Ea Energy Analyses

gras

FINAL REPORT

Cowichan Valley Energy Mapping and Modelling

REPORT 6 – FINDINGS AND RECOMMENDATIONS

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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

OCM – 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 final report 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 Renewable Energy Resources 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. The task results are described in the report 'Energy Density Mapping Projections'. In addition, GHG mapping under the various scenarios was also undertaken.

Findings and recommendations

The present report is the final report and 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.

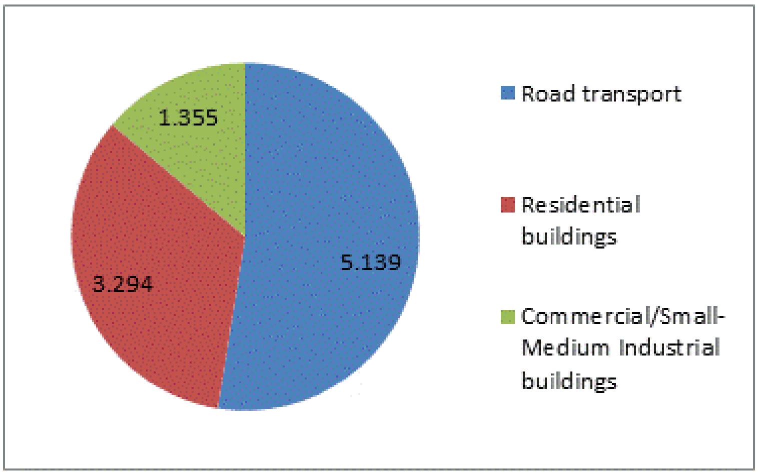


Figure 2: 2007 CVRD total energy consumption by sector (TJ) excluding large industrial users and Indian Reserves (BC Ministry of Environment, 2010).

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.

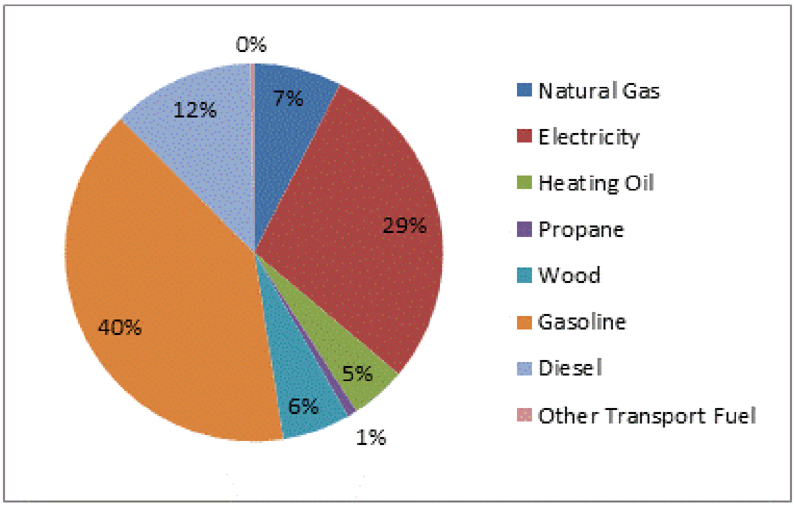


Figure 3: 2007 CVRD total energy consumption by source (TJ) excluding large industrial users and Indian Reserves (BC Ministry of Environment, 2010).

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.

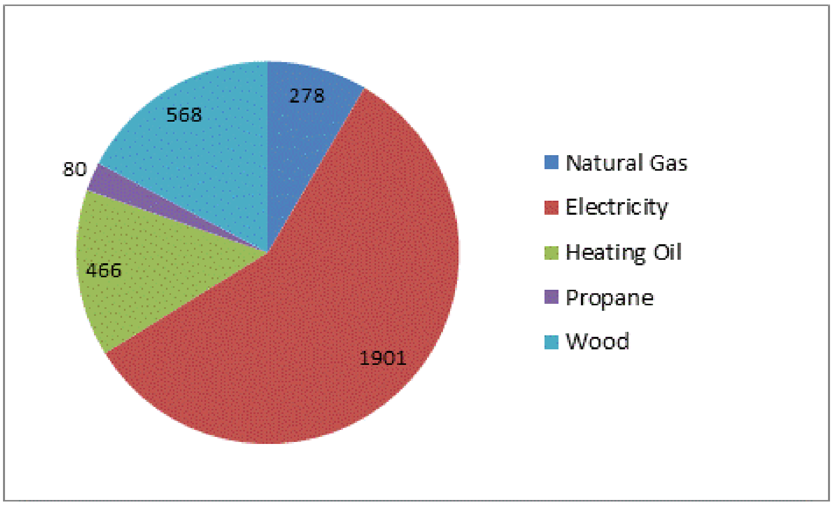


Figure 4: 2007 CVRD residential sector energy use (TJ) (BC Ministry of Environment, 2010).

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.

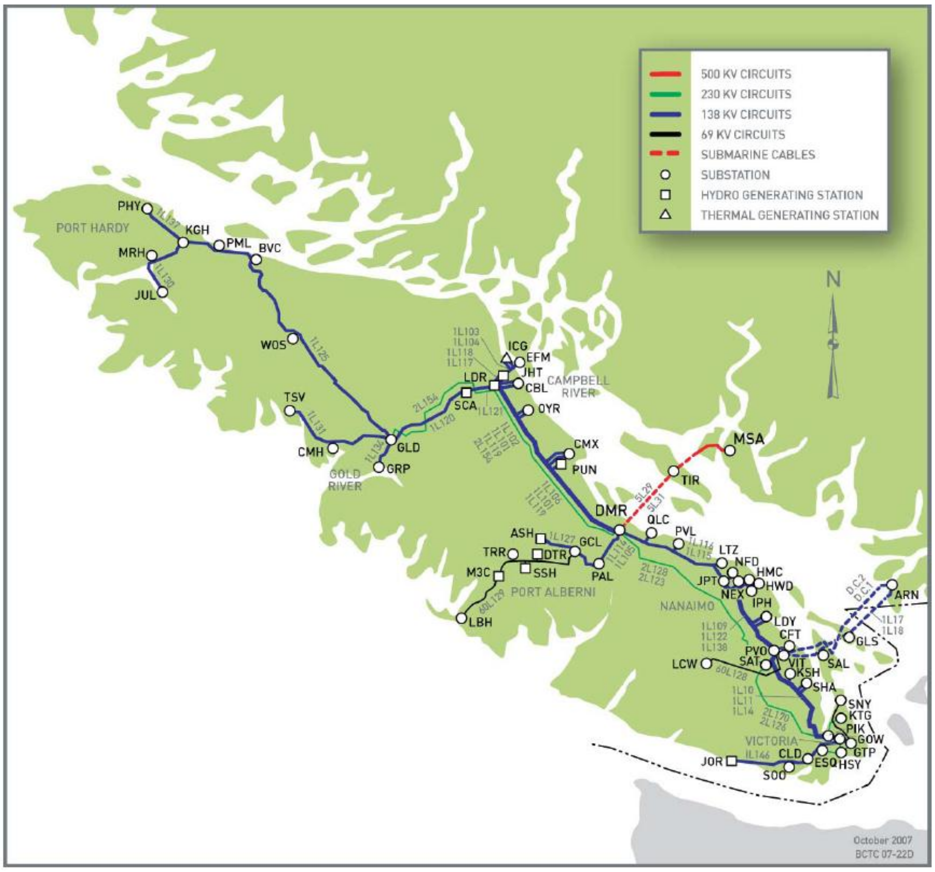


Figure 5: Vancouver Island Transmission network as of October 2007 (BC Hydro, 2007).

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.

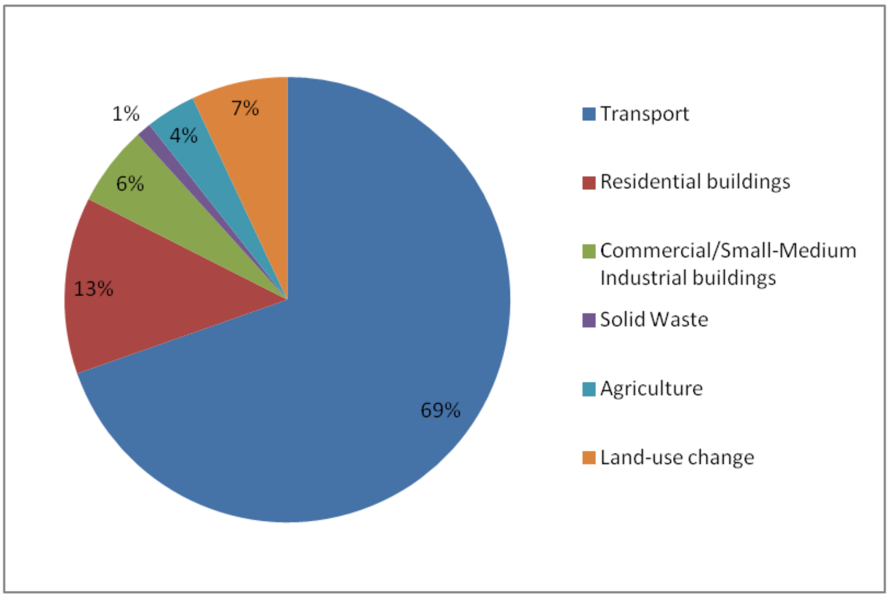


Figure 6: 2007 CVRD GHG emissions according to source excluding large industrial users and Indian Reserves. Total emissions were just over 503,000 tonnes of CO_2 (BC Ministry of Environment, 2010)

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

This report briefly summarises the findings of tasks 1-5 and provides a set of recommendations to the CVRD based on the project findings as a whole.

The report starts with a brief discussion of energy resiliency from a CVRD perspective. This is followed by a discussion of tools used in energy planning in general, and more specifically as they relate to this project. The results of the energy mapping and scenario analyses are presented starting with the assessment and mapping of local RE sources and local energy consumption, after which the modelled costs of local RE exploitation are summarised and the scenarios compared against the CVRD's development targets (energy resiliency, GHG, etc.). Finally, the report concludes with suggested next steps for the CVRD to move forward with its energy planning process.

As a reference for the reader, a table in appendix 1 gives an overview of the various energy-related terms and units utilised.

2 The resiliency target

The CVRD resiliency targets stem from an interest in protecting the district from extreme events or emergencies such as a disruption of an electricity cable to the mainland, from price shocks and general increases in fuel prices, as well as a wish to contribute to climate protection. In addition, achieving these goals will assist in creating a more robust community through an expanded local economy and a reduction of energy based costs for its members.

Resiliency targets

In consultation with the CVRD it was therefore determined that the 2050 'resiliency' target within the residential sector should focus on addressing energy imports, as well as security of supply. As such the 2050 resiliency target includes:

- Phase out fossil fuels for primary heating in the residential sector (oil, natural gas, and propane).
- Meet 75% of residential energy demand with local renewable energy (RE) sources.[3]

Consider the context

Focusing on the residential sector first makes sense from a political and practical standpoint, particularly given some of the low hanging fruits to be harvested (i.e. conversion of oil furnaces to heat pumps), and local government's opportunities for direct influence on residential development.

However, it should be kept in mind that there are other sectors that should be incorporated into the overall energy planning, and this represents a reasonable next step in the CVRD energy planning process. There may, for example, be possibilities for action within the industrial, commercial, or transport sector that are more cost-effective to realise and have additional benefits. Possibilities for exploiting synergies with industrial production should also not be overlooked. Here local government also has an opportunity to take leadership in the development or realisation of energy infrastructure via direct or indirect investment.

Delimitation

According to 2007 figures, transport accounts for nearly 70% of the CVRD's GHG emissions and more than half of its gross energy consumption (BC Ministry of Environment, 2010). As a result, if the CVRD is to greatly reduce its overall GHG emissions and fossil fuel reliance in the long-term, then the transport sector will have to be included in the Region's overall energy

[3] In calculating this figure, all RE produced electricity within the CVRD from non-industry is counted as being utilised by the residential sector, and firewood for non-primary heating is not counted.

planning. Inter-regional and/or inter-governmental cooperation will likely be necessary to see through transport related developments. Furthermore, as transport becomes more electricity and/or biomass driven, energy and transport sectors are going to become increasingly intertwined.

Similarly, if GHG emissions are a priority then the focus should be on reducing *global* GHG emissions. If achieving agreed national GHG targets is the goal then the focus should be on limiting *Canadian* GHG emissions. If instead the focus is on the geographical area of the CVRD then *local* GHG emission reductions will be given priority over that of other geographical areas, even on Vancouver Island.

An analysis of GHG reduction pathways could serve as a mechanism to utilise energy upgrades or expenditures as an investment vehicle for other regions.

Cooperation within the CVRD and with other regions

Energy resources and energy consumption do not follow politically determined boundaries. Therefore cooperation within the CVRD, and with other regions on Vancouver Island, is important for successful energy planning. An example within the CVRD is Duncan and North Cowichan where cooperation in providing a district heating system could be a possibility, while potential cooperation with other regions could include a municipal solid waste based CHP facility or wind farms that operate across political boundaries.

In this regard, our recommendations are therefore:

- to periodically revisit the established resilience targets and the boundaries restricting who would be involved in helping to achieve these targets,
- to include data on all sectors of the economy as they become available and incorporate them in the analyses, and
- to ensure a running dialogue and information exchange with neighbouring jurisdictions.

3 The planning tools

The main activities of this project were energy mapping and modelling using Excel-based models, linking information with GIS, and scenario analysis. Altogether they serve to inform energy planning, as well as provide tools to assist with decision-making.

3.1 Energy scenario analysis

The vast majority of the CVRD's energy needs are met by resources imported from outside the region. By mapping the potential RE resources within the CVRD it becomes apparent that there are significant RE resources to be found locally.

With technological data, fuel prices, efficiency measures, as well as forecasted energy demand and growth development as additional inputs, this information helps to identify which resources are economically and politically feasible now , and what the tipping point may be in the future. Each factor serves as an input into the development of scenarios, as depicted in the figure below.

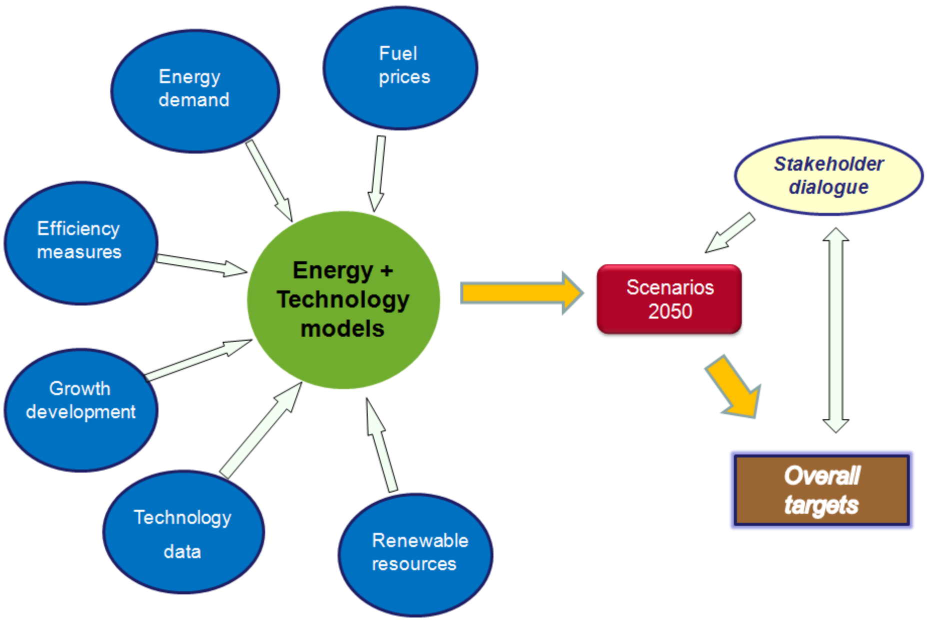


Figure 7: Scenario development

What are scenarios?

Scenarios are stories about how the future might unfold and as such are not predictions or forecasts. They are provocative and plausible accounts of how external forces can give rise to challenges and opportunities, including those related to policy development, scientific and technological development, social dynamics, and economic conditions.

Why energy scenarios?

Energy scenarios provide an overview and help to identify opportunities, threats and points of action. They usually include 'elements' that can be influenced and 'elements' that cannot be influenced. Scenarios assist in dealing with uncertainty by looking at a range of possibilities that allows deciding on a strategic direction in the face of present and future possibilities and uncertainties.

An additional benefit of scenario analysis is that it can be a means to involving stakeholders in long-term decision-making and help them reach a common point of reference. As such, stakeholder consultation is often an integral part of the scenario analysis work process. The dialogue established during the consultation process is often educational for all parties, including the scenario analysts, and often results in the identification of potential win/win situations for all stakeholders. This dialogue can also assist with the next steps in policy-making and create anchoring in the constituency (either public or political).

Different kinds of scenarios can be outlined, including:

- Predictive – what future seems most likely given the continuation of current trends?
- Explorative – what futures are possible and how do we prepare for sets of equally plausible futures?
- Anticipative – what future is preferable and how can we get there?

Anticipative scenarios

This project is focused on anticipative scenarios, as these help to highlight the different ways one can achieve a target. Such scenarios can, for example, help to determine whether achieving resiliency via a large-scale centralised approach is preferable to a small-scale decentralised approach, or vice versa. Through dialogue with relevant stakeholders, one can identify which pathways are economically, technically, and politically feasible, and those which are not feasible at this point in time. Anticipative scenarios are very useful tools for planners and politicians alike, as they may help to answer questions such as 'If we want to get here, what is the likely cost?' These scenarios therefore give politicians a better basis upon which to make their decisions as well as present their rationale for doing so.

It is worth noting that a high level of data detail and accuracy does not always provide additional value in scenario analysis. The main goal is to provide a reasonably accurate impression of the consequences for a set of alternatives and uncertainties. Great complexity in the development of a scenario (for example by attempting to include every single potential input, regardless of how significant the individual input may be for the overall result) may shift the focus to technical details rather than the broader perspectives.

Within the project, a series of training workshops and briefings were provided to each of the local governments within the CVRD on the use of the models as well as scenario development. For the purposes of this study a number of scenarios where chosen to illustrate various future pathways and impacts.

Why long term planning?

The potential benefits associated with carrying out scenario analysis a decade or more into the future are not always apparent, and can sometimes be met with scepticism. However, the ability to measure current energy use, and 'play' with future potential scenarios, is a valuable tool in understanding present and future challenges and what can be done to overcome these. Energy infrastructure has long lead-times and lifetimes, and as such decisions made today shape the physical environment for several decades to come. It is therefore extremely relevant that planners can forecast the results of decisions made today under different scenarios. Simple Excel tools can assist in this, and GIS mapping of their results provides valuable spatial representations of these findings which are particularly useful in assisting decision-making. Visual tools such as scenarios and GIS maps are well suited to communicate the situation and its challenges to a broad spectrum of stakeholders.

A perfect example of how long term planning can affect local short-term planning was seen during our study tour visit to the island of Bornholm in Denmark from September 26th-30th, 2011. The island has a general vision of becoming a carbon-neutral society based on sustainable and renewable energy by 2025, and this overall vision is to be achieved via 12 'areas of action'. For each of these 12 areas, individual concrete energy and emissions targets are monitored on an on-going basis, allowing planners to make timely adjustments so that the overall vision can be achieved.

Building capacity and familiarity

Among other deliverables, the following were developed for this project: a technology cost model, an energy model, and an associated GIS maps. A key component and deliverable was a series of presentations and hands on sessions for staff to become familiar with the concepts and the tools prepared. Specific technical training sessions for GIS and planning staff were provided.

This project has provided an opportunity for energy planners within the CVRD to practise long-term scenario analysis and to coordinate their modelling using these tools. In order to maximise the benefits of these modelling tools in the years to come it is recommended that capacity be built to maintain, exploit and expand upon these tools. A strategy for updating and expanding the tools should be outlined.

Capacity building could be carried out via CVRD workshops and seminars that:

- Explain the relevance of both measuring current energy use, as well as modelling future energy scenarios.
- Provide further training in the use of tools that allow for future scenario modelling (e.g. simple Excel spread sheet tools).
- Provide further training in the use of tools that allow for a spatial display of current and future energy resources and usage (e.g. GIS mapping).
- Provide a peer-to-peer support system in the continued expansion of the materials and opportunities for cross boundary synergies.

3.2 Data foundation

Data was amassed for 14 different administrative areas and processed in a consistent manner using the same classifications. As is often the case, some data was missing; in other cases better data would have been useful, and with a view to the future energy planning work, data on additional new items could become relevant to seek out. On-going data refinement should be considered as well as continued provincial partnerships and data exchange.

Commercial and industrial sectors

The level of detail in the energy model is limited regarding commercial and industrial consumers due in part to the lack of detailed data. Consequently the main focus of the scenario analysis was placed on the residential sector and not on commercial and industrial sectors at this time.

Energy efficiency

Energy efficiency was not the primary focus area of this project. However, energy efficiency parameters are present in the models. A more in depth energy efficiency study, particularly regarding the costs, could provide valuable data inputs to the model, thus giving a more accurate basis for comparing potential energy-related initiatives or courses of action.

Update, improve, and expand

Regular updating of the dataset is important for the future usefulness of the developed models, but also for tracking the impacts of past and existing policy measures. New trends in population growth and changes in the mix of primary heating systems in the residential sector are examples of information that should replace the existing data.

With the rise of new technologies and the evolution of existing ones, data on the cost, efficiency, lifetime, etc. of these should be added to the present technology cost model.

Our recommendations are to outline a routine for data 'maintenance' and agree on a plan for data improvement and expansion. Aligning data wishes with established data collection organisations, such as by statistical bureaus, can help minimise the cost of regular data collection. In some cases it is also possible to get an extra question added to existing data collection rosters and thus easily access otherwise unavailable information. Concrete examples could include the regular regional Ipsus Reid surveys or other local government data collection systems.

Data collaboration

Having readily available energy data that is easy to access, utilise, share, and make comparisons with is of particular value when undertaking inter-regional studies. As such, collaboration with other parties in the early stages of classification and data collection is a worthwhile endeavour. It is therefore highly recommended to continue close cooperation with the TaNDM project, as well as encourage other relevant stakeholders to join, in order to ensure that future energy data is accessible and in a useful format for all relevant parties. If the intention is to put the energy data on a map to enable spatial analysis, then it is equally recommended that the CVRD initiate the development of a more integrated and shared GIS-data infrastructure.

3.3 Capability of models

Technology cost model

The technology cost model is essentially a technology catalogue that for each technology includes parameters such as:

- Capital costs
- Operation & maintenance costs
- Efficiency
- Lifetime
- Capacity factor
- Fuel input costs.

These parameters and their estimated development up till 2050 are used to produce a series of cost figures for the various technologies, thus allowing comparison on a cents/kWh basis.

Energy model

The energy model used for the scenario analysis uses a bottom-up approach[4] to model energy demand, gross energy consumption by fuel, source and sector, GHG emissions, costs, RE production, fuel imports, etc. The cost of available supply options is automatically pulled from the technology cost model, and this is combined with local administrative area data, related to:

- population growth
- number, type, and size of residential units
- primary heating sources
- renovation and demolition rates
- building codes
- energy efficiency and conservation rates.

For the industrial, commercial, and transport sectors, simple and generic forecasts and input possibilities were included in the model.

Each of the 14 administrative areas in the CVRD has its own worksheet in the CVRD overall energy model, and also its own smaller version of the model. These smaller workbooks allow for individual areas to undertake their own scenario work, but still utilise the general CVRD wide assumptions. This particular aspect made the model development much more complex, and will require slightly more effort with respect to maintenance and upkeep of the overall model.

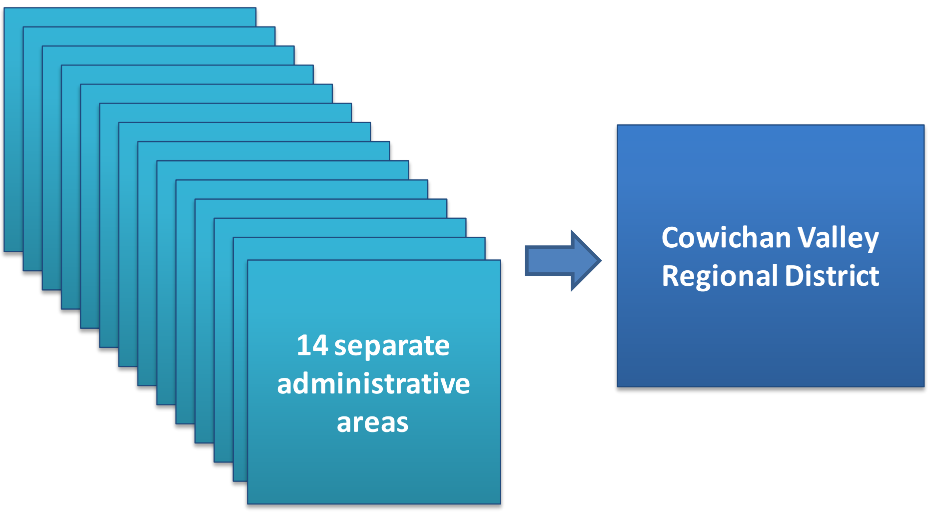


Figure 8: Information for each of the 14 administrative districts feed in to CVRD overview.

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

Model interplay in scenario work

The dwelling types, primary heating technologies, and energy sources included in the technology cost model and the energy model are shown in the figure below. The choice of energy resource in a given scenario is determined by the primary heating technology used in dwellings and the cost and availability of the energy resources required for the heating technology to operate.

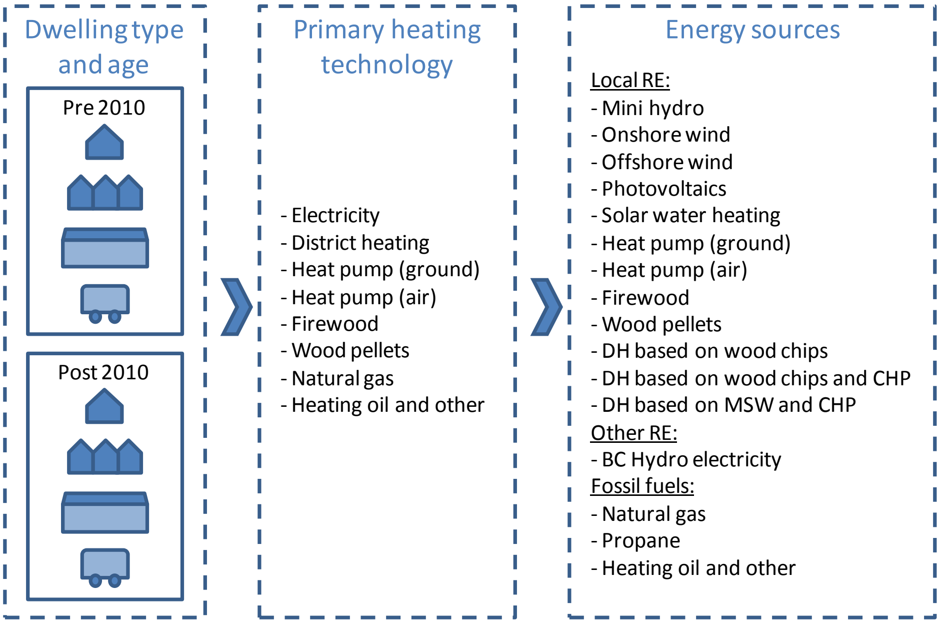


Figure 9: Illustration of the dwelling types, primary heating technologies, and energy sources included in the technology cost model and the energy model.

Model drivers

Future residential energy demand is modelled using simple energy efficiency multipliers that are based on building typologies (assumed equal across the CVRD) and the building's heating source. These multipliers can easily be altered to reflect different goals for energy efficiency amongst existing building stock (pre-2010) and/or new buildings (post-2010). The change in dwelling area is determined by the change in population. This is illustrated in Figure 10.

Figure 10: Illustration of the driving elements of the modelled energy consumption.

GIS

Energy maps bring together building, land use, and energy data into a single database to display energy usage across the CVRD region. Normally such datasets are developed and maintained separately by different organisations, but combining these datasets as part of the baseline mapping process and again for the future scenarios the database, can provide valuable information about energy consumption trends.

GIS-mapping in combination with energy scenario modelling can assist in spotting unrealistic predictions in scenario development. For instance, in the scenario work the assumed population growth figures dictated that a number of new dwellings would be established in Duncan by 2050. However, when it came time to use the GIS mapping to place these new units, it became apparent that there was insufficient space in Duncan for their placement.

The spatial unit for mapping energy consumption is the parcel. However, in the CVRD no single organisation is in charge of maintaining a harmonised parcel layer. This has implications for mapping endeavours that seek to perform analyses for the region as a whole. Spatial mis-registrations and incomplete and non-standardised attributes all contribute to inaccuracies. Thus the ease of mapping would be greatly improved if a harmonised parcel layer for the CVRD as whole could be composed.

4 Energy mapping and scenario analysis findings

In this chapter a summary overview of the energy mapping and scenario analysis results are presented, starting with the potential local renewable energy resources and the energy consumption in the CVRD area, followed by the estimated cost of local RE exploitation and the results of the scenario comparisons.

Before listing the local RE potentials it is worth mentioning that the CVRD is blessed with access to electricity that is primarily hydro based, and as a result the electricity consumed within the CVRD today is roughly 95% RE based, a percentage that is anticipated to increase in the forthcoming years (BC Gov, 2011). In addition, as a great deal of it is produced via dams, production can be adjusted according to overall system needs, a characteristic that makes it ideal for integrating renewables whose production can fluctuate.

4.1 Local RE resources

The first task in the project was the production of a series of thematic GIS maps and associated databases of potential RE resources in the CVRD. The RE sources mapped were solar, wind, micro hydro and biomass (residues and waste). In the absence of site-specific data no attempt was made to map out the geo-exchange heat potential. However, the geo-exchange heat potential is highly relevant and included in modelled the energy scenarios.

Please note that although the maps provide reasonably realistic estimates of the RE potentials they cannot substitute detailed in-field assessments of a given location's potential.

Solar energy

The majority of the CVRD has an average solar radiation potential between 1,200 and 1,500 kWh/m^2 per year, with the more densely inhabited lowland areas to the east at the lower end of this range (1,200-1,300 kWh/m^2). Areas with potentials greater than 1,500 kWh/m^2 per year are at higher elevations and for the most part located some distance from existing building mass and power transmission lines (cf. Figure 11).

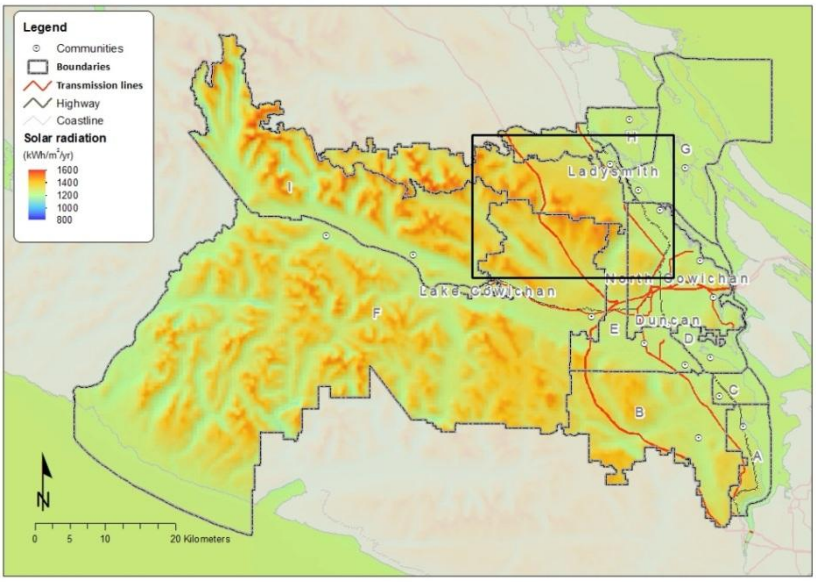


Figure 11: Solar resource map for the CVRD with annual solar potential measured in kWh/m^2 on a horizontal surface.

Wind energy

The Canadian Wind Atlas functioned as the key data source for mapping the spatial variation in wind speeds both onshore and offshore. It should be noted that the maps do not take into consideration restrictions on where wind turbines can be installed as a result of urban areas, water bodies, and national parks.

Maps depicting the annual mean wind speeds at 30, 50, and 80 meters above ground level were generated for the entire CVRD. The map for 80 meters is displayed below.

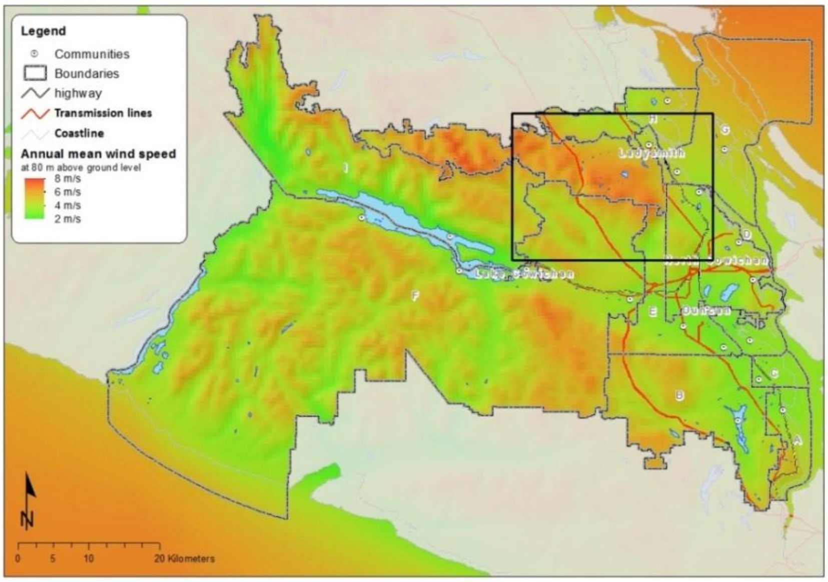


Figure 12: Annual mean wind speed in m/s in the CVRD at 80 meters above ground level.

Figure 12 indicates that the majority of the CVRD has relatively uninteresting wind regimes with annual average wind speeds of less than 5 m/s. Areas with average mean wind speeds greater than 6 m/s can, however, be found in the south-eastern corner of the Cowichan Lake South / Skutz Falls electoral area, as well as the western half of the Saltair / Gulf Islands electoral area. The latter area has the highest annual mean wind speeds (> 6.5 m/s) in the CVRD and a close-up of this area is displayed below in Figure 13.

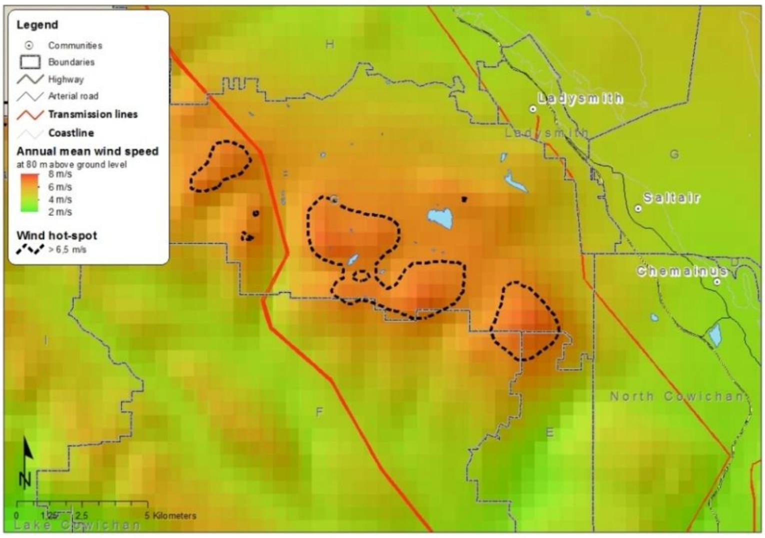


Figure 13: Annual mean wind speed in m/s in the western half of the Saltair / Gulf Islands electoral area (cf. black frame in Figure 12).

The map of offshore wind shows that the potential for offshore is limited to an area just north-east of the CVRD and close to Gabriola Island. Although the area with the greatest offshore wind potential is located outside the CVRD, it is relatively close to the main transmission line system.

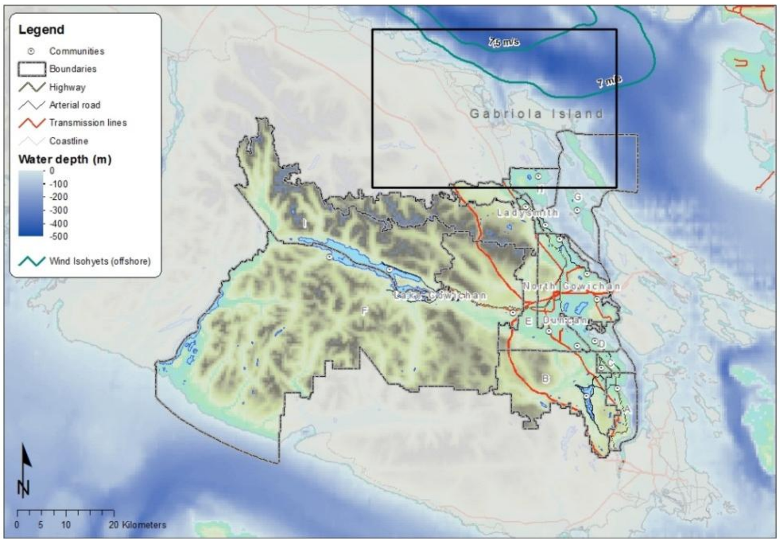


Figure 14: Water depths surrounding the CVRD shown and along with the off-shore wind isohyets equal to or larger than 7 m/s.

Small-scale hydro power

The assessment of the small-scale hydro power potential in the CVRD was undertaken by estimating actual energy potential as calculated from digital maps of slope and runoff. The approach adopted was to look for an ideal combination of sustainable high flow rates and steep gradients, which would be required to create the necessary head for micro-hydro power generation. The greatest anticipated hydro potential appears to be in the western portion of the CVRD, thus quite some distance from existing transmission lines and energy demand centres.

If a criterion of an annual energy potential larger than 1 GWh is applied the number of potential sites is reduced to 19 (cf. Figure 15), with the Gordon River location as the largest.

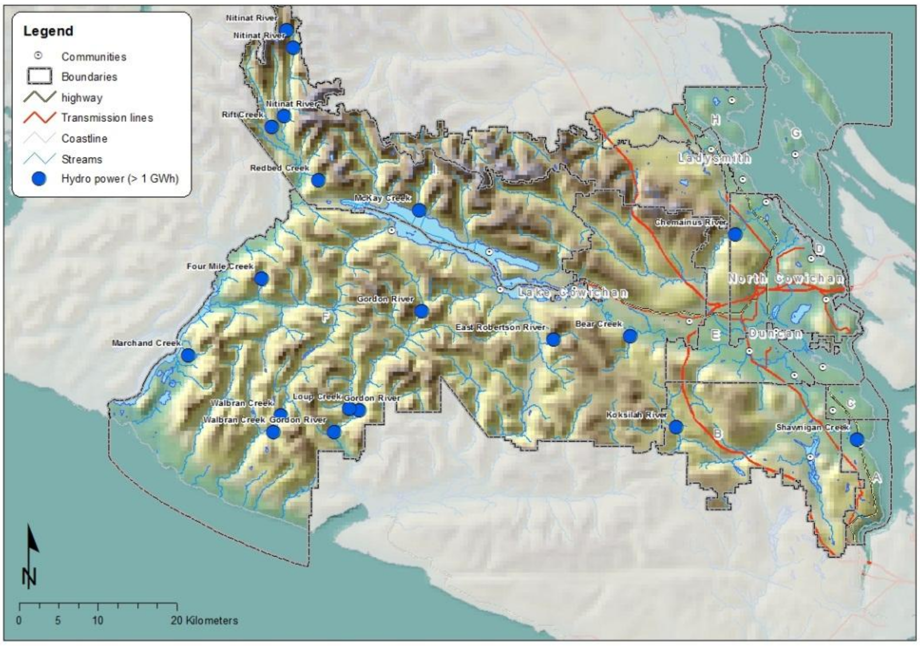


Figure 15: Sites with an annual micro hydro potential larger than 1 GWh.

Biomass

The CVRD has a large biomass resource base of residues from forestry/forest products (by far the largest potential), but also agriculture and municipal solid waste.

The biomass energy potential from forest residues has been mapped using the Earth Observation for Sustainable Development of Forests (EOSD) forest cover map and aggregated inventory data from the Biomass Inventory Mapping and Analysis Tool (BIMAT) on forest harvest residues from timber harvesting and wood processing operations. The mapping reveals a significant potential from residues produced at roadside landings alone. This potential, which is close to 2,500 TJ, is also readily exploitable since it is based on estimates of harvest residues produced annually at roadside landings within commercial forests.

In contrast, estimates based on the standing biomass would be much more theoretical since exploitation of the standing biomass is only viable if the resource is underutilised and if its removal is not leading to detrimental nutrient loss. However, as neither of these conditions seem to apply for the CVRD, which has a long and extensive logging history, and much of the remaining forest is located in rugged terrain, standing biomass has not been analysed (Environment Commission 2010).

The EOSD forest cover map of the CVRD is shown in Figure 16 along with the location of biomass units and relative forest residues for the area.

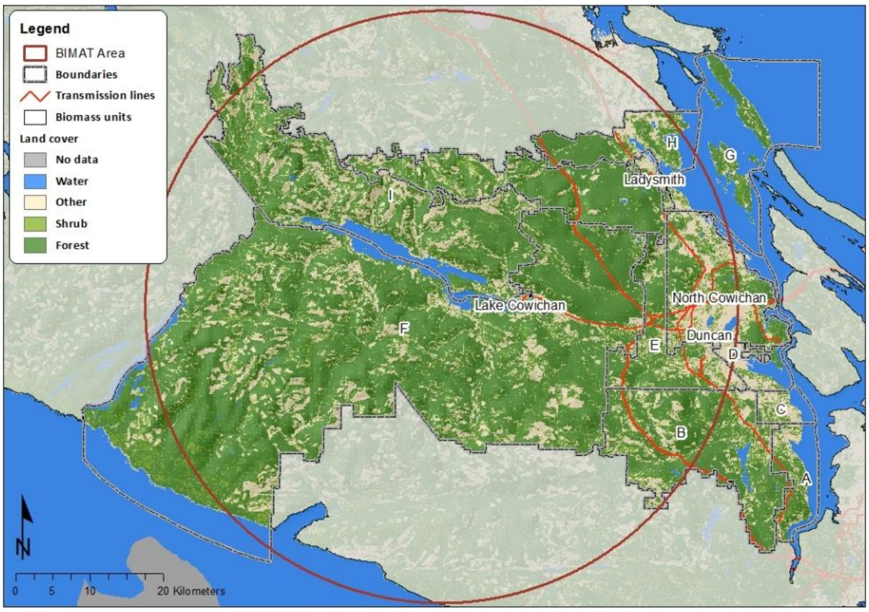


Figure 16: The EOSD forest cover map of the CVRD. The circle represents the BIMAT area used to calculate the input parameters for the estimation of mean roadside residues pr. hectare forest in CVRD.

4.2 Energy consumption

Energy consumption was mapped following the general framework as proposed by the Tract and Neighbourhood Data Modelling (TaNDM) project (2011-2012), where building information obtained from BC Assessment is linked to their respective parcels.

In our adaptation of the TanNDM framework, building information was obtained from BC Assessment and served as the basis for classifying the building mass into a number of building archetypes. Thereafter, energy intensity factors for each building type were developed.[5]

The energy consumption density mapping is presented in 42 separate maps, both as energy usage per parcel, and as energy usage per m^2. An index of these maps is presented below in Figure 17.

For the region as a whole, the residential energy consumption density is extremely low, which is primarily due to the largely rural nature of the communities and administrative areas. Some areas, primarily in the municipalities, do, however, have segments with consumption densities high enough to warrant, for example, district heating consideration.

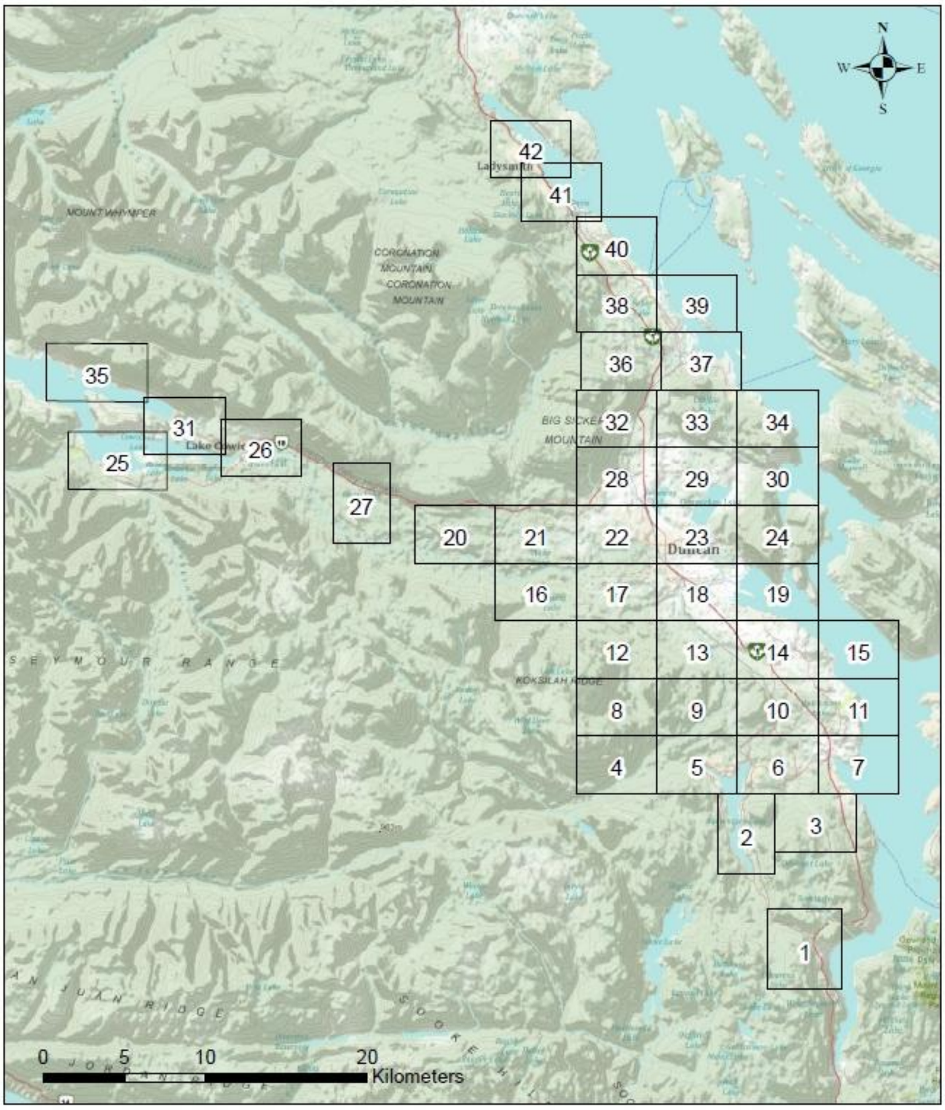


Figure 17: Index over the 42 energy consumption density maps.

[5] For a more detailed explanation of the methodology used, please see report 2 in this series.

Energy usage per m²

A map corresponding to map 23 and a portion of 29, and covering much of Duncan, is displayed below in Figure 18. It clearly highlights that the City of Duncan has the highest energy consumption density, which can be mainly attributed to the higher density of commercial and industrial properties. However, also among the residential areas it is possible to find energy consumption densities considerably higher than the CVRD average.

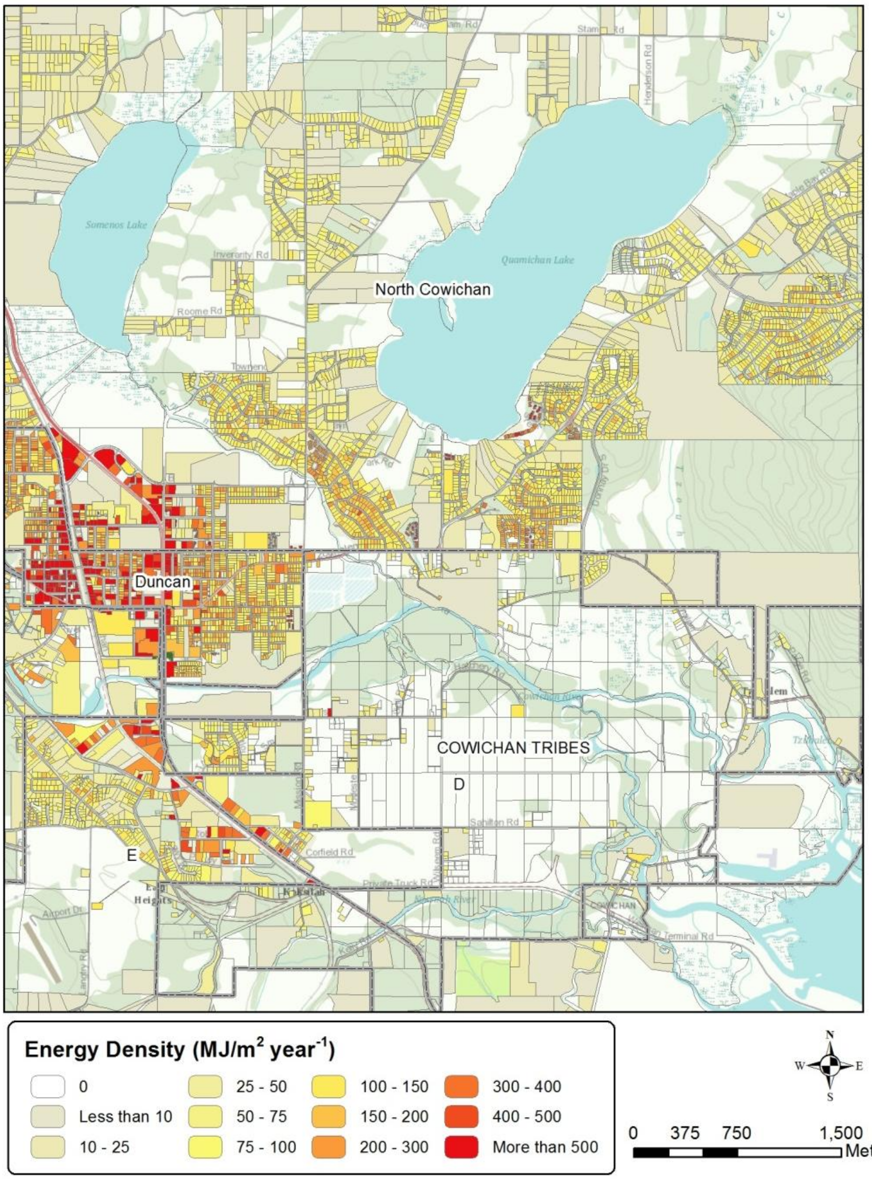


Figure 18: Residential energy consumption density for a portion of the Duncan and North Cowichan area (MJ/m² per year)

The map below shows a 'close-up' of an area just south of Quamichan Lake with an above-average energy density. It can be seen that there are a number of residential areas with energy densities greater than 200 MJ/m^2 per year, and some pockets with densities greater than 500 MJ/m^2 per year.

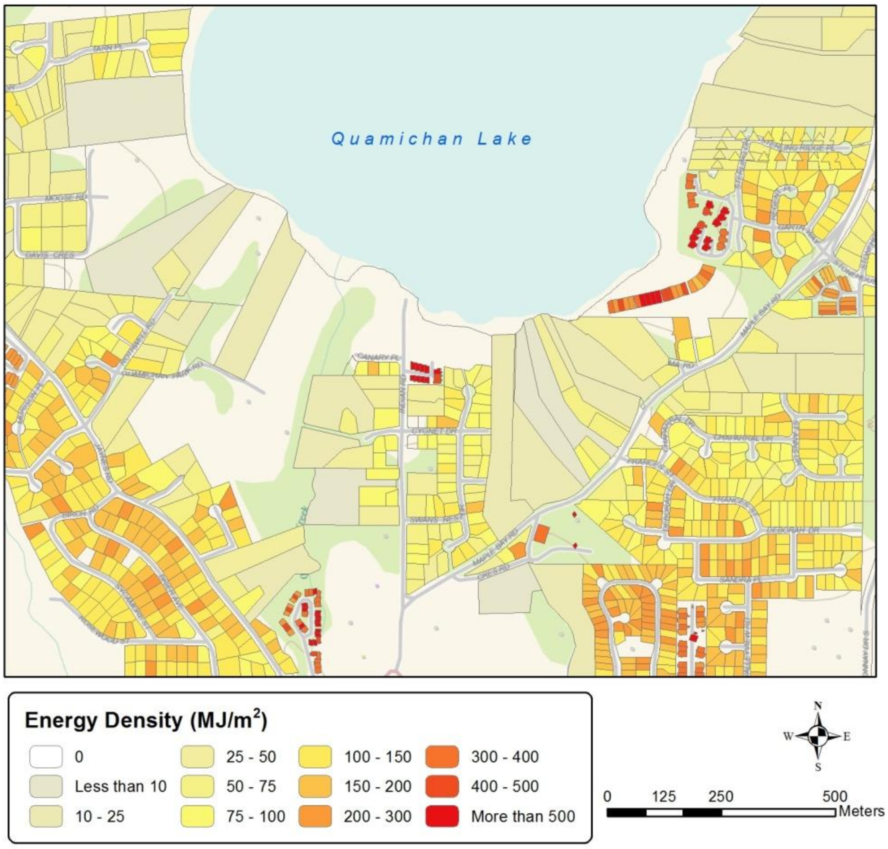


Figure 19: Annual residential energy consumption in MJ/m^2 for an area south of Quamichan Lake.

Energy usage per parcel

An alternative approach to mapping the consumption density by m^2 is to map the energy consumption per parcel. As parcel size varies greatly this gives a different picture altogether (a large parcel may have a relatively low energy consumption density on a per m^2 basis, but its total energy consumption may be significant). While mapping energy consumption per m^2 can be valuable when for example undertaking a screening for district heating (which benefits from high energy consumption densities), mapping energy use by parcel can be useful in integrating into Official Community Plan (OCP) development and updates as it allows for a zoning based analysis.

A map for the same area as that in Figure 19, this time depicting energy usage per parcel, is displayed below. Please note that the unit of energy is not the same for the two maps – In Figure 19 it is MJ/m^2 while in Figure 20 it is GJ per parcel (1 GJ = 1,000 MJ).

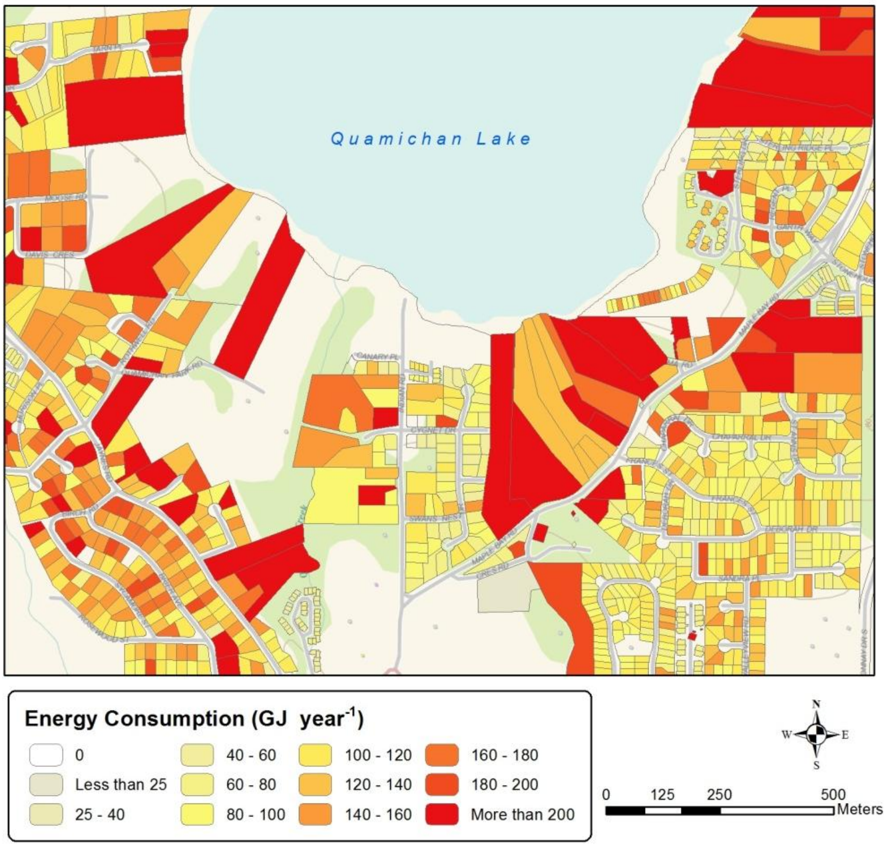


Figure 20: Annual residential energy consumption GJ/parcel for an area south of Quamichan Lake.

4.3 Cost of heat and electricity supply

After identifying RE potential and energy demand, the next step is to assess the cost of exploiting RE resources and compare these with traditional fossil fuel-based technologies. Taking into consideration capital costs, O&M costs, fuel costs, CO_2 taxes, and distribution costs, (but excluding HST and any technology rebates), an end-user cost for each technology is calculated. As it is expressed in cents/kWh of energy supplied this allows for a comparison across energy technologies.

Fuel cost

One of the most important factors in determining the end-user cost for each technology is the fuel cost. Figure 21 displays the assumptions regarding the cost of the various fuels for the period 2010-2050 including CO_2-tax, delivery, and flat fees, but excluding HST.

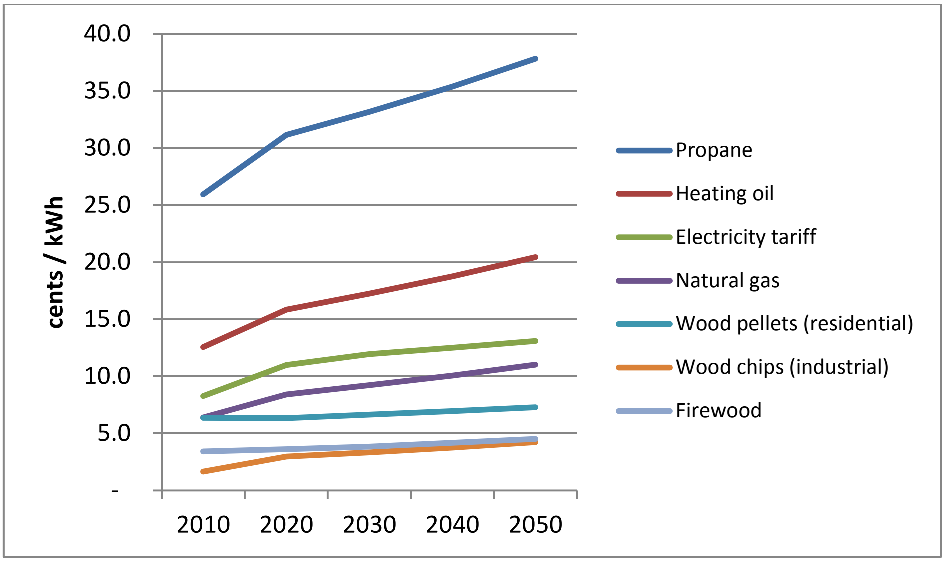


Figure 21: Fuel costs utilised in scenarios including CO_2, delivery, and flat fees, excluding HST.

Energy supply costs

Anticipated heat and electricity supply costs are based on the technology cost model described in report 3. The figures below give an overview of the cost inputs produced through the model and used in the scenarios

As an example, Figure 22 below illustrates the cost of energy supplied via each heating option on a per kWh basis in the business-as-usual (BAU) scenario.

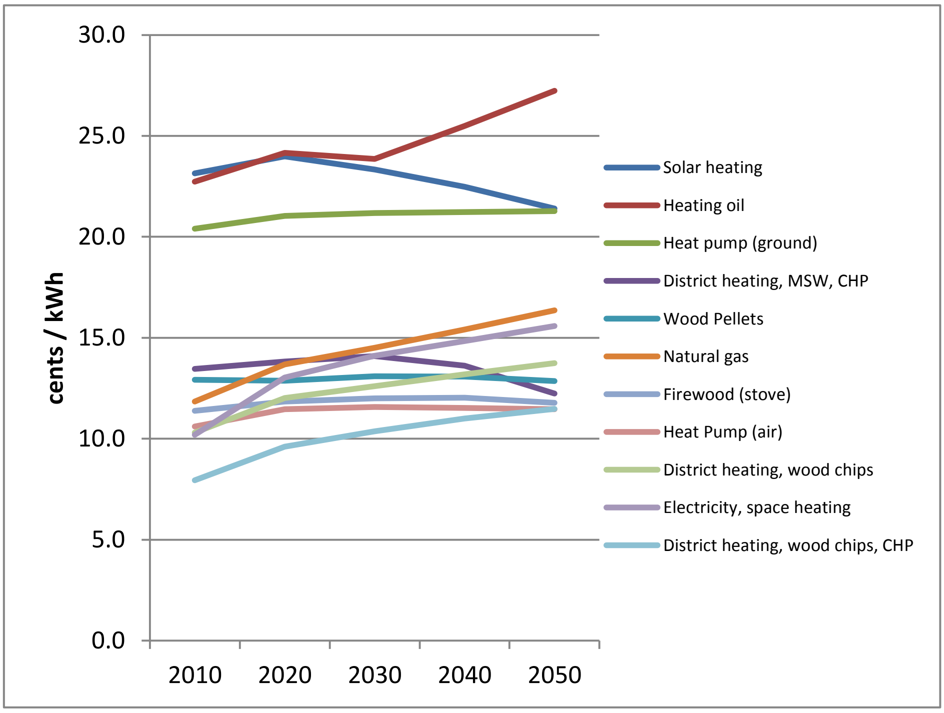


Figure 22: Cost of heat supplied to end-users including capital, O&M, and fuel costs. Excludes HST and technology rebates. The cost is a weighted average according to residential dwelling type and whether it is an existing or new dwelling. Costs for district heating in particular can

vary substantially depending on building type, location, etc. For heat pumps, the existing fuel technology in place also affects the conversion cost. Figures are for the BAU scenario.[6]

As illustrated, solar heating, heating oil, and geo-exchange (ground source heat pumps) are the most expensive options, while wood chip-based district heating using CHP remains the cheapest throughout the period.

Meanwhile, Figure 23 illustrates the anticipated cost of supplying locally produced electricity via the various technologies examined.[7]

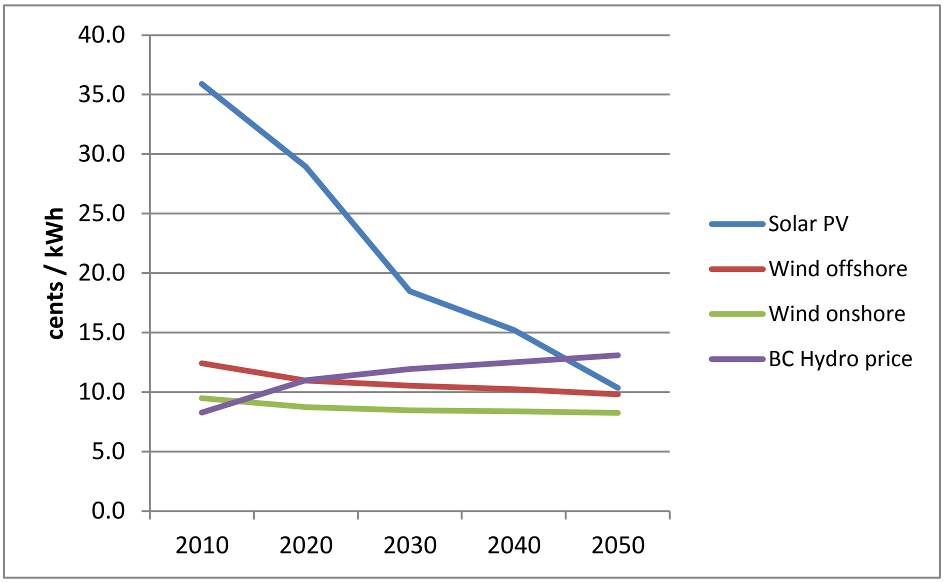


Figure 23: Cost of electricity supplied to residential end-users (BC Hydro price), vs. cost of locally produced and distributed electricity.

The figure does not include the costs for mini hydro as these are extremely site specific. Solar PV is initially about three times as expensive as the other options but falls steadily to reach approximately the same level as offshore wind by 2050.

4.4 Results of the scenario comparisons

Resiliency targets

There are two ways for the CVRD to meet its energy resiliency targets within the residential sector, namely energy conservation and increased production

[6] The costs displayed in this figure are for the BAU scenario, and are slightly different for each of the scenarios. This is due to the fact that some technologies have a higher fixed cost vs. operational cost ratio than others (i.e. a heat pump with high upfront costs but low running costs vs. electric baseboard heating with its lower upfront cost, but much higher running costs). In scenarios where energy efficiency takes place, there are less kWhs to spread the fixed costs can over, and therefore on a per kWh basis, technologies with high upfront costs become slightly more expensive relative to technologies with low upfront costs.

[7] Seen from the end-user perspective, electricity costs from CHP plants are modelled as though they were the same as from BC Hydro, with the cost variation taking place on the heat side, and therefore the electricity prices from CHP are not included in the graph.

of local renewable energy. As illustrated below, these can serve as stand-alone or combined strategies for improving resilience.

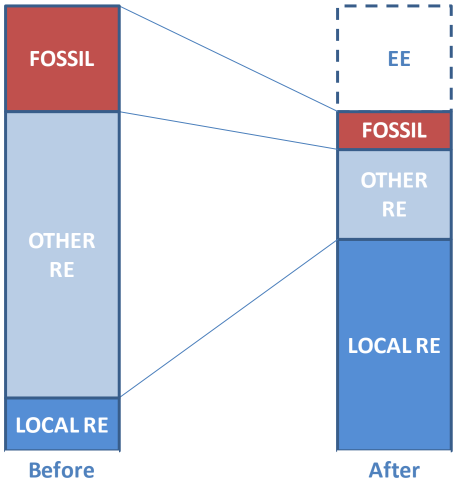


Figure 24: Illustration of how reducing energy use from fossil fuel based sources, and/or via increasing local RE production can increase resiliency, i.e. the ratio of local RE production relative to total demand.

Energy conservation

With respect to energy conservation, it is worth noting that roughly 60% of residential units in the CVRD today are heated via electric baseboard heating. While electricity has traditionally been a cheap and abundant resource in British Columbia, from an energy standpoint, baseboard heating is an inefficient use of a high value product. A conversion of these baseboard units to, for example, heat pumps would reduce the electricity consumption of these customers from somewhere between a half to a third of their current demand. Meanwhile, because roughly 2/3 of the heating provided from the heat pump comes from the local environment, this would at the same time increase the share of locally produced RE. This dual benefit is an example of the interplay between conservation and increased local RE production, as converting to a more efficient heat delivery system would also reduce the amount of investment in local electricity production in order for the CVRD to meet its long-term energy resilience targets.

Local RE production

With regards to local RE production, three available options include:

1. Building integrated renewable energy production (i.e. heat pumps, wood pellet stoves, solar PV, etc.)
2. Stand-alone renewable energy production (i.e. wind or small-scale hydro)
3. Renewable resource-based district heating (i.e. wood chips).

The technical aspects of each of these categories are described in greater detail in report 3 'Analysis of Potentially Applicable Distributed Energy

Opportunities', where the assumptions underlying current and future cost factors are also detailed.

Modelled scenarios

Based on consultations with the CVRD, four different scenarios were developed and are detailed below. While the models used to explore the scenarios also include inputs for the commercial/industrial and transport sectors, the focus of the scenarios is on the residential sector.

Business-as-usual (BAU) – This scenario depicts a situation where current and anticipated trends, strategies, and policies take shape in the form of certain levels of energy efficiency, building codes, etc. It assumes that the primary heating source for residential dwelling remains unchanged relative to 2010.[8] This scenario provides:

- A picture of what the future may look like given current and anticipated growth trends, strategies, and policies.
- A point of reference for comparison with alternative scenarios.

Increased energy efficiency (EE) – This scenario could be referred to as a 'savings scenario' as it addresses questions such as:

- What cost savings can be achieved through increased energy efficiency alone?
- What fuel and CO_2 reductions can be achieved through energy efficiency improvements alone?

As the model does not have a direct cost for efficiency improvement measures and, like the BAU, assumes that the primary heating sources for residential dwellings will remain unchanged relative to 2010, this scenario will provide a cost savings figure that can then be used to determine whether the savings are enough to warrant the required investment in energy efficiency.

Increased local renewable energy production (RE) – This 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.

[8] This is in reality likely an overly conservative assumption as even under a BAU scenario it could be expected that dwellings change primary heating source, for example from oil furnaces to cheaper alternatives.

Increased energy efficiency plus increased local renewable energy production (EE+RE) – A combination scenario where increased energy efficiency is equal to that of the EE scenario and then “topped up” by increased local renewable energy production, to the point where the overall resilience targets are met. As was the case with the RE scenario, the EE+RE scenario relies primarily on the lowest cost technologies from the technology cost model to meet the targets. However, these are not necessarily the same as those selected in the abovementioned RE scenario, as the energy savings through increased efficiency affects the relative cost of the various energy production technologies. This scenario thus allows for a comparison with the RE scenario to see:

- How much less local RE production is needed if energy efficiency improvements are also undertaken?
- Which technologies become more/less cost-effective when there is greater energy efficiency?

Scenario assumptions

An overview of some of the main assumptions underlying the scenario work is displayed below. A more extensive description of the various assumptions can be found in report 4.

Parameter	BAU	EE	RE	EE+RE
Population growth rates	Growth rates for each admin area till 2020 based on previous 5-10 year average* Growth rates[9] from 2020-2050 for all admin areas of 1.1%**			
Residential unit type	The ratio of residential unit types from today is held nearly constant till 2050.			
Interest rate	An interest rate of 5% is used for private households, and 2% for the CVRD			
Renovations per year	4%	5%	4%	5%
Tear downs per year	2%	2%	2%	2%
Annual improvement in building code	0.5%	2.0%	0.5%	2.0%
Efficiency improvement via renovation	10%	12.5%	10%	12.5%
Reduction in non-heat electricity usage, propane and firewood (per year)	None	0.3% to 2020, 0.6% to 2030, 0.9% to 2040, 1.0% to 2050.	None	0.3% to 2020, 0.6% to 2030, 0.9% to 2040, 1.0% to 2050.

Table 1: Assumptions utilised in the scenarios.

* For the four municipalities, growth up to 2020 is forecasted to continue at an annual average equal to that from 2001-2011. For the nine electoral areas, previous Statistics Canada census figures are only available back to 2006. For the Indian Reserves a rate of 2.5% was used.

** For the Cowichan Tribes, an annual growth rate of 1.5% from 2020 to 2050 is implemented.

[9] In analysing the past population growth statistics it is apparent that growth rates across the respective administrative areas fluctuate a great deal over time, therefore an annual average population growth rate of 1.10% (equal to the CVRD average annual growth rate from 2001-2011) was applied for all 14 administrative areas from 2020 to 2050.

Scenario results

Primary heat source

In the RE and EE+RE scenarios the building stock according to primary heating source is drastically different from the BAU and EE scenarios. Air-to-air heat pumps are the dominant technology, with the remaining dwellings being biomass based in one form or another. In reality one technology may not come to dominate so extensively, but given the assumptions made in the modelled scenarios, air-to-air heat pumps represent the preferred technology, particularly in new dwellings where the dwelling can be designed with ventilation systems in mind.

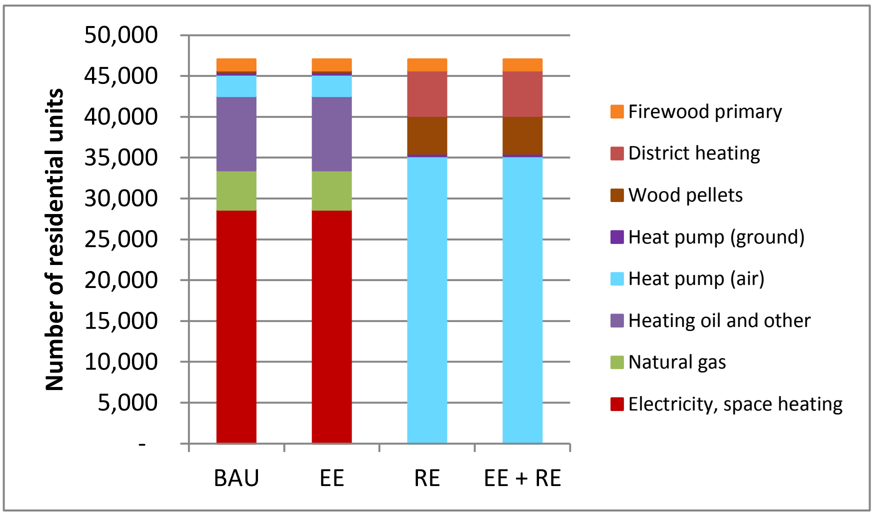


Figure 25: Dispersal of residential units according to primary heating source in 2050 under the four scenarios.

Gross energy consumption

How the dispersal of primary heating units affects the gross energy consumption is highlighted in the RE and EE+RE scenarios in the following figure. Natural gas, heating oil, and a part of electricity to heating are replaced with biomass and local heat pump energy, thus completely eliminating fossil fuels from primary heating, with only residual propane use left. Meanwhile, in the scenarios involving EE, the gross energy consumption of all fuels is reduced considerably.

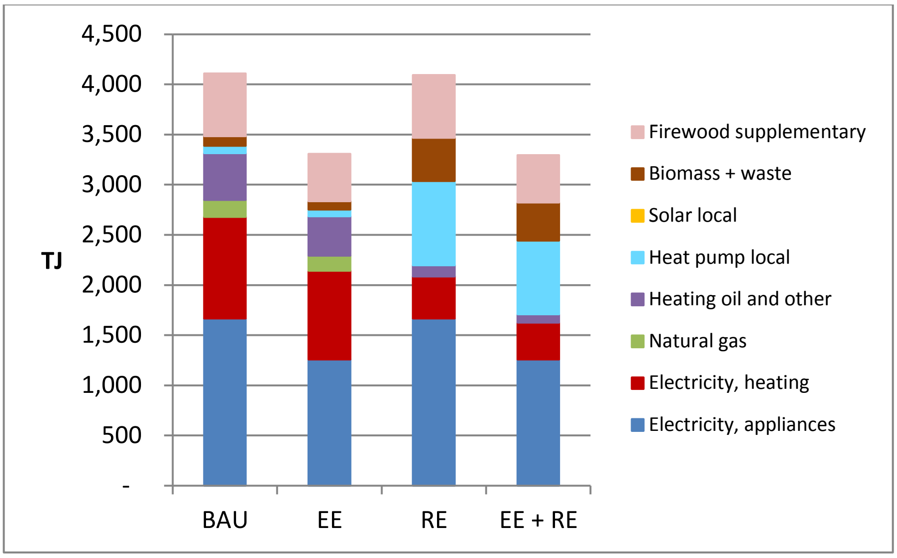


Figure 26: Gross energy consumption in the CVRD residential sector by energy source in 2050 under the four scenarios.

GHGs

Comparing GHG emissions in 2050 under the four scenarios illustrates the fact that the largest reductions are made when fuels with high CO_2 intensities (heating oil and natural gas) are replaced with renewables and/or low CO_2 intensive electricity.

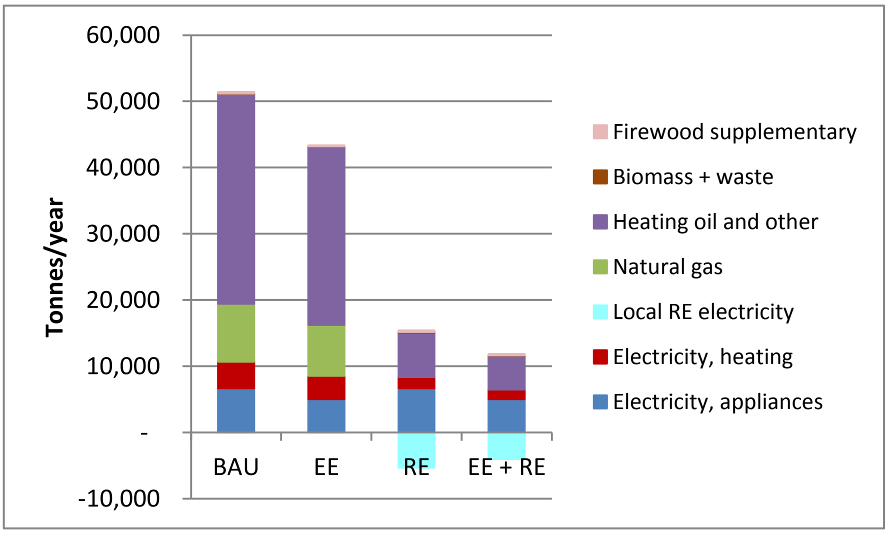


Figure 27: GHG emissions from the CVRD residential sector by source in 2050 under the four scenarios. The electricity that is produced from onshore wind within the CVRD is assumed to be carbon neutral. Meanwhile, the electricity that this replaces from BC Hydro has a small CO_2 content, which in 2050 is 14.4 g CO_2/kWh. These CO_2 savings are represented by the light blue portion in the figure.

Once heating oil and natural gas are replaced, increased efficiency does not result in large CO_2 savings. However, this is in large part due to the very low CO_2 intensity of electricity utilised in the calculations. If a higher figure were used reflecting the marginal CO_2 intensity, then EE would bring about greater

GHG emission savings. The emission development up to 2050 is displayed below.

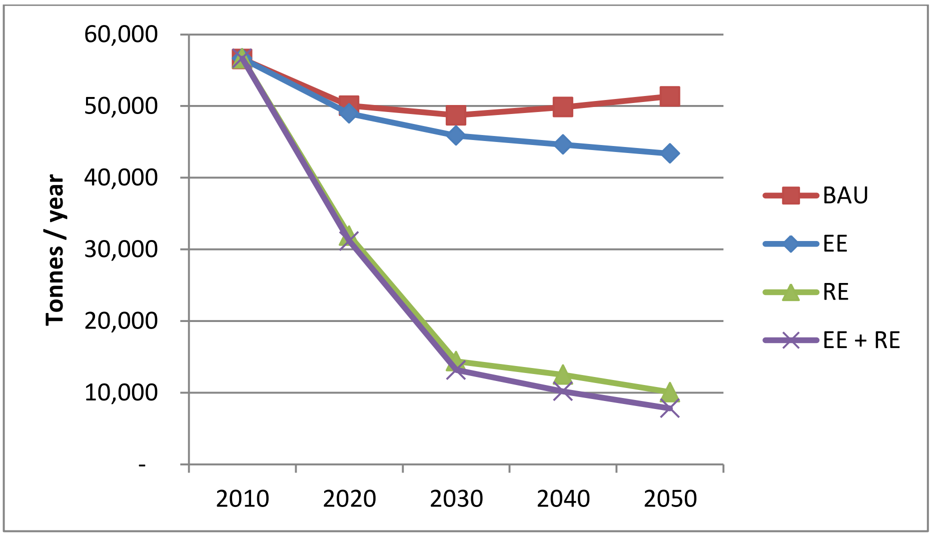


Figure 28: Residential GHG emissions in the CVRD under the four scenarios.

Costs

Relative to the BAU scenario, the EE+RE scenario in 2050 has annual residential sector costs that are 63.5 million CAD lower, or roughly 1,350 CAD/household. It is important to note that the cost savings related to efficiency improvements were brought about 'for free', and the cost of implementing these policies would have to be subtracted from this total. However, when we look at the RE scenario alone, we see that the majority of savings from the EE+RE scenario compared to the BAU scenario are brought about by shifting over to RE technologies, and the cost of implementing these fuel shifts are fully accounted for. This highlights the fact that there is an significant opportunity for local investment that will result in substantial savings over time.

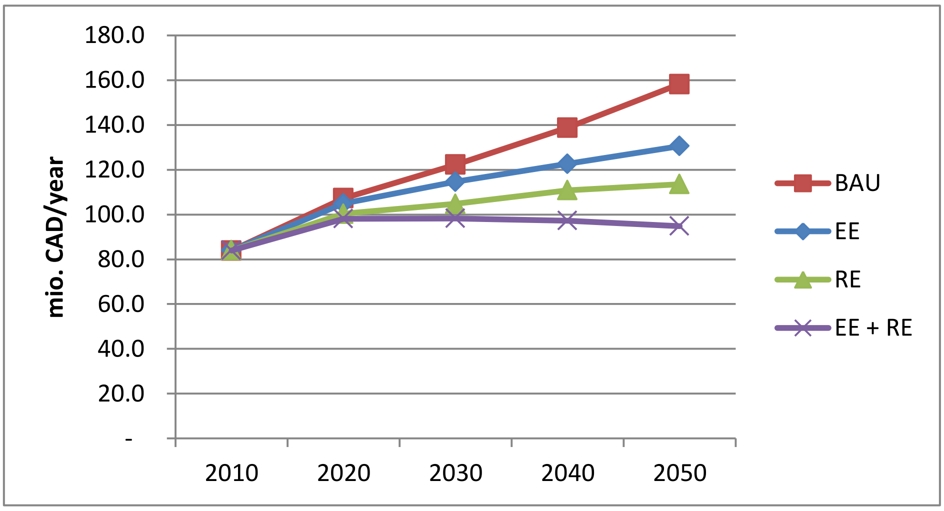


Figure 29: Total energy costs for the residential sector under the four scenarios.

Energy resiliency

In the RE and EE+RE scenarios the 75% energy resiliency target is met, but thanks to reductions in end-user consumption, the total amount of RE electricity production from within the CVRD that is required to meet this target is reduced by nearly 25%.

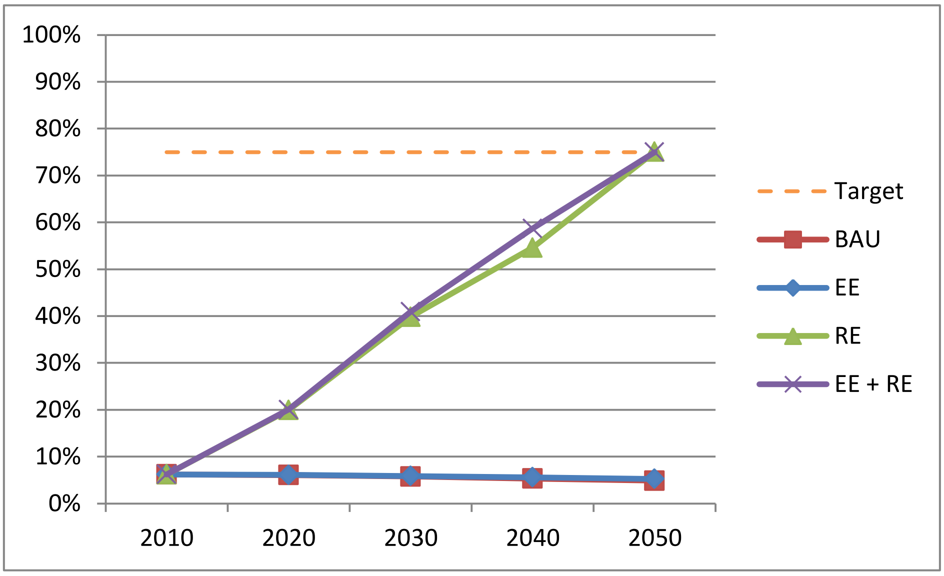


Figure 30: Energy resiliency in the CVRD residential sector in the four scenarios.

Additional targets

In addition to the overarching energy resiliency target, each scenario has been assessed with regards to additional sub-targets listed below:

- 95% renewable energy use by the residential sector by 2030.[10]
- 75% reduction in residential GHGs in 2030 relative to 2010.
- A new home in 2030 is twice as efficient as a new home in 2010.

The results of this assessment are presented in Table 2. Only the RE and EE+RE scenarios meet the 95% renewable energy use target. The BAU scenario shows first a slight increase and then a larger decrease in GHG reductions relative to 2010. The RE and EE+RE scenarios on the other hand show a significant improvement – as expected. In the EE and EE+RE scenarios energy usage of new homes in 2030 relative to new homes in 2010 improves by over 30%, whereas new homes in 2030 in the BAU and RE scenarios improve by less than 10%.

[10] There may still be some secondary and luxury fossil fuel use, for example propane, natural gas, etc. for heating of warm water, fireplaces, barbeques, etc.

Target	BAU	EE	RE	EE+RE
Renewable energy use in residential sector (%)[11]				
- 2010	76.2%	76.2%	76.2%	76.2%
- 2020	78.9%	78.9%	88.3%	88.3%
- **2030 (95%)**	**80.5%**	**80.3%**	**96.9%**	**97.0%**
- 2040	81.2%	80.6%	96.9%	97.0%
- 2050	81.7%	80.8%	96.8%	97.0%
Reduction in residential GHGs relative to 2010 (%):				
- 2020	12%	14%	44%	45%
- **2030 (75%)**	**14%**	**19%**	**75%**	**77%**
- 2040	12%	21%	78%	82%
- 2050	9%	23%	82%	86%
Energy usage of new homes relative to 2010 (%):				
- 2020	95.1%	82.0%	95.1%	82.0%
- **2030 (50%)**	**90.5%**	**67.3%**	**90.5%**	**67.3%**
- 2040	86.1%	55.2%	86.1%	55.2%
- 2050	81.9%	**45.3%**	81.9%	**45.3%**

Table 2: Statistics regarding additional CVRD sub-targets under the various scenarios. Red figures indicate targets met, while blue indicates target met in a later year.

[11] It is assumed that all electricity comes from RE sources. In 2010 a slight portion of BC electricity does not come from RE sources. Secondary firewood is not included in these calculations.

5 Main findings

EE scenario

The EE scenario shows that energy efficiency efforts alone can contribute to moderate GHG emission reductions. Relative to the BAU scenario, these efforts also result in lower direct energy costs. Further analysis regarding the cost of implementing energy efficiency is required to quantify the net value of investing in these efforts.

With respect to energy resiliency, within this study it is measured as the % of local consumption that is covered by local RE production. As such, energy efficiency alone does very little to increase overall energy resiliency because energy efficiency does not result in fuel and technology shifting.

It is recommended to investigate the cost and feasibility of measures that directly or indirectly lead to:

- Accelerating the renovation rate,
- Requiring efficiency improvements during renovations,
- Requiring energy efficiency upgrades at sale,
- Reporting of home energy efficiency on BC Assessment reports,
- More stringent building codes for new buildings, and
- Reduced supplementary electricity, propane, and natural gas usage.

The CVRD and its administrative areas are best suited to determine the most feasible options for implementing these measures, but potential measures include building codes, information campaigns to inform residents about potential cost outlays and savings, subsidies for renovation work, and zoning regulation with renovation requirements.

RE scenario

The RE scenario is more predicated on market prices, as it is primarily the lowest cost options that are implemented. It is assumed that end-users shift technologies because it is in their financial best interest to do so. There can be substantial capital costs included in these transformations, and as such these changes will not occur overnight, but instead over a running period as heating systems near the end of their product lifetime. If future heating technology options are considered when building new homes and/or undertaking renovations, then the capital costs related to a technology conversion can be greatly reduced. A prime example is air-to-air heat pumps, where a conversion to this technology is considerably less expensive if ducts are already in place.

As such, an additional recommendation is to look into a requirement that new developments must be heat pump ready.

In addition to lack of public awareness regarding the total lifecycle cost of a heating technology, end-users can also be deterred from overall lower costs options due to high upfront costs. Potential tools to deal with these challenges could be information campaigns regarding the expected total life-cycle costs of various technologies, as well as providing information and perhaps assistance for homeowners regarding financing options. This is particularly of interest given the larger community wide savings accrued.

EE+RE scenario

In the combined EE+RE scenario, the reduced energy consumption results in technologies becoming more expensive on a per kWh basis (there is less consumption over which to spread the capital costs). This is particularly a problem for capital-intensive heating technologies (for example district heating), and as such selecting a heat technology should not only be based on current heat demand figures, but also consider the future demand expectations.

Conversely, it will be important to determine the long term strategy for areas where district heat may be feasible so as not to require either efficiency or energy upgrades which may not be cost effective for the end-user, or detrimental to the overall strategy.

A review of deferred/avoided energy costs from the basis of a business strategy for the region would provide further detail as a potential mechanism to fund future infrastructure.

The focus should be on the technologies that are cost-effective in all three alternative scenarios. For example, despite their relatively high capital costs, air-to-air heat pumps were amongst the cheapest options in all scenarios, due to their high efficiencies, thus illustrating the robustness of this technology given the cost assumptions used.

Big picture

The completed scenario analysis was undertaken for the CVRD alone, however, it is important to keep in mind that the CVRD is part of a larger energy infrastructure that includes the whole of Vancouver Island, the BC mainland, and beyond, and therefore planning decisions should take into account this bigger picture. A perfect example of this in the scenario work was the decision to not select the MSW CHP option in the RE and EE+RE scenarios despite the fact that it was a cheaper alternative. The reason for doing so was that the 'Tri-Regional District Solid Waste Study' had earlier found that a facility serving both the CVRD and the neighbouring CRD and RDN areas would not be optimally placed inside the CVRD (AECOM 2011). This is not to say that the CVRD should not consider the possibility of a MSW plant within its borders (quite the contrary, the CVRD should continue to explore options for its MSW), but a more inter-regional perspective with respect to its optimal placement should be maintained.

It is also important to consider a wider perspective when considering the broader climate effects of changes within the CVRD. For example, reducing the demand for electricity 'imported' from outside the CVRD, either through savings or local RE electricity production, would allow for a greater amount of low CO_2 intensive electricity to be exported from BC to areas that have a higher electricity CO_2 content (Alberta, for example). Seen from a global climate perspective, there is a greater GHG incentive to reduce and/or produce RE electricity locally than is reflected in the current GHG intensity factors for BC electricity.

If the BC policy on emissions and required reductions is strengthened, local governments may be required to not only set targets and action plans, but also reduce community wide emissions. This analysis and mapping provides key information on the strategic policy development that will be necessary to transfer the residential sector. This base also provides a mechanism to develop the cost analysis for any such program that will drive efficiency and energy upgrades.

6 Next steps in the energy planning process

6.1 Concrete projects

District heating

District heating from CHP is one of the options highlighted in the RE and EE+RE scenarios due to its high energy efficiency and flexibility. It is important to highlight the fact that actual prices for district heating are extremely site specific, and vary considerably depending on size of the system, number of connections, etc. It is therefore recommended that the CVRD investigate this option further, keeping in mind:

- How will heat and energy demand evolve over time as increased energy efficiency reduces loads?
- How will MSW resources evolve over time?
- Are there commercial/industrial/institutional end-users that will be large stable users for a long time and can 'anchor' the network?
- What form of price stability and availability of feedstock can be expected?
- Starting with small pilot projects as opposed to an over-dimensioned system is inherently less risky.

In terms of CHP from biomass the CVRD has large amounts of woody biomass that are currently burned off by the forestry industry. Local and global markets for biomass continue to develop, and as such these currently underutilised resources will soon have economic value, primarily as inputs for heat and electricity generation. In the long-term however, biomass will eventually become a scarce resource, and is likely to be used for bio refining, as well as for air, sea and heavy transport in the form of biofuels. Meanwhile, heating and personal transportation will be increasingly become electrified via non-biomass generated RE electricity.

Inspiration regarding the development of a new wood chip plant could be garnered from the new Aakirkeby wood chip power plant that was visited on Bornholm, Denmark.

Wind

Based on the wind resource mapping it appears as though there may be areas with pockets of wind with average annual wind speeds high enough to produce electricity at costs around 8-10 cents/kWh. It is important to note that this is based on an initial screening, and local wind conditions are extremely important in refining these costs. If the CVRD is interested in exploring wind resources, it should first be determined whether it is feasible to erect wind turbines in these areas, whether public acceptance is an issue, and most importantly undertake onsite measurements as part of any (pre-) feasibility study. Another factor to consider is the local transmission systems' ability to integrate wind production, and as such consultation with BC Hydro is of course an important part of any (pre-) feasibility study as well.

6.2 Energy planning process

The data processing, GIS mapping, modelling, and scenario analysis carried out within the realm of this project is just one step in a long procession of energy planning activities and cooperation.

Model upkeep

An important aspect of this process is data and model upkeep. With respect to the scenario models, in order to maximise their value it is recommended that the CVRD ensure that there is capacity in the CVRD to maintain them. The technology cost model is essentially a technology catalogue that, with periodic updating, and when combined with updated BCAA input data in the energy model, can provide a very dynamic picture and basis for future analysis.

With regard to decisions on whether or not to pursue a certain line of action, such as technology investments or policies, this may require further analysis based on a more refined detail of data followed by feasibility studies reflecting site specific conditions.

Figure 31: One step in a long progression of steps.

Discussion of policy portfolio

An example of a next possible step in this planning process could be a preliminary discussion on what policy measures would be relevant for achieving the changes assumed in the modelled alternative energy development scenarios and their individual qualities. (I.e. if large-scale heat pump uptake is to occur, what are the most cost-effective methods available to bring this about?)

Another possible step could be to consider the CVRD in a larger context such as BC or federal level. How do the CVRD's aspirations align with national ambitions and targets? Are there opportunities that can be exploited to gain from being a frontrunner or from pilot testing certain aspects of RE energy alternatives?

Joint energy planning and cooperation

At a Vancouver Island level, it is recommended that the CVRD work towards the creation of a common long-term energy vision or goal, and broaden the approach to include transport. By working across regional boundaries, numerous synergies and economies of scale can be realised, particularly with respect to waste, biomass, wind farms, etc. In terms of optimal electricity and transport infrastructure development such cooperation is vital.

Inspiration here be can be drawn from the BASREC project 'Energy policy strategies of the Baltic Sea Region for the post-Kyoto period' which focused on how synergies and savings can be realised when regions develop joint energy policy (see text box below).

Case Study: Energy Perspectives for the Baltic Sea Region (Post-Kyoto 2011)

Objectives:

- To promote a common energy agenda for the Baltic Sea Region through the involvement of key stakeholders
- To provide a substantial basis for discussion of different energy scenarios for the region based on an analysis of energy data

Process:

- Phase I
  - Review of current energy situation
  - Scenarios for 2030 – Big-tech and Small-tech
- Phase II
  - Detailed scenarios of the electricity markets in the region 2010-2030
- Phase III
  - Follow-up analyses
  - Case studies

Key Findings:

- The targets can be met at reasonable costs
- Potential for more efficient generation and consumption
- Benefits of regional cooperation
  - Interconnectors
  - Electricity markets
  - RE policies and projects
- Stronger targets are possible

Visionary pilot region

Conversion to a fossil fuel-free society requires a dynamic energy system which in turn requires the implementation of technologies such as electric vehicles, smart grids, and smart metering.[12] If BC as a whole is to achieve

[12] With a shift from fossil fuel based heating systems and vehicles to heat pumps and electric vehicles, GHG emissions and energy usage can be reduced, however a substantial shift over to these technologies can potentially lead to congestions in electricity distribution grids. Through the use of smart grids and smart metering it will be possible to manage and/or provide incentives to avoid these congestions (by shifting the load of some devices to another time).

long-term targets of greatly reduced GHG emissions and greater RE penetration this will require that these policies and technologies are first tested on a smaller scale. One of the most important aspects of this testing is how end-users respond, and as such this is something that cannot be simulated but must be field-tested. The CVRD is one of the most progressive regions in BC and could capitalise on this by becoming a pilot region for the demonstration and testing of these various technologies. For example, illustrate how a largely rural area could embrace electric vehicles and develop the necessary infrastructure in such a setting.

Inspiration for such a project could again be drawn from the island of Bornholm which is testing electric vehicles in a small island context and was visited during the study tour (see text box below).

Case Study: Bornholm – a smart grid laboratory (Bornholm 2011)

Denmark has set a nationwide goal of being 100% fossil free by 2050, and a vital link in this plan is the testing of the various technologies, markets, and polices that will be required to make this ambition a reality. The island of Bornholm in Denmark has become a test centre for a number of these technologies and markets, and as such it has acquired substantial funding from both Denmark and the EU.

The Edison project (Electric vehicles in a Distributed and Integrated market using Sustainable energy and Open Networks) used Bornholm as its site for field testing of electric vehicles.

The largest intelligent power grid in the world will be established on Bornholm in the coming years as part of the €21 million EcoGrid EU project. EcoGrid EU Bornholm is a large-scale demonstration of the complete power system.

Of a total of 28,000 consumers on Bornholm, approx. 2,000 residential consumers will participate with flexible demand response to real-time price signals. Installation of smart solutions will allow real-time prices to be presented to consumers and allow them to pre-program their automatic demand-response preferences, e.g. through electricity contracts.

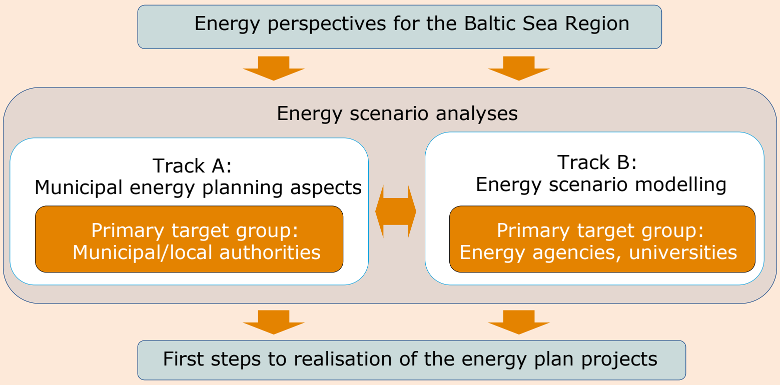
Capacity building

In successfully becoming a pilot region and/or implementing joint energy planning across Vancouver Island and the mainland, overall continuation of energy based capacity building will be critical. Capacity building helps to establish a common understanding between various stakeholders and impart on them the value of undertaking long-term energy planning and scenario analysis. In the Baltic Rotating Energy Planning Academy (BALERPA) for example (see text box below), various stakeholders come together to take part in scenario exercises and the consensus and common understanding created via this capacity building result in scenarios evolving into concrete projects. The CVRD could facilitate a similar project and thereby target stakeholders it wishes to cooperate with going forward.

Case Study: Baltic Rotating Energy Planning Academy (BALREPA 2011)

BALREPA aims to further a macro-regional approach to energy planning in the Baltic Sea Region through joint training activities and formulation of concrete projects. The idea is that each year a new country/region will host an international academy, where authorities, energy companies, universities and NGOs engage in common training and exchange of expertise, which address topical energy planning issues. Key to the academy idea is local involvement and cooperation. The results of the group work are at the end of the training presented to e.g. peers, political decision-makers or the public.

BALREPA is focused on the link between the international, regional and national levels and the local level. This is reflected both in the structure of the actual academies and in this manual. The academy includes two different educational modules; track A and B. Track A is targeted at municipal and local authorities, and focus on municipal energy planning aspects. Track B is targeted at energy agencies and universities, and focuses on energy scenario modelling.



The on-going participation and partnership with Provincial authorities as well as research and ENGO institutions provides the CVRD with a mechanism to stay abreast of emerging issues and partnership opportunities, particularly as a leader and innovator within local government. Additional work with Pacific Climate Impacts Consortium (PCIC) and Local Governments for Sustainability (ICLEI) are two additional ways in which to continue to leverage the work done to date. The CVRD is currently recognised as a leader, and continued work in this area will prove valuable in securing future investments in research and development, as well as other programs.

7 References

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8 Appendices

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 the report.

Aspect	Symbol	Name	Value
<u>Energy quantity</u> 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}
<u>Power</u> 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}
<u>Energy quantity</u> 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}
<u>Conversion factors:</u>	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	