. 2011. Privacy Issues and Utility Energy Use Data. Memorandum prepared for Natural Resources Canada.

[30]Ontario (Attorney General) v. Pascoe (2002), 166 O.A.C. 88 (C.A.) at para. 2 and para. 6.

[31]Siegel, Arianne. 2011. Ibid.

[32]Natural Resources Canada. 2011. Intellectual Property Law Backgrounder. Canadian Geospatial Data Infrastructure Information Product 19e. [Online] http://ftp2.cits.rncan.gc.ca/pub/geott/ess_pubs/291/291932/cgdi_ip_19e.pdf (accessed Mar. 2015).

[33]International Institute of Business Analysis. Ibid.

[34]GeoConnections. 2007. Understanding Users' Needs and User-Centered Design. [Online] http://wmsmir.cits.rncan.gc.ca/index.html/pub/geott/ess_pubs/292/292113/cgdi_ip_24e.pdf (accessed Mar. 2015).

[35]BC Assessment. Glossary. [Online] http://www.bcassessment.ca/about/Pages/Glossary.aspx (accessed Mar. 2015).

[36]Municipal Property Assessment Corporation. Property Valuation Explained. [Online] https://www.mpac.ca/PropertyOwners/Diva (accessed Mar. 2015).

[37]AMEC Earth & Environmental. 2010. Best Practices for Sharing Sensitive Environmental Geospatial Data. Natural Resources Canada. [Online] http://ftp2.cits.rncan.gc.ca/pub/geott/ess_pubs/288/288863/cgdi_ip_15_e.pdf (accessed Mar. 2015).

[38]Privacy Commissioner of Ontario. 2009. Privacy by Design. [Online] www.privacybydesign.ca/index.php/about-pbd/7-foundational-principles/ (accessed Mar. 2015).

[39]Cavoukian, Ann, Information &Privacy Commissioner of Ontario. 2013. Privacy by Design: Fundamentals for Smart Grid App Developers. [Online] https://www.privacybydesign.ca/index.php/paper/privacy-design-fundamentals-smart-grid-app-developers/ (accessed Mar. 2015).

[40]Natural Resources Canada. 2010. Geospatial privacy awareness and risk management guide for federal agencies. [Online] http://data.gc.ca/data/dataset/d2ab4e27-eef4-50e9-9128-6e063f74ebfd (accessed Mar. 2015).

[41] UT Dallas Office of Research. Types of Research Agreements. [Online] http://www.utdallas.edu/research/osp/contracts/types_of_agreements/ (accessed Mar. 2015).

[42] Treasury Broad of Canada Secretariat. Guidance on Preparing Information Sharing Agreements Involving Personal Information. [Online] http://www.tbs-sct.gc.ca/atip-aiprp/isa-eer/isa-eer06-eng.asp (accessed Mar. 2015).

[43]Government of Canada. Open Government. [Online] http://open.canada.ca/en (accessed Mar. 2015).

[44]Province of British Columbia. DataBC. [Online] http://www.data.gov.bc.ca/ (accessed Mar. 2015).

[45]Government of Canada. GeoGratis. [Online] http://geogratis.cgdi.gc.ca/ (accessed Mar. 2015).

[46]Hickling Arthurs Low Corporation and GeoConnections Division, Natural Resources Canada. 2010. Get Geography Working for You: Access, Integrate and Use Framework Data. Presented at the Canadian Geomatics Conference, Calgary Alberta.

[47]Government of Canada. The Federal Geospatial Platform. [Online] http://www.nrcan.gc.ca/earth-sciences/geomatics/canadas-spatial-data-infrastructure/geospatial-communities/federal (accessed Mar. 2015).

[48]Quality Performance Associates. 2007. National Parcel Data System: Feasibility Report and Business Case.

[49]GeoNOVA. Nova Scotia Civic Addressing. [Online] http://www.novascotia.ca/snsmr/pdf/geomatics-civic-addressing-faq.pdf (accessed Mar. 2015).

[50]British Columbia Ministry of Environment. 2014. Ibid.

[51]National Renewable Energy Laboratory. U.S. Utility Rate Database. [Online] http://en.openei.org/wiki/Utility_Rate_Database (accessed Mar. 2015).

[52]Webster, Jessica, Brett Korteling, Raymond Boulter, Ken Cooper, Adrian Mohareb, Liz Saikali and Rory Tooke. 2013. Evaluating Residential Energy, Emissions and Cost Scenarios for Prince George's Official Community Plan: integrated community energy modelling approach, methods and SCEC^3 model results. [Online] http://www.princegeorge.ca/environment/savingenergy/Documents/NRCanSCEC3_FinalDraftReport.pdf (accessed Mar. 2015).

[53]HB Lanarc-Golder. 2012. Pragmatic Building Energy Reporting for Local Governments: Strategic Guidance for Applying TaNDM. Internal report prepared for GeoBC as part of an NRCan – Province of BC project.

[54]Natural Resources Canada. Canada's Spatial Data Infrastructure. [Online] http://www.nrcan.gc.ca/earth-sciences/geomatics/canadas-spatial-data-infrastructure/10783 (accessed Mar. 2015).

[55]GeoConnections. 2008. The Dissemination of Government Geographic Data in Canada: Guide to Best Practices.[Online] http://ftp2.cits.rncan.gc.ca/pub/geott/ess_pubs/288/288853/cgdi_ip_08_e.pdf (accessed Mar. 2015).

[56]Natural Resources Canada. 2008. Good Practices in Regional-Scale Information Integration. By Hickling Arthurs Low.

[57]Natural Resources Canada. Geospatial Standards and Operational Policies. [Online] http://www.nrcan.gc.ca/earth-sciences/geomatics/canadas-spatial-data-infrastructure/8902 (accessed Mar. 2015).

[58] Open Geospatial Consortium [Online] http://www.opengeospatial.org/ (accessed Mar. 2015).

[59] Natural Resources Canada. Geospatial Standards and Operational Policies. Ibid.

[60] University of British Columbia Centre for Interactive Research on Sustainability. Modelling, Visualization and Engagement. [Online] http://cirs.ubc.ca/research/modelling-visualization-engagement(accessed Mar. 2015).

[61] Black, Henry Campbell, Joseph R. Nolan and Jacqueline Nolan-Haley. 1990. Black's Law Dictionary, 6th edition. West Publishing Co.: St. Paul, MN. [Online] http://archive.org/stream/BlacksLaw6th/Blacks%20Law%206th_djvu.txt (accessed Mar. 2015).

[62]Doja, M.N. 2007. International Encyclopedia of Engineering and Technology. International Scientific Publishing Academy: New Delihi.

[63]Building Owners and Managers Association - BOMA, 1996 & BCAin BCA Glossary [Online] http://www.bcassessment.ca/about/Pages/Glossary.aspx (accessed Mar. 2015).

[64] Ibid.

[65]ESRI. GIS Dictionary. http://support.esri.com/en/knowledgebase/GISDictionary/search

[66]Province of British Columbia. Assessment Act, [RSBC 1996] s. 1, "parcel”. [Online] http://www.bclaws.ca/civix/document/id/complete/statreg/96020_01 (accessed Mar. 2015).

[67]ESRI. Ibid.

[68]BCA. BCA Glossary. [Online] http://www.bcassessment.ca/about/Pages/Glossary.aspx (accessed Mar. 2015).

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About CanmetENERGY

Natural Resources Canada's CanmetENERGY is the Canadian leader in clean energy research and technology development. Our experts work in the fields of clean energy supply from fossil fuel and renewable sources, energy management and distribution systems, and advanced end-use technologies and processes. Ensuring that Canada is at the leading edge of clean energy technologies, we are improving the quality of life of Canadians by creating a sustainable resource advantage.

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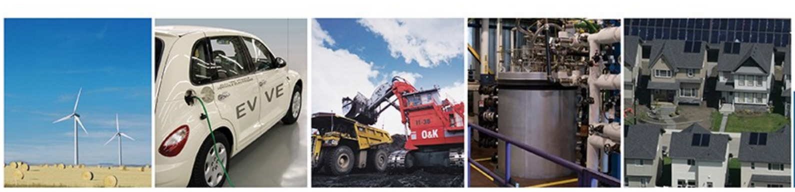

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