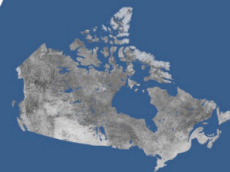




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The SCEC³ Model: Action-Research Exploring the Use of Government of Canada Data and Building Energy Simulation Tools for Community Energy and Greenhouse Gas Planning

Summary

Natural Resources Canada's (NRCan) CanmetENERGY is developing the **Spatial Community Energy, Carbon and Cost Characterization Model (SCEC³)** for the City of Prince George, British Columbia. The SCEC³ model enables the estimation of community-wide energy, emissions and costs for the City's entire building stock. First used to support the City's Smart Growth on the Ground (SGOG) process and currently informing the myPG integrated long-range planning initiative, the model explores the use of existing federal datasets and tools for community scale energy and greenhouse gas (GHG) planning.

Currently, estimates are most accurate for the residential housing stock and less so for commercial, institutional and industrial buildings. Research is ongoing in order to improve upon initial results and to make data available for the development of map-based Integrated Community Energy Models in British Columbia and across Canada.

Background

Building on results of the Urban Archetypes Project¹ in 2008, CanmetENERGY was seeking an opportunity to develop a Geographical Information System (GIS)-based methodology to characterize residential energy use, emissions and costs in neighbourhoods and communities. Prince George's Smart Growth on the

Ground initiative proved to be a good match: the City and Smart Growth BC both required a credible partner to monitor and provide information about energy use, and CanmetENERGY had the tools and the expertise to do it.

When it was first created in 2008/09, the model was originally limited to energy performance of the existing residential housing stock. At this time, the community-wide model took a back seat since energy information at the building scale was found to be the most useful in the PG-SGOG process. For instance, when provided with information on the comparative energy performance of different representative house and apartment types in the city, PG-SGOG participants were able to set a target of 25–50% improvements on the Model National Energy Code for Buildings (MNECB) for new apartments and mixed use buildings in the City's downtown core.

The SGOG process was a resounding success, bringing together researchers, academics, planning practitioners, the business community and citizens in an engaging process to guide the long-term revitalization of the downtown. The SGOG community charrette took place in May 2009 and led to the development of a Concept Plan² that was approved by council in September 2009.



Figure 1 Prince George Mayor Dan Rogers facilitates dialogue with SGOG charrette participants.

¹ http://canmetenergy-canmetenergie.nrcan-nrcan.gc.ca/eng/buildings_communities/communities/urban_archetypes_project.html

² <http://www.sgog.bc.ca/content.asp?contentID=144>

In the fall of 2009, Prince George City Council, City staff and community members embarked on the myPG³ planning initiative, which includes the development of an Integrated Community Sustainability Plan (ICSP) and the review of the City's Official Community Plan (OCP). NRCan agreed to further collaborate with the City by working together to develop a community-wide energy map for houses, institutional, commercial and industrial buildings. The ICSP and OCP update are the main planning mechanisms that integrate information derived from the SCEC³ model into energy and emissions initiatives and policy for the City of Prince George.

NRCan's CanmetENERGY is the proponent and developer of the SCEC³ model and the Canadian leader in clean energy research and development. Its support for research and development into integrated energy maps as tools for community energy and GHG emissions decision support is part of an overarching research direction to develop a more consistent methodology for characterization of energy and GHGs in Canadian communities.

British Columbia-based consultants contributing to the development of the SCEC³ included Vive le Monde Mapping and SAR Engineering. Vancouver-based planning and design consultancy HB Lanarc was retained by the City to lead the myPG process. This firm also uses map-based approaches to support sustainable community planning and effectively integrated information derived from the SCEC³ model into the myPG process.

Legislative Framework and Community Targets

British Columbia's Bill 27 — the Local Government (Green Communities) Statutes Amendment Act⁴ — requires local governments to include GHG targets in their Official Community Plans, effectively linking energy use and GHG emissions to the land use planning process. Responding to this new requirement, which came into effect in May 2010⁵, the City of Prince George adopted in its OCP targets originally set as a part of the Partners for Climate Protection program, to 10% below 2002 inventory levels for corporate emissions and 2% below 2002 inventory levels for community emissions. Both corporate and community targets are set to be achieved by 2012.

³ www.mypg.ca

⁴ http://www.leg.bc.ca/38th4th/3rd_read/gov27-3.htm

⁵ Effective May 2011, regional districts will also be required to include GHG targets in their Regional Growth Strategies.

The Tool

The functionality of the SCEC³ model enables the calculation of present-day energy aspects for the building sector, including residential, institutional, commercial and industrial buildings. It strives for an accurate accounting of the current building stock by combining simulated building energy information with building floor areas and typologies that originate from BC Assessment (BCAA) building attribute information. The model connects data tables containing energy, emissions and cost information to a GIS layer of the City's parcel boundaries via parcel ID (PID) numbers. A dynamic exploration of current and future energy use, emissions profiles and related cost scenarios is enabled through a series of custom queries developed in an MS Access database and custom scripts developed in ESRI ArcMap GIS software.

The SCEC³ model facilitates the exploration of future energy, carbon and cost scenarios through the addition of new buildings in specific locations and the retrofit of the current building stock in random locations. Retrofits can also be targeted to select neighbourhoods.

Energy modelling for homes was completed by HOT2000, using ecoENERGY Retrofit Audit records from Prince George, obtained from NRCan's Office of Energy Efficiency. Seven housing types were selected for modelling as being representative of both the ecoENERGY Retrofit audit records and the overall housing stock as described by the BCAA data. In addition to baseline energy, GHGs and operating energy costs, low cost and low energy retrofit scenarios were developed for individual housing types based on information contained in the audit records.

Five housing types were derived for existing houses: a single detached, one-storey family dwelling built between 1943 and 1977; a single detached, one-storey dwelling built between 1978 and 1996; a single detached, two-storey dwelling built between 1978 and 1996; a one-storey row house built between 1963 and 1992; and a mobile home built between 1920 and 1998. Two types were also derived for new housing: one for new single family dwellings, and the other for new townhouses, both built to the 2008 BC Building Code.

The model's objective was to match values for residential, commercial and industrial buildings contained in the 2007 CEEI data. To calibrate the model to the 2007 CEEI, 2007 weather year data and 2006 census occupancy profiles (prorated to 2007) were used in housing simulations. Residential simulations also referred to values for internal temperatures and lighting and appliance needs used in BC Hydro's 2007 Conservation Potential Review.⁶

Commercial and industrial building categories were developed based on a relationship between BCAA Manual Class and Actual Use codes and designed to match the archetypes contained in the *Screening Tool for New Building Design*. These archetypes included commercial extended care facilities, hospital, small office, retail – big box, retail – strip mall, retail – suburban, and schools. Industrial buildings were divided into two classes of warehouse: one with minimal process energy and the

second to which additional process energy could be assigned. Actual buildings reflective of these categories were identified in the BCAA data and their attributes were used for simulation.

Due to the limited functionality of the *Screening Tool*, it was not possible to calibrate commercial and industrial building simulations using the 2007 weather year. Additionally, no retrofit information corresponding to representative buildings was available; therefore, assumptions of 10, 20 and 30% efficiency improvements were assigned.⁷

SCEC³

Spatial Community, Energy, Carbon and Cost Characterization Model Software Building Blocks

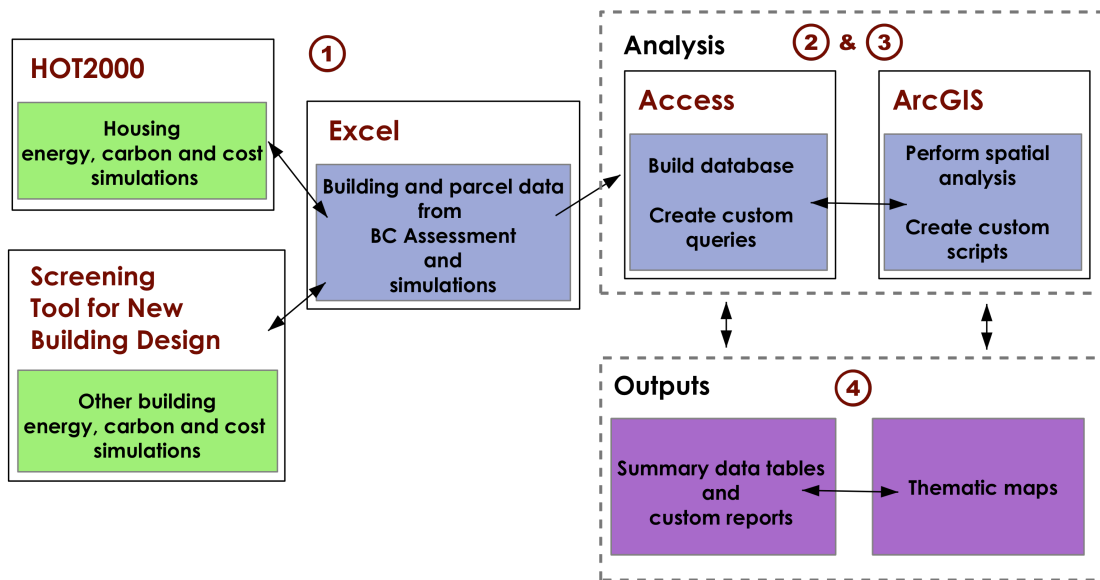


Figure 2
The SCEC³ model is built using NRCan-developed tools and commercially available, off-the-shelf software.

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http://www.bchydro.com/etc/medialib/internet/documents/info/pdf/info_2007_conservation_potential_review_summary_report.Par.0001.File.info_2007_conservation_potential_review_summary_report.pdf

⁷ Greenhouse Gas Emission Assessment Guide: for British Columbia Local Governments. February 20, 2008.
<http://www.localmotion.gov.bc.ca/examples.html>

Data and Assumptions

Datasets used to develop the baseline included:

- BC Assessment Authority Jurisdiction, roll numbers and associated building attribute information, reflecting the housing and building stock in 2007 and previous years
- ecoENERGY Retrofit Audit records for Prince George
- 2007 weather year data from Environment Canada
- 2006 census residential occupancy profiles by building type from Statistics Canada (prorated to 2007)
- Cost information including 2007 electricity and natural gas rates
- Capital costs of residential retrofits
- Construction of new buildings to 2008 BC Building Code

Two scenarios were developed to enable the modelling of future energy, emissions and costs for the Prince George building stock: low cost, where minimizing costs was the objective; and low energy, where minimizing energy use was the objective.

- The **low cost** scenario used only the single least expensive retrofit option for existing houses and assumed standard energy performance according to 2008 BC Building Code requirements for new construction.
- The **low energy** scenario used a more complete set of retrofit options for existing houses (typically five retrofits: attic upgrade to R56, furnace upgrade, window upgrade to argon-filled soft coat, basement upgrade to R20, and air source heat pump), and was assumed 25% more efficient than 2008 BC Building Code for new construction.

Within each of these two scenarios, two growth patterns were explored to reflect possible differences in the types of new houses to be built. The constant growth pattern showed an increase of 2821 new Single Family Dwellings (SFD) and 2038 Multifamily (MURB) homes by 2038. The trended growth pattern showed an increase of 69 new SFD and 5009 MURB by 2038.

SCEC³

Spatial Community, Energy, Carbon and Cost Characterization Model

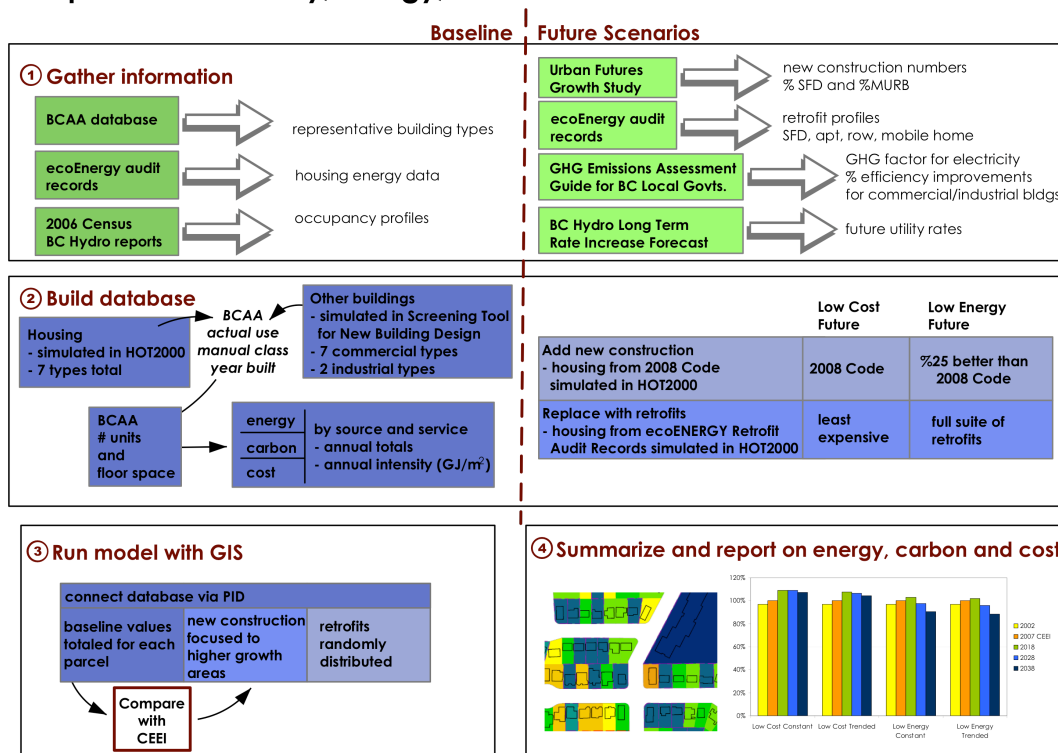


Figure 3 Data required and steps taken to develop the Spatial Community Energy Carbon and Cost Characterization Model (SCEC³).

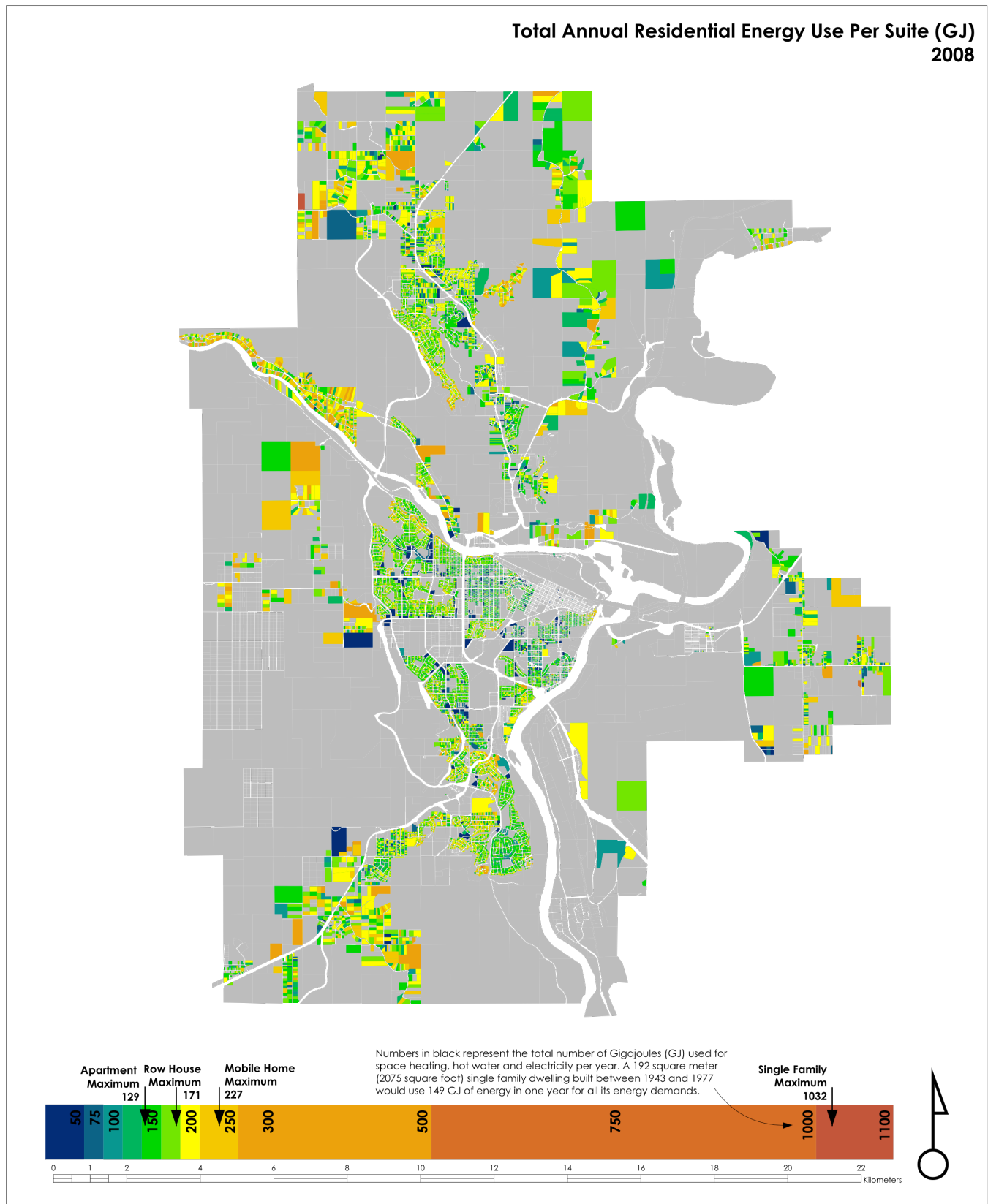


Figure 4 This map shows, for the City of Prince George at the community scale, total annual energy use in dwellings per suite for the year 2008.

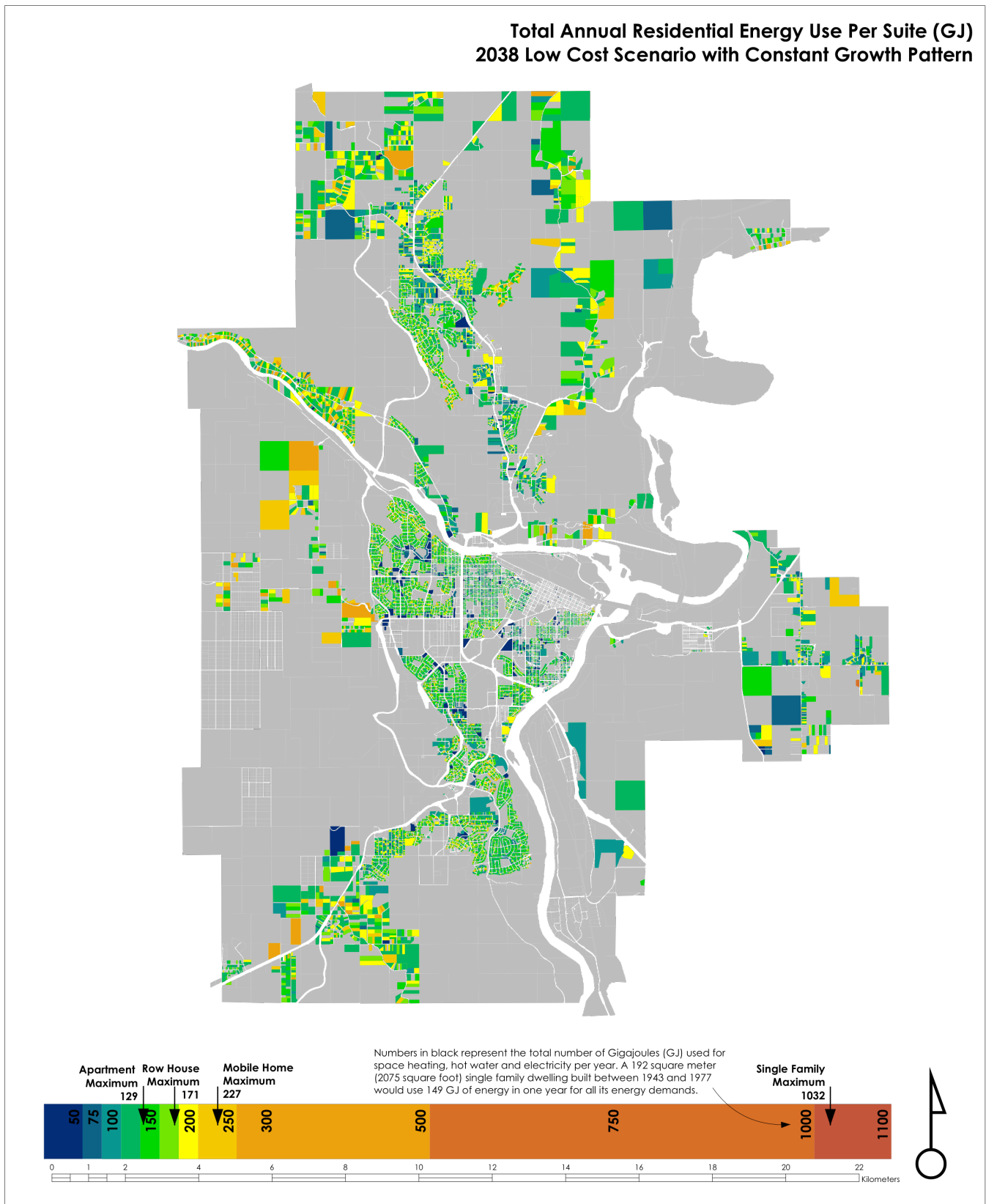


Figure 5 This map shows, at the community scale, total annual energy use in dwellings per suite under the “low cost” scenario in the year 2038.

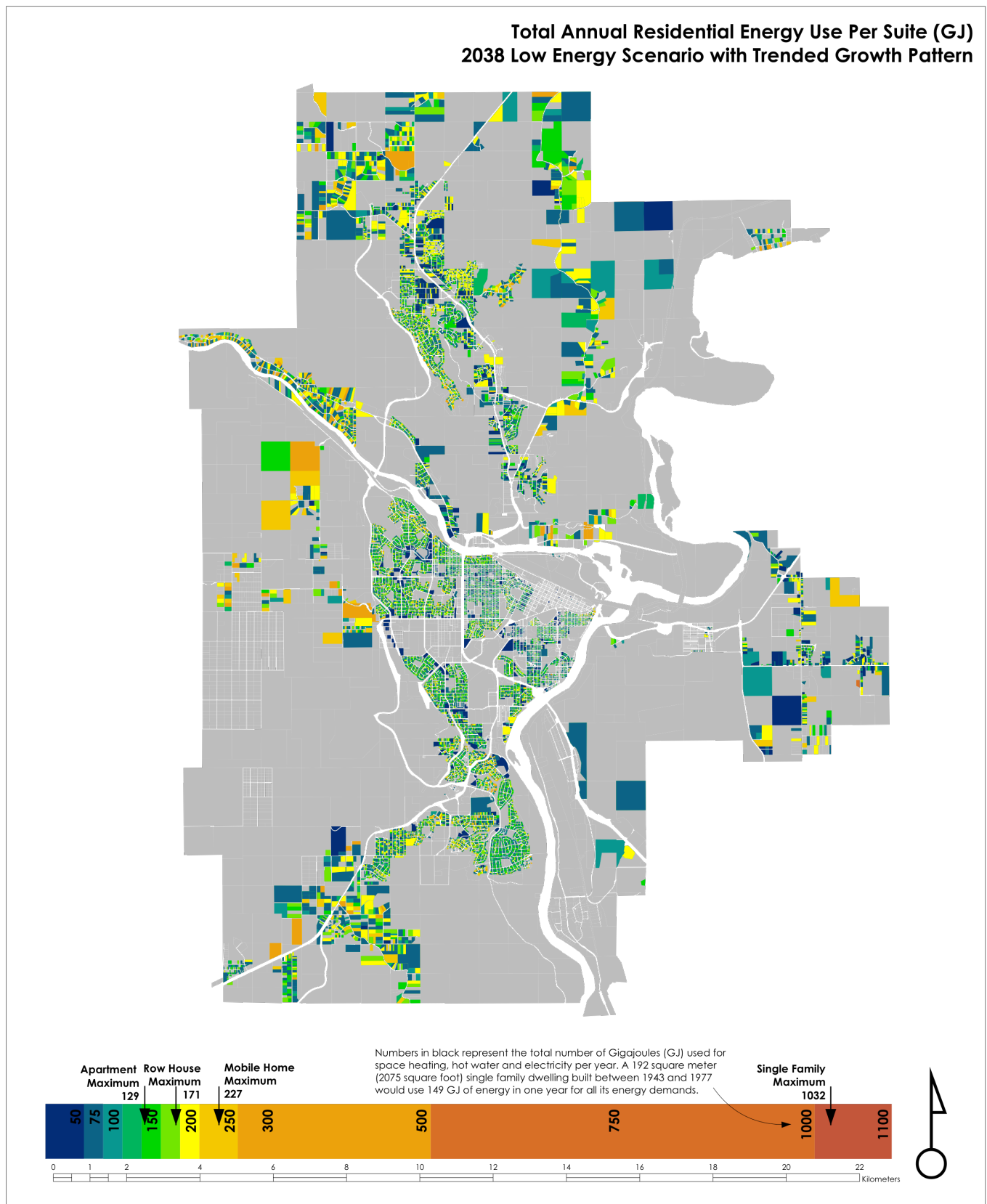


Figure 6 This map shows, at the community scale, total annual energy use in dwellings per suite under the “low energy” scenario in the year 2038.

Just as assumptions were made to reflect an increase in the types and numbers of new dwellings for all future scenarios, the percentage of retrofits occurring in existing dwellings needed to be specified. These retrofit rates were assumed to be as follows:

- In 2018 - Apartment 5%, Mobile Home 5%, Row House 10% and Single Family 15%
- In 2028 - Apartment 10%, Mobile Home 10%, Row House 20% and Single Family 30%
- In 2038 - Apartment 15%, Mobile Home 15%, Row House 30% and Single Family 45%

These percentages were calculated based on the present uptake of the ecoENERGY Retrofit program, with the assumption that buildings participating in the program would achieve a retrofit within the next five years, and a further assumption that this retrofit rate would be replicated in each subsequent five-year period.

In all cases, build-out scenarios were guided by the Official Community Plan, in five-year time steps.

Results

Given the previously acknowledged limitations surrounding the data for buildings other than residential, the main question that can currently be answered by the SCEC³ model is:

Will the residential sector in Prince George do its part to meet the community-wide target of 2% reduction from 2002 by 2012?

When running the low energy scenario with trended growth for new construction, it was found that by 2018 the emissions from residential houses will be 109% of 2007 CEEI inventory levels and 112% of 2002 levels. It was only in 2028 that the residential housing stock would achieve 99% of 2002 levels (96% of 2007 CEEI levels). It can therefore be concluded that under the most aggressive scenario, it will be sometime after 2028 that the residential housing stock will meet the target that was to have been achieved by 2012. Based on these results, more widespread retrofits in residential houses, and the introduction of renewable energy technologies are required for this sector to do its part to achieve the community's target of 2% reduction from 2002 levels by 2012.

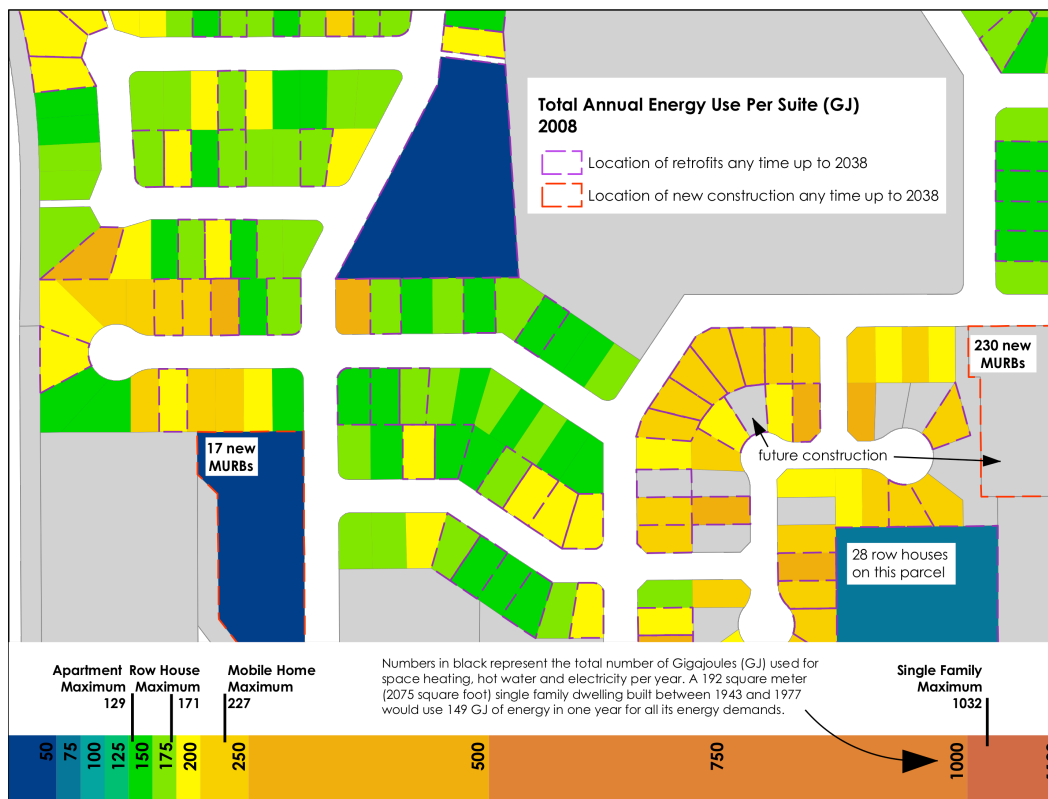


Figure 7
This neighbourhood level map shows total annual energy use per suite in 2008. Cooler colours represent households consuming less energy and warmer colours represent households consuming more.



Figure 8
This neighbourhood level map shows total annual energy use per suite in the year 2038 under the "low cost" energy scenario with trended growth where only one retrofit has been done.

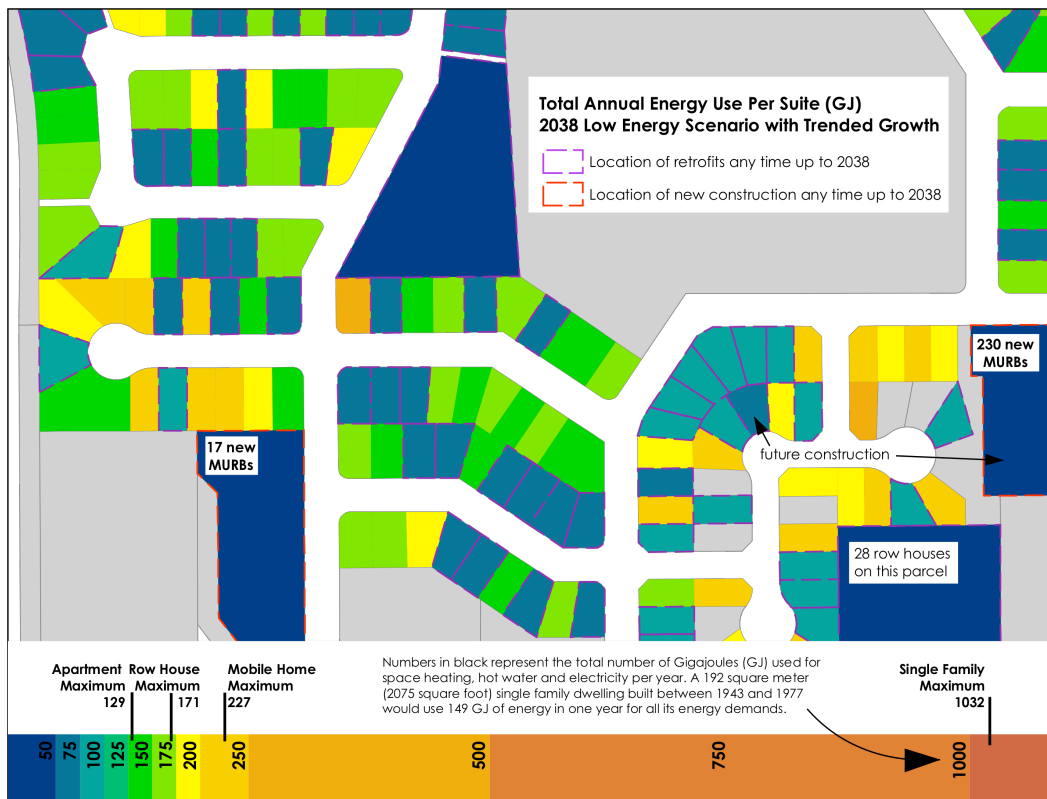


Figure 9
This map shows total annual energy use per suite in the year 2038 under the "low energy" scenario, where a combination of five retrofits have been done.

Compare the "low cost" and "low energy" maps and notice that many of the parcels are cooler, with residents using less energy, under the "low energy" scenario.

Benefits and Challenges

In the development of the SCEC³ model to support the myPG process, the model was found to enable a more accurate understanding of housing energy consumption and GHG emissions specific to the Prince George context. This reliable modelling specific to the local planning context makes possible a quantitative assessment of potential energy and emissions reductions that could result from different types of housing retrofit and new construction scenarios. In so doing, the model demonstrates the value of NRCan ecoENERGY Retrofit audit records and the retrofit information they contain for quantifying energy efficiency scenarios for the residential sector. These calculated energy and emissions numbers guided by retrofit and new construction simulations assist with the development of better-informed energy and emissions reduction strategies.

The model also advances exploration of use of BCAA Jurisdiction and roll data, using this information to inform modelling and linking of building energy information to parcel IDs (PIDs). The ability to generate numeric as well as chart and map-based outputs means that a variety of information products could be developed in support of a community planning process.

The SCEC³ model has been developed using housing energy information that is not presently readily available for use by local governments or that otherwise must be generated through simulation; more work is required to make this data available and readily useable for the purpose of modelling a community's building stock.

The limited availability of data for commercial and industrial buildings hinders the accuracy of this aspect of the model. The *Screening Tool for New Building Design* is limited in the range of building archetypes it can model and simulations cannot be calibrated using weather from a specific year. Lack of retrofit and capital cost information for commercial and industrial buildings means that more generalized assumptions are relied upon.

The functionality of the model is highly customized; a high level of complexity would currently preclude this model from being readily used by either consultants or municipalities. Work is ongoing to simplify inputs, automate query processes and standardize outputs for optimal use in local and regional government decision making.

Next Steps

At the time of writing in the summer of 2010, work on the model is ongoing. Additional scenarios will be run to determine what combination of housing retrofits will achieve greater energy efficiency in a cost effective manner. This information will be developed in preparation for the Prince George energy design charrette anticipated this fall. In addition to the development of increased and more accessible model functionality, a series of possible energy and emissions policies that could be included in the Prince George OCP will be explored in the fall of 2010 and winter of 2011.

The City of Prince George is working to hire a Community Energy Manager who will focus on strategies to reduce community-level energy and GHG emissions. The City is also working with its partners to evaluate options and strategies for other sectors such as transportation, commercial and light industrial: these could account for energy and GHG reductions that contribute towards meeting the 2012 target. An energy design charrette is planned for the fall of 2010 to look at technical and design elements of community energy savings. Both of these initiatives will incorporate work from the SCEC³ model and ongoing scenario development.

At the 2010 convention of the Union of British Columbia Municipalities, the City of Prince George was awarded the 2010 Community Energy and Climate Action Award in the *Community Planning and Development* category. The City addressed technical challenges, issues and perceptions around bioenergy and is now developing the downtown District Energy System (DES) with the support of the community. The community's use of innovative energy mapping was also mentioned in the context of the award.

Contact

For more information on the SCEC³ model or community energy planning initiatives in the City of Prince George, please contact:

Jessica Webster

Community Energy Planning Analyst
CanmetENERGY, Natural Resources Canada
T: (613) 992-9532 E: jessica.webster@nrcan.gc.ca

Dan Adamson

Environment Manager
City of Prince George
T: (250) 614-7891 E: dadamson@city.pg.bc.ca