CANADIAN STANDARDS ASSOCIATION

REVIEW OF ENERGY AND GHG EMISSIONS CHARACTERIZATION METHODS

Report Prepared by CSA for Natural Resources Canada

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CONTENTS

1 EXECUTIVE SUMMARY

Municipalities have been taking action for a number of years to reduce their energy consumption and their greenhouse gas (GHG) emissions. As part of this effort many have compiled community energy and GHG emission inventories. Yet these efforts have been hampered by the lack of a widely-accepted or standardized method for calculating and compiling these inventories. This affects the comparability and consistency of these efforts and creates a challenge for decision makers who wish to plan energy or emission reduction efforts.

For this reason Natural Resources Canada on behalf of the Technical Committee on Urban Energy Characterization (TCUEC) commissioned a review and evaluation of available methods for energy and GHG characterization. This review focused primarily on publicly available methods for producing:

- Community-level energy inventories;
- Community-level GHG inventories;
- Estimates of energy and emission reductions from integrated community-based projects; and,
- GHG inventories for municipal operations;

In all, 62 methods were reviewed and evaluated. Proprietary models were excluded from the evaluation, in part, because of lack of extensive experience with these models and limited documentation on the assumptions and data supporting these models.

The evaluation of the methods was conducted using a set of criteria developed by consulting international standards on energy and GHG characterization and by considering the objectives identified by the TCUEC. These criteria were reviewed and approved by NRCan prior to conducting the evaluation.

Results of the assessment demonstrate that there are:

- fewer community-level energy inventory methods and more methods that combine energy and GHG accounting at the community level. However, those methods that do exist for energy inventorying can be used to produce transparent, complete, accurate and consistent energy inventories;
- There is a good selection of project-level methods for estimating GHG

reductions from integrated community-level projects;

- There is a coalescing of various efforts on GHG estimation methods that are based on the World Resources Institute – World Business Council for Sustainable Development GHG Protocol Corporate Accounting Standard. This effort has lead to the development, by the International Council for Local Environmental Initiatives (ICLEI), of an International GHG Protocol for community-level and corporate municipal emissions.
- GHG inventorying methods that are currently used, such as the guidance and spreadsheets from the Partners for Climate Protection Program, do not meet some basic requirements of transparency, completeness and consistency. Efforts would be needed to improve these methods to meet the new levels of rigour that are expected in the GHG accounting world.
- There are efforts being implemented at the provincial and national scale to compile energy and GHG emissions inventories at the municipal level. These efforts have the advantage of using more easily accessible top-down data sources but could suffer from a lack of accuracy in some estimates and for some smaller municipalities.
- Efforts at the municipal level to use predictive modeling of energy and GHG emissions typically focus on spatial analysis that supports land-use planning and transportation decision making. Other community planning tools for energy and GHG emissions have also been developed but the energy and GHG estimation methods that support these planning tools are not always transparent enough to properly assess.

Overall, the methods that scored the highest in the evaluation were those that allowed a community to produce a transparent, complete, accurate and consistent energy or GHG inventory or project-level emission reduction calculation. These methods were found to generally already be aligned with international energy or GHG accounting standards or methodologies that support these principles. This finding is a positive result for any effort by NRCan or TCUEC to propose the development of a widely accepted energy and GHG characterization method, since there appears to already be some consensus developed on the core principles and characteristics of these methods.

If NRCan or TCUEC were to move ahead with development of a widely-accepted or standardized method for community-level energy and GHG characterization it is recommended that a consensus-based process with a balanced representation from stakeholder groups be used for this effort. A process similar to the voluntary standards development process in Canada would be recommended.

2 INTRODUCTION

Municipalities are key consumers of energy and sources of GHG emissions. They also have influence over certain aspects of the consumption of energy and the GHG emissions in their jurisdiction. Over the years there have been many efforts to try and provide municipalities with the methods or tools for better understanding their energy consumption and GHG emissions[1]. These methods have ranged from community energy profiles to GHG emission reduction project methodologies. Since there is such a vast array of methods available to municipalities, there is confusion as to which method is the most appropriate and there is possibly a need for a widely accepted method that most municipalities would use so that information prepared by municipalities could be compared.

As a starting point towards establishing a widely accepted method for energy and GHG emissions characterization at the community level, Natural Resources Canada has commissioned a review and evaluation of existing methods for energy and GHG characterization in order to possibly guide future efforts in this area.

2.1 Background

This report documents the efforts of the Canadian Standards Association (CSA) to review and evaluate available greenhouse gas (GHG) and energy quantification methods that may be appropriate for establishing a community-level energy and GHG emission inventory that can be used for benchmarking, planning and scenario based studies. The evaluation will also provide recommendations on how to proceed with developing a consensus-based method to inventory and measure energy consumption and GHG emissions at the community-level.

Municipal energy and GHG inventories are useful for measuring the energy use and emissions characteristics of a community over time, and in particular, help policy and decision makers assess the impacts of policies or projects that have been or might be implemented in order to improve a community's energy use and reduce its GHG emissions.

This effort is in response to the ongoing work being undertaken at Natural Resources Canada in regards to the promotion of sustainable communities in Canada. In particular,

[1] Among these are the Cities for Climate Protection program, which in Canada is called the Partners for Climate Protection, which is managed by the Federation of Canadian Municipalities. More information can be found at http://gmf.fcm.ca/Partners-for-Climate-Protection/

the Technical Committee on Urban Energy Characterization (TCUEC); which includes members from Natural Resources Canada, Environment Canada, Canadian Mortgage and Housing Corporation, Infrastructure Canada, Statistics Canada and Transport Canada has set forth an objective to develop a standardized methodology for measuring energy inputs to and outputs from communities and from community projects for improved accountability in attaining energy efficiency and GHG reductions.

It is anticipated that the work completed in this project could be part of the foundation for the development of a formal method to compile energy and GHG emissions inventories to facilitate community design and decision-making through performance measurement and, in the case of projects, possible consideration of GHG reductions for generation of offset credits.

2.2 Purpose of Report

The sectors that comprise a community, as defined for the purposes of this project, include:

- Residential and commercial built environment
- Transportation
- Waste and waste water systems
- Municipal waste
- Municipal services

The ultimate objective and hope of the TCUEC is that community-level energy and GHG information will be scalable in that it can be both aggregated and scaled up in order to help assess existing initiatives in regards to the potential contribution of communities, provincial, territorial and national energy efficiency and GHG emission reduction efforts.

2.3 Energy and GHGs in Communities

It is well recognized that cities, towns, and urban areas in general are important consumers of energy as well as contributors to the release of greenhouse gas (GHG) emissions associated with this energy use. This is in part due to the mass of population and economic activity which conglomerates in the urban area, with energy consumed to heat homes and commercial buildings, run businesses and industry, provide transportation via personal or public transport vehicles, or to power the electricity generation units, waste management sites, or other facilities that provide services to the community at large. In the case of towns and rural communities GHG emissions can

result from agricultural, forestry or industry-related activities. It is also important considering that over 80% of Canadian's live in urban areas, amongst one of the highest rates of urbanization in the world.

There is an emerging trend in both Canada and other countries to establish community energy plans in order to help facilitate the reduction of greenhouse gas emissions and help communities become more energy self-sufficient. There are numerous Canadian communities where community-level energy plans have been or are being developed. This is likely because more communities now recognize the importance and need to better understand the impacts of policies and projects in their community that affect the energy use patterns of not only their corporate operations, but also in terms of the community's residential homes, commercial businesses and industry, and the transport of people, services, and goods.

The increasing attention that is being given to what communities can do to increase energy conservation and efficiency, improve their energy self-sufficiency, and reduce GHG emissions, is important in the context of the goals of this project. In particular, with the uptake of such tools as a community energy plan, it is important to help develop a widely-accepted methodology which could be used to help communities establish a baseline of energy use and GHG emissions to measure progress towards making their communities more sustainable. It is anticipated that the analysis of methods contained in this study will be useful to all sizes and types of communities.

2.4 Methods to account for energy use and GHG emissions

Efforts have been ongoing in the general area of GHG and energy accounting and quantification to establish peer reviewed or credible methodologies for these undertakings. This is because of the need to ensure credibility and accuracy in terms of activities and actions to reduce GHG emissions and/or improve aspects of energy security. Having widely-accepted and credible methodologies further ensures consistency of approach amongst the various parties and entities that may be undertaking such efforts, thereby improving the transparency of these efforts and affording others the ability to help monitor and evaluate the validity of any claims for savings in energy use or reductions of GHG emissions.

Notable amongst these efforts to establish useable standards for GHG and energy practitioners are the GHG quantification standards established by the World Resources Institute (WRI), the World Business Council for Sustainable Development (WBCSD) and the International Organization for Standardization (ISO). The WRI/WBCSD standards

were developed by the GHG Protocol initiative and the ISO standards are part of the ISO 14000 environmental management series of standards, namely ISO 14064 parts 1, 2, and 3. These standards have set precedence for GHG practitioners worldwide, helping establish GHG inventories (needed to measure total emissions and progress towards targets), the quantification of emission reductions resulting from a project or program, followed by the independent validation and verification of these emission inventories or project-based reductions. In addition, more project and technology specific quantification methodologies (also referred to as quantification protocols) have been developed through the Clean Development Mechanism under the Kyoto Protocol. Learnings from this effort have helped other regional and national trading regimes develop their own quantification methods and protocols.

There are also prominent methods to compile national and regional "energy balances" that quantify energy use and demand through the quantification of the entire energy system, from points of extraction, refinement and processing, to energy transmission, distribution, or in the case of electricity, transformation, to the point of final consumption. Important amongst these are examples of national-level energy balancing, such as is done by Statistics Canada and which is compiled internationally by the International Energy Agency (IEA). These methods have been used in different types of models at the community level that are typically used in predictive studies for land-use and transportation planning.

Methods for conducting energy audits of buildings and other energy consuming activities also exist at a finer geographical and technological resolution. These range from the regional and municipal energy audits to industrial plant audits that help identify areas where energy savings can be obtained. In the GHG field, these methods have been used to assess the GHG reduction potential of different types of project activities.

Figure 1 represents these four main approaches to energy and GHG characterization that have emerged as the main approaches used at the community level. Typically community level energy and GHG inventories will rely on historical data, as will those for municipal operations. Energy or GHG reduction projects will typically be more forward looking and be quantified in comparison to a hypothetical baseline of emissions (the emissions that would have occurred in the absence of the project). Projections will be made of energy or GHG emission reduction potential and these will confirmed and verified annually before GHG credits or offsets are awarded. Finally, community-based models have been developed to help with land-use planning and transportation decisions. These models typically use historical data to develop a predictive scenario of

where energy and GHG emissions will rise or fall.

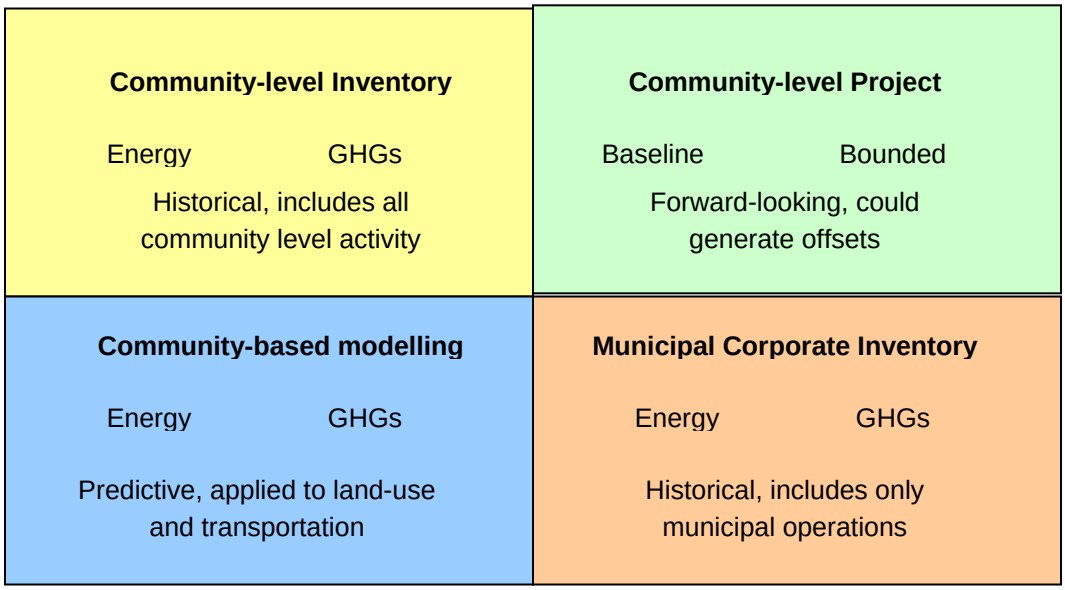

Figure 1: Types of Energy and GHG Characterization at the Municipal Level

Typically community-level inventories will inherently include energy and emissions estimates from municipal operations and any community-based project-level emission reduction activities will be reflected in the historical account of energy or emissions. However, it is typically not possible to disaggregate an inventory to the level that individual results of projects will be visible. For this reason a project-specific method is typically used to demonstrate these project-level results. Finally, inventory data can be used in predictive modelling to develop energy or emissions forecasts and for planning purposes.

Each of these efforts contributes important knowledge to the area of energy and GHG characterization at the community level and each needs to be evaluated to determine the common elements that might assist municipalities compile a comprehensive and robust profile of its energy use and GHG emissions.

3 TASKS AND DELIVERABLES

There are three different general tasks and associated deliverables for this project.

1. Review of energy characterization and GHG quantification methodologies

- Conduct a review of information gathered by NRCan's Technical Committee on Urban Energy Characterization (TCUEC) on community energy and GHG emissions data and the methodologies used to compile this data. These are specifically to be evaluated from the context of addressing all or part of the needs of the TCUEC. The evaluation of these energy and GHG accounting methodologies will eventually help us consider their pros and cons as well as identify gaps (but only after the development of criteria to do so, as described in task/deliverable 2).

2. Making recommendations on how to achieve a widely accepted methodology for municipal energy and GHG accounting

- Upon completion of the review and evaluation, recommendations on adoption or adaptation of these methodologies or development of new energy and GHG accounting methodologies are to be provided.
- Recommendations are also to be provided on approaches for developing a widely accepted national energy and GHG accounting methodology that applies to Canadian communities.

These recommendations will be based on:

- Indicators, or decision making criteria for classifying/reviewing the methodologies;
- Comparing the identified methodologies against the indicators or decision making criteria, scopes and goals of the assessment;
- Identifying candidate methodologies that are of interest for the purposes of establishing widely-accepted energy and GHG accounting methods;
- Identifying gaps or limitations that have to be addressed in developing the methodology;
- Develop options for establishing a strong, consensus-based energy and GHG

accounting methodology that will be acceptable to governments and stakeholders.

3. Presenting in a form decision makers will best understand

- From the evaluation of methodologies, mock-ups of various presentation scenarios for the recommendations on a widely-accepted methodology will be developed. NRCan and TCUEC are to be consulted for the best approach to present information to decision makers. It is required that the details of the evaluation are transparent and convincing to decision makers.

This report outlines the outcomes of tasks 1 and 2. Separate documents will be developed to meet task 3.

4 REVIEW AND EVALUATION METHODOLOGY

CSA assembled a team of 4 staff to conduct the review and evaluation of energy and GHG characterization methods. A stepwise approach was used to conduct the evaluation.

Step 1: Identify methods that would be appropriate for the evaluation: a broad spectrum research effort was undertaken to identify methods that would be appropriate for evaluation. Some basic criteria were used to weed out the irrelevant documentation that was found and only focus on the methods. These criteria included:

- **Focus on methods and guidance:** although there are many informational reports on energy consumption and GHG emissions, this project focused specifically on methods that could be used to characterize energy use and GHG emissions.
- **Avoid duplication of similar methods:** many energy and GHG characterization methods build off of core methods that have been established for years. These methods have now become de facto standards in the area and therefore it is best to evaluate the main standard and perhaps some key documents that have allowed the standard to be used at the community level. A key example here is the GHG Protocol from the World Resources Institute/World Business Council on Sustainable Development. This core standard is the foundation for much of ICLEI's most recent methods as well as the California Climate Action Registry, The Climate Registry and the USEPA's Climate Leaders program. As such, only a selection of these documents was evaluated.
- **Avoid proprietary models:** as part of the research it was recognized that many companies and other organizations have developed proprietary models that can be used at the municipal level. Often the methodological assumptions supporting these models are confidential and therefore they cannot be evaluated with the same rigour as other methods.

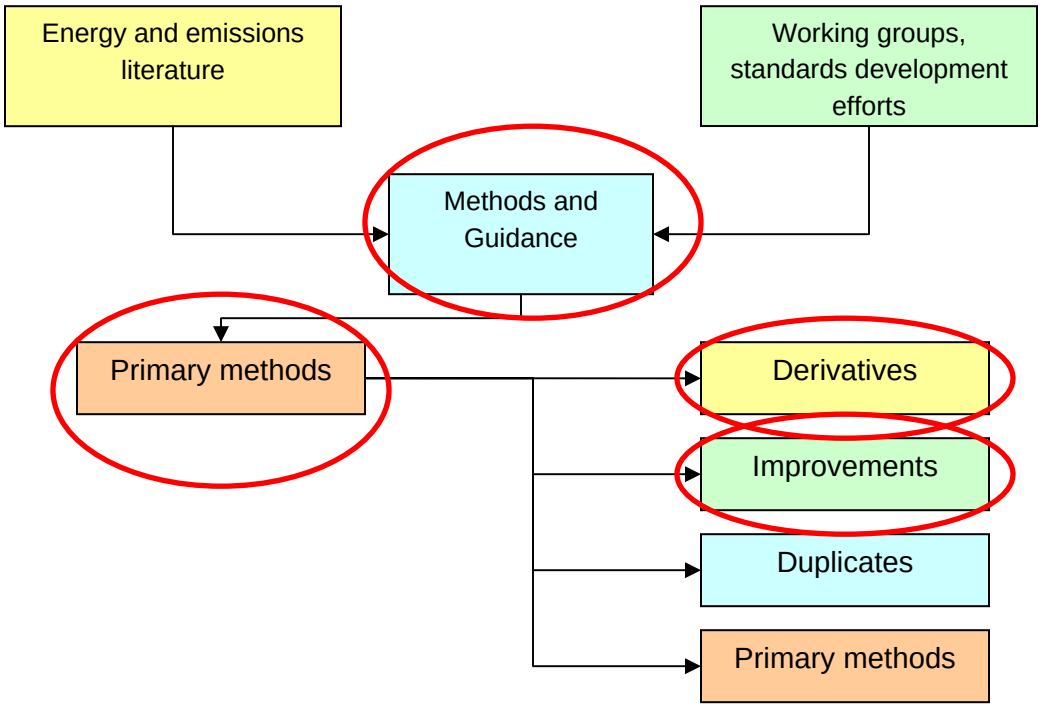

Figure 2: Approach to reviewing methods

Figure 2 illustrates the approach taken to selecting methods for review. As a general rule, individual elements of the literature were not reviewed since these typically end up being reviewed by methodological work groups or standards development committees and translated into methods. Within these methods the evaluation effort focused on primary methods, any derivatives or adaptations to these primary methods and any improvements to these primary methods that, in particular, assisted municipalities to perform energy or emissions characterization.

Step 2: Develop evaluation criteria: in order to properly structure the evaluation and allocate the different methods to the members of the team, a set of criteria were developed and vetted by the NRCan team. These criteria were then incorporated into a semi-quantitative evaluation tool which was used for the evaluation process. The criteria were classified into two broad categories:

- **Good Practice Guidance:** As energy and GHG quantification standards have

evolved, a set of underlying principles have developed to support robust quantification methods. These principles have now become considered as good practice guidance and were incorporated into the evaluation.

- **Scope and Goals Criteria:** In the scope of work identified by NRCan, there were some predefined criteria that were incorporated into the evaluation. Additional criteria were also added to evaluate specific elements of methods, such as how they dealt with leakage of energy or emissions outside community or project boundaries. The process is illustrated in Figure 3.

A spreadsheet was then created containing the criteria embedded and a set of ranking questions was created for each criterion. Each ranking question was given a score from 0 to 3 and the spreadsheet was used to total the evaluation scores for each of the methods reviewed. For example, the criterion of **Transparency** was evaluated using the following 4 questions:

- Method does not encourage presentation of transparent information – score of 0
- Method requires further language to encourage transparent presentation of information – score of 1
- Method encourages sufficiently transparent information to meet most international standards – score of 2
- Method requires full transparency such that calculations can be fully understood and reproduced – score of 3

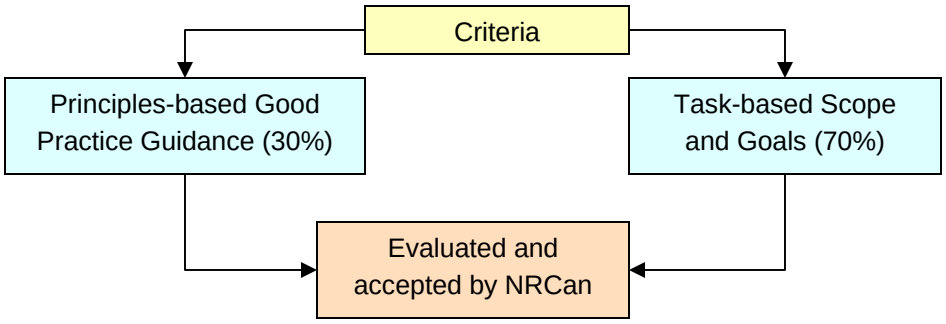

Figure 3: Process for development of criteria

The criteria for the evaluation and the ranking questions used are presented in **Error! Reference source not found.**.

Table 1: Evaluation Criteria and Ranking Questions for Methods

Criteria and Evaluation Questions		
Good Practice Guidance Criteria	**Alignment with International Standards**	Mmethods that aligned with accepted GHG accounting and measurement standards will have greater consistency and allow for comparability of GHG inventory data.
	Transparency	Disclose sufficient and appropriate GHG-related information to allow intended users to make decisions with reasonable confidence.
	Relevance	Select the GHG sources, GHG sinks, GHG reservoirs, data and methodologies appropriate to the needs of the intended user.
	Accuracy	Reduce bias and uncertainties as far as is practical.
	Consistency	Enable meaningful comparisons in GHG-related information.
	Completeness	Include all relevant GHG emissions and removals.
Scope And Goal Criteria	***Covers all appropriate domains/sectors)***	Includes residential and commercial built environment, transportation, water and wastewater systems, municipal waste, municipal services OR description of urban form
	Applicable / accessible / useful data sources	Methods that provide, identify or reference data sources are easier to use, since collection of data is one of the most resource intensive steps in inventory preparation.
	Ability to track progress over time	Methods that require calculation of base year emissions and comparison of inventory year emissions with the base year are more useful demonstrating the benefits of actions to reduce emissions.
	Definition of scale and boundaries	Methods that have clear definitions for municipal or community boundaries help promote comparability and consistency in inventories.
	Treatment of leakage	Methods that recognize the possible movement of emissions outside community boundaries provide more accurate inventories
	Accounting for operational boundaries	Methods that clearly define which sources and gases must be included in the inventory promote increased comparability, consistency and completeness of inventories.
	Ability to account for project-level emission reduction efforts	Methods that provide guidance on how to account for project-level emission reductions promote these types of activities and can allow for tracking of progress over time..
	Applicable and transferable to communities of various sizes	Methods that can be applied in large and very small communities are typically the most practical and usually enable more comprehensive comparisons across communities.
	Ability to link project, community and larger energy systems (i.e. national or regional energy balances)	Methods that allow aggregation of information to regional or national scales tend to maintain consistency with these top-down inventorying methods and can enable additional comparisons or data quality checks.

One additional element in the scoring was that the scope and goals criteria were considered to more relevant to the purpose of the evaluation so the scoring on these criteria was weighted at 70%, while the good practice guidance criteria were only weighted at 30% of the overall score.

Step 3: ensure consistency of evaluation: Since 4 different staff were evaluating methods it was necessary to 'practice' evaluating a few methods together to ensure an appropriate consistency of scoring against the evaluation criteria. This exercise was conducted on 3 separate methods until all staff were comfortable with the scoring methodology.

4.1 Methodologies Reviewed

Using the results of the broad spectrum research as a basis, we first identified and then reviewed candidate methodologies that relate to either or both the inventorying of energy and GHG emissions (see appendix A which provides the results of this review). In doing so, we categorized and reviewed the methodologies according to the following:

- Title of method/guideline/plan, etc
- Developer
- Scope (i.e. whether if the document provides a specified method or more a guide or a provision of general information)
- Focus areas (e.g. project-level, community-level (all sectors), community-level (only corporate), etc)
- URL (if applicable)
- Other comments (if appropriate)

Following this process of review, we then considered in more detail methods/guidelines/plans that may be of more interest in terms of the needs of this particular project. The reviews are contained in Appendix A of this report, and they are organized by Title and Developer. In addition, a bibliography of the methods reviewed is also provided before the appendices.

5 RESULTS OF THE EVALUATION

As per the requirements of the Statement of Work, the evaluation focused on methods that could be applied at the community and project level and that could be used for calculation of energy use or GHG emissions. Additional clarification was sought from Natural Resources Canada to determine which type of energy or emission reduction projects would be most appropriate to evaluate. This consultation focused the evaluation on 'integrated community-level projects' which were defined as projects where more than one element of the community was affected by the project. This led to research for the following types of projects:

- District heating;
- District heating systems
- Community energy systems
- Community-level energy efficiency projects
- Multi-unit energy retrofits
- Waste heat recovery in community buildings (i.e. arenas and pools)
- Other related projects
- Integrated land-use planning
- Intermodal (i.e. park and rides, public transit)

The City of North Vancouver 100 Year Sustainability Vision and the Energy Mapping Study prepared for the City of Calgary were both methods evaluated that employed spatial analysis, measured utility data and assumptions on building energy performance as an approach to determining the energy and emissions impacts of land use planning. The level of detail on the methods used to arrive at the results was limited in both studies and therefore these methods scored in the bottom 1/3 of methods because of lack of transparency. While community energy mapping could be a method of quantifying the impacts of land use planning and community-wide efficiency measures, as it is a complex domain requiring both spatial analysis and energy and/or GHG expertise, more detailed technical information and either best practice guidance or standardization of data and approaches is required.

In total, 62 energy and GHG methods were evaluated. The scores of the evaluation are presented in Annex 2 with those that ranked highest presented in Table 2. The Annex lists the methods that were evaluated by Title and developer and a separate

spreadsheet of the evaluation is available for consultation. For the better scoring methods a brief rationale is also provided for why the method scored well in the evaluation.

5.1 Summary of High-level Findings

Following the scoring of the methods they were organized by score to determine which of the methods was best suited for the purposes of energy or GHG characterization at the municipal level. Since the evaluation criteria allowed an evaluation of both community inventory and project-level methods as well as both energy and GHG characterization methods, the scores did not allow differentiation among the methods for these different purposes. The following provides an explanation of the results segregated by the purposes of each method.

5.1.1 Community-level Energy Inventorying Methods

The highest ranked community-level energy inventorying method was the ***Guide to Community Energy Profiling*** published by the Ontario Ministry of Energy. This guide was published in the early 1980s and provides communities with detailed guidance on how to compile an energy inventory within municipal boundaries. The key elements that allowed the method to score highly are:

- Data sources are identified in the method and approaches for obtaining the data are provided;
- Alternative methods for estimating energy consumption are provided when primary data sources may not be available;
- The guidance provided is very practical, taking into account the realities and capabilities of municipal governments;
- The method is supported by real-world case studies from different cities in Ontario.

An appendix to the Guide to Community Energy Profiling was also reviewed which presents the results of from several Ontario municipalities who implemented the methods in the Guide, including learnings from these efforts that helped improve the guidance in the document.

Another energy characterization method that scored highly was the ***Energy Efficiency Planning and Management Guide*** from NRCan's Canadian Industry Program for Energy Conservation. Although this method is specifically focused on industrial energy

efficiency, the presentation of the energy auditing techniques are sufficiently transparent and well explained for this to be a useful source of guidance for municipalities when compiling energy inventories.

The next highest ranked energy inventory method was a community energy plan. The ***Community Energy Plan for the Town of Banff*** prepared by the Sheltair Group for the town of Banff is sufficiently transparent and well explained to be a valuable source of guidance for municipalities undertaking this type of exercise. Because of the real-world nature of this report, it highlights some typical pitfalls that might be encountered during the preparation of a community-level energy inventory and the types of alternative approaches that can be used to work around these pitfalls.

5.1.2 Community-level GHG Inventory Methods

A sector-specific method ranked highest among the GHG inventorying methods for communities. The ***Climate Leaders GHG Inventory Protocol – Direct Emissions from Municipal Solid Waste Landfilling*** published by the USEPA's Climate Leaders program provides a very detailed approach for communities to inventory emissions from municipal solid waste landfills. Methods for GHG accounting are proposed for two different situations:

- Municipal Solid Waste (MSW) landfills that do not have a landfill gas capture and flaring or utilization system in place, and;
- MSW landfills with a capture and flaring or utilization system in place.

Landfills without a capture system in place are recommended to use the USEPA's LandGEM model for estimating fugitive methane emissions from the landfill, while landfills with capture systems can use the measured data on the quantity of methane captured combined with the capture system efficiency to estimate overall emissions from the landfill. The targeted nature of this method and its transparent guidance on estimating emissions from a particular difficult source for municipalities ranked it highly among the methods evaluated.

A more comprehensive GHG inventorying method was also ranked highly in the evaluation. The ***International Local Government GHG Analysis Protocol*** published by ICLEI International adapts the WRI/WBCSD GHG Protocol for inventorying corporate municipal GHG emissions and community-wide GHG emissions. The Local Government Protocol is still only in draft form and does not provide extensive guidance on how to

perform the calculations, but it is specifically targeted to the dual purposes identified for this evaluation. It was assumed and anticipated that the available WRI/WBCSD GHG Protocol calculation tools and the Climate Leaders calculation methods would be directly applicable with the Local Government Protocol, thus supplementing the method and making even more useful for communities.

Another U.S. federal government guide also ranked highly in the evaluation. The ***Technical Guidelines for Voluntary Reporting of GHGs Program*** published by the Department of Energy (DOE) provides detailed estimation methods for emission sources that are directly related to energy consumption in communities. The guide is primarily to be used for reporting under DOE's 1605(b) voluntary reporting program, but contains sufficient transparency and detail to allow municipalities to use it as guidance for reporting to other programs.

5.1.3 Energy and GHG Projects

Several Clean Development Mechanism (CDM) methods ranked highly in the evaluation for their detailed guidance for estimating energy and GHG reductions that would be applicable at the community level. Firstly the ***Methodology for Fuel Switching from Coal or Petroleum Fuel to Natural Gas*** was seen as a useful method that would allow municipalities to quantify energy and GHG savings from any type of fuel switching project that they may have within their community boundaries. The guidance in CDM methodologies also requires that GHG projects go above and beyond business as usual activities, thus encouraging municipalities to plan projects that lead to transformational change.

Secondly, the method for ***Introduction of a New Primary District Heating System*** was viewed as particularly applicable to communities that were implementing district heating in an integrated fashion within the community. The detailed energy and GHG savings calculations were seen as helpful to municipalities in understanding the important design elements of a district heating system that would allow the greatest savings in terms of energy and GHGs.

Finally, the method ***Boiler Rehabilitation or Replacement in Industrial or District Heating Sectors*** was also evaluated as a very useful method because of the details provided on the energy and GHG calculations. It was felt this method was particularly helpful for understanding the savings potential for boiler retrofits. Similar calculations could be used by municipalities when implementing energy system rehabilitation or

replacement in many different situations.

Figure 4 provides an overview of how different methods scored, but using a categorization by intended use.

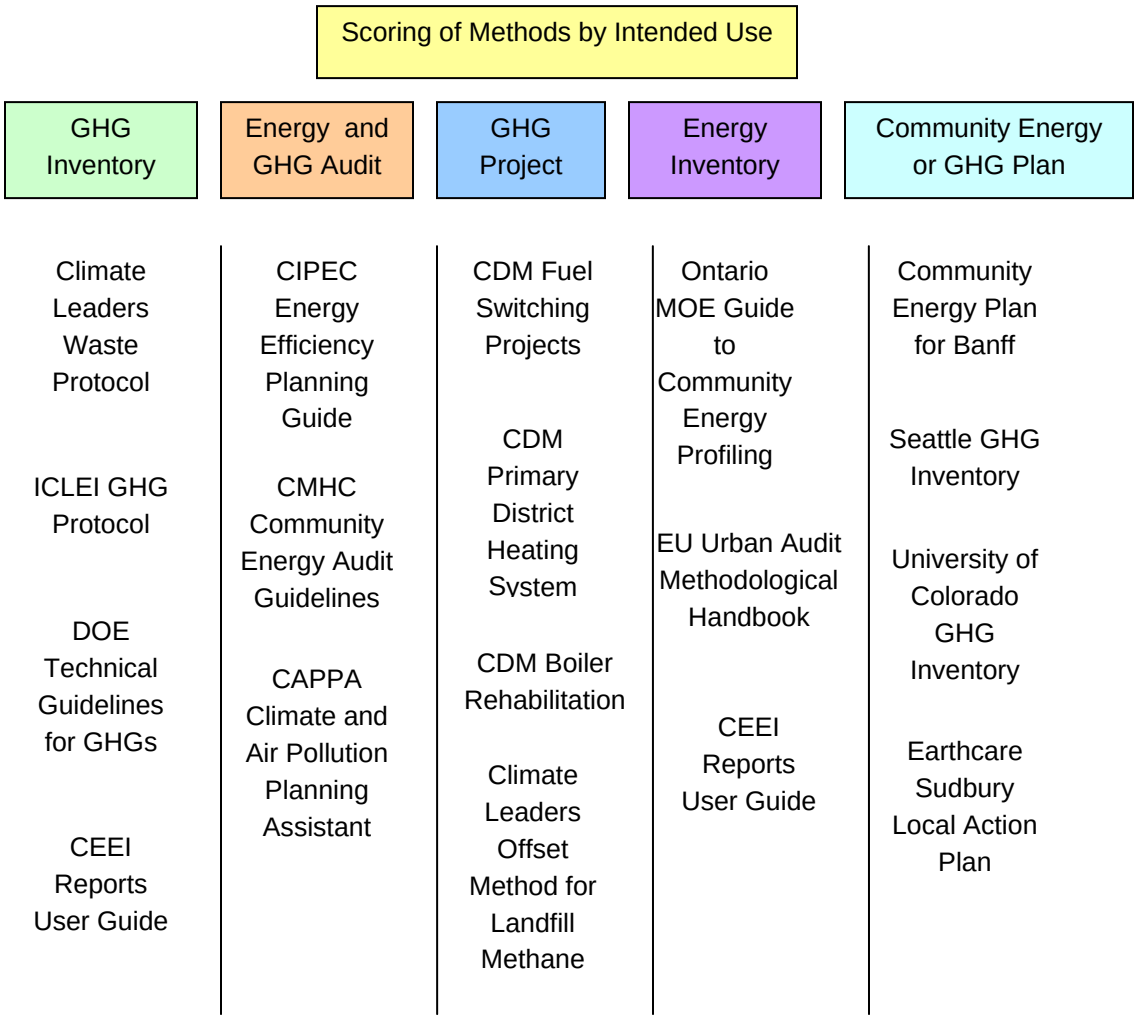

Figure 4: Scoring of Methods by Intended Use

5.2 General Observations on the Methods

Some of the project-level methods ranked fairly high in the evaluation because of their clear focus on an area of interest in the evaluation as well as their level of detail and transparency. In addition, some of the more recent methods that have been built from

the World Resources Institute/World Business Council on Sustainable Development (WRI/WBCSD) GHG Protocol scored well, since these methods follow an established approach for compiling a corporate GHG inventory that can also be applied at the community level[2]. In addition, several of the calculation methods that have been crafted to support these programs also ranked highly because of their transparency and direct applicability to an area of concern to municipalities[3].

Most of the above methods focused on compiling GHG inventories, but there were also some methods that ranked highly and were only focused on producing community energy inventories. These methods, from the Ontario Government or Canada Mortgage and Housing, were published in the early 1980's when energy conservation was a major concern for governments.

5.2.1 New approaches to community energy and emissions inventorying

The Government of British Columbia has worked for more than a year to provide municipalities with estimates of their community-level energy consumption and GHG emissions. This effort, known as the Community Energy and Emissions Inventory (CEEI) Initiative, has recently published more than 180 community-level reports of energy and GHG emissions. The process for developing the estimation method and producing the reports has been inclusive and comprehensive.

Along with the various CEEI community-level reports a user guide was produced to explain how the inventories were compiled. This user guide was evaluated along with other methods and was among the higher-ranked methods. Unfortunately the user guide did not provide enough technical detail to be ranked higher in the evaluation. A technical user's guide is expected from the CEEI initiative in the near term.

The innovative approach taken by the CEEI mainly involves assisting municipalities with the data collection portion of the community-level inventory exercise. The provincial government was able to consolidate this data collection process for all the concerned municipalities and eliminate duplicate data requests to provincial utilities and other data

[2] These methods have been published by well-known programs such as the International Council for Local Environmental Initiatives (ICLEI), The California Climate Action Registry (CCAR), USEPA Climate Leaders, and The Climate Registry.

[3] The calculation methods evaluated were mainly from the USEPA Climate Leaders program, but similar calculation methods and tools have also been prepared by CCAR and The Climate Registry.

providers. This dramatically reduced the burden on the data providers and resulted in more data being made available.

Energy and GHG emissions data compilation methods were also developed specifically for the type of data that was obtained. These methods will likely have more longevity because they are built from data sources that are regularly published and will remain available for some time. Using these comprehensive data sets will also allow for the comparability of the inventories to be higher. Energy and emissions estimates have been produced for most of the relevant community-level sectors (residential, commercial, transportation, waste) and regional emission and removal estimates have been produced for the land-use change and forestry sector. Methodological issues still remain for some of the estimates and the CEEI initiative continues to address these challenges.

5.2.2 Planning methods and tools

Clearly the purpose of calculating energy and GHG inventories at the community level is not an end in itself. The purpose of having an inventory is to assist in planning of energy and GHG reduction efforts. Community energy planning is currently being performed in many municipalities and a selection of these plans was evaluated as part of this study. However, the most interesting planning tool that was evaluated was the Climate and Air Pollution Planning Assistant (CAPPA) published by ICLEI. This planning tool scored moderately in this evaluation of methods primarily because it is not transparent on how it calculates energy and emissions savings. However, the tool does provide an interesting starting point for municipalities for the planning process, since it avoids all the data collection and calculation steps before scenarios can be evaluated to achieve energy, emissions and cost savings in communities. It would be valuable for the CAPPA tool to be more transparent on the assumptions that go into the estimates and also allow flexibility to adapt those assumptions depending on a municipality's particular circumstances.

5.2.3 Low scoring methods

One key omission from the top-ranked methods is the method currently used under the Partners for Climate Protection (PCP) program. This method is supported by a guide and spreadsheets to assist municipalities in compiling corporate and community-level

GHG inventories and is widely used in Canada at the present time[4]. However, this method seems to suffer from a lack of transparency, completeness and consistency. It should be noted that the software initially distributed to PCP communities is no longer supported by the PCP program, as it was a proprietary model. ICLEI has provided municipalities with GHG calculation templates as well as additional assistance as a stopgap, while they await the release of a tool developed around the ICLEI International GHG Protocol which will serve municipalities better in the future because of its more structured, transparent approach[5].

Although the PCP method did not score highly it is widely used, so exploring approaches to improve it would be beneficial. This is explored in the next section.

[4] Over 180 communities participate in the PCP 5 milestone framework, which includes the compilation of a corporate and community-level GHG inventory. More information can be found at http://gmf.fcm.ca/Partners-for-Climate-Protection/

[5] ICLEI's International GHG Protocol has been adapted form the WRI/WBCSD document and adheres to the same principles and requirements. This protocol is also the foundation for an effort by Microsoft and the Clinton Foundation to build a municipal government calculation tool called Project 2 Degrees (http://www.project2degrees.org/Pages/default.aspx)

6 ANALYSIS AND DISCUSSION

The results of the evaluation seem to indicate that there are a number of methods for conducting energy or emissions inventories that are suited to the needs of communities. The following presents some analysis and discussion of the challenges still facing communities in order to have more inventories of this nature compiled.

6.1 Approaches to Energy and Emissions Characterization

From the methods reviewed it is apparent that there are three main types of approaches used to compile community level energy or GHG information. These include:

- Top-down disaggregation of national or regional scale statistics or estimates. The European Union's Urban Audit, Methodological Handbook is an example of this type of method;
- Top-down compilations of statistics or estimates compiled using regional statistics. British Columbia's Community Energy and Emissions Inventory (CEEI) initiative is an example of this;
- Bottom-up compilations of statistics or estimates gathered by the municipality from local or regional information. The Partners for Climate Protection methods or ICLEI International GHG Protocol are examples of this.

6.1.1 Top-down methods

The advantage of the first two of these approaches is that it increases the comparability of the community-level information, enabling broader policy planning efforts because lessons can be learned from the energy or emissions profiles of different communities that have implemented different approaches to complex policy problems.

However, these approaches do sacrifice accuracy in the estimates for the benefit of comparability. Because these efforts use aggregate regional or national statistics and must adapt or adjust the data to fit the different types of municipalities that may be included in the study, the estimates are most likely less accurate than if they were calculated using local data. There is also possibly a problem related to the comprehensiveness or completeness of the inventories, since aggregate level data may not be available for all elements of the energy or GHG emissions profile of a

community[6].

One other significant advantage of top-down efforts is the accessibility of data. Regional or national authorities often have legal authority to compel the collection or provision of energy or other types of data. Data collection for bottom-up efforts is typically the most resource intensive step in compiling an energy or GHG emissions inventory, therefore efforts that streamline this step are often sought after by governments.

6.1.2 Bottom-up methods

As was found in this evaluation, the number of bottom-up methods for compiling energy and emissions inventories far outnumbers the number of top-down methods. Also, within the bottom-up methods there is a mix of data collection, estimation and modeling approaches used to arrive at complete energy or GHG inventories. This is mainly because access to primary data (e.g. fuel use, electricity consumption) is often difficult for communities and other types of approaches need to be used.

For example, in the transportation sector methods that use vehicle kilometers travelled (VKT) are often used when data on fuel sales within the community are limited or inaccessible, or when having a spatial element to the data is desired. Access to primary data has become more of an issue over the past few decades as business confidentiality issues have become more pronounced. Other sectors, such as industrial or commercial, can be affected by claims that the energy use must be kept confidential by the utilities.

Case in Point

In 1983 the Government of Ontario published a guide for compiling a community energy profile in which it was assumed that municipalities would be able to easily obtain fuel sales data from local suppliers. However, in Guelph's Community Energy Inventory, published in 2007, most of the energy data presented was produced using modeling or estimates because access to primary data was incomplete

[6] For example, information on energy consumption of wastewater system is likely incorporated into other categories within regional or national statistics, meaning that separating this municipal function in a top-down inventory would be difficult.

However, the bottom-up methods have multiplied and have been supported by calculation tools to assist municipalities as much as possible.

6.2 Community-level energy and GHG inventory methods

While most Canadian municipalities that are compiling community-level energy or emissions inventories are doing so using the Partners for Climate Protection methods and speadsheets, there is an emerging trend towards methods that are consistent with the WRI/WBCSD GHG Protocol. Several U.S. programs have followed this standard, which is also consistent with the ISO 14064-1 standard. This standard provides requirements and guidance for compiling a corporate GHG inventory and has been widely adopted by corporate reporters for voluntary reporting under programs like the Carbon Disclosure Project, the California Climate Action Registry and The Climate Registry.

A recent effort by ICLEI International has adapted the WRI/WBCSD GHG Protocol for reporting by municipalities and across communities. This ICLEI International GHG Protocol is available in draft form at the moment and will be the supported by a web-based tool for emissions calculation and reporting (http://www.project2degress.org). In addition, The Climate Registry, the California Climate Action Registry and the California Air Resources Board have adapted this protocol for use within their programs. Since 10 Canadian provinces and two territories are members of The Climate Registry, it is likely that the ICLEI International GHG Protocol will become the standard for communities to report their GHG emissions.

This finding is also supported by the evaluation conducted for this report. The ICLEI International GHG Protocol is among the top 3 methods in the ranking developed by this study. All of the other adaptations of this protocol are among the top 25 of the ranked methods. However, it is likely that data collection to implement these methods will be a challenge for communities. The various web-based calculation and reporting tools may assist with this, but they will not be a substitute for a robust data collection and management system within the municipality.

While these methods are primarily focused on estimating GHG emissions, they must be supported by the collection or estimation of energy-related data. Therefore it is likely that these methods could be used for the secondary purpose of compiling a community energy profile, if lessons learned from the various energy-focused methods evaluated during this study are considered.

6.3 Integrated community-level project methods

Energy and GHG reduction projects have become popular from the perspective of achieving cost savings and also for the possibility of generating revenue through the sale of GHG offset credits. There are key opportunities within communities to achieve efficiencies of energy production and use simply due to the proximity of buildings and other services that require energy.

This section summarizes the results of the evaluation of community-level energy/GHG reduction projects. The project categories for which methodologies were considered were:

- District heating systems
- Community energy systems
- Community-level energy efficiency projects
- Multi-unit energy retrofits
- Waste heat recovery in community buildings (i.e. arenas and pools)
- Other related projects
- Integrated land-use planning
- Intermodal (i.e. park and rides, public transit)

The first step in the evaluation was to search the various policy regimes that exist for greenhouse gas emission reduction projects for already approved methodologies for the quantification of emission reduction offsets accruing from these activities (e.g. CDM, etc). Although this is focused primarily on the GHG emissions, it was believed that any protocol or best practices work developed for these purposes would be important to consider for its energy reduction potential as well. The different programs considered included:

- The Clean Development Mechanism of the Kyoto Protocol – over 100 project-based methodologies are available but they are specific to the situation of GHG emission reductions in developing countries;
- The Alberta offset system – over 25 project-based protocols are available for different project types from sequestration in agricultural soils to waste heat recovery along natural gas pipelines.
- Feasibility studies and project reports from the Federation of Canadian Municipalities Green Municipal Fund – over 100 studies are available from this uniquely Canadian program focused on municipalities.

The review of available project-specific methodologies illustrated a number of lessons learned:

- Project-based methodologies do exist which attempt to link into the energy characterization and use patterns of the community at large. These project methodologies could ultimately be useful for communities undertaking specific projects to help improve their energy use characterizations and/or reduce GHG emissions
- The project-specific methodologies reviewed are sector-specific, thereby limiting their usefulness for any sectors other than what they are geared towards
- There are no widely-tested protocols, methodologies, or best practice guidelines that exist for assessing the energy or emission impacts of integrated land-use planning. The use of spatial analysis to develop community-wide energy and emissions impacts of integrated land use planning is a complex domain where more detailed methodological information is required, leading to best practices and standard development.

The review of GMF studies (http://gmf.fcm.ca/Search/Search/Search.aspx?lang=e) was performed in order to identify relevant projects and, from this, to determine if there might be useful information in terms of suitable project methodologies for use in this project. The categories of projects considered include:

- Energy Efficiency Projects
- Community energy systems
- District Energy Systems

Based on the review and assessment of various GMF projects, it appears that feasibility studies and project documentation provide limited or no methodological information on how energy characterizations or emissions savings were understood. Further, many cities who received funding to help develop a GHG inventory did so following the Partners for Climate Protection process.

It is of interest to note some of the work undertaken at the Department of Civil Engineering at the University of Toronto on the life cycle energy and emissions analysis of of energy use and greenhouse gas GHG emissions associated with high and low

residential development in terms of the City of Toronto.[7] This work specifically provides an example of possible steps and data sources which could be used to assess the energy and GHG impacts of different land use forms or projects or policies that could influence the specific technical characteristics of building or transportation infrastructure.

Three distinct analytical approaches were employed for estimating the energy use and GHG emissions characteristics of each of these three elements: (1) for the construction materials an economic input–output life-cycle assessment model was applied; (2) for building operations, nationally averaged public datasets were utilized; and (3) for public and private transportation, detailed location-specific data for the Greater Toronto Area were utilized. This was undertaken for both low- and high- density development to help understand the energy and emission characteristics of each.

The results showed that on a per capita basis, low-density suburban development is more energy and GHG intensive by a factor of 2.0–2.5 when compared to high-density urban core development.

[7] See Norman et al. (2000): Comparing High and Low Residential Density: Life-Cycle Analysis of Energy Use and Greenhouse Gas Emissions, available from http://www.growingsensibly.org/cmapdfs/Comparing%20High%20and%20Low%20Resedential%20Density%20-%20Life%20Cycly%20Analysis%20of%20Energy%20Use%20and%20Greenhouse%20Gas%20Emmissions.pdf

7 CONCLUSIONS

The review of energy and GHG emissions characterization methods was conducted to provide a basis for decisions on the development of a standardized approach for energy and GHG accounting at the community level. Over 60 methods were reviewed and evaluated against approved criteria. The scope of the evaluation was limited to methods where sufficient detail was publicly available to make appropriate judgements, therefore proprietary models were not evaluated.

7.1 Energy and emissions characterization

Energy and emissions characterization is being widely applied in Canadian municipalities and various methods are being used to build these inventories. It appears that most Canadian communities are using methods provided by the Partners for Climate Protection program for compiling their community-level GHG inventories. While this is happening in practice, several efforts have produced more standardized approaches to GHG accounting and other jurisdictions have explored the possibility of using top-down approaches for providing community-level energy and GHG emissions information. Work is also been done by a range of academic research institutions that is applicable to this project. One example of such research has been provided.

7.1.1 Top-down methods

Methods that use top-down aggregate statistics for producing community-level energy and GHG inventories have evolved. Methods from the EU and British Columbia can now produce relatively accurate and comparable inventories for communities. The key to these types of efforts is the community engagement that allows for buy-in on the estimation methods and final results. It is important that top-down methods benefit from bottom-up engagement strategies for them to be successful.

Top-down methods benefit from the accessibility and reliability of data sources, but they are hampered by difficult municipal boundary issues for smaller communities. Top-down methods allow for efficient use of resources, requiring only one contact with local utilities for data collection rather than hundreds of contacts. They are, however, hampered by data confidentiality issues, since some utilities are prevented from divulging energy consumption for industrial sectors with one or two actors.

Work continues, particularly in British Columbia, on improving these top-down approaches and finding work arounds for some of the more challenging sectors, like transportation. Ultimately, if top-down approaches are successful, national and provincial governments can save municipalities significant resources for the production of community-level energy and GHG inventories. However, municipalities will likely need to still produce their own inventories at a more disaggregated level if they wish to track the success of their more bottom-up energy and GHG reduction initiatives.

7.1.2 Methods for Spatial Analysis

There is also a variety of work being undertaken in terms of assessing the energy and GHG impacts of changes in urban form. In particular, examples have been provided of research and analysis related to using spatial analytical tools and datasets to help determine how urban form impacts on these factors. For example, energy mapping is an emerging area seeing increasing interest due to its potential as a tool to map out patterns and changes in energy use spatially due to changing land use policies, development patterns, etc. There is also an array of work being done in the academic research community to assess the spatial patterns of energy use and GHG emissions. Many of these approaches use spatial analysis tools such as Geographical Information Systems (GIS) or remote sensing, often drawing upon extensive data sets to help in determining spatial and temporal patterns of energy and emissions. Nonetheless, although this work exists, there are no formal methodologies available as of yet, nor has an attempt been made to review and assess the range of analysis and research that has been undertaken.

7.1.3 Bottom-up methods

Because of the challenges posed by top-down energy and GHG characterization initiatives, there are many more bottom-up methods for inventorying energy and GHG emissions. These range from fairly widely accepted methods such as the Partners for Climate Protection (PCP) to emerging methods from new programs like The Climate Registry. The main finding from this study is that the methods based on the internationally-recognized GHG Protocol[8] are becoming best practice for producing municipal corporate GHG inventories and could become best practice for compiling

[8] The World Resources Institute / World Business Council for Sustainable Development GHG Protocol is aligned with the ISO 14064-1 standard produced by the International Organization for Standardization (ISO).

community-level GHG inventories[9].

Notable among these is the ICLEI International GHG Protocol, which builds off of the WRI/WBCDS GHG Protocol and has been adapted by several voluntary GHG reporting programs (e.g. The Climate Registry, the California Climate Action Registry and the California Air Resources Board). This new protocol provides a basis for municipalities to begin estimating their energy and GHG emissions in a more consistent, comparable and complete way. As was demonstrated by the review and evaluation, this method scored much higher than the PCP methods against these key evaluation criteria.

Bottom-up methods generally require more investment of time and resources from the municipality for data collection and processing. For smaller communities the required effort leads to rejection of the inventory project by upper management or by municipal council. For larger municipalities with more resources, energy and GHG inventories can be compiled in a first year, but maintaining the inventory over time becomes problematic.

Bottom-up methods that attempt to simplify the GHG inventory process generally lead to less transparent and less accurate inventories, but can support decision making none-the-less. An approximate picture is often enough to allow municipalities to take action and this is often the primary goal of municipal engagement initiatives.

However, it is becoming more important in a carbon-constrained world that communities have an accurate picture of what their energy and emissions profile is. This profile can support efforts to plan and execute offset projects, plan energy conservation efforts and also justify efforts such as integrated land-use planning and public transit initiatives. The ICLEI International GHG Protocol and The Climate Registry's Local Government Operations Protocol are a response to this need.

7.1.4 Gaps and how to fill them

For top-down energy and GHG characterization initiatives the gaps of data availability in the industrial and transportation sectors require different approaches. In the industrial sector, the main issue is confidentiality of data. The only way around this is to use proxy data to arrive at an emissions estimate. Industrial production data or dollars of value

[9] Although these methods have the primary purpose of compiling GHG emissions, the energy data required to support the GHG emission estimates can be used to establish a comprehensive energy inventory.

added can sometimes be used as proxy data to arrive at an energy or emissions estimate, however, the relationship (i.e. correlation) between the proxy data and the energy or emissions data needs to be well supported and justified by underlying studies. The Government of British Columbia has conducted useful studies to support their CEEI initiative and will likely be able to develop proxy estimation techniques in the industrial sector.

For the transportation sector, proprietary models exist and are used by transportation planning departments. However, the usefulness of these tools for energy and emissions characterization is doubtful, given their primary purpose is transportation planning. Again, proxy estimation methods are useful for energy and emissions profiles in the transportation sector. Vehicle registrations by census track or average kilometres travelled can be correlated with gasoline or diesel sales data to develop fairly reliable estimates of transportation-related emissions. However, no reliable method for dealing with leakage of transportation emissions from one community to the next seems to be available at this time.

The transportation sector will likely always be a challenge for bottom-up inventory methods in communities, because of the varied quantity and quality of data to support emissions estimates in this sector. This is somewhat disappointing since this is typically one of the largest emissions sources in communities and municipal action to reduce these emissions can be effective.

7.2 Integrated community-level project methods

One of the additional objectives of this study was to assess whether their existed robust integrated community-level project methods that might be applied by municipalities. The main methods found were focused on community energy systems and these methods were generally found to be quite comprehensive and robust, often scoring quite highly in the evaluation. Although there may not be many communities in Canada applying these methods as of yet, there is interest in these methods because they can lead to generation of emission reduction credits that could provide an additional revenue source to municipalities, through sales of these credits on the carbon markets.

Not many of the energy or GHG inventory methods maintained a link with project-level activities. This is typically because all project-level energy or emissions reductions are inherently captured in an inventorying activity, since it is based on a historical accounting of activities. However, some of the methods (e.g. WRI/WBCSD GHG Protocol, ISO

14064) allow for separate accounting of project-level activities. This allows a showcasing of activities that have reduced energy or emissions while not affecting the comprehensive accounting approach in an energy or GHG emissions inventory.

As well, GHG emission reduction projects are typically quantified differently from emissions inventories. The emissions from a project activity are typically quantified against a hypothetical reference case of what would have occurred in the absence of the project. This hypothetical reference case is typically called the 'baseline'. Because of this different quantification approach it is difficult to reconcile project level quantifications with inventory calculations, thus leading to them being reported separately.

What was missing from the methods that were evaluated was an inventory approach that would be disaggregated enough to allow specific emission reduction projects to be quantified in the same way as an inventory is quantified (i.e. using historical before and after estimates). This is perhaps a gap in the methods, but would also likely add a significant resource burden on to municipalities that attempted to compile such an emissions inventory. Therefore it is expected that integrated community-level projects will continue to be quantified using the hypothetical reference case methods.

Although they were not evaluated specifically in this study, it is useful to recommend that proprietary tools that enable quantification of specific project types be investigated. This would likely mean evaluating document data and methodologies used in modeling studies and for related academic research. For example, VandeWeghe and Kennedy undertook a census-track level analysis of energy and GHG characterizations of the City of Toronto where residential greenhouse gas (GHG) emissions were spatially analyzed to determine the impact of urban form on emission-causing activities. [10]

The key methods and data sets used to undertake the analysis included:

- For buildings: values were acquired for electricity and fuel use for each census tract based on average annual payments for these services, as reported in the 2001 Statistics Canada Census. To translate these average payments into applicable GHG emissions, several conversion factors were used.

[10] A Spatial Analysis of Residential Greenhouse Gas Emissions in the Toronto Census Metropolitan Area, *Jared R. VandeWeghe and Christopher Kennedy, Journal of Industrial Ecology*

- For transportation: the authors used travel surveys in conjunction with modeling software (EMME/2) to determine trip distances and then GHG emissions.

The above data were then mapped accordingly.

Assessing these proprietary approaches might allow municipalities to decide whether these project-specific tools that might take a more holistic or systems approach to the community are appropriate for their use. These tools typically take an energy or emissions flow approach, using different estimation techniques to quantify the impact of more community-wide initiatives, such as integrated land-use planning or sustainable transportation.

7.3 Recommendations on a Developing a Widely-accepted Method

From the more than 60 methods reviewed it is clear that there exists sufficient work in the area of energy and GHG emissions accounting at the community level to support a consensus-based process to develop a widely-accepted method for Canada. In addition, the most highly ranked documents in this evaluation are already supporting a North-America-wide effort to encourage municipalities to voluntarily report their corporate GHG emissions. Among these efforts, The Climate Registry has the most Canadian participation at the moment, with all 10 provinces and two territories participating. Each of these jurisdictions has committed to encourage organizations within their borders to report to The Climate Registry.

Consistent with these goals, British Columbia has created the Climate Action Charter, which encourages all B.C. municipalities to compile and report their corporate GHG emissions. The B.C. government is also providing an incentive by reimbursing the provincial carbon tax to those municipalities who join the Charter. This effort will likely lead to significant adoption of The Climate Registry's Local Government Operations Protocol (which is based on the ICLEI International GHG Protocol).

While these efforts are primarily focused on municipal corporate GHG emissions, they are a significant step to making municipalities comfortable with a new way of estimating their energy use and GHG emissions. Extending these methods to cover the entire community and also encourage the reporting of energy consumption should be relatively simple if appropriate incentives (e.g. tools, provincial support) are provided. A consensus-based process, such as that used by standards development organizations in Canada, could be used to develop a guideline or standardized method for this purpose.

There will still be challenges with data collection and capacity to implement these methods within municipalities. Developing a standardized method will not solve these challenges, therefore provincial and federal governments should assess where additional support can be provided in these key areas where municipalities universally hit roadblocks when attempting to compile their energy and GHG inventories. Solutions to these challenges could also be part of the consensus-based process for extending the existing methods to include the whole community as well as energy consumption.

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ANNEX 2: SUMMARY EVALUATION AND RANKING

The following table provides a list of the top-ranked methods in the evaluation along with a description, the evaluation score, the author of the method and the classification of the method as either a community or project method and as either an energy characterization or GHG characterization method.

Table 2: List of Top-ranked Methods

Method Title	Developer	Community, Project, Energy, or GHG Method	Rationale	Score
Methodology for Fuel Switching From Coal or Petroleum Fuel to Natural Gas	UNFCCC Clean Development Mechanism	Proj., GHG	Method focused on the needs of the intended user. Was also a project-level activity relevant to communities	20.1
Climate Leaders GHG Inventory Protocol - Direct Emissions from Municipal Solid Waste Landfilling	U.S. Environmental Protection Agency Climate Leaders	Comm., GHG	Method focuses specifically on the MSW sector and estimating GHG emissions.	19.8
International Local Government Greenhouse Gas Emissions Analysis Protocol	ICLEI	Comm., GHG	Guide follows GHG Protocol and focuses on corporate and community inventory	19.8
Guide to Community Energy Profiling	Ontario Ministry of Energy	Comm., GHG	Guide focuses on community-wide energy inventory with full methods	19.6
Introduction of a New Primary District Heating System Methodology	UNFCCC Clean Development Mechanism	Comm., En	Method focused on the needs of the intended user. Was also a project-level activity relevant to communities	19.4
Technical Guidelines Voluntary Reporting of Greenhouse Gases Program	Office of Policy and International Affairs - U.S. Department of Energy	Proj., GHG	Guidelines focus on development of GHG reporting documents and provide substantial background and guidance as to how to complete GHG accounting; applicable to both project and community levels.	19.2
Energy Efficiency Planning and Management Guide	Canadian Industry Program for Energy Conservation	Comm., GHG	Guide focuses on industrial sector but provides extremely comprehensive calculation methods	18.2
Boiler Rehabilitation or Replacement in Industrial and District Heating Sectors	UNFCCC Clean Development Mechanism	Proj., En	Method focused on the needs of the intended user. Was also a	18

Method Title	Developer	Community, Project, Energy, or GHG Method	Rationale	Score
Methodology			project-level activity relevant to communities	
Community Energy Plan for the Town of Banff	Prepared by: The Sheltair Group Resource Consultants Inc. for the Town of Banff	Comm., En	Method focused on the needs of the intended user. Most sectors were also considered. Method drew upon primary energy use data and fuel sales data and not default metrics. A more accurate approach	17.2
Climate Leaders GHG Inventory Protocol - Design Principles	U.S. Environmental Protection Agency Climate Leaders	Comm., GHG	Guide follows GHG protocol but extends to focus on continuous improvement.	16.6
2007 Community Energy and Emissions Inventory Reports User Guides	CEEI Working Group	Comm., GHG	Method outlines how data was compiled for this effort, what sectors are covered and limitations on data	16.5
Local Government Operations Protocol - Appendix D: The Climate Registry Reporting Requirements	The Climate Registry	Comm., GHG	Guide adapts ICLEI International Protocol to the rules of The Climate Registry	15.6
2005 Inventory of Seattle Greenhouse Gas Emissions - Community and Corporate	Prepared by: Roel Hammarschlag for the City of Seattle Office of Sustainaility and Environment	Comm., GHG	This method provides the details for the City of Seattle's GHG inventory. It includes GHG sources from residential, commercial, industrial, waste and transportation.	15.4
Local Government Operations Protocol - For the Quantification and Reporting of GHG Emissions Inventories	Prepared by: California Air Resources Board, California Climate Action Registry, and ICLEI for The Climate Registry	Proj., GHG	Guide adapts ICLEI International Protocol to California Climate Action Registry and Air Resources Board.	15.3
Climate Leaders GHG Inventory Protocol - Offset Project Methodology for Landfill Methane Collection and Combustion	U.S. Environmental Protection Agency Climate Leaders	Comm., GHG	Method focuses specifically on emission reductions in MSW sector	15.3
Climate Leaders GHG Inventory Protocol - Direct Emissions from Stationary Combustion Sources	U.S. Environmental Protection Agency Climate Leaders	Comm. En., GHG	Methods for estimating all types of stationary combustion sources.	15.2
Climate and Air Pollution Planning Assistant (CAPPA)	ICLEI	Comm., GHG	Method for evaluating different energy and emissions management	14.9

Method Title	Developer	Community, Project, Energy, or GHG Method	Rationale	Score
			options	
Canadian Municipal Benchmark Project - Final Report	Prepared by: The Sheltair Group Resource Consultants Inc. for Natural Resources Canada, Sustainable Buildings and Communities	Comm., GHG	Method provides Canadian data sources for compiling a community energy inventory.	14.9
University of Colorado at Boulder GHG Emissions Inventory FY 2007-08	The University of Colorado at Boulder Environmental Centre	Comm., GHG	Method focused on the needs of the intended user. Most sectors were also considered. Method drew upon primary energy use data and fuel sales data and not default metrics. A more accurate approach	14.8
Climate Leaders GHG Inventory Protocol - Indirect Emissions from Purchases/Sales of Electricity and Steam	U.S. Environmental Protection Agency Climate Leaders	Comm., GHG	Method provides approach for quantifying emissions from electricity purchases or sales.	14.6
Climate Leaders GHG Inventory Protocol - Direct Emissions from Mobile Combustion Sources	U.S. Environmental Protection Agency Climate Leaders	Comm., GHG	Method provides detailed calculations for the transportation sector	14.5
General Reporting Protocol for the Voluntary Reporting Program	The Climate Registry	Comm., GHG	Methods for corporate GHG reporting, can be used at the municipal level	14.2
The Greenhouse Gas Protocol - A Corporate Accounting and Reporting Standard	The World Resources Institute and the World Business Council for Sustainable Development	Comm., En.	General standard for reporting corporate GHG emissions. Can be extended to include emissions that municipalities influence	13.9
Community Energy Audit Guidelines	Canada Mortgage and Housing Corporation	Comm., En	Methods for conducting energy audits at the community level	13.8
EarthCare Sudbury Local Action Plan	Prepared by: EarthCare Sudbury Partners for the City of Greater Sudbury	Comm., En., GHG	Extensive methods and guidance for conducting energy balances. Could help guide municipalities in complex energy issues.	13.7
Energy Statistics Manual	International Energy Agency	National, Energy	Method explains how energy balances are compiled and contains very useful information for understanding	13.6

Method Title	Developer	Community, Project, Energy, or GHG Method	Rationale	Score
			energy forms and statistics	
Urban Audit - Methodological Handbook	European Commission	Comm., En., GHG, others	Top-down method for auditing of all types of municipal indicators, including energy and emissions.	13.5

Table 3 provides the ranking of the remaining 35 methods from the evaluation. References to these methods are provided in the bibliography.

Table 3: Ranking of the Remaining Methods

City of Boulder GHG Emissions Plan - GHG Emissions Inventory	City of Boulder	13.2
Climate Leaders GHG Inventory Protocol - Optional Emissions from Commuting, Business Travel and Product Transport	U.S. Environmental Protection Agency Climate Leaders	13
Inventory of Energy Usage and Associated Greenhouse Gas Emissions	Prepared by: The Climate Action Committee for the Jefferson County Board of County Commissioners and City Council	12.9
Energy Conservation in Buildings and Community Systems Program – Annex 33: Advanced Local Energy Planning – A Guidebook, International Energy Agency	International Energy Agency	12.9
Greenhouse Gas Emissions Reduction Action Plan for Fiscal Year 2008-2009	Idaho Department of Environmental Quality	12.1
California Climate Action Registry General Reporting Protocol	California Climate Action Registry	11.9
Canada's National Inventory Report 1990-2006	Environment Canada	11.8
City of Guelph Community Energy Plan	Prepared by: Garforth International llc for the City of Guelph	11.8
EMAS Energy Efficiency Toolkit for Small and Medium Sized Enterprises	Eco-Management and Audit Scheme (EMAS) of the European Commission	11.5
Data Requirements for Community Energy and Emissions Inventory	Prepared by: Hyla Environmental Services for the BC Ministry of Environment Community Energy and Emissions Inventory Working Group	10.6

Developing Inventories for GHG Emissions and Energy Consumption - A Guidance Document for Partners for Climate Protection in Canada	Prepared by: Hyla Environmental Services for the Federation of Canadian Municipalities Partners for Climate Protection	10.5
Municipal Energy Audit: A Practical Guide to the Identification of Energy Expenditures	Energy, Mines and Resources Canada - Conservation and Renewable Energy Branch	10.3
Energy Mapping Study and Lessons Learned	Prepared by: The Canadian Urban Institute for the City of Calgary and Natural Resources Canada	10.3
Oil Crises and Climate Challenges - 30 Years of Energy Use in IEA Countries	International Energy Agency	9.7
Energy and Greenhouse Gas Inventories by Local Governments in BC: Implications for the CEEI (Community Energy and Emissions Inventory) Initiative – Final Report	Prepared by: The Sheltair Group Resource Consultants Inc. for the B.C. Ministry of Environment Community Energy and Emissions Inventory Working Group	9.4
City of North Vancouver 100 Year Sustainability Vision: GHG Measurement and Mapping - Technical Paper	Prepared by: Duncan Cavens and Nicole Miller of UBC's Design Centre for Sustainability for the BC Ministry of Environment Community Energy and Emissions Inventory Working Group	9.4
Inventory Quantification Support Spreadsheet	ICLEI	8.3
Estimated Inventory Guide	Federation of Canadian Municipalities Partners for Climate Protection	8.2
Assessing Vehicular GHG Emissions – A Comparison of Theoretical Measures and Technical Approaches	Prepared by: Pacific Analytics Inc. for the B.C. Provincial Community Energy and Emissions Inventory Working Group	7.9
NACWA Comments on Wastewater Treatment Emissions Estimates in EPA's Inventory of U.S. GHG Emissions and Sinks 1990-2005	National Association of Clean Water Agencies (NACWA)	7.9
The Community Energy Profile	Ontario Ministry of Energy	7.7
Benchmarking and Best Practices Guide for College Facility Managers	Natural Resources Canada - Office of Energy Efficiency	7.1
2003-2004 Progress Report on Energy Efficiency and GHG Reduction	Prepared by: British Columbia Building Corporation for the Canadian GHG Challenge Registry	6.9
Climate Protection Manual for Cities	Natural Capital Solutions	6.9

Promotion of the Use of Energy from Renewable Sources	European Parliament	6.8
Indicators of Energy Use and Efficiency - Understanding the Link between Energy and Human Activity	International Energy Agency	6.5
Energy Savings Toolbox - An Energy Audit Manual and Tool	Canadian Industry Program for Energy Conservation	6.3
Town of Victoria Park Milestone 1 Inventory Summary	Prepared by: Omega Environmental Strategies for Victoria Park Town Council	6.2
Community Energy and Emissions Planning – A Guide for B.C. Local Governments	Community Energy Association	6
Comparing High and Low Residential Density: Life-Cycle Analysis of Energy Use and GHG Emissions	Jonathan Norman, Heather L. MacLean, Christopher A. Kennedy of the Department of Civil Engineering, University of Toronto - appears in the Journal of Urban Planning and Development, March 2006	5.8
Implementation Guide - Information and Resources for Participating Institutions	Prepared by: Julian Dautremont-Smith of the Association for the Advancement of Sustainability in Higher Education for the American College and University Presidents Climate Commitment	5.2
Community Energy and Greenhouse Gas Emissions Inventory – User Needs Research	Prepared by: Elevate Consulting for the B.C. Ministry of Environment Community Energy and Emissions Inventory Initiative	4.7
Emission Baselines - Estimating the Unknown	International Energy Agency	4.2
Reviewing Gaps in Resource Mapping for Renewable Energy in North America	Prepared by: The Delphi Group with the Instituto de Investigaciones Electricas for the Commission for Environmental Cooperation	2.1