100% Renewable Energy Model for the West Kootenays: Methodology Report

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The West Kootenay EcoSociety compiled this report through research and conversations with the local utilities and experts as part of its 100% Renewable Kootenays initiative in 2017.

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# Table of Contents

1. Introduction .................................................................................................................. 1  
   1.1. About the West Kootenay EcoSociety ................................................................. 1  
   1.2. The West Kootenays ......................................................................................... 1  
   1.3. Purpose ............................................................................................................. 1  
   1.4. The 100% Renewable Energy Approach ......................................................... 2  
2. Planning Environment .................................................................................................. 3  
   2.1. Clean Energy Act ........................................................................................... 3  
   2.2. B.C. Carbon Tax ............................................................................................. 3  
   2.3. Climate Leadership Plan ................................................................................. 3  
3. Methodology ................................................................................................................ 4  
   3.1. Data sources ...................................................................................................... 4  
       3.1.1. Archival sources ....................................................................................... 4  
       3.1.2. Interview data .......................................................................................... 4  
   3.2. Data analysis and calculations ......................................................................... 5  
       3.2.1. Current consumption rates ..................................................................... 5  
       3.2.2. Future Load Forecast ............................................................................ 10  
       3.2.3. Current Power generation ..................................................................... 11  
   3.3. Energy Modelling ............................................................................................. 12  
   3.4. Limitations ........................................................................................................ 13  
4. Current consumption ................................................................................................... 13  
5. Long term load forecast and future demand ............................................................... 16  
   5.1. Electricity ......................................................................................................... 16  
   5.2. Heating ............................................................................................................ 16  
   5.3. Transportation .................................................................................................. 17  
6. Supply-demand balance ............................................................................................ 19  
   6.1. Resources included in the study ....................................................................... 19  
       6.1.1. Solar energy ............................................................................................... 19  
       6.1.2. Renewable natural gas ............................................................................ 20  
       6.1.3. Biomass .................................................................................................... 21  
   6.2. Resources excluded from the study ................................................................. 21  
       6.2.1. River hydro and micro hydro ................................................................. 22  
       6.2.2. Wind ......................................................................................................... 22  
       6.2.3. Geothermal ............................................................................................... 22  
7. Planning strategy - Prioritization of energy production .............................................. 23  
8. Modelling Result – Projected energy mix .................................................................. 23  
9. Conclusion ................................................................................................................... 24  
Bibliography .................................................................................................................... 25  
Appendix 1 ....................................................................................................................... 26  
Appendix 2 ....................................................................................................................... 27
1. Introduction

1.1. About the West Kootenay EcoSociety

Founded in 1994, the West Kootenay EcoSociety (EcoSociety) is a non-profit, community-driven organization. The EcoSociety works to bring local residents together to protect the natural environment while building just, equitable, healthy, and livable communities in the West Kootenay region. Along with its other community programs like the Nelson Farmers’ Markets, the Kokanee Creek Nature Centre, and Kootenay Rideshare, the EcoSociety is organizing a 100% Renewable Kootenays initiative (the Initiative).

The Initiative's ultimate goal is to phase-out fossil fuels by transitioning to 100% renewable energy by 2050 in West Kootenay communities, in order to do our part to address the climate crisis, while building strong communities and creating green jobs. This transition must take place at the community energy level, including electricity, heating and cooling, and transportation. By transitioning to 100% renewable energy, we can mitigate the impacts of climate change, such as drought, flooding and other extreme weather events.

This transition must also support vulnerable people from low-income environments and with limited abilities, ensure Indigenous owned justice and reconciliation for Indigenous Peoples, and provide training to workers from the fossil fuel industry to transition to long term green jobs.

1.2. The West Kootenays

The West Kootenay region is not an official administrative entity, so definition of the included communities is needed. For the purpose of this report and the EcoSociety’s 100% Renewable Kootenays initiative, the West Kootenays consists of the whole Regional District of Central Kootenay, plus Area A and B from the Regional District of Kootenay Boundary, as well as the municipalities of Rossland, Trail, Fruitvale, Montrose and Warfield.

The list of included communities can be seen in Appendix 1.

1.3. Purpose

This study investigates the possibility of designing an alternative energy system based on 100% renewable resources with the help of the EnergyPLAN modelling tool. The report was created to provide information to residents and decision-makers in the West Kootenays in order to determine the region’s starting point for transitioning
to 100% renewable energy. This transition includes the electricity, heating and cooling, and transportation sectors. This report presents the current energy need of the region and introduces a proposed 100% renewable energy scenario for the year 2050.

It is important to emphasize that the proposed scenario is not the only possible solution, but one of many. An extensive study, with access to more accurate data about current loads and other renewable resource potentials, would be beneficial in creating a more diverse (and thereby robust) renewable energy portfolio. In considering the current limitations to accurate data, the EcoSociety believes that the following proposed solution is both viable and achievable.

1.4. The 100% Renewable Energy Approach

Our current fossil fuel-based industry and energy system has led to multiple convergent crises including climate change, air and water pollution, ocean acidification, the threat of mass extinction, water and food shortages, and geopolitical tension. However, the world’s climate and energy security issues are not caused by energy, but rather by the fuel we are using.

By replacing polluting energy resources, we would not just mitigate the impacts of climate change, but would create new environmentally viable jobs worldwide, ensuring a sustainable future for humanity.

As seen in examples across Western Europe and North America, renewable resources should be the frontrunner of this 100% transition approach. For example, in Oslo, Norway the objective is to go 100% renewable energy in public transportation and heating by 2020 and 100% carbon neutral by 2050. In Denmark, the target is to meet 100% of electricity and heating needs with renewable energy sources by 2035 and phase out fossil fuel use entirely in all energy sectors (including transportation) by 2050. [1] We can also find three examples in Canada as the City of Vancouver, City of Victoria, and Oxford County have adopted 100% renewable targets.

Clear leadership from the provincial government, local government, and the energy industry will be required in order to take advantage of the potential of renewable energy and the many benefits that these cleaner energy options offer. A 100% renewable energy transition doesn’t happen from one day to another, but by working together, we can achieve a clean energy future by 2050.

Renewable energy systems need to be designed based on the renewable and sustainable resources available in each community. Which renewable energy sources should be used, and to what extent, is not only a technological concern, but also a basis for domestic debate. Together, politicians, local stakeholders and citizens need to deliberate and discuss what sort of renewable energy development is desirable for all, taking equally into account environmental, social, and economic perspectives.
2. Planning Environment

The planning environment includes relevant external factors that can impact the planning procedure such as policies, regulations, and laws.

B.C.’s regulatory framework\(^1\) includes several climate change policies such as the *Carbon Tax Act* and the *Clean Energy Act (CEA)*. Since introducing the *CEA* in 2010, B.C.’s energy policies have been largely directed towards a low carbon energy future. In August 2016, the Government of B.C. released the *Climate Leadership Plan* which specifies several action items to reduce GHG (greenhouse gas) emissions while promoting development and creating jobs.

2.1. Clean Energy Act

“The act introduces 16 specific energy objectives by expediting clean energy investments, protecting B.C. ratepayers, ensuring competitive rates, encouraging conservation, strengthening environmental protection and aggressively promoting regional job creation and First Nations’ involvement in clean electricity development opportunities.” [2] Among others, the 16 objectives include energy conservation, GHG emission measures and a 93% renewable electricity generation goal.

2.2. B.C. Carbon Tax

In 2008 the Government of British Columbia enacted the *Carbon Tax Act*. The tax rate was initially $10 per ton of carbon dioxide equivalent, reaching $30 per ton in 2012. In September 2016, the Canadian Government released a new plan to implement a national price on carbon, starting in 2018. According to this plan, the price will reach $50 per ton by 2022, which means that B.C.’s carbon tax is expected to increase above its current level by 2021.

2.3. Climate Leadership Plan

In August 2016, the Government of B.C. announced the *Climate Leadership Plan (CLP)* with 21 action items intended to help the Province reach its target of an 80 percent reduction in GHG emissions from 2007 levels by 2050. The Plan recommends that 100% of B.C.’s electricity generation should be clean or renewable by 2025. It also supports zero-emission vehicle charging stations in buildings and the expansion of the Clean Energy Vehicle program to support new vehicle incentives and infrastructure.

\(^1\) The established system of regulations, instituted by a government.
100% Renewable Energy Model for the West Kootenays

The Plan also promotes the development of net zero buildings, including accelerating increased energy requirements in the B.C. Building Code by taking steps to make buildings ready to be net zero by 2032. The CLP urges forest replanting and wood fiber recovery in B.C., which may increase the future availability of wood fiber as biomass fuel in the future that could be used for power generation [3].

There are several renewable energy and carbon pollution reduction programs in the region, which are introduced extensively in the EcoSociety’s West Kootenay Community Energy & Infrastructure Report.

3. Methodology

In the following, the methods applied in the study are introduced including data sources, data analyses and calculations, and the limitations of the study.

3.1. Data sources

During the research, written (archival) documents and personal interviews were used as data resources. Generally, the availability of data was an issue during the study, which will be addressed later in the report.

3.1.1. Archival sources

During the research, different governmental and utility reports were used. These are the Community Energy and Emissions Inventory (CEEI) from the province of British Columbia, FortisBC Electric’s 2016 Long Term Electric Resource Plan and 2016 Long Term Demand Side Management Plan, FortisBC Natural Gas’ 2014 Long Term Resource Plan (natural gas resource plan). Additionally, Nelson Hydro provided aggregated consumption and production data from its service territory.

3.1.2. Interview data

During the data collection, eight meetings were conducted with the local utilities\(^2\) and energy experts. The list of interviews can be found in Appendix 2.

The meetings were used to gather the best information available about current energy consumptions, future energy demand forecasts, available renewable resources, and diverse perspectives about EcoSociety’s 100% renewable energy approach.

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\(^2\) In the region, there are 3 electricity utility providers, FortisBC Electric, BC Hydro and Nelson Hydro; FortisBC Gas is the only natural gas provider.
3.2. Data analysis and calculations

After analyzing the available data, the most appropriate data was selected. This is explained in detail in the following section with a breakdown of the calculations and assumptions.

3.2.1. Current consumption rates

The first step of the energy modelling was the determination of current energy demands. After evaluation of the accessible consumption data, the decision was made that because of the lack of sufficient industrial electricity and heating consumption data, only residential and commercial loads would be included in the study together with the region’s transportation energy needs.

The aim of the study is to satisfy the region’s energy demand with renewable energy. Since most of the renewable resources are intermittent in nature (i.e. they depend on different weather phenomena and can only generate according to availability of wind, sun, etc.), an hourly demand-supply balance is needed to model a 100% renewable energy approach. In other words, the hourly energy production must fit the hourly energy demand throughout the year.

3.2.1.1. Yearly consumption

Even though the latest Community Energy and Emissions Inventory (CEEI) is only from 2012, it is the most consistent and reliable source of data.

In the CEEI, the yearly aggregated consumptions of different divisions – buildings, transportation, solid waste - are reported, separated out by their different energy sources such as electricity, natural gas, gasoline, etc. Due to confidentiality reasons, the consumption data of the commercial sector is not accurate, so only residential sector data is used in this study. The transportation data was collected by the Community Energy Association and was also available from 2012.

Because electricity generation data and the future consumption forecasts were available from 2015, the decision was made that 2015 will be the base year of the analysis. This means that it was necessary to calculate current consumption data for this year. Using the 2012 CEEI data, the natural gas and electricity consumption was forecasted to 2015. A similar calculation was made to define the yearly energy need in the transportation sector.

It is to be noted that although natural gas consumption doesn’t cover all of the heating demand as electric heaters are also commonly used in the region, for simplification of
the report, natural gas consumption is presumed to equal the heating demand. This does not affect the energy model and is only for the purposes of the report.  

To define commercial energy uses, reports from the three utilities were used. The residential/commercial electricity consumption ratio of the three utilities are as follows: FortisBC – 1.52 [3], BC Hydro – 2.78 [4] and Nelson Hydro – 1.75. Weighting these values based on the number of the utilities’ consumers, the average residential/commercial ratio of the region was calculated as 2.0. This means that the residential electricity use is 2 times that of the commercial use.

Similarly, the commercial natural gas use was defined based on FortisBC’s report on natural gas use, where the residential/commercial ratio is 1.36 [5].

With these values, the yearly electricity, natural gas and transportation energy needs of both the residential and commercial sector were forecasted to the base year of 2015.

---

3 This conceptual distortion won’t lead to mistakes in the result, as the aim of the study is to summarize all of the current energy uses and the electrical heating segment is calculated as part of the electricity load.

4 The data applies for FortisBC’s whole service area
3.2.1.2. Hourly distribution

As it was explained above, yearly consumption data is not adequate enough in the case of modelling a renewable energy system. The determination of an hourly distribution was necessary to model the energy scenario.

From Nelson Hydro, aggregated monthly consumption data was available from the previous five years. Working with the assumption that electricity consumption in the Nelson Hydro territory is similar to that of the West Kootenay region, a region-specific electricity load pattern was made (Figure 1).

Nelson Hydro also provided access to aggregated hourly electricity consumption data from a few months of the previous year. With the help of the data provided by Nelson Hydro, the hourly load profile was made for a typical summer and winter month, and can be seen in Figure 2 and Figure 3.
The disparity between the summer and winter months is rooted in the electric heating during the heating period.

With these hourly load patterns, the electricity consumption was calculated for every hour of the year.

Regarding the natural gas consumption, only the yearly CEEI data was available, as the utility was unable to provide more distributed information. The natural gas consumption (heat demand) consists of two parts, the space heating and domestic hot water use. The hot water demand was defined as 10% of the heat demand, while the space heating as 90%.

The hourly space heating consumptions were calculated with the help of the Heating Degree Day (HDD) model. Space heating needs are governed by the outside temperature, as when it is colder outside, more energy is needed to heat up the rooms to a comfortable temperature.
Using the HDD model, the number of hours was determined where the outside temperature was lower than the temperature needed inside the houses to provide a comfortable ambient temperature. The base temperature for heating degree days was set to 18 °C, while the designated heating period starts on October 1st and ends on April 30th. Between these two dates, the hours must be determined and counted when the outside temperature is lower than the base temperature and when heat has to be supplied. One heating degree hour means one hour when the outside temperature is 1 °C lower than the base temperature.

\[ HDD = \sum T_{\text{base}} - T_o \]

Where \( T_{\text{base}} \) means the base temperature and \( T_o \) indicates the outside temperature.

From EnergyPRO software, local weather data was available, so the heating degree hours were possible to calculate for every hour of the year. Space heating demand makes up 90% of the natural gas consumption, so this portion of the aggregated yearly consumption was distributed based on the HDDs.

The domestic hot water is the other part of the heating demand, which is responsible for 10% of the natural gas consumption. The monthly/seasonal consumption is considered constant, while alteration during the day can be seen in the following Figure 4.

![Figure 4: Hot water pattern](image-url)
100% Renewable Energy Model for the West Kootenays

Using this hot water consumption pattern, the hourly hot water demand was calculated.

Hourly demand cannot be defined in the transportation sector, as the majority of vehicles are equipped with internal combustion engines and the refilling of the vehicles is happening at individual gas stations, not from an energy grid. Hourly demand will need to be calculated for 2050 as the transportation sector is fully electrified in the proposed scenario.

3.2.2. Future Load Forecast

Of the three sectors (electricity, heating, and transportation), the only forecasts available for the region are for electricity consumption growth and electricity savings. FortisBC is expecting a 0.8% annual residential growth rate and a 1.6% annual commercial growth rate in their service territory in the upcoming years [3]. Although their service territory is not wholly within the West Kootenay region, it is comparable and so this value was used in the modelling.

The Navigant Consulting company prepared the British Columbia Conservation Potential Review for FortisBC where electricity saving potential was examined. Figure 5 shows Navigant’s forecast about electricity saving in the future.

![Figure 5: Electric Energy Economic Savings Potential by Sector as a Percent of Sector Consumption](source: Navigant)

The forecast was made until 2035, and if this trend continues until 2050, a 25% savings can be reached in the residential sector and a 30% savings in the commercial sector.

Considering developments in energy efficiency, better quality insulation and the changes in the Province’s Building Code, the heating demand – and consequently the natural gas consumption – is expected to decrease in the future. Although this
100% Renewable Energy Model for the West Kootenays

Reduction in heating demand is expected, for the purposes of this model, the heating needs from burning natural gas were kept constant due to the lack of forecast data regarding heating demand reductions.

Similarly, no forecasts are available for the transportation sector, so it is assumed that the transportation energy demands will remain constant through to 2050. This is unlikely to be the case, but this energy modelling project is limited by the availability of accurate data.

With the help of the previously described forecasts, the hourly energy need was calculated for 2050 with electricity demands changing while transportation and heating (i.e. natural gas) demands remained constant.

3.2.3. Current Power generation

As the aim of the project is to supply 100% of the needed energy from renewable resources, determination of the current energy generation is needed. This is important to identify which parts of the energy mix are already renewable and which resources will need to be transitioned in the future. Using natural gas for heating and burning transportation fuel is not a renewable solution, consequently their production share will need to be displaced with renewable energy options.

Tracking down the origin of electricity is usually not possible in a highly interconnected system like our electricity system. You cannot be sure where the used electron is coming from. This is especially true in the case of the West Kootenay region, where a large share of BC’s river hydro production is occurring, but the locally produced electricity is not used solely within the region. The locally produced hydroelectricity would be able to cover the regional needs, but because of export, other, non-renewable resources are also used in the region. Table 1 shows the list of hydroelectric generation sites in the region.

<table>
<thead>
<tr>
<th>Name</th>
<th>Generation Capacity [MW]</th>
<th>Owner</th>
<th>Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corra Linn Dam</td>
<td>51</td>
<td>Fortis BC</td>
<td>Fortis BC</td>
</tr>
<tr>
<td>City of Nelson Powerplant</td>
<td>16</td>
<td>Nelson Hydro</td>
<td>Nelson Hydro</td>
</tr>
<tr>
<td>Upper Bonnington Dam</td>
<td>66</td>
<td>Fortis BC</td>
<td>Fortis BC</td>
</tr>
<tr>
<td>Lower Bonnington Dam</td>
<td>54</td>
<td>Fortis BC</td>
<td>Fortis BC</td>
</tr>
<tr>
<td>South Slocan Dam</td>
<td>54</td>
<td>Fortis BC</td>
<td>Fortis BC</td>
</tr>
<tr>
<td>Kootenay Canal Dam</td>
<td>580</td>
<td>BC Hydro</td>
<td>BC Hydro</td>
</tr>
<tr>
<td>Brilliant Dam</td>
<td>145</td>
<td>Columbia Basin Trust and Columbia Power Corporation</td>
<td>Fortis BC</td>
</tr>
<tr>
<td>Brilliant expansion</td>
<td>120</td>
<td>Columbia Basin Trust and Columbia Power Corporation</td>
<td>Fortis BC</td>
</tr>
<tr>
<td>Waneta damn</td>
<td>450</td>
<td>Teck Resources, Fortis Inc and BC Hydro</td>
<td>Fortis BC</td>
</tr>
<tr>
<td>Waneta expansion</td>
<td>395</td>
<td>Fortis Inc [51%], Columbia Power [32.5%], Columbia Basin Trust [16.5%]</td>
<td>Fortis BC</td>
</tr>
<tr>
<td>Arrow Lakes Generating Station</td>
<td>185</td>
<td>Columbia Power Corporation</td>
<td>Fortis BC</td>
</tr>
</tbody>
</table>

| Table 1: River hydro generation in the West Kootenays |

BC Hydro and FortisBC were not able to provide hourly or monthly generation data, but the annual share of renewable resources in their generation profile was available.
Data was available from the 3 utilities for their current renewable share in the electricity generation and a total share was calculated as 97%. The utilities’ share can be seen in Table 2 [7], [8], [9].

<table>
<thead>
<tr>
<th>Renewable generation share</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FortisBC</td>
<td>95.8%</td>
</tr>
<tr>
<td>BC Hydro</td>
<td>98.0%</td>
</tr>
<tr>
<td>Nelson Hydro</td>
<td>100.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>97.0%</strong></td>
</tr>
</tbody>
</table>

*Table 2: Renewable electricity share in the West Kootenays*

Due to the unavailability of data, the assumption was made that the renewable generation share remains constant at 97% for every hour of the year while following the electricity consumption and that the production is expected to stay the same until 2050.

### 3.3. Energy Modelling

With the hourly energy demand data and the locally available renewable resources, an hourly supply-demand model was made using EnergyPLAN software. EnergyPLAN is developed by the Sustainable Energy Planning research group in Denmark and has been used several times during the development of national or regional energy planning strategies in Europe (e.g. Smart Energy Denmark and Smart Energy Europe).

This energy modelling project used the EnergyPLAN software as a tool to analyze energy systems with a high share of renewable energy and fluctuating production. The software has been used to simulate large energy systems that include heating, cooling, electricity, transport, and industry on an hourly basis [10], so it was deemed a good fit for this project.

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5 This assumption does not mirror the reality because of the river hydro production’s seasonal nature, but without any relevant data, is still considered as the best possible way to estimate the generation.
3.4. Limitations

During the study, there were different limiting factors which influenced the result of the project.

The most significant factor in generating the energy model was the accessibility of data for energy consumption, production and renewable resource potential in the region. In some cases, complex agreements between multiple utilities regarding water licenses made it challenging to determine the energy production of a dam. In other cases, privacy concerns limited the availability of region specific consumption data.

Additional notable factors were the available funding and time constraints with regards to completing the project. The West Kootenay EcoSociety is a non-profit organization that relies on grants, membership fees and donations for its operations. It is recommended that this work act as a foundation on which to further refine the energy model in the future as data becomes more readily available and funding is available to complete the work.

4. Current consumption

The first step of designing an energy system is the identification of the base year demand (current demand). The current energy demand of the residential and commercial sector is added up from the electricity and natural gas use. Electricity is also used for space heating and domestic hot water heating, but the proportion of these uses was not available during the research. It is recognized that there are other heating solutions aside from electrical and natural gas such as burning heating oil and wood, but this was not included in the analysis due to inadequate data.

As it was explained in Section 3, the CEEI data was available for residential buildings from 2012, so a base calculation was needed to define the consumption in 2015 for the West Kootenay region. The consumption data for 2012 and 2015 can be seen in Table 3. The total residential electricity consumption in 2015 is calculated to be 0.505 TWh, while the natural gas consumption is 0.323 TWh.

---

6 There is no need to differentiate between the different type of electricity uses, as the aim of the study is to summarize all of the current energy use and try to fulfill all of the future demand with clean or renewable energy.

7 1 TWh is equal to 1 million MWh or 1000 million kWh. An average household consumes 12-14 MWh electricity during a year in the region.
Table 3: Community Annual Consumption Rates

<table>
<thead>
<tr>
<th>Location</th>
<th>Energy consumption 2012</th>
<th>Consumption change</th>
<th>Calculated Energy consumption 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Castlegar</td>
<td>37 384 571</td>
<td>159 414</td>
<td>-0.25%</td>
</tr>
<tr>
<td>Creston</td>
<td>22 911 261</td>
<td>111 548</td>
<td>0.39%</td>
</tr>
<tr>
<td>Trail</td>
<td>10 364 600</td>
<td>38 072</td>
<td>-1.00%</td>
</tr>
<tr>
<td>Kaslo</td>
<td>8 142 363</td>
<td>No natural gas service</td>
<td>-1.86%</td>
</tr>
<tr>
<td>Montrose</td>
<td>5 275 795</td>
<td>22 214</td>
<td>0.59%</td>
</tr>
<tr>
<td>Nakusp</td>
<td>12 022 000</td>
<td>No natural gas service</td>
<td>-0.18%</td>
</tr>
<tr>
<td>Nelson</td>
<td>46 300 000</td>
<td>233 086</td>
<td>0.91%</td>
</tr>
<tr>
<td>New Denver</td>
<td>4 089 000</td>
<td>No natural gas service</td>
<td>-0.50%</td>
</tr>
<tr>
<td>Rossland</td>
<td>19 655 414</td>
<td>98 201</td>
<td>0.38%</td>
</tr>
<tr>
<td>Salmo</td>
<td>7 437 811</td>
<td>22 016</td>
<td>-0.46%</td>
</tr>
<tr>
<td>Silverton</td>
<td>1 873 000</td>
<td>No natural gas service</td>
<td>0.05%</td>
</tr>
<tr>
<td>Slocan</td>
<td>2 878 214</td>
<td>No natural gas service</td>
<td>-2.20%</td>
</tr>
<tr>
<td>Trail</td>
<td>38 197 162</td>
<td>195 140</td>
<td>-0.75%</td>
</tr>
<tr>
<td>Warfield</td>
<td>8 604 998</td>
<td>44 893</td>
<td>-1.19%</td>
</tr>
<tr>
<td>CK unincorporated</td>
<td>249 686 623</td>
<td>245 150</td>
<td>0.11%</td>
</tr>
<tr>
<td>KB unincorporated in the West</td>
<td>34 834 283</td>
<td>36 970</td>
<td>-0.48%</td>
</tr>
<tr>
<td>Kootenay area</td>
<td>510 255 095</td>
<td>1 206 704</td>
<td>0.12%</td>
</tr>
</tbody>
</table>

Table 3: Community Annual Consumption Rates

The commercial electricity and natural gas energy demand was calculated using the residential/commercial ratio, 0.252 TWh and 0.238 TWh respectively. The calculated base year electricity need is the total of the residential and commercial needs, 0.758 TWh, while the aggregated natural gas demand is 0.561 TWh.

Similarly, the aggregated transportation energy need is calculated based on the CEEI data. Because the inventory is not available in every year for every community, trends cannot be determined. Consequently, the assumption was made that the transportation need didn’t change between 2012 and 2015. The base year demand is 1.22 TWh and can be seen in Table 4.

Table 4: Yearly energy need in the transportation sector

<table>
<thead>
<tr>
<th>2012=2015</th>
<th>Current transportation energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cars</td>
<td>Yearly (GJ)</td>
</tr>
<tr>
<td>Central Kootenay Regional District</td>
<td>43 923</td>
</tr>
<tr>
<td>Kootenay Boundary Regional District (Area A &amp; Area B)</td>
<td>7 826</td>
</tr>
<tr>
<td>Total</td>
<td>51 749</td>
</tr>
</tbody>
</table>

The base year energy mix with the distribution between the sectors can be seen in Figure 6.
As explained above, hourly distribution is needed to make an appropriate renewable energy model. With the help of the previously mentioned load profiles, the hourly energy needs were defined using the peak electricity demand, the hour in every year that demands the most electricity, of 143 MWh, and the peak heating demand of 187 MWh. The distribution of the natural gas consumption can be seen in Figure 7.

The peak demand(s) are important during the sizing of the power generation system, because system capacity must be sufficient during the system “peak”.

Figure 6: 2015 energy mix

Figure 7: Hourly natural gas consumption 2015
5. Long term load forecast and future demand

5.1. Electricity

Planning for future needs in any sector of society is a challenging exercise. It is especially true for electricity because changes can occur in consumers’ behavior, available technologies and the regulation framework.

With the help of Fortis BC’s electricity consumption forecast and Navigant’s electricity saving forecast, the hourly residential and commercial demand was calculated for the year 2050. The two forecasts describe contrary processes, which almost balance each other out. While electricity consumption is expected to increase due to factors such as population growth, systems are also expected become more efficient due to factors such as improvements in technology. Taking these two considerations into account, the yearly demand will be 0.809 TWh in 2050 compared to the 0.758 TWh used in 2015.

5.2. Heating

Although heating demand is expected to decrease in the future due to more energy efficient buildings, built according to newer building codes, and retrofit programs [11], forecasts or large-scale energy saving results in the heating sector are not available for the West Kootenay region. Due to the lack of heating demand reduction forecasts, the hourly heating demand in 2050 is assumed to be the same as that of 2015 (0.561 TWh). It is recognized that there is a significant potential in energy saving opportunities, as can be seen in the case of electricity from Navigant’s study. As data becomes available, the model could be further refined to account for these savings. A reduction in heating demand would result in a less challenging energy planning environment, as the requirement for newly introduced renewable energy would decrease with the amount of heating energy saved.
5.3. Transportation

Similarly to the heating sector, information is not available about how the transportation energy use will change in the future. Therefore, the demand in 2050 was assumed to be the same as the base year demand.

In the model, electrified transportation displaces fossil fuel-based transportation. Current electric vehicles’ tank to wheel/on-board efficiency is four times better than conventional cars with internal combustion engines. [12], [13], [14], [15], which means that the future energy needs will be a quarter of the current need, at 0.305 TWh, if vehicle usage remains the same.

Electrifying the transportation sector means that the electricity system will need to be able to supply the transportation system’s demand, therefore hourly charging data is needed. For the purposes of analysis, the assumption was made that every home will be equipped with home EV charging stations with a smart charging system that will control the charging of each vehicle. As a result, the charging demand can be adjusted to the ‘normal’ electricity demand and high peak demand(s) can be avoided by charging the vehicles overnight or in the middle of the day. The modified average hourly electricity demand can be seen in Figure 8.

![Figure 8: Average hourly electricity consumption modified with EV charging](image)

8 Tells how efficiently engines turn fuel into movement.
9 The charging system monitors the consumption of the electricity and electrical grid loads, regulating charging over a preset amount of time. Users are able to designate when the vehicle will be required, allowing for flexibility in when it gets charged within that time frame as energy is available from the grid. In practice, it means that the car will be charged out of peak demand periods.
With the help of the smart charging system, the EV’s battery can be used as an efficient electricity storage option in the future, but currently this technology is not available.

The projected aggregated energy demand is added together from the previously mentioned 3 sectors (electricity, natural gas, and transportation fuel) and is 1.675 TWh (Figure 9). This demand is 34% less than the base year demand.

![Projected Energy Demand in 2050 [TWh]](image)

*Figure 9: Projected Energy Demand*
6. Supply-demand balance

The amount of electricity consumed in any electrical grid changes constantly throughout the year. The generated electricity must match the demand, within very small tolerances, otherwise the electrical grid becomes unstable. In the future energy mix of the region, renewable electricity will play a large role, therefore it is important to ensure an hourly balance between energy consumption and generation.

The 100% Renewable Kootenays initiative aims to replace fossil fuels from the energy mix with the addition of new, renewable resources. Some renewable energy options available to communities in the West Kootenays are as follows.

6.1. Resources included in the study

6.1.1. Solar energy

Solar photovoltaic (PV) generates electricity from the sun and is therefore considered a renewable resource. The extent of yearly solar radiation in the region makes the resource an excellent option for energy generation. By calculating solar production ($m^2$) using EnergyPRO's weather data, it is concluded that the annual production is $1,402 \text{ KWh/m}^2$. This is based on local data from Park Siding, a site near Castlegar.

Because of local geographical features, such as mountains or trees, the actual production varies between and within every community. Consequently, a regional solar potential map should be developed in the future to determine the most suitable locations for electricity generation.

The production varies greatly during the year and also during the days, peaking in the summer months and in the afternoon. The monthly and daily distribution in Castlegar (Park Siding) can be seen in Figure 10 and in Figure 11.
6.1.2. Renewable natural gas

The B.C. Bioenergy Strategy aims to "launch British Columbia as a carbon-neutral energy powerhouse in North America [and] help B.C. achieve its targets for zero net greenhouse gas emissions from energy generation, improved air quality, electricity self-sufficiency and increased use of biofuels." [16].

Biomethane or renewable natural gas is produced from decomposing organic waste from landfills or agricultural byproducts. After capture and cleaning, renewable
natural gas is interchangeable with traditional natural gas and can be distributed in the existing natural gas system.

FortisBC has already started to examine the potential of biogas production in their service territory recognizing that "biogas is readily available in British Columbia and most importantly, it is a renewable fuel". The full potential of renewable natural gas is not yet known in the West Kootenays, so the assumption was made that it would be able to displace 20% of the current natural gas use.

6.1.3. Biomass

According to the Intergovernmental Panel on Climate Change (IPCC), biomass is considered a renewable resource and “bioenergy has a significant greenhouse gas (GHG) mitigation potential, provided that the resources are developed sustainably and that efficient bioenergy systems are used.” [17] This is especially true if the source of biomass is residue or other hog fuels (waste products from forestry industry). However, biomass use can lead to direct or indirect loss of carbon stocks which, in some cases, neutralize the net positive GHG mitigation impacts. [17]

There is a surplus of both residual hog fuel (roadside residues and debris) and sawdust within the region from forestry operations. This surplus is expected to persist in the future. The estimated Sustainable Biomass Supply is 407 GWh/year [18].

The biomass and solar resources are already part of the City of Nelson’s Low Carbon Path to 2040 action plan to reduce GHG emissions: “Biomass (wood) and solar energy can make an important contribution to reducing greenhouse gas emissions by displacing natural gas. The City and Regional District are in a unique position to secure enough sustainably sourced waste-biomass to supply a large commercial boiler or a District Energy System” [11].

6.2. Resources excluded from the study

The following resources could be a valuable and significant part of the future energy mix, but due to a variety of reasons they were not included in the study. These potential resources include wind, river and micro hydro, and geothermal. With the exception of wind, the potential of the previous resources could be significant, but due to the lack of available quantitative data, were not included in the study.
6.2.1. River hydro and micro hydro

Hydroelectricity is already responsible for 97% of the current electricity production in the region. This capacity will remain in use until and beyond 2050, but further generation was not included in the model of the generation system as this would require the construction of additional dams. Although the potential exists for micro hydro production, the complexity of the current regulation framework and water licenses extends beyond the limitation of this study, therefore the resource was not included as part of the analysis.

6.2.2. Wind

According to the generally available wind data, the region’s potential is not adequate for establishing wind turbines. With more detailed wind potential analysis of the region, it is possible a different conclusion may be reached. The public availability of existing and future renewable resource data would be a significant benefit to the region in energy planning procedures.

6.2.3. Geothermal

Data on geothermal potential for the West Kootenays was also not available during the research, but based on the number of hot springs in the region, it is likely that there is geothermal potential. The inclusion of geothermal heating into the energy model would make the future scenario much more diverse and locally accessible.
7. Planning strategy - Prioritization of energy production

The main principle while designing the system was to use all the available renewable natural gas and biomass resources within the region and cover the rest of the demand with other renewable resources.

To use biomass more effectively, the proposed future scenario includes the installation of three small biomass CHP (Combined Heat and Power) plants. The operational strategy of the plants prioritizes heat production to fulfill certain heating demands in Nelson, Castlegar and Trail (the three cities where the power plants would operate). Using the rest of the available biomass, the CHP plant produces electricity during the remainder of the year.

As the available renewable natural gas and biomass heat cannot cover the total heating demand of the region, the remaining load is electrified. In the winter months, solar generation is not efficient enough to cover all of the region’s needs and so energy import would be required during this period. The energy model scenario was designed in such a way that the energy import/export balance would be net zero during the year. In this way, the renewable energy exported during the summer months balances the energy imported during the winter months. With the help of future energy storage developments, the import/export of energy can be avoided through the use of an effective seasonal energy storage system.

8. Modelling Result – Projected energy mix

The renewable natural gas resource is intended to cover 20% of the calculated natural gas demand, namely 0.112 TWh during the year. This is 6.7% of the total demand and distributed equally throughout the year.

The available biomass will be burned in the CHP plants, regulated by the heat demand. This means that fulfilling the heat demand of Nelson, Castlegar, and Trail (0.150 TWH) is the priority during the year, while a surplus resource of 0.20 TWh of electricity is generated during the year in conjunction with the heating supply.

Renewable natural gas and biomass are not adequate to cover the 0.561 TWh heating demand in the region, consequently the rest of the load is electrified. With the current electricity production being 97% renewable and the increasing electricity need over the next 30 years, mostly due to the EV load, the introduction of new, renewable generation is necessary. As stated in Section 6, the only other included resource is solar electricity, so the PV system will need to supply the extra 0.46 TWh of demand during the year. Accurate sizing is necessary to avoid excessive solar PV installation, while keeping the net renewable balance at 100%.
As part of the modelling scenario, the installation of 320 MW solar PV is needed to fulfill this demand. These solar panels are generating 0.28 TWh surplus during the summer months, which can be exported. This exported surplus is equal to the needed imported electricity during the winter months. The yearly generation of the PV panels is 0.46 TWh.

9. Conclusion

The purpose of this modelling exercise was to determine the achievability of a renewable energy future. It is just one of many possible scenarios and is likely not even the best scenario, but it is feasible based on the knowledge and technology currently available. Although the primary renewable energy resources considered were biomass, renewable natural gas, and solar photovoltaic; the more diverse the energy mix, the more robust the system. Inclusion of other technologies such as geothermal and micro hydro would improve the resilience and performance of the energy portfolio. As data in these areas become available, the model can be refined to include them in the 100% renewable energy scenario. This energy modelling project supports EcoSociety’s campaign for a 100% Renewable Kootenays and demonstrates that a renewable energy transition is possible.
Bibliography


Appendix 1

**List of West Kootenay territories**

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# Appendix 2

## List of interviewees

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<tr>
<td>Sanjay De Zoysa</td>
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<td>Katherine Muncaster</td>
<td>Senior Policy Advisor, BC Ministry of Energy</td>
<td>E-mail</td>
<td>August, 2017</td>
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