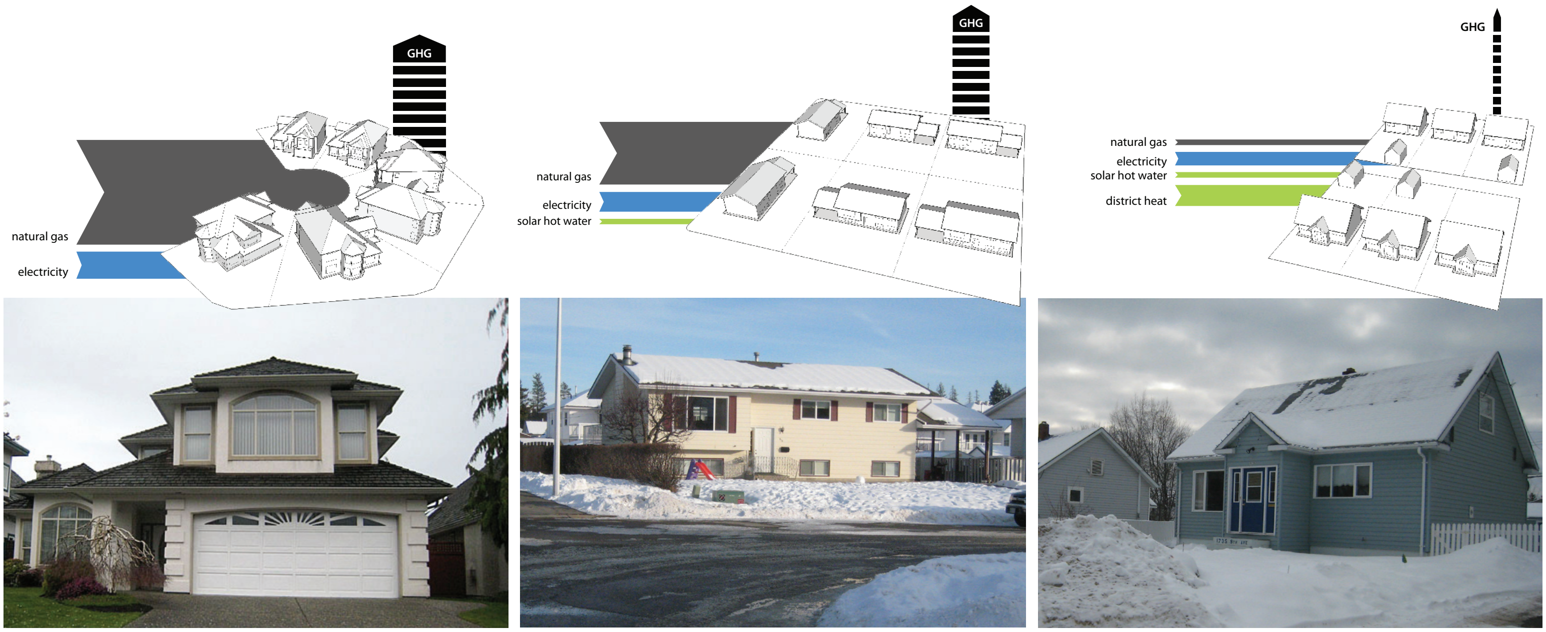
# THE RETROFIT CHALLENGE
## EXECUTIVE SUMMARY




Re-thinking Existing Residential Neighbourhoods for Deep Greenhouse Gas Reductions

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The Collaborative for Advanced Landscape Planning at the University of British Columbia specializes in sustainable landscape planning and design, landscape visualization and environmental perception, with a focus on assessing and visualizing local climate change impacts, response options, and greenhouse gas mitigation.

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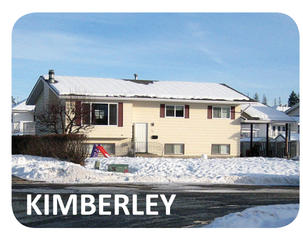
# EXECUTIVE SUMMARY

British Columbia has established targets of 33% reductions in total Provincial greenhouse gas (GHG) emissions by 2020 and 80% reductions by 2050 (Province of British Columbia 2007). Among the major sectors contributing to climate change, buildings – and the residential sector in particular – play a substantial role. Buildings across BC contribute 12% of total Provincial GHG emissions and account for nearly a quarter of all household emissions. A majority of building related emissions (57%) is attributable to residences (Province of British Columbia 2008) and is primarily due to the combustion of fossil fuels for the provision of space heating and hot water. Even with currently proposed policies and actions, reducing total GHG emissions from buildings will not be easy. While new construction has clear advantages for incorporating low-energy and GHG design and technologies, the scale of GHG reductions required cannot be achieved through new construction alone.

This research project examines a range of different options to retrofit existing residential neighbourhoods for building-related GHG reductions out to 2050. The study looks at the GHG reductions achievable under existing policy directions and grant programs, intensive building-level retrofits, and shared opportunities for reductions, including neighbourhood-scale renewable energy systems. The purpose of the study is to test what current policy might achieve in comparison to an 80% GHG reduction target for residential buildings, and to consider how this target might be achieved through individual and shared actions. The study did not include GHG emissions related to transportation, although neighbourhood design and location can have a significant impact on transportation emissions.

1990's cul-de-sac subdivision

The examination of shared actions tested the hypothesis that achieving GHG emission reduction targets will require not only actions for individual buildings, but also consideration of neighbourhood, city and regional scale planning. New energy and GHG strategies such as small-scale energy supply technologies (e.g. district energy), waste-heat sharing, and the shaping of urban form to maximize solar access and other energy opportunities require that neighbourhoods be thought of as systems, rather than simply as groups of individual buildings. In addition, the study sought to explore regional differences, and the trade-offs between demand reductions, energy efficiency, and low-carbon energy supply.



1970's subdivision

A combined scenario and case study methodology was used to examine different approaches for neighbourhood scale GHG reductions across BC. Three neighbourhoods from different climatic regions - Delta, Kimberley and Prince George - were selected as representative of typical street designs, building types and building ages. The Delta case study neighbourhood, with 199 single-family homes on 10.6 hectares, represents recent subdivision development, including large, complex houses, and a disconnected, cul-de-sac street system. Kimberley's

Older, adjacent to downtown

neighbourhood, with 71 single-family homes on 7.2 hectares, represents 1960s and 1970s suburban/rural development, including rectangular building forms and an irregular but interconnected street system. Prince George, with 335 mixed single-family and apartment units on 11.2 hectares, represents an older neighbourhood adjacent to a downtown area, with a grid street system including back lanes.

Three scenarios - Current Policy Direction, Intensive Building Retrofits, and Neighbourhood Focused Approach - were developed to represent how each case study neighbourhood could evolve by 2050, using a variety of retrofit strategies (Table 1). Redevelopment rates were assumed to be low for Delta and Kimberley, with 10% building replacement and no increase in the number of units. In contrast, redevelopment was assumed to add 54% more units for the Prince George case study, given the neighbourhood's older age, proximity to the downtown core, and identification by the City as a neighbourhood to target for infill development.

Neighbourhood models were produced using an energy strategy assessment, building energy modeling, and neighbourhood-scale spatial analysis. Retrofits were assumed to have 100% uptake across the case study neighbourhoods. Twelve neighbourhood model runs (1 baseline and 3 scenarios for each of the 3 different case studies) were used to measure the total energy use and GHG implications across the scenarios.

**TABLE 1. KEY STRATEGIES FOR DEMAND, EFFICIENCY AND HEATING SYSTEMS, AND HEATING ENERGY**

| | Scenario 1<br>Current Policy Direction | Scenario 2<br>Intensive Buildings | Scenario 3<br>Neighbourhood Approach |
|---|---|---|---|
| **DELTA** | | | |
| Demand reductions | Minor | Extreme | Moderate |
| Efficiency/System Changes[a] | Efficiency upgrades | Air to air heat pumps | Air to air heat pumps |
| Main Energy Supply | Natural gas | Electricity | Electricity |
| **KIMBERLEY** | | | |
| Demand Reductions | Moderate | Extreme | Moderate |
| Efficiency/System Changes[a] | Efficiency upgrades | Wood stoves | Shared District Heat |
| Main Energy Source | Natural gas | Biomass | Biomass |
| **PRINCE GEORGE** | | | |
| Demand Reductions | Moderate | Extreme | Moderate |
| Efficiency/System Changes[a] | Efficiency upgrades | Individual Geothermal | Shared District Heat |
| Main Energy Source | Natural gas | Electricity | Biomass |

a. All case studies additionally include solar hot water, with some implementation in Scenario 1, and increased implementation across Scenarios 2 and 3.

## RESULTS

The Current Policy Direction Scenario focuses on current practices for energy retrofits, as promoted by federal, provincial and other organizations for home-owners, and "green buildings" for new construction. The core strategy of this scenario is demand reductions through building envelope upgrades and heating system efficiencies, with minimal energy system or source changes. Some solar hot water is implemented. Overall, the scenario achieves GHG reductions of 33-50% for the case study neighbourhoods. The Kimberley case study shows the greatest reductions because the vintage of the houses means that greater gains are available from efficiency retrofits than for the newer homes in Delta. The older Prince George residences can achieve considerable energy savings with upgrades; however, these are partially offset by the 54% increase in residential units.

The goal of the Intensive Building Retrofits Scenario is to find strategies that move residences off fossil fuels altogether, with a specific GHG reduction target of +80% reductions from the baseline. The scenario therefore employs aggressive building scale retrofits, including substantial building renovations not typically contemplated in current practice, such as moving or re-sizing windows, re-cladding houses with extra insulation, and adding ground level insulated sub-floors. Heating and hot water systems are changed to heat pumps, wood stoves, and solar thermal (where possible) with on-demand backup. New construction is designed to meet very high energy and GHG performance standards (e.g. Passivhaus). The strategies thus represent substantially more aggressive buildings changes, costs, and lifestyle impacts, and achieve higher GHG reductions: overall, the scenario achieves GHG reductions of 55-93% for the case study neighbourhoods. The low result for Prince George is due to the increase in electrical use for the geothermal heat pumps, and the overall energy demand increases due to the 54% increase in dwelling units. Responsibility for successful implementation lies with home-owners and builders.

The goal of the Neighbourhood Focused Approach Scenario is to temper the extreme space heating demand reductions required by the second scenario by finding alternate ways of reducing GHG emissions. This scenario therefore explores strategies at the neighbourhood scale, including biomass-based district energy systems for heat and hot water, and multi-parcel approaches such as shared solar thermal, and redevelopment of the worst-performing buildings. As in the second scenario, a target of 80% GHG reductions for the neighbourhoods was adopted. Overall, this scenario achieves GHG reductions of 80-94% for the case study neighbourhoods, even with the 54% increase in units in the Prince George scenario. Due to the shared systems, responsibility for successful implementation lies with local government as well as home-owners and builders.

Compared to Scenario 2, the move to a shared low-carbon energy supply (biomass-based district energy) for heat and backup hot water enables the smaller total energy reductions but greater or equivalent GHG reductions in Kimberley and Prince George. In addition, it is only in Scenario 3 that growth in residential units can be accompanied by deep GHG reductions, shown by Prince George. However, the Delta results also show that for some neighbourhoods, a shared approach may not be as effective as an intensive, individual house retrofit approach.

**TABLE 2. SIMPLIFIED SCENARIO RESULTS TABLE**
Percent change from the baseline in energy use and GHGs, for the neighbourhoods as a whole.

| | Scenario 1<br>Current Policy Direction | Scenario 2<br>Intensive Buildings | Scenario 3<br>Neighbourhood Approach |
|---|---|---|---|
| **DELTA** | | | |
| Total Energy | -30% | -78% | -75% |
| **Total GHGs** | **-33%** | **-89%** | **-80%** |
| **KIMBERLEY** | | | |
| Total Energy | -45% | -82% | -60% |
| **Total GHGs** | **-50%** | **-93%** | **-94%** |
| **PRINCE GEORGE** | | | |
| Total Energy | -36% | -70% | -54% |
| **Total GHGs** | **-34%** | **-55%** | **-92%** |

## CONCLUSION

The results illustrate that deep reductions in building-related GHGs in existing residential neighbourhoods are achievable with currently available technologies. Scenario 1 achieves results that meet the 2020 BC Government targets of a 33% reduction, but will not achieve the 80% reductions required to meet 2050 targets. Scenarios 2 and 3 demonstrate that 80% reductions are achievable, and that there are different pathways to significant GHG reductions. All of the scenarios assume a rate of retrofitting, 100%, that is almost inconceivable. Critical questions regarding which technological pathway to choose, who is responsible, how to pay, and how to implement remain.

Five no-regrets moves that apply across all scenarios are evident. They will require uptake of improved technology, and collaboration between policy-makers, builders/developers, the building trades, the real estate industry, and home-owners to implement. They are:

1. Building envelope upgrades are required for most if not all current residences;

2. Solar thermal (hot water) will need to become a standard feature for retrofits and new-buildings;

3. Significant reductions in current electrical use will be required;

4. Redevelopment to rowhouses and multi-family, using compact geometry and smaller unit sizes, rather than single-family dwellings, can help to achieve net-zero neighbourhoods;

5. It is easier to "build green" from the beginning than to retrofit later: all new construction should be built to net-zero or Passivhaus standards.

In addition, the study shows that low-carbon, locally available energy supplies, such as biomass, will be important for many communities to achieve deep GHG reductions, as demand reductions and energy efficiency are critical but not necessarily sufficient.

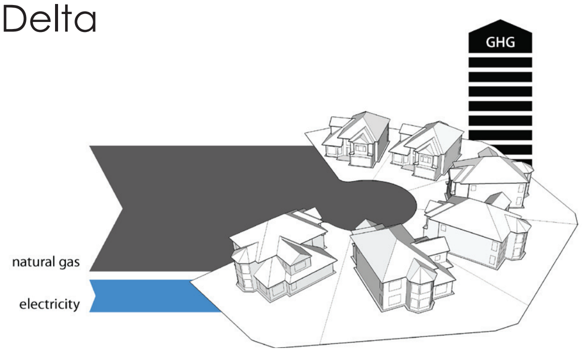
Beyond the initial "no regrets" steps, the three case studies demonstrate that a single retrofit/redevelopment solution will not be applicable to every neighbourhood across BC. Each neighbourhood will require a specific assessment of its particular potentials and constraints with respect to reducing GHGs. The analysis needs to consider the characteristics of individual homes (including age, orientation and construction details), the overall spatial configuration of the neighbourhood, and the age and condition of existing neighbourhood infrastructure, the availability of local renewable energy sources, and the local climate.

Other criteria that will help communities to make decisions about which pathway to follow include quality of life trade-off, levels of responsibility, and economic considerations. The Intensive Building Retrofits scenario places most of the responsibity on individual home-owners, and requires considerable quality of life and behavioural changes, while the Neighbourhood Approach places a shared responsibility across home-owners and local governments, with fewer quality of life changes. Costing, which was beyond the scope of the research study, will also point to the best way to move forward, enabling a richer comparison across scenarios.

**FIGURE 1. CROSS-CASE STUDY RESULTS**
Average energy use and greenhouse gas emissions per household.

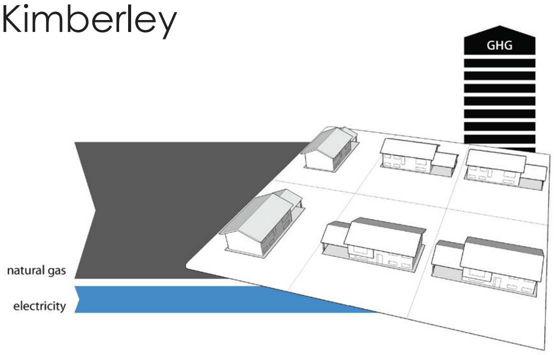
| BASELINE | Scenario 1<br>Current Policy Direction |
|---|---|

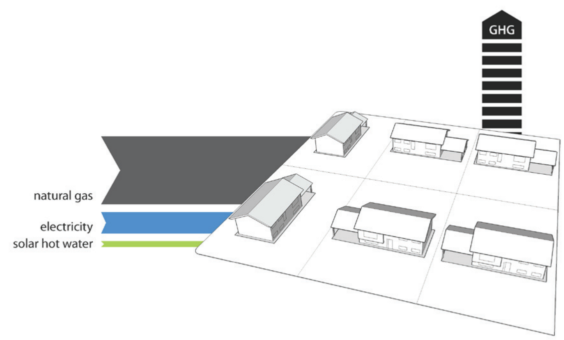
## Delta



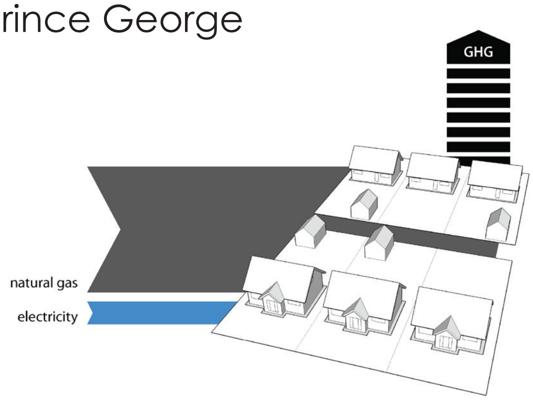


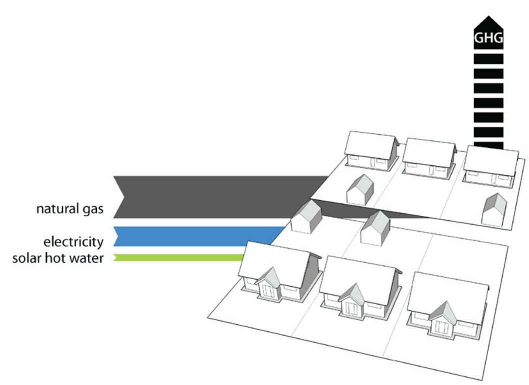
## Kimberley



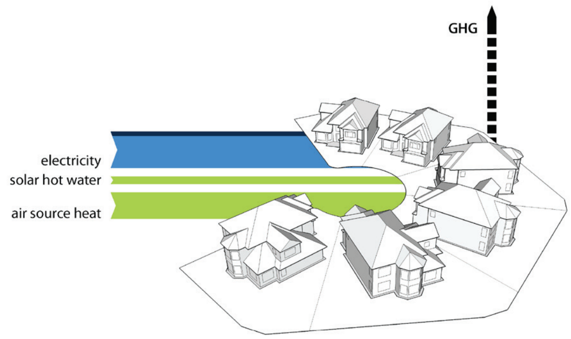

## Prince George

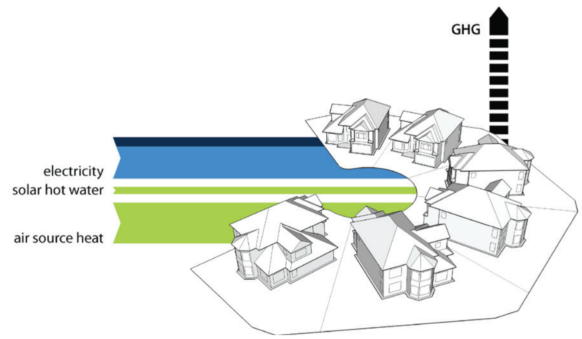


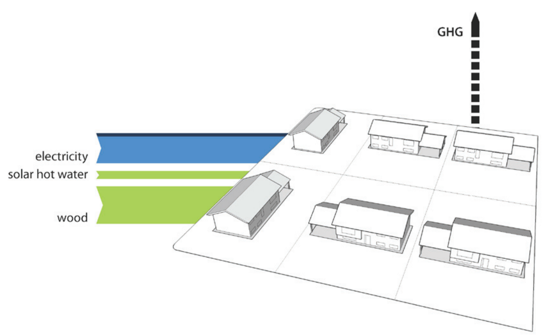



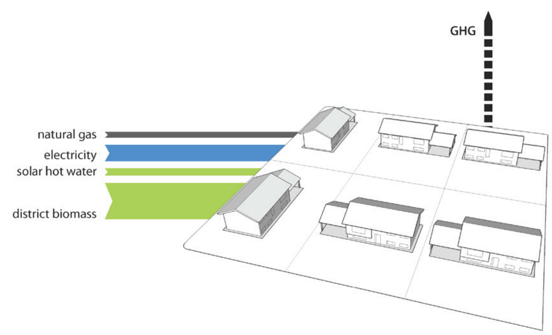
## Scenario 2
## Intensive Building Retrofits

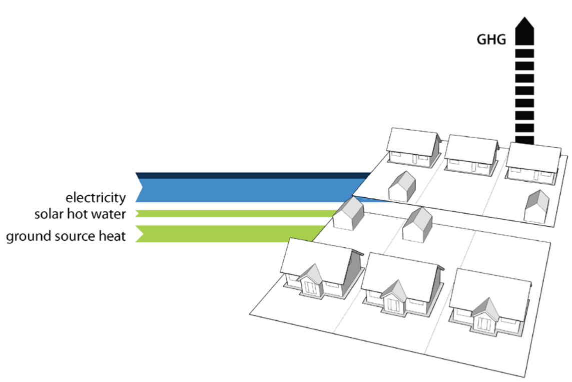
## Scenario 3
## Neighbourhood Approach

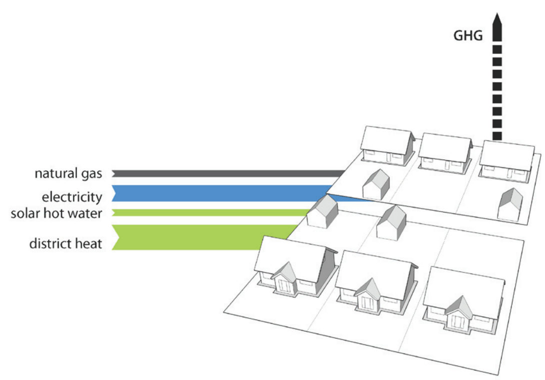



Electrical load beyond 100% of the baseline is shown in dark blue, and is assumed to be met by natural gas-fired electricity.

Institutional and costing factors, rather than technology development, are the likely barriers to overcome in realizing deep greenhouse gas reductions within existing residential neighbourhoods. Builders, developers, realtors, local governments, home-owners and others are critical players in forwarding the strategies for meeting the challenges posed by climate change mitigation within existing BC communities. On-going work is needed to determine how best to achieve the building and neighbourhood changes required for deep GHG reductions as it is clear that implementing the strategies presented in this report will require substantial buy-in from individuals, the real estate industry, and local and higher levels of government. How best to achieve this buy-in remains an open question; at a minimum, it will require informed, engaged, and motivated community members - residents, developers, realtors - working closely with local government.