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Greenhouse Gas Implications of Land-Use Scenarios for the Regional Growth Strategy

Submitted to:

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Regional District of Central Okanagan

January 25, 2012

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Sustainability Solutions Group (SSG) is a collective of Canada's leading sustainability professionals. We are an innovative worker's cooperative that collaborates with clients to develop meaningful and creative strategies to integrate ecological, economic and social sustainability in their projects, organizations and communities. We pride ourselves in working closely with our clients to achieve real, on the ground social and ecological change through projects of unusual integrity.

As a team, we demonstrate that the whole is much more than the sum of its parts - we build on each other's experiences, enthusiasm, skills and innovation. SSG's approach to our work is unique because it embodies the following principles:

- Action-focused;
- Based on solid theory;
- Considers the whole picture;
- Participatory in design and implementation;
- Fosters social change; and
- Takes care of the commons.

Our vision is a world of just, sustainable and healthy communities everywhere. Our co-operative of experts in energy, policy and design inspire sustainable buildings, communities and organisations.

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Executive Summary

Sustainability Solutions Group (SSG) modeled the impact of different potential land-use decisions on community-wide greenhouse gas (GHG) emissions in the Regional District of Central Okanagan (RDCO). The scope of the analysis included private and commercial transportation, private and commercial buildings, solid and liquid waste, forest area and agricultural activity. A baseline was created for the year 2007 in SSG's model GHGProof, and three different scenarios were compared against that baseline. The scenarios included a business as usual (BAU) case, and the evaluation of a 33% reduction over 2007 levels by 2020 (Scenario 1) and an 80% reduction over 2007 levels by 2050 (Scenario 2).

The BAU scenario found that emissions would increase by 25% by 2020, mainly due to continuing population increase and continuing land-use development according to historical patterns. Significant changes in land-use and technology would be required to achieve the GHG emissions reduction target of 33% or 793,000 tonnes carbon dioxide equivalent (tCO2e) by 2020. However, those changes would difficult to implement because many dwellings projected to be constructed by 2020 have already been permitted or are in the planning process, and emission reductions possible through other measures like transportation and agriculture would be limited. Instead, it is recommended that as a medium term target the RDCO focus on stabilising emissions by 2020 at 1.2 million tCO2e. Stabilizing GHG emissions would be a reduction of 25% from the BAU scenario. A 25% reduction target will still be challenging given the projected population increase over that period. Additionally, the adoption of the 80% by 2050 over 2007 levels is recommended for the Regional Growth Strategy (RGS). This target brings the RDCO back in line with provincial goal and the RDCO will have more time to work with member municipalities on a common regional vision and strategy to reduce emissions.

The effort to reduce GHG emissions can also be justified by reducing household energy costs. For example, if the RDCO were able to achieve the 33% reduction by 2020, a simple economic calculation indicates (without accounting for inflation or energy price increases) that per person energy costs would decline from just under $3,000 per year to $1,578 per year. This results in substantial financial savings for homeowners, and releases almost $260 million in the region that would have otherwise been spent on fuel for vehicles and heating and cooling of dwellings. There are ranges of other co-benefits to GHG reduction, which merit further analysis, including:

- **Municipal capital and operating costs are significantly lower** in a community with low GHG emissions than one with high GHG emissions. A study by the IBI Group for the City of Calgary compared a scenario of growth that reflects current patterns and policies (dispersed scenario) with a scenario that intensifies population and jobs in existing areas (recommended scenario)[1]. IBI Group found that the dispersed scenario would cost the municipality 33% more to build than the recommended scenario with additional savings for operations and maintenance. Water and wastewater systems alone would be 55% cheaper in the recommended scenario. Other savings would be found in road construction, transit costs, fire stations, recreation centres and schools.
- Land-use planning which reduces GHG emissions will also **improve public health outcomes** by supporting higher levels of physical activity, improved traffic safety, reduced overall air pollution, reduced noise pollution, enhanced social interactions and improved mental health outcomes.

1 IBI Group (2009). The implications of alternative growth patterns on infrastructure costs. Prepared for the City of Calgary.

Health conditions, which can be positively influenced by land use planning, include heart disease, hypertension, stroke, diabetes, obesity, osteoporosis and depression[2].

- The green economy has grown in prominence as **a solution to both the economic slowdown and environmental challenges**. A study in British Columbia assigned 10.2% of the Province's current GDP or $15.3 billion dollars, to the green economy, accounting for 166,000 jobs[3]. Efforts to reduce GHG emissions stimulate innovation in renewable energy development, manufacturing and installation, energy efficiency retrofits, green building, energy efficient technologies, local agriculture activities, new infrastructure for public transit and cycling, amongst others.

The analysis includes recommendations for the following goals:

- Stabilise GHG emissions in the RDCO by 2020 at 2007 levels.
- Achieve a region wide GHG emission reduction target of 80% by 2050 over 2007 levels.
- Report on energy consumption, GHG emissions, and other climate related indicators bi-annually to inform decision making at the local and regional levels.

Policies are identified for the RGS to support the implementation of these goals. The RDCO can work with its regional partners to agree on a coordinated cross-boundary approach to implementing strategies necessary to achieve regional GHG targets.

1. Commit to identifying, quantifying and modeling energy and emissions implications, as well as climate adaptation considerations, for all local and regional government decisions.

2. Work with the provincial government, municipalities, service providers, public and private agencies to support the ongoing monitoring and refinement of energy consumption data and GHG emissions on a local and regional scale.

3. Plan for and commit appropriate financial and human resources to achieve energy and emissions goals in collaboration with local governments, major employers and the community at large, to provide for:

    - Citizen education and engagement, including at schools, homes and businesses
    - Energy and climate related data and indicators
    - Municipal leadership and carbon neutral commitments
    - Climate change adaptation measures.

4. Develop an adaptation strategy that identifies risks, hazards, assets, costs, benefits and strategies to reduce the impacts of climate change on social, economic and environmental systems in the RDCO.

2 Frank, L., Kavage, S., and Litman, T. (2008). Promoting public health through Smart Growth. Prepared for Smart Growth BC. Av
3 Globe Foundation (2010). British Columbia's Green Economy. Building a strong low carbon future.

1 Introduction

SSG was contracted by RDCO to evaluate the GHG emissions implications of land-use decisions for the RGS. SSG's open source model, GHGProof, has been used for similar analyses with more than fifteen municipalities and regional districts including Capital Regional District and Fraser Valley Regional District.

Land-use decisions determine transportation patterns, building design, public infrastructure and energy supply systems for fifty to hundreds of years into the future Illustration 1 shows the trickle downward impacts of planning decisions. For example, long distances between where people live and where they work, play, study and shop results in a dependence on personal automobiles. Switching to public transit would be both very expensive and logistically challenging.

Illustration 1: Planning implications

Land-use decisions result in a phenomenon called path dependence or “lock-in” the investment in buildings and infrastructure is so large that it is difficult to back away from that investment even if there are significant financial, health and environmental costs to its ongoing operation and maintenance. In contrast, land-use patterns that support compact, complete communities broaden the spectrum of opportunities in the future, “keeping the options open”. For example, the density associated with compact communities increases the economic feasibility of potential district energy systems or new transit routes, and helps with many non-GHG related infrastructural systems like water and wastewater, schools, and firehalls. Creating compact communities also makes them more livable and vibrant, and makes places where local business owners are able to set up shop and thrive, because they have regular local customers.

Illustration 2: Path dependence for automobile-oriented planning

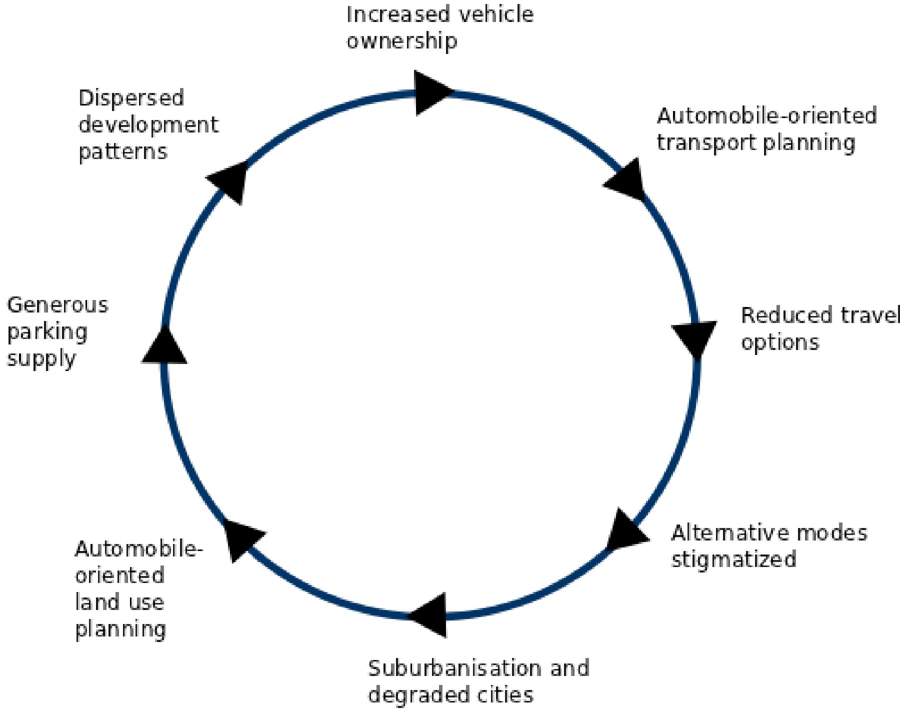


Illustration adapted from: Litman, T. (2011). Evaluating transportation land-use impacts. Victoria Transport Policy Institute

Compact, complete communities reduce household costs of energy for heating and cooling and for transportation, as destinations tend to be closer, or even walkable. Municipal costs decline as infrastructure is more compact and services are less spread out. This type of development also reduces the impact of escalating energy costs, both to the inhabitants and to society. Jaccard et al proposed a hierarchy of decisions for community energy planning based on the simple concept that whatever lasts longest is most important[4]. Land-use decisions have implications for 50 to 100 years and are therefore prioritised above building design (implications for 25-50 years) or the selection of energy efficient equipment (implications for 5-20 years). To put this approach in context, the most effective strategy to reduce GHG emissions from the RDCO's perspective is to create compact, complete communities. A retrofit such as replacing streetlights with LEDs will reduce GHG emissions but will have significantly less impact over the long-term.

Legislators in California, Washington and British Columbia (BC) have passed laws requiring municipal plans to include GHG emissions targets. In May 2008, BC's "Green Communities" legislation (Bill 27) amended the *Local Government Act* and *Community Charter*. Under the amendment, local and regional

4 Jaccard, M., Failing, L., & Berry, T. (1997). From equipment to infrastructure: community energy management and greenhouse gas emission reduction. Science, 25(13), 1065-1074.

governments are required to adopt GHG emission reduction targets, and actions and policies for achieving those targets. These efforts reflect a growing understanding of the relationship between the design of community settlements, energy consumption and GHG emissions.

Model GHGProof

SSG used the open source model, GHGProof, for this project. GHGProof can be used to analyse past and present land-use patterns, project the impact of future land-use patterns and generate land-use scenarios to achieve a set target. All of the calculations, inputs and assumptions in GHGProof are visible to the user. Key strengths of the model include:

- **Comprehensive**: Seeks to address all major land-use impacts on GHG emissions, and some public and private energy costs.
- **Adaptable:** Can be used for a rigorous analysis of a large city or in a one-day workshop for a small community.
- **Affordable**: Free to use for non-profit purposes, open source.
- **Transparent**: All assumptions and calculations are visible and can be altered.
- **Scope:** Can be used at the scale of a large-scale development, a municipal plan and a regional plan
- **Policy relevant:** Allows local governments to develop or evaluate targets to address provincial legislation.
- **Accessible:** Uses simple Geographic Information Systems (GIS) analysis and an excel-based calculator; limits number of inputs to those that have greatest potential GHG impacts.

It is important to note that the model's outputs do not represent the actual outcomes; the only model that will behave, in all ways, as the original system is that system itself. In other words, GHGProof will not determine outcomes with certainty; it illustrates the effects of choosing among various outcomes. Thus, for a user to trust a model, both the assumptions and the means of creating and presenting the model need to be fully transparent. In GHGProof, all of the calculations, inputs and assumptions are visible to the user.

The model was developed with support from the Fraser Valley Regional District and Canada Mortgage and Housing Corporation. GHGProof is licensed through Creative Commons as an open source tool and can be freely used for non-profit purposes. The model is available as a download at www.sustainabilitysolutions.ca/resources/GHGProof.

2 Energy and GHG Emissions Baseline (2007)

2.1 Overview of baseline

A review of RDCO's GHG emissions is detailed in a Technical Report, attached as Appendix 1, using data from the Community Energy and Emissions Inventory (CEEI)[5]. CEEI includes GHG emissions from residential and commercial buildings, private and commercial transportation and solid waste. CEEI uses actual data from energy utilities for buildings but estimates GHG emissions from vehicles and solid waste. Vehicle emissions are estimated using vehicle registrations and a model calibrated using Air Care mileage readings from the Lower Mainland.

We compared GHG results from RDCO against results from other regional districts. Investigating the differences between Regional Districts can reveal opportunities for reducing GHG emissions. RDCO has the 4th largest GHG emissions in the province at 1.2 million tonnes carbon dioxide equivalent (tCO2e) in 2007. In comparison, Metro Vancouver produced 10 million tCO2e and Stikine Regional District was approximately 10,000 tCO2e. On a per capita basis, RDCO has the 11th lowest GHG emissions in the province at 6.4 tCO2e but is significantly higher than Capital Regional District (CRD)'s 3.9 tCO2e/capita and lower than Peace River at just over 13.5 tCO2e/capita. Note that none of the provincial Regional District totals includes emissions from First Nations communities.

2.2 Assumptions

GHGProof uses a large number of assumptions, drawing where possible on local studies and otherwise employing provincial or national averages. All of the assumptions are adjustable in order to test different possibilities. In the baseline, assumptions are calibrated to align the model with the relevant categories from CEEI. A complete list of assumptions as well as sources is shown in Appendix 2.

2.3 Baseline inputs

Following the identification of assumptions, inputs for the 2007 baseline year, including population (173,745) and households (66,255) from BC Stats, were entered into the Inputs tab of GHGProof. The average Vehicle Kilometres Travelled (VKT) was calculated using GIS by assessing the distance between key destinations in the region (central business districts, schools, hospital, employment clusters) and each dwelling. This average is then calibrated against fuel consumption data from CEEI to calculate an average VKT for the baseline (14.9 km). The number of dwellings by type (detached, attached, apartments < 5 storeys, apartments >5 storeys, mobile homes) was identified from BC Assessment data. GIS was used to calculate the number of dwellings within a density of 50 units per hectare, a threshold for district energy. Solid waste data was provided by RDCO and GIS was used to identify the number of dwellings served by primary, secondary or tertiary waste treatment. GIS was also used to calculate the area of land in Agricultural Land Reserve and area of forest in the RDCO. The Agricultural Census provided data on agricultural practices.

5 The first edition of the 2007 Community Energy and Emissions data was used as SSG's provincial database was compiled prior to the release of the second edition of the 2007 CEEI.

2.4 Baseline results

The total GHG emissions in the 2007 Baseline result in GHGProof differing with the total GHG emissions reported in CEEI for that year by less than 2%, indicating that GHGProof is closely calibrated to the CEEI data. This exercise of spatialising the data results in a tool that will enable the RDCO to test options more fully. This difference is the result of a number of strategies used to create a spatial model of GHG emissions as well as the addition of different variables including:

- Inclusion of emissions/absorption from forest cover in GHGProof;
- Inclusion of emissions from liquid waste in GHGProof;
- Inclusion of GHG emissions from the transportation of food outside of the community in GHGProof;
- Assumption of diesel vehicles as equivalent in GHG emissions to gasoline vehicles;
- Different methodology in GHGProof for calculating emissions factors for residential and commercial buildings based on the dwelling mix;
- Agricultural emissions include more variables than those in CEEI; and
- Lower GHG emissions factor for solid waste to reflect landfill gas capture.

The inclusion of the above variables beyond CEEI is helpful for RDCO because this add more opportunities to achieve GHG reductions, including opportunities to support existing initiatives in the Region. For example, the inclusion of forest cover in GHGProof directly relates to the intent of the Municipal Properties Tree Bylaw in Kelowna and further supports existing bylaws and policies that guide the region to reducing GHG emissions.

CEEI indicates that total GHG emissions for RDCO are 1.19 million tonnes of CO2e whereas the GHGProof calculates 1.21 million tonnes of CO2e: it is closely calibrated to CEEI with some additional variables. As with other types of modeling, such as economic or demographic modeling, it is critical that the same methodology is consistent between the baseline and the scenarios.

3 Future Scenarios

3.1 What is a Scenario?

GHGProof uses different scenarios as a mechanism to evaluate potential futures for communities. A scenario is a view of what the future might turn out to be not a forecast, but one possible future outcome. A good set of scenarios is both plausible and surprising but scenarios can also be misleading if, for example, there are too few so that one scenario is ‘‘good’’ and the other “bad”.

Our approach to the development of scenarios for this project aims to address five aspects of scenarios including:

- Alternatives: variations of housing types, locations and technologies can be expressed using different scenarios in the model.
- Consequences: the immediate and cumulative effects are expressed through the outputs of the analysis and through a GIS mapping exercise.
- Causations: causal bonds between alternatives and consequences are illustrated using transparent equations between assumptions and inputs.
- Time frames: periods of time between implementation of the alternatives and the unfolding of their consequences are indicated in the inputs spreadsheet.
- Geographical footprints: the place oriented blueprints or alternatives are developed using a GIS methodology.

3.2 Modeled Scenarios

Three different scenarios were developed and evaluated. The BAU scenario uses forecasting to predict the impact on energy consumption and GHG emissions based on existing land-use patterns. Scenarios 1 and 2 (described below) use a technique called back-casting in which we work backwards from a point in the future. A number of possible strategies were selected, as described below, based on the most feasible combination of strategies required to achieve the targets for Scenarios 1 and 2. However, other combinations of strategies with different emphasis are equally possible to achieve those same targets. It is envisioned that different combinations of strategies can be explored as part of the public engagement process. Detail on the assumptions for the scenarios is found in Appendix 1.

Business as Usual (BAU). This scenario is designed to reflect the best understanding of what would happen to GHG emissions in the region if there were no additional strategies added to reduce GHG emissions than are currently in place. This scenario was informed by both a data review and consultation with the RDCO and the RDCO municipalities. The BAU scenario projects to 2020, the same time period used for the GHG targets included in the OCPs of RDCO municipalities. BC Stats projects a total population of 220,074 in 2020, an increase over 2007 by 28,669 households, or just under 27%.

GIS was used to locate new households according to current planning applications, neighbourhood plans and OCP projections. We then applied the same methodology as in the Baseline for calculating trip length and found that average trip length would increase from 14.9 to 15.6 km as dwellings continue a pattern of spreading out over the region[6]. GIS was used to identify the number of dwellings within walking distance (400m) to transit and the central business district, both of which increased over the baseline. The number of dwellings, which met the threshold for district energy, also increased over the baseline. The federal fuel efficiency standard was included in the BAU as was energy efficiency improvements to the BC Building Code. Forest cover and agricultural activity were not impacted by the additional dwellings and were maintained at the same levels as in the Baseline. Other variables such as liquid and solid waste increased at a rate proportionate to the projected population increase.

Scenario 1 - 33% reduction by 2020 over 2007. Scenario 1 was designed to test what would be required for the RDCO to achieve the GHG target adopted by the municipalities and rural areas. Instead of evaluating land-use plans as was the approach for the Baseline and BAU scenario (a forecasting approach), we started with the target and worked backwards (back-casting).The first step was to calculate the 33% reduction over the 2007 baseline, which resulted in a total of 796,835 tCO2e. This total is approximately half of the 1,510,000 tCO2e that we projected would result in the BAU scenario. We then used the goal seeking function in GHGProof to create, using our best judgement, a combination of inputs that would result in this 33% reduction.

An example of a combination measures that could achieve a 33% target reduction over the 2007 baseline by 2020 is as follows:

- Average trip length by car is cut by 35%;
- The number of dwellings within 400 metres of a town centre climbs from 2,555 in the Baseline to 29,791;
- The number of dwellings within 400 metres of frequent public transit doubles from 31,340 to 60,099;
- Only 30% of new dwellings are detached homes; the remainder are apartments and attached homes;
- 31,000 dwellings are attached to district energy systems;
- Per capita solid waste production declines by 50%;
- Local consumption of food increases from 20% in the Baseline to 30%;
- Municipal forest cover increases by 33%;
- The mix of energy used in buildings includes a decline in natural gas by 10% and an increase in electricity by 10%;
- New dwellings are 50% more efficient than the existing building stock;
- 20% of the existing building stock is retrofitted for a 25% energy savings; and

Scenario 2 - 80% reduction by 2050 over 2007. Scenario 2 was selected in direct response to a realisation that the dwellings required to meet the projected population up until 2020 were already allocated or approved in a business as usual land-use pattern. This indicated that there was very little room to move from a land-use perspective before 2020 and achieving the 33% reduction over 2007 would be extremely difficult. It was concluded that the RDCO would be better served to use a longer time frame with more options for influencing land-use patterns. The 80% by 2050 over 2007 is a BC Government target and was considered appropriate to model, acknowledging that as the time period

6 Average trip length is calculated by identifying key destinations in the RDCO and calculating the average distance from each dwelling to those destinations. If dwellings are further away from the destinations, that number will be higher whereas if the dwellings are closer, the number will be lower. On average there are 3.44 trips per person in the RDCO each day so even a small reduction in trip length results in a signficant GHG emissions reduction from vehicular emissions.

increases, so does the degree of uncertainty. Despite this uncertainty, land-use patterns tend to last between 50 and 100 years, beyond the scope of this scenario.

BC Stats population projections do not go out to 2050 so we used the average population increase between 2020 and 2035 to project out to 2050, with the result being a projected population of 307,515. In order to achieve the 80% reduction total GHG emissions would need to fall to 239,768 tCO2e. While on the face of it, this target seems extraordinarily difficult, there are a number of developments that will make this target more feasible to consider, including:

- The projected widespread deployment of electric vehicles, and planned carbon neutral electricity in BC[7];
- The ability to concentrate development around new destinations or nodes in areas that may be currently sprawling;
- Real estate trends that are favouring downtown development over the outskirts with smaller homes and much higher levels of density[8]; and
- Increased market penetration by technologies for heating and cooling that are solely renewable such as heat pump systemss[9]and solar photovoltaics systems[10],.

The following is an example of a combination of measures that could achieve an 80% reduction over 2007 levels by 2050:

- Average trip length by car is cut from 14.9 km to 5.2 km, 35% of the Baseline;
- The number of dwellings within 400 metres of a town centre climbs from 2,555 in the Baseline to 135,324;
- The number of dwellings within 400 metres of frequent public transit triples from 31,340 to 97,815;
- Only 10% of new dwellings are detached homes; 70% are apartments;
- 86,000 dwellings are attached to district energy systems;
- Per capita solid waste production declines by 60%;
- Agricultural production doubles and 80% of what is produced is locally consumed up from 20% in the Baseline;
- Total forest cover doubles;
- The of mix energy used in buildings includes a decline in natural gas by 20% and an increase in electricity by 20%;
- New dwellings at 60% more efficient than the existing building stock;
- 50% of the existing building stock is retrofitted for a 25% energy savings; and

7 Projections for electrict vehicles range up to 64% of sales in the US by 2030. See: Becker, T, and Sidhu, I. (2009). Electric vehicles in United States. A new model with projections up until 2030. Center for Entrepreneurship and Techology, Technical Brief. University of California, Berkely. Available at: http://cet.berkeley.edu/dl/CET_Technical%20Brief_EconomicModel2030_f.pdf.

8 Condominium apartments accounted for a progressively higher proportion of housing starts in Canada during the past decade. See: Canadian Home Builders Association (2011). Canadian Housing Industry – Performance and Trends. Available at: http://www.chba.ca/uploads/policy%20archive/2011/Housing%20Industry%20Performance%20and%20Trends%20Oct%202011.pdf

9 Heat pump market in Canada has been growing rapidly over the last decade. For a detailed overview of the market see: Canadian GeoExchange Coalition (2010). The State of the Canadian Geothermal Heat Pump Industry 2010. Available at: http://www.geo-exchange.ca/en/UserAttachments/article64_Industry%20Survey%202010_FINAL_E.pdf.

10 The cost of installed photovoltaics fell by 17% between 2009 and 2010. See: Barbose et al. (2011). Tracking the Sun IV: An Historical Summary of the Installed Cost of Photovoltaics in the United States from 1998 to 2011. Available at: http://eetd.lbl.gov/ea/emp/reports/lbnl-5047e.pdf

3.3 Results of scenario analysis

Numerical results of the analysis are described in the following table. Note that cost savings were not calculated for the 2050 scenario because costs are difficult to predict over that timeline in the absence of a more complex financial model.

	BAU			*Scenario 1*			*Scenario 2*		
	tCO2e	*GJ*	*Energy Costs ($)*	*tCO2e*	*GJ*	*Energy Costs ($)*	*tCO2e*	*GJ*	*Energy Costs ($)*
Private transportation	691,035	10,069,494	$361,383,249	300,592	4,380,101	$193,391,516	36,614	533,519	N/a[11]
Commercial transportation	204,664	2,982,283		184,198	2,684,054		171,589	2,500,332	
Buildings	405,898	14,804,851	$231,139,508	204,664	7,464,985	$153,814,447	158,197	5,770,147	N/a
Solid waste	66,244			28,657			32,034		
Liquid waste	27,111			27,111			37,883		
Agriculture and transportation	441,197			430,413			489,463		
Forests	-329,988			-438,884			-659,976		
Total	*1,510,202*	*27,856,628*	*$592,522,757*	*792,860*	*14,529,140*	*$347,205,963*	*243,966*	*8,803,998*	
Per capita	6.9	126.6	$2,692	3.6	66.0	$1,578	0.8	28.6	

[11] N/a indicates that costs were not projected for scenario 2 because costs are difficult to predict in a reasonable manner up until 2050 in the absence of a complex financial model.

4 Analysis

4.1 Analysis of results

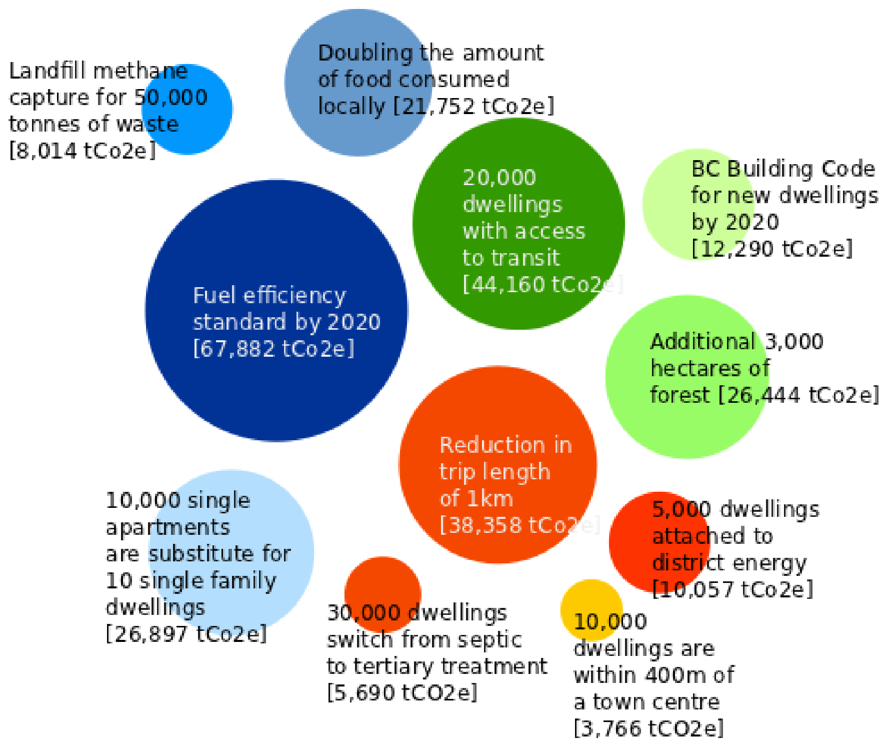
Major reductions in GHG emissions are required to achieve both the 33% and the 80% targets detailed in Scenarios 1 and 2. Favouring complete, compact communities in land-use planning reduces energy consumption because the size of dwellings tend to decrease for new construction, there are an increased number of shared walls which reduce energy consumption, more efficient heating and cooling systems become possible with higher density housing forms, and there are increased opportunities for district energy. On the transportation side, trips in vehicles tend to be shorter and there are increased opportunities for people to walk, cycle and take public transit. In addition to focusing land-use on compact, complete communities, the RDCO can support increasing the forest coverage as a carbon sink as well as identifying strategies to expand local food production and consumption, reducing the transportation of food and growing the local green economy.

Developing and implementing a land-use strategy to reduce GHG emissions and energy consumption is a long-term strategy, but this focus lays the foundation for effective, future investments in public transit system and district energy as well as a range of co-benefits. It clearly describes the need for a coordinated, regional approach to land-use planning in order to adequately address, and plan for, climate change mitigation strategies.

Policies from provincial and federal government will enhance the energy savings resulting from land-use change including fuel efficiency standards for vehicles, low carbon fuel regulations, energy efficient design and systems required in the building code, building retrofit programs and enabling and incentivising renewable energy. While the regional government can both lobby for and help implement these policies, the evolution of their scope and detail is largely beyond the mandate of the RDCO.

Illustration 3 is an example of the types of reductions that can be achieved from different strategies. To calculate these numbers each strategy below was modelled individually in the BAU scenario. Note that they do not represent the strategies that were used in the scenarios; they simply illustrate what kinds of reductions occur as a result of different kinds of strategies. Also, note that in GHGProof there are relationships and feedback between the strategies so it is not possible to add up the reductions from each strategy to get a total reduction for a scenario.

Illustration 3: Examples of the GHG impacts of different potential strategies



Through analysis of regional new dwelling allocations through comprehsive neighbourhood plans, and planning applications, indicates that the BAU land-use pattern in the RDCO is unlikely to change significantly, at least until 2020. As a result, it is proposed that the RDCO set both a medium and a long-term target. The proposed medium term target is to stabilise GHG emissions at 2007 levels by 2020 which represents a 25% reduction over the BAU Scenario. This is a more achievable target than the 33% reduction by 2020 (which is a 58% reduction over BAU Scenario), and is both challenging yet feasible. The proposed longer term target is an 80% reduction by 2050. This creates breathing space for the RDCO and all member municipalities to plan for the longer term, comprehensive, coordinated, land use changes necessary to achieve the municipal committed emission reduction targets. Both of these targets however will still require that the RDCO aggressively pursue land-use and other strategies to reduce GHG emissions wherever and whenever possible.

4.2 Goals and policies

The following section outlines how the GHG targets can be translated into the RGS. In addition to a section of the RGS dedicated to the climate action, other strategies can also be integrated throughout the document in sections that address the other eight growth issue areas:

Regional Growth Issue Areas	Policy options
1. Air, Energy and Greenhouse Gas Emissions	Better air quality, reduction targets, energy conservation
2. Agriculture and Rural Land Area Protection	Agriculture protection, encouraging local food production and consumption using a variety of tools
3. Economic Development	Focus on growing the green economy as a solution to economic slow downs and environmental challenges;
4. Environment, Recreation Space and Sensitive Areas	Increase forest cover; protection of ecosystems and regional biodiversity
5. Housing	New housing types that encourage multi-family, smaller lots, and more density in town centres
6. Regional Governance and Service Delivery	Protection against future infrastructure deficit by clustering services; provide services that are timely, affordable and effective
7. Transportation	Regional transportation demand management, alternative modes of transportation;
8. Water Resources, Lakes and Streams	Protection against infrastructure deficit and potentially also risk of climate change to water supply along with climate adaptation strategies (outside the scope of this study),

As a regional plan, the RGS can represent a common, cross-municipal border vision for:

- Additional green spaces and forest areas;
- Health and active transportation;
- Enhancing agricultural productivity and local food consumption;
- Target growth areas focused on mixed-use town centres;
- District heating/energy zones; and
- Regional public transit.

In the section of the RGS on climate action, it is proposed that the following **goals** are included:

- Stabilise GHG emissions in the RDCO by 2020 at 2007 levels, a 25% reduction over BAU Scenario;
- Achieve a region wide GHG emission reduction target of 80% by 2050 over 2007 levels; and
- Report on energy consumption, GHG emissions, and other climate related indicators bi-annually to inform decision making at the local and regional levels.

The following **policies** are proposed for the RDCO[11]:

1. Commit to identifying, quantifying and modeling energy and emissions implications, as well as climate adaptation considerations, for all local and regional government decisions.
2. Work with the provincial government, municipalities, service providers, public and private agencies to support the ongoing monitoring and refinement of energy consumption data and GHG emissions on a local and regional scale.
3. Plan for and commit appropriate financial and human resources to achieve energy and emissions goals in collaboration with local governments, major employers and the community at large, to provide for:
   - Citizen education and engagement, including at schools, homes and businesses;
   - Energy and climate related data and indicators;
   - Municipal leadership and carbon neutral commitments; and
   - Climate change adaptation measures.
4. Develop an adaptation strategy that identifies risks, hazards, assets, costs, benefits and strategies to reduce the impacts of climate change on social, economic and environmental systems in the RDCO.

In addition, climate action is a cross-cutting theme and additional policies should be included in the relevant sections of the RGS to support agriculture, waste reduction, compact built environment and public transportation. In order to track progress towards the goals and success in implementing the policies, the following **indicators** are proposed.

Category	Indicator	Data source
GHG Emissions	Total GHG emissions	Community Energy and Emissions Inventory (CEEI)
	Per capita GHG emissions	Community Energy and Emissions Inventory (CEEI), BC Stats
Transportation	Annual VKT per household	Community Energy and Emissions Inventory (CEEI), BC Stats
	Mode share for walking, cycling and public transit	Transportation survey
Waste	Tonnes of solid waste per capita	RDCO municipalities
	% of waste in a landfill with methane capture	RDCO municipalities
Buildings	New dwellings by type	Building permits
	% of new dwellings within 400m of key destinations	RDCO GIS analysis

11 These policies are based on climate action policies proposed for the Capital Regional District's Regional Growth Strategy, which represent best practice.

Category	Indicator	Data source
Agriculture and forests	Actively farmed agricultural area	Survey conducted by RDCO
	Annual sales from Farmers Markets	Survey conducted by RDCO
	Area of forest	GIS analysis

It is recommended that the indicators be reported on every two years.

4.3 Actions

The following table describes potential actions that could be employed by the RDCO or municipalities to achieve the strategies modelled for the RDCO. These actions have not been evaluated for feasibility and are provided for with accompanying co-benefits for illustration purposes.

Theme	Examples of Actions to reduce GHG emissions by 2020	Short-term	Long-term	Examples of Co-benefits
Land-use	• Concentrate development in compact, complete community nodes			• Reduced municipal infrastructure costs • Accessibility for elderly, youth and poor • Reduced air pollution • Reduced crash damages • Reduced congestion • Reduced noise • Reduced asthma, heart disease and other health outcomes • Reduced parking requirements • Reduced demand for road expansion • Reduced household expenditures on transportation • Improved neighbourly interactions
Transportation	• Regional public transit strategy identifying transportation nodes			
	• Transportation demand management strategy			
	• Increased and improved walking and cycling infrastructure			
	• Provide infrastructure for electric vehicles and/or public transit			
Buildings	• Incentivise density			• Opportunities for new businesses in energy provision • Creates jobs in energy efficiency • Stimulates innovation • Stimulates economic diversification • Creates opportunities for new economic niches.
	• Innovation committee to enable new construction that delivers energy efficiency benefits but doesn't meet code			
	• Create district energy zoning designation			
	• Create a bulk-buy program for renewable energy technologies			
	• Partner with local financial institution to provide energy efficiency retrofit loans			
	• Create a regional or municipal utility			
	• Create a microgeneration policy			
Waste	• Increase recycling			• New economic opportunities • Reduced air pollution • Reduced waste disposal costs • Potential revenue stream from compost and recycling.
	• Introduce household composting			
	• Capture methane from all landfills for district energy			
	• Capture methane from liquid waste treatment facilitates for district energy			
Forest cover	• Acquisition of forest area for parks or wildlife reserves			• Improved air quality • Improved community aesthetics • Cooling benefits in the summer • Enhancement of biodiversity
	• Tree bylaws in all municipalities			
	• Urban tree planting program			

Theme	Examples of Actions to reduce GHG emissions by 2020	Short-term	Long-term	Examples of Co-benefits
Agriculture	• Permanent spaces for farmers markets			• Improved health outcomes • Increased food security • New employment opportunities • Higher quality food
	• Provision of community gardens			
	• Development of urban farms			
	• Local food purchasing programs			
	• Protection of agricultural lands			

4.4 Next steps

The other key strategy in the short term is community engagement around land-use. The analysis of the impacts of land-use is a new field, and engaging residents in a discussion on the costs and benefits of different land-use patterns will build support for further action by municipalities and the RDCO. Additional studies and research on climate change impacts and adaptation, health impacts and municipal infrastructure and servicing costs will help inform this discussion.

5 Conclusion

Following our analysis of the GHG implications of different land-use scenarios in the region, we have prepared the following six conclusions:

1. Achieving a 33% reduction over 2007 levels by 2020 for the region will be extremely difficult given existing land-use commitments at level of municipalities.
2. Initially focusing on stabilising emissions at 2007 levels can involve a variety of strategies such as transportation demand management, regional transit improvements, waste reduction, forest canopy increases and a focus on local agriculture can contribute to this goal. In addition identifying key nodes for compact, complete communities and incentivising development in these nodes will lay the groundwork for achieving the longer term target.
3. Adopting the target of 80% reduction over 2007 levels by 2050 in the RDCO provides a longer term goal that can inform all future land-use decisions.
4. Ensure that climate action is a cross-cutting theme in the RDCO and is reflected in each of the RGS categories where it has relevance.
5. A focus on community engagement to build community literacy on the costs and benefits of different land-use patterns and their co-benefits will create an informed discussion.
6. Continue to track results against indicators and measure the impact of major developments or land-use decisions in the region using GHGProof.

Appendix 1: Technical Report

Appendix 2: Assumptions

The following tables describe the assumptions that were used for each of the scenarios. The numbers in the Baseline and BAU scenarios were calculated from existing and projected land-use plans. The assumptions for Scenarios 1 and 2 were generated using best judgement in order to achieve the GHG targets. The combination of assumptions for Scenarios 1 and 2 in this report represent one possible combination, though other combinations are possible.

Population

Populations were based on numbers from BC Stats (up until 2036) and were then extrapolated until 2050 using the same rate of increase from between 2020 and 2036.

Table : Population projections

	Baseline (2007)	BAU/OCP Scenario (2020)	Scenario 1: 33% reduction by 2020	Scenario 2: 80% reduction by 2050
Population	173,745	220,074	220,074	307,515
Households	66,255	94,924	94,924	132,640

Source: BC Stats, Calculations

Transportation

Table: Transportation assumptions

	Baseline (2007)	BAU/OCP Scenario (2020)	Scenario 1: 33% reduction by 2020	Scenario 2: 80% reduction by 2050
Average trip length (km)	14.9	15.6	9.7	5.2
Percent change	0%	+ 5%	-35%	-65%
# of dwellings within 400m of a town centre	2,555	4,848	29,791	135,324
# of dwellings within 400m of frequent public transit	31,430	44,281	60,099	97,815
Total additional new dwellings		*28,669*	*28,669*	*77,690*

Source: GIS analysis, GHGProof

In addition to land-use variables, other assumption were also included resulting from policies and regulations of other levels of government. These assumptions are based on the adoption of US fuel efficiency and low carbon fuel standards (Canada is expected to harmonize standards with the US). The assumptions include:

1. Average fleet efficiency of new cars meets Canada/US requirements of 15.15 km/l (2016) and 23.17 km/l (2025), increasing to an average of 40 km/l by 2050 as high efficiency vehicles come online.
2. Average fuel emissions declines from 2.5 kgCO2e/litre of fuel in 2010 to 0.77 kgCO2e/litre in 2050 as electric vehicles come online.
3. 10% increase in fuel efficiency of commercial transportation by 2020 and 40% increase by 2050.

Dwellings

Planned or potential dwellings- BAU Projections

	Planned or Potential Units	Single-detached house	Semi-detached house	Row house	Apartment, duplex	Apartment, 5 or more storeys	Apartment, under 5 storeys	Other single-attached house	Movable dwelling
Kelowna	20,085	8,565	0	0	4,670	6,850	0	0	
West Kelowna	7,472	484	1,459	3,143	60	1,446	880	0	0
Lake Country	4,372	3,500	500	0	0	0	372	0	0
Peachland	5,076	151	70	112	3,158	112	1,473		
WFN	2,564	986	0	80	0	0	1,158	0	340
Central Okanagan East	0	0	0	0	0	0	0	0	0
Central Okanagan West	43	43	0	0	0	0	0	0	0
Totals	39,612	13,729	2,029	3,335	7,888	8,408	3,883	0	340

Table: Dwelling mix

	Baseline (2007)	BAU/OCP Scenario (2020)	Scenario 1: 33% reduction by 2020	Scenario 2: 80% reduction by 2050
Detached	38,130	43,814	46,731	44,768
Attached	11,655	18,898	14,522	24,932
Apartments <5 storeys	12,235	25,511	26,570	45,427
Apartments >5 storeys	555	3,294	3,422	13,832
Mobile Homes	3,680	3,680	3,680	3,680

Source: BC Stats, GIS analysis, GHGProof

Assumptions describing building code improvements are described in the table below. In order to achieve the 33% and 80% reductions, additional enhancements to the building code beyond the changes announced by the BC Government last year are required. These improvements apply only to new build.

Table: Building code improvements for new build

	Baseline (2007)	BAU/OCP Scenario (2020)	Scenario 1: 33% reduction by 2020	Scenario 2: 80% reduction by 2050
Energy efficiency increase for new dwellings		20%	50%	60%

Source: Government of BC, GHGProof

Existing buildings will be retrofitted to achieve the following energy savings:

Table: Retrofitting existing residential buildings

	Baseline (2007)	BAU/OCP Scenario (2020)	Scenario 1: 33% reduction by 2020	Scenario 2: 80% reduction by 2050
Percentage of existing buildings retrofitted	0%	20%	20%	50%

Source: GHGProof

To achieve the 33% and 80% reductions, the energy mix for residential and commercial buildings shifts from natural gas to air-to-air and geothermal heat pumps using electricity.

Table: Energy mix for residential buildings

	Baseline (2007)	BAU/OCP Scenario (2020)	Scenario 1: 33% reduction by 2020	Scenario 2: 80% reduction by 2050
Electricity	38%	38%	48%	58%
Natural gas	55%	55%	45%	35%
Heating oil	1%	1%	1%	1%
Propane	1%	1%	1%	1%
Wood	5%	5%	5%	5%

Source: CEEI, GHGProof

Table: Energy mix for commercial buildings

	Baseline (2007)	BAU/OCP Scenario (2020)	Scenario 1: 33% reduction by 2020	Scenario 2: 80% reduction by 2050
Electricity	47%	47%	58%	65%
Natural gas	53%	53%	32%	20%
Heating oil	0%	0%	0%	0%
Propane	0%	0%	0%	0%
Wood	0%	0%	10%*	15%*

Source: CEEI, GHGProof

* Utilisation of biomass district energy

District Energy

Table: District energy projections

	Baseline (2007)	BAU/OCP Scenario (2020)	Scenario 1: 33% reduction by 2020	Scenario 2: 80% reduction by 2050
Number of dwellings connected to District Energy	0	4,658	30,819	89,619

Source: GIS analysis

Solid waste

Table: Solid waste

	Baseline (2007)	BAU/OCP Scenario (2020)	Scenario 1: 33% reduction by 2020	Scenario 2: 80% reduction by 2050
Solid waste (tonnes per capita)	0.87	0.87	0.44	0.35
Solid waste- % change over Baseline (2007)	100%	100%	50%	60%
Solid waste with methane capture	77%	77%	100%	100%

Source: RDCO

Agriculture and Forests

Table: Agriculture assumptions

	Baseline (2007)	BAU/OCP Scenario (2020)	Scenario 1: 33% reduction by 2020	Scenario 2: 80% reduction by 2050
Area of land actively farmed (ha)	27,201	27,201	27,201	48,962
% of food produced that is locally consumed	20%	20%	30%	80%

Source: Statistics Canada, GHGProof analysis

Table: Forest area assumptions

	Baseline (2007)	BAU/OCP Scenario (2020)	Scenario 1: 33% reduction by 2020	Scenario 2: 80% reduction by 2050
Area of forest controlled by the municipality (ha)	36,700	36,700	48,811	73,400

Source: RDCO, GIS analysis