FINAL REPORT

Cowichan Valley Energy Mapping and Modelling

REPORT 5 – ENERGY DENSITY MAPPING PROJECTIONS

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Acronyms and abbreviations

AUC – Actual use codes
BAU – Business-as-usual
BC – British Columbia
BCAA – British Columbia Assessment Authority
BIMAT – Biomass Inventory Mapping and Analysis Tool
CEEI – Community Energy & Emissions Inventories
CIBEUS – Commercial and institutional building energy use survey
CRD – Capital Regional District
CVRD – Cowichan Valley Regional District
DEM – Digital elevation model
EE – Energy efficiency
EOSD – Earth Observation for Sustainable Development of Forests
ESRI – Environmental Systems Resource Institute
GHG – Greenhouse gas
GIS – Geographic Information System
HVAC – High voltage alternating current
JUROL – Jurisdiction and roll number
LIDAR – Light detection and ranging
MSW – Municipal solid waste
NEUD – National energy usage database
NRC – Natural Resources Canada
OCP – Official community plans
O&M – Operation and maintenance
PRISM – Parameter-elevation regressions on independent slopes model
RDF – Refuse derived fuel
RDN – Regional District of Nanaimo
RE – Renewable energy
RMSA – Root mean square area
SSE – (NASA's) Surface meteorology and Solar Energy (dataset)
TaNDM – Tract and neighbourhood data modelling

Contents

1 Introduction

Overall project

This report is the fifth in a series of six reports detailing the findings from the Cowichan Valley Energy Mapping and Modelling project that was carried out from April of 2011 to March of 2012 by Ea Energy Analyses in conjunction with Geographic Resource Analysis & Science (GRAS).

The driving force behind the Integrated Energy Mapping and Analysis project was the identification and analysis of a suite of pathways that the Cowichan Valley Regional District (CVRD) can utilise to increase its energy resilience, as well as reduce energy consumption and GHG emissions, with a primary focus on the residential sector. Mapping and analysis undertaken will support provincial energy and GHG reduction targets, and the suite of pathways outlined will address a CVRD internal target that calls for 75% of the region's energy within the residential sector to come from locally sourced renewables by 2050. The target has been developed as a mechanism to meet resilience and climate action target. The maps and findings produced are to be integrated as part of a regional policy framework currently under development.

GIS mapping of renewable potentials

The first task in the project was the production of a series of thematic GIS maps and associated databases of potential renewable energy resources in the CVRD. The renewable energy sources mapped were solar, wind, micro hydro, and biomass (residues and waste). Other sources were also discussed (e.g. geothermal heat) but not mapped due to lack of spatially explicit input data. The task 1 findings are detailed in a report entitled 'GIS mapping of potential RE sources in the CVRD'.

GIS mapping of regional energy consumption density

The second task in the overall project was the mapping of regional energy consumption density. Combined with the findings from task one, this enables comparison of energy consumption density per area unit with the renewable energy resource availability. In addition, it provides an energy baseline against which future energy planning activities can be evaluated. The mapping of the energy consumption density was divided into categories to correspond with local British Columbia Assessment Authority (BCAA) reporting. The residential subcategories were comprised of single family detached dwellings, single family attached dwellings, apartments, and moveable dwellings. For commercial and industrial end-users the 14 subcategories are also in line with BCAA Assessment as well as the on-going provincial TaNDM project of which the CVRD is a partner. The results of task two are documented in the report 'Energy Consumption and Energy Density Mapping'.

Analysis of potentially applicable renewable energy opportunities

The third task built upon the findings of the previous two and undertook an analysis of potentially applicable distributed energy opportunities. These opportunities were analysed given a number of different parameters, which were decided upon in consultation with the CVRD. The primary output of this task was a series of cost figures for the various technologies, thus allowing comparison on a cents/kWh basis. All of the cost figures from this task have been entered into a tailor made Excel model. This 'technology cost' model is linked to the Excel scenario model utilised in task 4. As a result, as technology costs change, they can be updated accordingly and be reflected in the scenarios. Please note, that the technologies considered at present in the technology cost model are well-proven technologies, available in the market today, even though the output is being used for an analysis of development until 2050. Task 3 results are detailed in 'Analysis of Potentially Applicable Distributed Energy Opportunities', which presents an initial screening for various local renewable energies and provides the CVRD with the means of evaluating the costs and benefits of local energy productions versus imported[1] energy.

Analysis of opportunity costs and issues related to regional energy resilience

Based on the outputs from the above three tasks, a suite of coherent pathways towards the overall target of 75% residential local energy consumption was created, and the costs and benefits for the region were calculated. This was undertaken via a scenario analysis which also highlighted the risks and robustness of the different options within the pathways. In addition to a direct economic comparison between the different pathways, more qualitative issues were described, including potential local employment, environmental benefits and disadvantages, etc.

The main tool utilised in this analysis was a tailor made Excel energy model that includes mechanisms for analysing improvements in the CVRD energy system down to an area level, for example renewable energy in residential buildings, renewable energy generation, and the effects of energy efficiency improvements. For the industrial, commercial, and transport sectors, simple and generic forecasts and input possibilities were included in the model.

The Excel 'technology cost' and 'energy' models are accompanied with a user manual so that planners within the CVRD can become well acquainted with

[1] The term 'imported' here refers to energy imported from outside of the CVRD

the models and update the figures going forward. In addition, hands on instruction as to how to link the Excel model with GIS maps was also provided to both planners and GIS professionals within the CVRD and associated municipal organisations.

Task 4 results are detailed in a report entitled 'Analysis of Opportunity Costs and Issues Related to Regional Energy Resilience'.

GIS mapping of energy consumption projections

Task 5 focused on energy projection mapping to estimate and visualise the energy consumption density and GHG emissions under different scenarios. The scenarios from task 4 were built around the energy consumption density of the residential sector under future land use patterns and rely on different energy source combinations (the suite of pathways). In task 5 the energy usage under the different scenarios were fed back into GIS, thereby giving a visual representation of forecasted residential energy consumption per unit area. The methodology is identical to that used in task 2 where current usage was mapped, whereas the mapping in this task is for future forecasts. These results are documented in this report. In addition, GHG mapping under the various scenarios was also undertaken.

Findings and recommendations

The final and sixth report presents a summary of the findings of project tasks 1-5 and provides a set of recommendations to the CVRD based on the work done and with an eye towards the next steps in the energy planning process of the CVRD.

1.1 Motivation for study

One of the motivations behind the overall study was to increase the resilience of the CVRD communities to future climate and energy uncertainties by identifying various pathways to increase energy self-sufficiency in the face of global and regional uncertainty related to energy opportunities, identification of energy efficiencies and mechanisms, and identify areas where local energy resources can be found and utilised effectively. Overall this strategy will reduce reliance on imported energy and the aging infrastructure that connects Vancouver Island to the mainland. Investigating future potential scenarios for the CVRD, and Vancouver Island as a whole, makes it possible to illustrate how this infrastructural relationship with the mainland could evolve in years to come.

This work supports the overall development of sustainable communities by:

- Increasing community resilience to price and energy system disruptions,

- Increased economic opportunities both at a macro energy provision scale and the development of local economies which support alternative energy systems and maintenance of those systems,
- Potential economic development by way of community based heat and power facilities which could be owned and operated by the community,
- Identification and exploitation of low cost low impact energy sources,
- Provision of a consistent overall strategic policy and planning framework for community planning,
- Incorporation of clearly defined energy policies in OCP and development permit and growth documents,
- Developing early strategies for the development of energy systems and infrastructure programs, particularly with regards to district heat or heat and power programs.

1.2 CVRD overview

Geography

The Cowichan Valley Regional District is located on the southern portion of Vancouver Island in British Columbia, Canada and covers an area of nearly 3,500 km^2. It consists of 9 electoral areas, 4 municipalities, and aboriginal lands, and has a total population of roughly 82,000 people. It is bordered by the Capital Regional District (CRD) to the south, which while roughly 2/3 in size, has a population of approximately 350,000 and is home to the Province's capital, Victoria. To the northeast, the CVRD is bordered by the Nanaimo Regional District (NRD) which has a land area of just over 2,000 km^2 and a population of roughly 140,000. Lastly, to the northwest the CVRD is bordered by the Alberni-Clayoquot Regional District, home to just over 30,000 people spread over a land area of nearly 6,600 km^2.

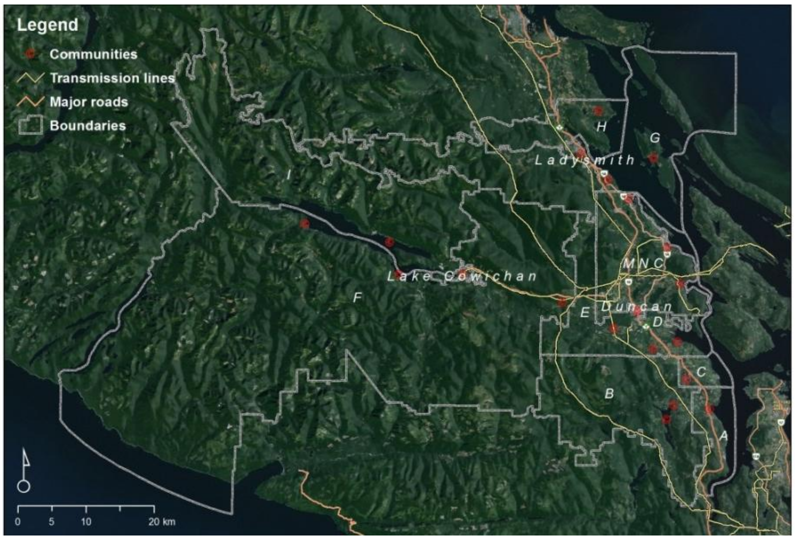


Figure 1: Map of the Cowichan Valley Regional District and its administrative areas (GRAS).

The fact that the vast majority of the population centres within the CVRD are concentrated along the east coast, with very little along the western portion is of great relevance when identifying potential energy generation sources, both with respect to physical access to sites, and proximity to electricity transmission and distribution networks. Figure 1 on the previous page illustrates this.

Energy consumption

Based on 2007 data[2], the CVRD as a whole had an energy demand of nearly 10 PJ or 2.7 TWh (for reference purposes an energy conversion factor is included as appendix 1). As depicted in the figure below, well over half of this went to road transport, slightly over a third to residential buildings, and just under 14% was used by commercial and small-medium industrial buildings.

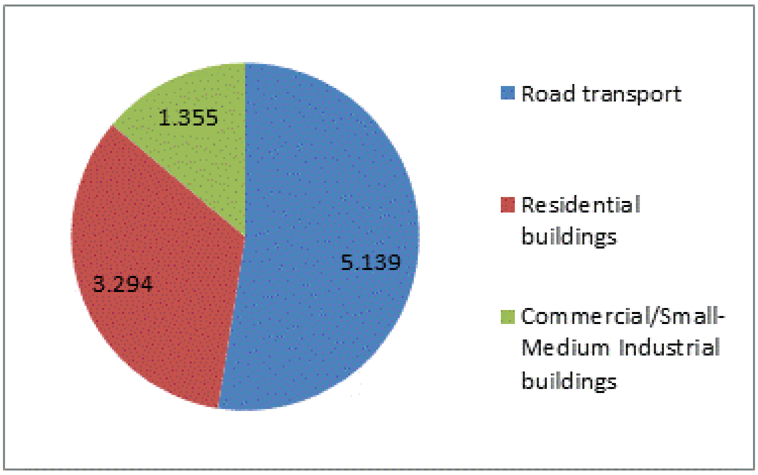


Figure 2: 2007 CVRD total energy consumption by sector (TJ) excluding large industrial users and Indian Reserves (BC Ministry of Environment, 2010).

In terms of fuel use by sector, it is thus not surprising that over 40% of the CVRD's energy needs are met by gasoline and 12% by diesel. Within buildings segment of consumption, the dominant sources are electricity, natural gas, wood, and heating oil. More specific breakdowns of these usages are displayed in the figure below.

[2] Excluding large industrial. Figures are withheld in CEEI publications when there are too few installations, as is the case with large industry in the CVRD.

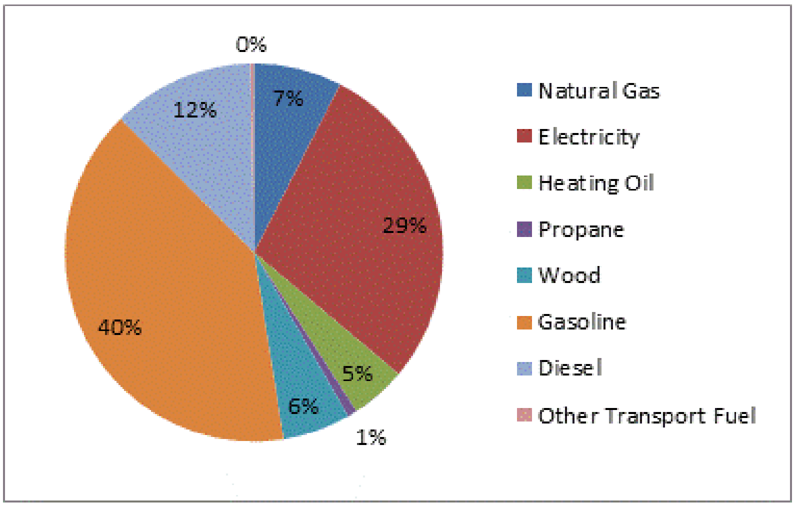


Figure 3: 2007 CVRD total energy consumption by source (TJ) excluding large industrial users and Indian Reserves (BC Ministry of Environment, 2010).

If we look at the residential sector which is the major focus of this project and is depicted in the figure below, the dominant inputs are electricity, wood, heating oil, and natural gas. It is worth noting that roughly 60% of residential dwellings are today heated via direct electric heating (i.e. electric baseboard heating), a phenomenon that is largely explained by the relatively cheap electricity that has historically been available in BC.

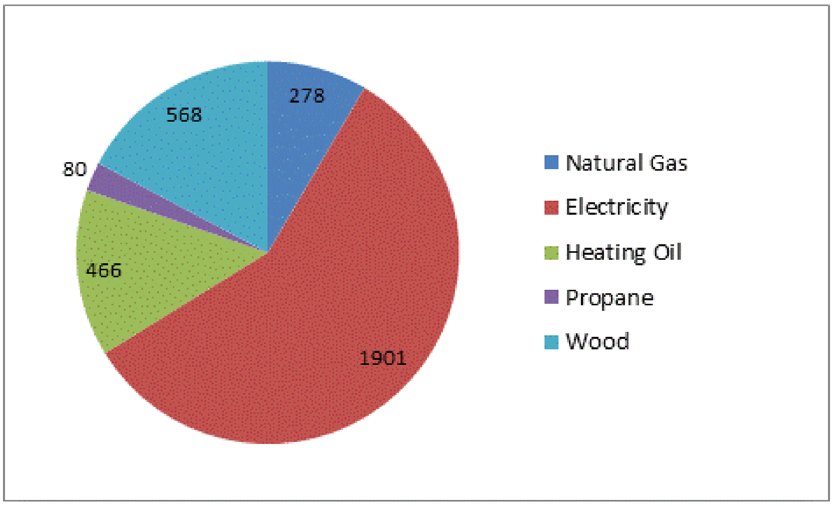


Figure 4: 2007 CVRD residential sector energy use (TJ) (BC Ministry of Environment, 2010).

Vancouver Island energy supply

Vancouver Island as a whole produces less than a third of its electricity consumption, with the remainder being supplied via undersea cables from the mainland. The largest of these connections is referred to as the 'Cheekye-Dunsmuir' which consists of two 500-kV HVAC lines and has an operational capacity of 1,450 MW (the red lines in the figure below). The other major connections are the 'HVDC Pole 2' connection from the Arnott (ARN) terminal station near Ladner on the mainland to the Vancouver Island Terminal (VIT) station located near Duncan with an operational capacity of roughly 240 MW, and the '2L129' connection also from ARN to VIT with an operational capacity of roughly 243 MW. (BC Hydro, 2011) The figure below displays the Vancouver Island transmission system as of October 2007, and as a result the new 2L129 connection is not depicted on the map.

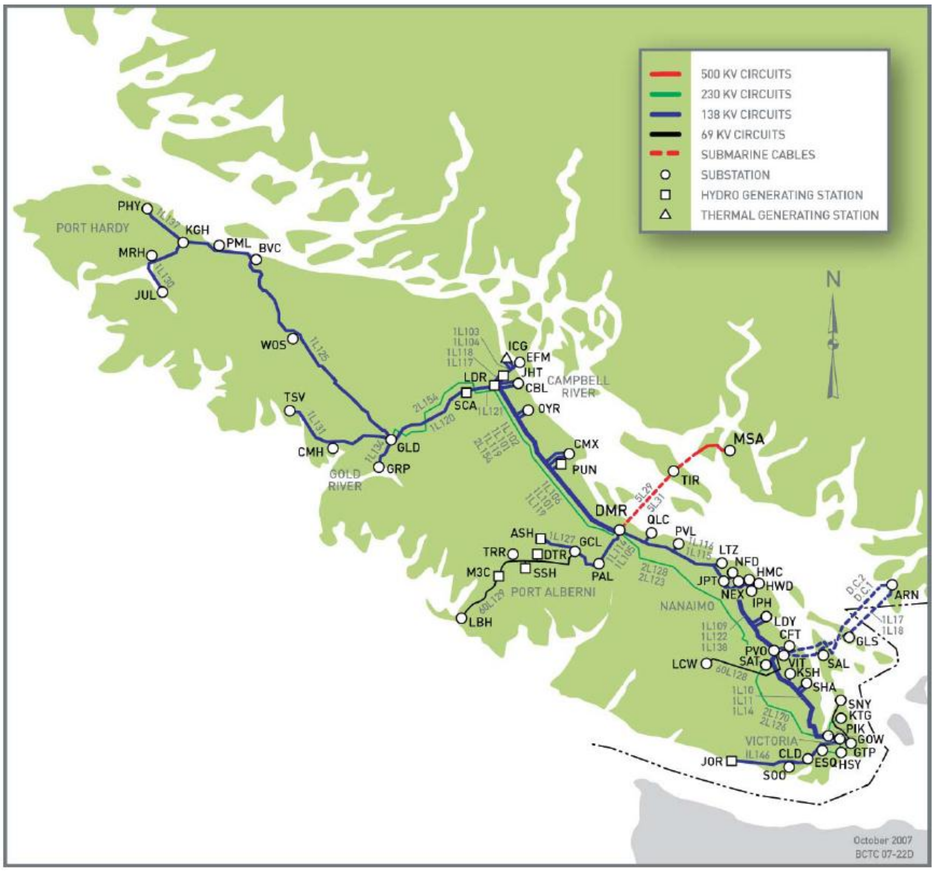


Figure 5: Vancouver Island Transmission network as of October 2007 (BC Hydro, 2007).

The majority of Vancouver Island's electricity is produced north of the CVRD, with the sole exception being the Jordan River facility located on the southern coast of the island. With the exception of the Elk Falls natural gas fired facility near Campbell River, all the electricity production on Vancouver Island currently comes from hydro, although new wind farm projects are in development in the Northern portion of the island.

CVRD energy supply

The CVRD therefore imports all of its electricity, some of it produced on the northern portion of the island, but a great deal of it is produced on the mainland. In addition all gasoline, diesel, natural gas, heating oil and propane are also imported from outside of the CVRD. As such roughly 95% of the CVRD's total energy demand is currently imported, with wood being the only local energy source.

GHG emissions

In terms of GHG emissions, the vast majority of the CVRD's GHG emissions can be attributed to road transport. Transport accounted for over 350,000 tonnes of CO_2 equivalent in 2007, or roughly 70% of the CVRD's total (503,000 - excluding large industrial emitters). In this report the term 'CO_2' is used synonymously to CO_2 equivalents.

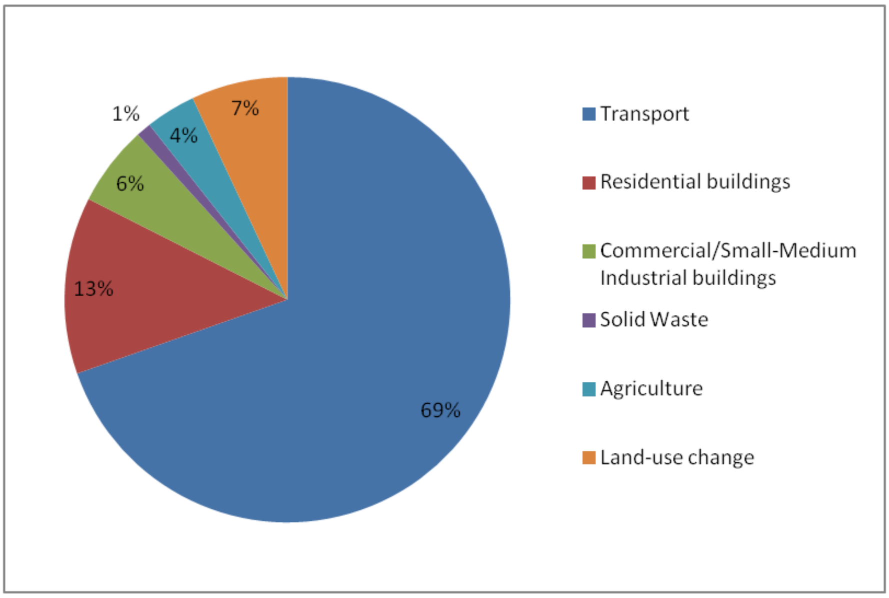


Figure 6: 2007 CVRD GHG emissions according to source excluding large industrial users and Indian Reserves. Total emissions were just over 503,000 tonnes of CO_2 (BC Ministry of Environment, 2010).

When calculating GHG emissions from electricity in British Columbia the CEEI reports utilise a CO_2 intensity of 24.7 g CO_2/kWh, as this represents the average amount of CO_2 found in electricity produced in British Columbia (CEEI, 2010). However, BC also imports and exports electricity, and when this is factored into the equation the average CO_2 intensity of electricity flowing through the power lines is over 3.5 times higher, at roughly 84 g CO_2/kWh (Pembina, 2011). It could be argued that using this latter figure when calculating GHG emissions is a more accurate representation of the actual carbon footprint from the use of electricity in BC. Doing so would increase CVRD residential sector emissions by roughly 50%, but transport related emissions would still be the most dominant source with well over 60% of CVRD emissions.

1.3 Report structure

The purpose of energy projection mapping, in this case, is to estimate and visualise the CVRD's energy consumption density under different scenarios. Scenarios developed for this project are built upon energy consumption density data under future land use patterns and provide an idea of outcomes resulting from different energy source combinations (the suite of pathways from Task 4).

The approach for projecting energy consumption patterns is similar to mapping energy consumption density (cf. report 2), however uses land use zoning versus parcels as the mapping unit.

To begin the report, the overall methodology is presented, followed by chapters detailing data, methods and results for each category. As a reference for the reader, a table in appendix 1 gives an overview of the various energy related terms and units that are utilised throughout the report.

2 Methodology

2.1 Overview

The approach for projecting energy consumption patterns is similar to mapping energy consumption density, however relies upon projected rather than observed data. Energy usage projections are based on different scenarios where appropriate alternative energy pathways are evaluated for use in the CVRD. The reference scenario will be "business-as-usual", which can be compared to other pathways that are comprised of different levels of alternative energy source usage. Through these comparisons, the most cost-effective energy strategy can be identified. When linked in a GIS, it is possible to map out the most energy efficient future land-use pattern that can accommodate the expected population growth, while also meeting the overall energy reduction targets. GIS models can also be used to identify optimal locations for district energy utilisation of renewable resources.

2.2 Background

The background for the energy density mapping projections is the scenario analysis provided in report 4. In short, the scenario analysis uses a bottom-up approach[3] to model energy demand and gross energy consumption, using information about dwelling types, primary heating technologies, and energy sources. The figure below displays the main components in the scenarios.

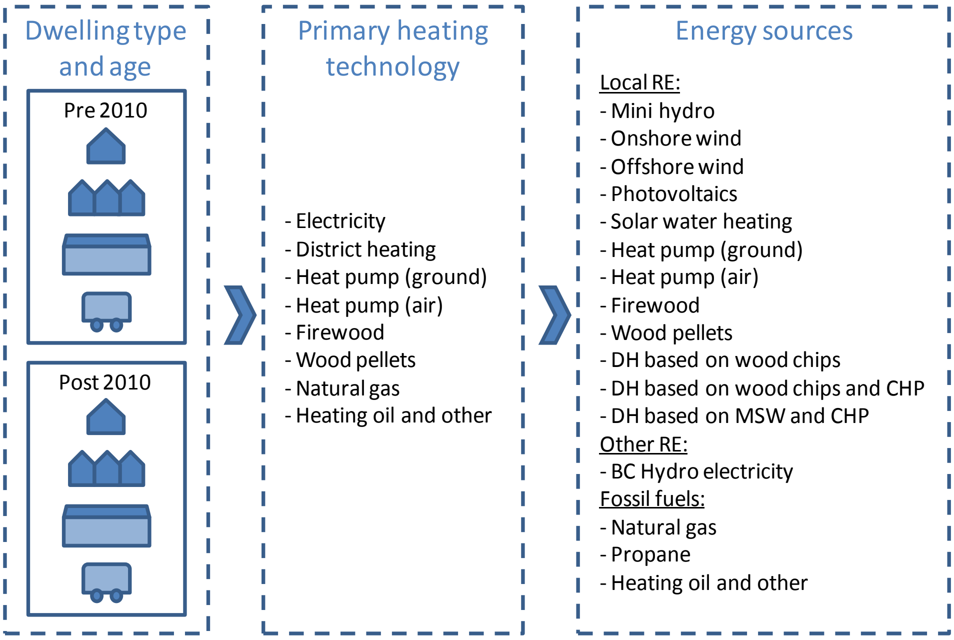


Figure 7: Illustration of the dwelling types, primary heating technologies, and energy sources included in the technology cost model and the energy model.

[3] 'Bottom-up' indicates that the energy use from each residential unit is modelled and summed together

The choice of energy resource in a given scenario is determined by the primary heating technology and the cost and availability of the energy resources.

Future residential energy demand per dwelling is modelled using simple energy efficiency multipliers based on building typologies (assumed equal over the CVRD) and heating source. These multipliers can easily be altered to illustrate the changing standards in energy efficiency for existing building stock (pre-2010) and/or new buildings (post-2010). How per dwelling future energy consumption was calculated using this multiplier is illustrated in the figure below. For a more extensive description of the scenarios and the methodology utilised please refer to report 4 in this series.

Figure 8: Illustration of the driving elements of the modelled energy consumption.

3 Mapping of scenarios

As described in report 4, different scenarios were developed in consultation with the CVRD and subsequently developed through custom-made Excel spreadsheet models. The aim of this chapter is to explain how the Excel model scenarios were then translated into maps.

Purpose

The purpose of the mapping process is to provide a geographical representation of future energy usage, as predicted by the different scenarios. The scenarios could not be directly transferred to a map however, and therefore certain modifications were needed.

Heating type

The first issue overcome by making modifications regards data reported by BCAA, which is the basis for the GIS mapping (cf. report 2). As this data does not include heating type, future energy demand was mapped using average figures based on expected growths in dwelling area and energy demand. These figures were embedded in an energy efficiency factor, which assumes that residential units will become more efficient (cf. Figure 8 above).

Energy usage dispersion

Change in energy efficiency over time varies according to type of demand (i.e. heating versus auxiliary electricity) and is another consideration that was factored in by assuming that for a typical dwelling, 70% of the energy used is for heat and 30% for auxiliary end-uses.

Energy efficiencies of new and existing buildings

The second modification made is due to another assumption built into the Excel model: a gradual tear-down of existing building stock. This assumption is difficult to transfer to the map, specifically in regards to the energy efficiency factor of the building, because as a building is replaced it becomes more efficient. Therefore, for all existing buildings, an efficiency factor equal to the average energy efficiency of pre-2010 buildings was applied, while for all new buildings, an efficiency factor equal to the average energy efficiency of post-2010 buildings was applied.

Use of OCPs

The estimated construction of new buildings was based on projected growth rates, and their energy usage simulated from average dwelling area and energy intensity factors, along with energy efficiency factors. As for predicting their location, Official Community Plans (OCPs) provided some guidance by indicating that new development areas and low-density areas would be given preference for future development permits. The latter also implies that the spatial resolution of the energy mapping projections is at an OCP level and not at a parcel level (as is the level used for mapping actual energy consumption).

Map development

After the necessary modifications were made, the maps were developed first by retrieving the centroid of all parcels with residential buildings. For each centroid, 2010 energy usage figures were preserved and thereafter served as the starting point for estimating future energy usage using the modified scenario approach as described above. In order to account for future growth, additional points representing new buildings were added to the centroid layer. Their placement was based on a random sample routine within OCP areas identified as suitable for new residential buildings.

The City of Duncan serves as an example to further discuss the methodology applied and to illustrate the results of mapping scenarios.

4 Example of results: City of Duncan

In this chapter some of the GIS maps that were generated for the four scenarios are described and displayed. For each scenario the City of Duncan is used as an example.

4.1 Growth rates and saturation

Based on projected growth rates approximately 800 new dwellings will be needed in Duncan by 2050 (cf. Table 1).

Category	2010	2050	Estimated growth	Realistic growth	Move to neighboring regions
Single detached	1,057	1,540	484	325	184
Single attached	145	211	66	25	41
Apartments	562	819	257	50	207
Total	**1,764**	**2,571**	**807**	**400**	**407**

Table 1: Estimated growth in the City of Duncan from 2010 to 2050.

Saturation

Looking at the city's current density of buildings in residential zones however, it is clear that zones will be saturated if another 800 dwelling were to be established. For example, if an additional 550 single family houses were to be built in the low density residential zone, the average surrounding area would drop to as low as 735 m^2, whereas the current maximum density reserves 820 m^2 per dwelling. As a basis for comparison: the current average density allows for 2,400 m^2 surrounding area per dwelling in the low density residential zone.

If the City of Duncan chooses to maintain its projected growth rate, increases to densification inherent in the OCP's regular updates would occur and potentially result in a different mix of building types. However for the purposes of this case study no such updates where made.

While the saturation problem is not as pressing for apartments as single detached buildings, a similar trend can be observed. The mapping therefore assumed that only 400 new dwellings (apartments and single family) would be established in Duncan, and the rest would be built in neighbouring regions (cf. Table 1).

For reference purposes, zoning from the City of Duncan's OCP is shown in Figure 14 in the appendices.

4.2 BAU scenario

The business-as-usual (BAU) scenario depicts a situation where current and anticipated trends, strategies, and policies are implemented to influence and establish energy efficiency, building codes, etc. It assumes that the primary heating source for residential dwelling remains unchanged relative to 2010.

Under this scenario another 400 dwellings in Duncan will increase the total annual energy usage by approximately 30,000 GJ, while efficiencies (replacements and renovations) will save approximately 9,000 GJ among existing building stock. In absolute terms the energy usage will increase from 165,000 GJ in 2010 to 186,000 GJ in 2050, which equals an increase in net energy usage by 11%[4].

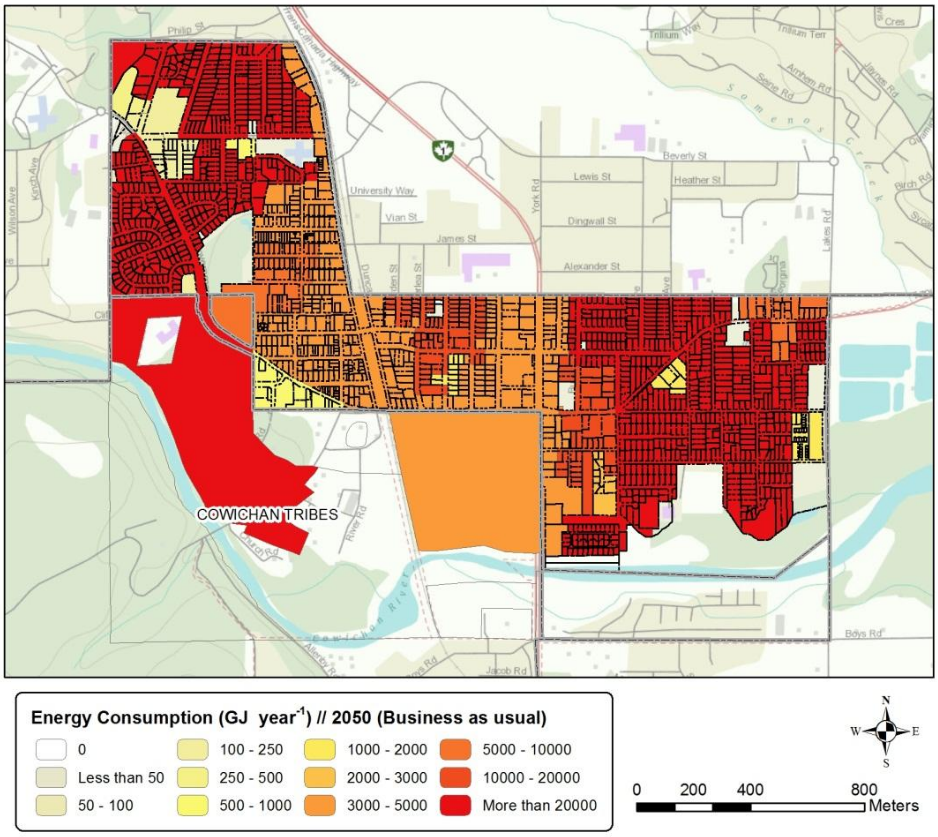


Figure 9: The 2050 energy consumption in the City of Duncan according to the BAU scenario.

[4] In comparison the Excel model predicts an increase by 24%. A similar number (i.e. 25%), however, would have been the outcome if the mapping was performed using the actual estimated growth numbers (i.e. 807 new dwellings in the City of Duncan as opposed to the 400 that were mapped).

4.3 EE scenario

The increased energy efficiency (EE) scenario could be referred to as a 'savings scenario' and like the BAU scenario it assumes that the primary heating sources for residential dwellings remain unchanged relative to 2010.

Under this scenario energy efficiencies will provide an estimated annual reduction of 9,000 GJ in the existing building stock, while new dwellings will use an estimated 27,500 GJ per year. Looking at the total numbers: total annual energy usage will be roughly 174,500 GJ in 2050, which is 11,600 GJ, or 6%, less than in the BAU scenario.

An energy consumption map for the EE scenario is shown below, followed by some summary statistics comparing the EE and the BAU scenarios (cf. Table 2).

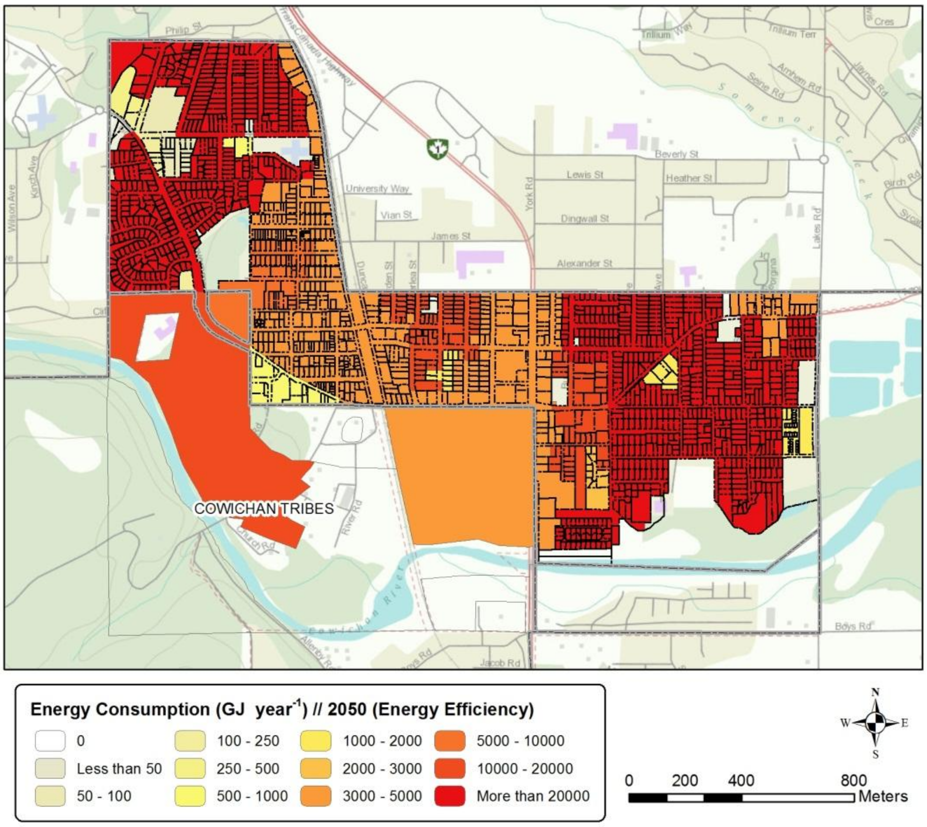


Figure 10: The 2050 energy consumption in the City of Duncan according to the EE scenario.

	BAU (GJ)	EE (GJ)	Difference (GJ)	Difference (%)
Pre 2010 buildings	156,149	147,217	8,932	6%
Post 2010 buildings	30,106	27,437	2,669	9%
Total	**186,255**	**17,4654**	**11,601**	**6%**

Table 2: Energy consumption in the pre- and post-2010 building stock for the City of Duncan as estimated by the BAU and the EE scenarios.

4.4 RE scenario

The renewable energy (RE) scenario assumes a business-as-usual development in energy efficiency, along with increased local energy production from renewables. To meet the CVRD's targets, technology options are primarily selected according to the lowest cost available, as laid out in the technology cost model. Technology selections are however not based solely on cost alone, as they are also tempered with assumptions regarding the feasibility of all units converting to a certain technology (i.e. not all residencies will be willing and/or able to implement a technology), resource availability, etc.

GHG emissions

It follows that energy usage in the RE scenario is similar to that in the BAU scenario, however the shift in technologies has a profound effect on GHG emissions in the RE scenario. In order to spatially depict the reduction in GHG emissions in this scenario, the total reduction in GHG emissions were estimated using energy demand per dwelling, as well as GHG emission factors which are both available from the Excel models general assumptions (cf. report 4).

	Heat	Aux. electricity	Wood	Propane
Single detached	53%	40%	4%	3%
Single attached	42%	51%	4%	3%
Apartment	49%	47%	2%	2%
Moveable dwelling	41%	53%	3%	2%
GHG emission factors (tonne CO_2/GJ)	0.05	0.0069 (2010)/ 0.0040 (2050)	0.00037	0.061

Table 3: Energy demand statistics per dwelling type which was used together with GHG emissions factors to estimate GHG emissions from the energy consumption data.

Compared to 2010 emissions and emissions under the BAU scenario, GHG emissions for the residential sector in the City of Duncan are drastically reduced in 2050 under the RE scenario (cf. Table 4). This is due to the introduction of district heating, heat pumps, and wood pellet heating, and the subsequent phasing out of oil and natural gas from individual primary heating. The only remaining fossil fuel GHG comes from supplementary propane.

Year	BAU	EE	RE
2010	4,969	-	-
2050	5,448	5,108	924
Reduction relative to 2010		-3%	81%
Reduction Relative to BAU		6%	83%

Table 4: GHG emissions (in tonnes per year) following different scenarios i.e. BAU, EE and RE.

The GHG energy emissions maps from the BAU and the RE scenarios are shown in Figure 11 and Figure 12 below.

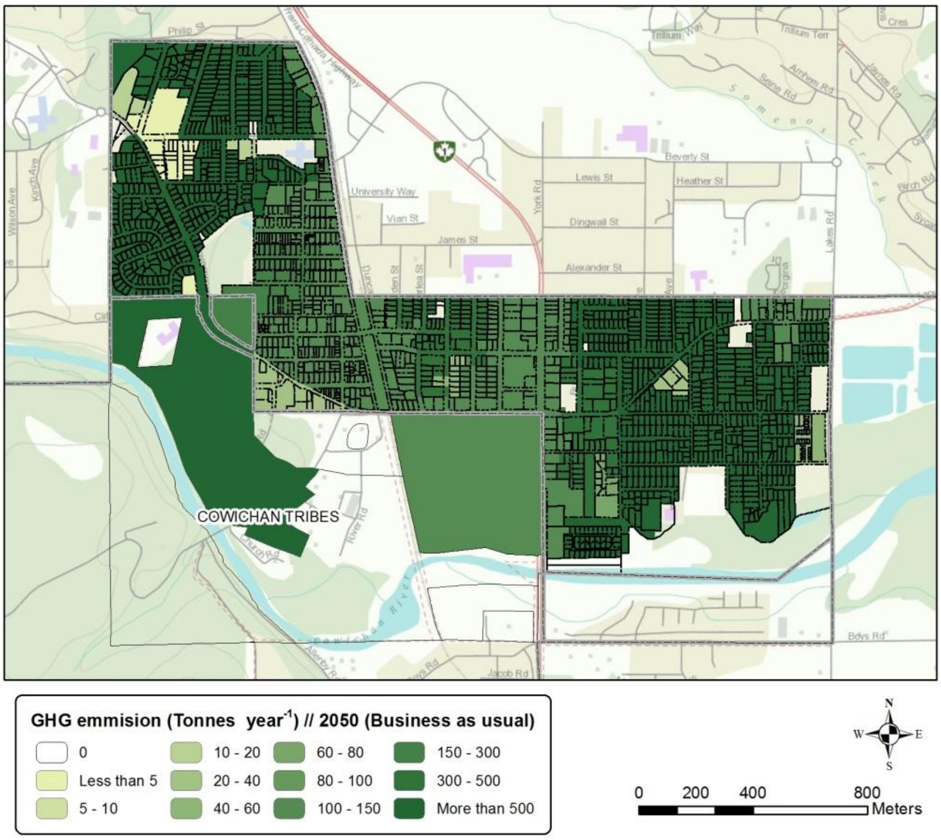


Figure 11: GHG emissions in 2050 for the City of Duncan following a BAU scenario.

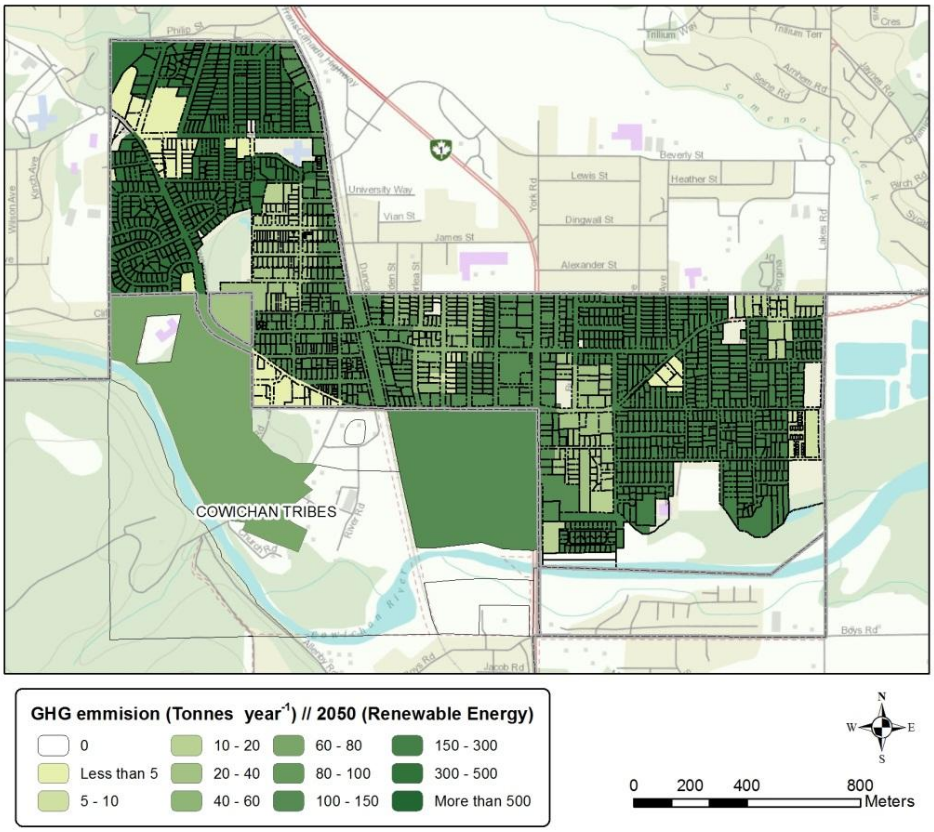


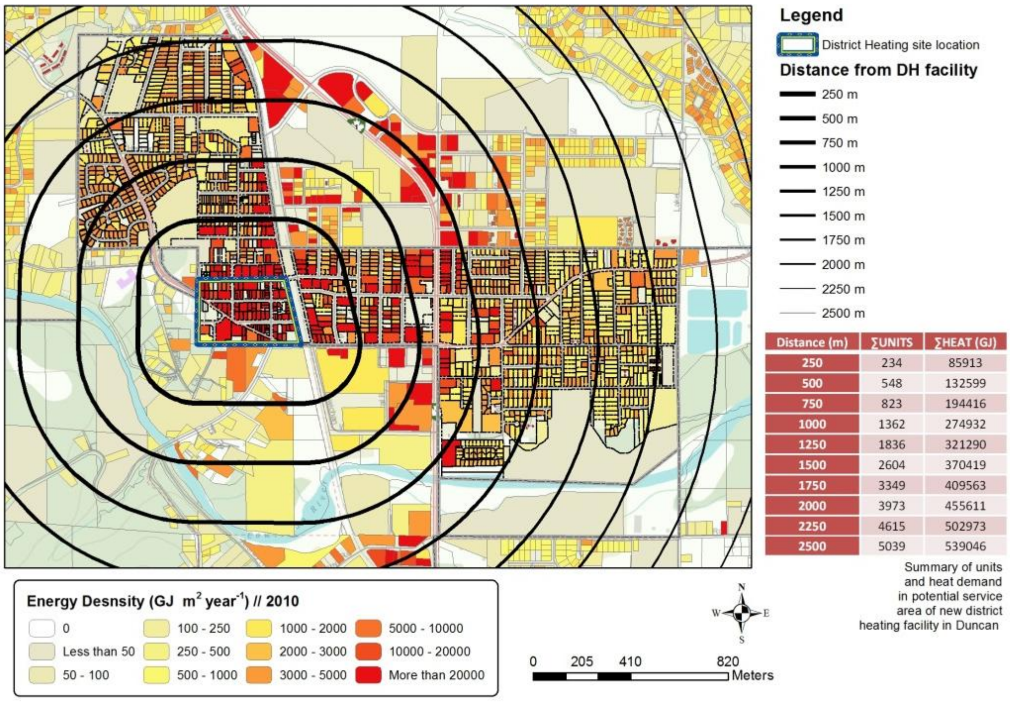
Figure 12: GHG emissions in 2050 for the City of Duncan following a scenario emphasising increased use of renewable energy (RE scenario).

District heating facility

A central part of the RE scenario is an anticipated shift in technology, which could result from decentralized systems such as heat pumps or wood pellet boilers, and/or centralized systems such as wind farm projects and district heating.

As discussed in report 3 a key point for both wind farms and district heating is location. Wind farms are dependent on adequate wind resources and appropriate distance to an energy grid, while district heating is only viable in areas with relatively high energy demands.

Based on the 2010 energy maps a high density area in Duncan was identified as a potential site for district heating and used as the basis for investigating the heat demand in the potential service area (cf. Figure 13).



Distance (m)	∑UNITS	∑HEAT (GJ)
250	234	85913
500	548	132599
750	823	194416
1000	1362	274932
1250	1836	321290
1500	2604	370419
1750	3349	409563
2000	3973	455611
2250	4615	502973
2500	5039	539046

Figure 13: Potential site for district heating and estimates of heat demand in associated service area in the City of Duncan.

What is evident from Figure 13 is that the energy demand in Duncan and surroundings is more than adequate for the consideration of district heating, even given current energy consumption levels.

4.5 EE+RE scenario

The EE+RE scenario increased energy efficiency (equal to that in the EE scenario), as well as increased usage of renewable energy sources. As was the case in the RE scenario, renewable energy production is then increased to the point where the overall resilience targets are met. The EE+RE scenario relies primarily on the lowest cost technologies included in the technology cost model to meet resiliency targets. However, these are not necessarily the same as those selected in the RE scenario, as the energy savings from increased efficiency will affect the relative cost of the various energy production technologies.

The total gross energy consumption in the EE+RE scenario is close to that in the EE scenario (and thus a duplicate map is not included here). However, relative to the EE scenario, the type of energy consumed is quite different and results in a significant impact on GHG emissions (much lower) and energy resilience (much higher). The latter is discussed more thoroughly in report 4, where it can also be seen that the GHG emission reduction of the EE+RE scenario is not decidedly different from that of the RE scenario.

5 Conclusions

The maps produced in this report show total energy use (GJ) or energy density (GJ/ha) under different scenarios for the City of Duncan. Using Duncan as a case study, this report shows how the scenarios developed for each administrative area were mapped to visualize energy projections.

The energy projection mapping process includes the following major components:

- Baseline energy maps showing how much energy is being consumed in 2010.
- Future energy maps showing where and how much energy will be used in 2050 if a BAU approach is followed.
- An alternative scenario showing how much energy can be saved in 2050 by focussing on energy efficiency strategies.
- An alternative scenario showing how much energy resilience can be improved and GHGs emissions reduced in 2050 via an increased uptake of renewable energy resources.

The main messages to be taken from this work is that a lower energy usage as a result of energy efficiency strategies, as well as technology shifts towards renewable energy sources, both contribute to moving the CVRD closer to its energy resilience and GHG emissions reductions goals.

It should be stressed that models and maps are subject to the accuracy and completeness of the input data. For the energy projection maps, energy data is represented at the OCP level, whereas current energy usage was mapped according to each individual parcel or property (cf. report 2). In the future, if a proper alignment between OCPs and parcels for all administrative levels can be achieved, it would be possible to disaggregate energy projections down to the parcel level and provide an even more accurate picture for each scenario.

Moreover, to fully evaluate options for improving energy efficiency, achieving higher energy resilience and reducing GHG emissions, commercial buildings and the transportation sector should also be considered. A full assessment of all sectors is therefore recommended to better understand the implications of proposed land-use and energy efficiency strategies. The mapping approach as described in this report along with the associated energy and technology cost models lay the foundation for this future work.

6 References

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BC Ministry of Environment (2010): *Cowichan Valley Regional District Updated 2007 Community Energy and Emissions Inventory*. Available at: http://www.env.gov.bc.ca/cas/mitigation/ceei/RegionalDistricts/Cowichan_Valley/ceei_2007_cowichan_valley_regional_district.pdf

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7 Appendices

OCP for the
City of Duncan

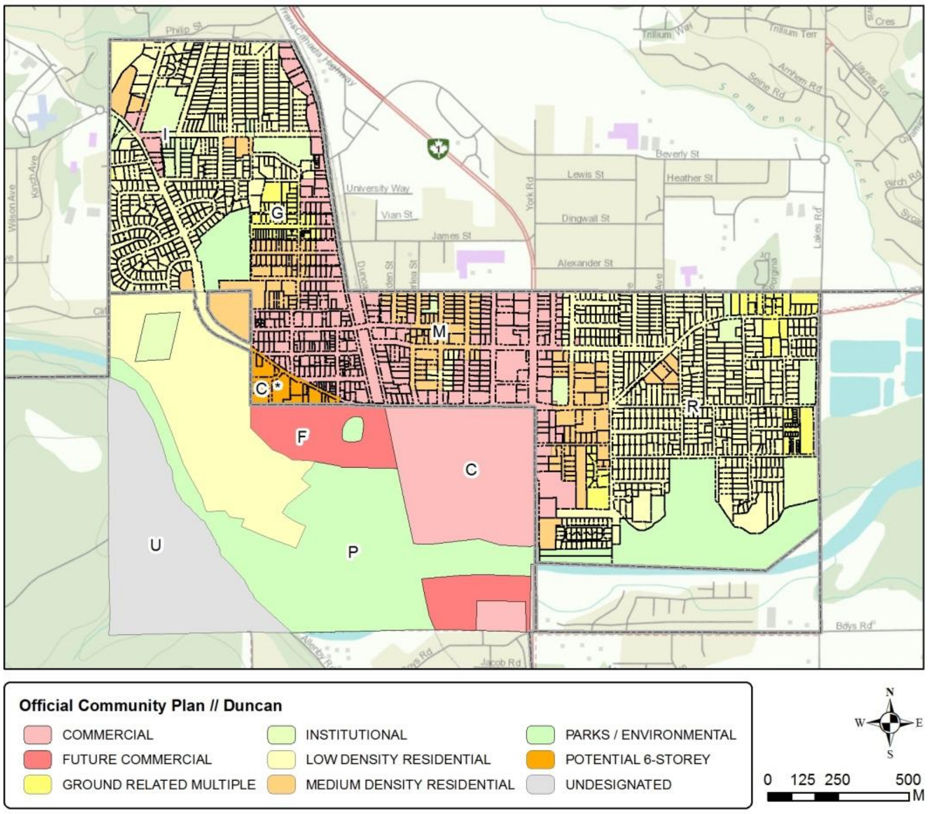

Figure 14: Official Community Plan (OCP) of the City of Duncan.

Energy conversion factors

As a reference for the reader, the table below gives an overview of the various energy related terms and units that are utilised throughout report.

Aspect	Symbol	Name	Value
Energy quantity Generally used to measure heat values	J	joule	1
	kJ	kilojoule	10^3
	MJ	megajoule	10^6
	GJ	gigajoule	10^9
	TJ	terajoule	10^{12}
	PJ	petajoule	10^{15}
Power Generally used to measure the output of a plant or device	W	watt	1
	kW	kilowatt	10^3
	MW	megawatt	10^6
	GW	gigawatt	10^9
	TW	terawatt	10^{12}
Energy quantity Generally used to measure the amount of electricity	Wh	watt hour	1
	kWh	kilowatt hour	10^3
	MWh	megawatt hour	10^6
	GWh	gigawatt hour	10^9
	TWh	terawatt hour	10^{12}
Conversion factors:	1 Wh	3,600 J	
	1 kWh	3.6 MJ	
	1 MWh	3.6 GJ	
	1 GWh	3.6 TJ	
	1 cent/kWh	10 CAD/MWh	