Defining and Describing Energy Poverty in British Columbia: The Distribution of Households' Energy Expenditure

Dr. Blake Shaffer
University of Calgary

Dr. Jennifer Winter
University of Calgary

Date: December 2020

Author Note

The authors can be contacted at blake.shaffer@ucalgary.ca and jwinter@ucalgary.ca.

We thank Emily Galley, Jinan Liu, and Kathleen Mullrooney for excellent research assistance on this project. Research paper commissioned by the Expert Panel on Basic Income, British Columbia. We gratefully acknowledge funding from the Government of British Columbia (spcs46008190052 and spsc46008190046) that helped support this research. All inferences, opinions, and conclusions drawn in this paper are those of the authors, and do not reflect the opinions or policies of the Data Innovation Program or the Province of British Columbia.

Abstract

Increasingly stringent environmental policy, such as the current CleanBC plan, has the potential to reduce households' ability to afford energy services. While Canada has an official poverty line, there is no official measure of energy poverty, which is a correlate of income-related poverty. We examine household energy poverty—the inability of households to afford energy services or maintain adequate living conditions—in British Columbia with several indicators from academic literature using 2017 Survey of Household Spending public-use microdata. The indicators provide different quantitative definitions of energy poverty, and we compare and contrast results across indicators to identify household characteristics common across indicators. Given the significant differences in the results of these energy poverty indicators, we propose a minimum bound for energy poverty in B.C. is the share of households that are identified by multiple indicators. Together, these indicators and aggregate definitions suggest energy poverty in B.C. is most commonly found in households that are low income (particularly those in the lowest income quintile); mostly singles and lone parents; live in single detached, older homes, with a mortgage; and seniors. We conclude with a discussion of existing policy supports to alleviate energy poverty, and discuss the potential distributional consequences of the CleanBC plan.

Introduction

This paper examines household energy poverty in British Columbia, informing our understanding of the potential effect of increasingly stringent environmental policy on households' ability to afford energy services. "Energy poverty" is the inability of households to afford energy services or maintain adequate living conditions. B.C.'s Climate Change Accountability Act sets emissions reduction targets of 40% below 2007 levels by 2030, 60% by 2040, and 80% by 2050 (British Columbia 2007, Part 1). In 2017, B.C.'s emissions were only 0.5% below 2007 levels, and the majority of emissions are from energy use, primarily transportation (Environmental Reporting BC, 2019). Changes in policy will be needed to meet these ambitious targets, which will in turn require changes in energy use and types of energy used by households and businesses. We can expect these changes to affect all British Columbians, and without consideration of existing vulnerabilities to detrimentally affect the most vulnerable.

The CleanBC plan sets an ambitious goal to reduce greenhouse gas emissions in British Columbia through numerous regulatory and policy actions, with an explicit goal that the changes "cannot leave anyone behind" (Government of British Columbia, 2019, p. 5). This follows and extends the imposition of a carbon tax in 2008 coupled with rebates to low-income, northern, and rural households. These policy actions affect households' ability to afford energy services. While there are estimates of the cost of carbon pricing to households and subsequent behavioural changes in B.C. (Beck et al., 2015; Murray & Rivers, 2015; Rivers & Schaufele, 2015), as well as economy-wide impact estimates (Böhringer et al., 2015; Carbone & Rivers, 2017; Rivers, 2013; Yamazaki, 2017; Yip, 2018), our understanding of how environmental policy interacts with poverty in Canada (and households at risk of poverty) is limited.

As part of a broader study on the potential for a basic income in B.C., we explore households' ability to afford energy services, or their risk of energy poverty.[1] We characterize energy poverty (using expenditure on in-home energy use) in B.C. with several indicators from academic literature, using the 2017 Survey of Household Spending public use microdata. We find that energy poverty in B.C. is most commonly found in households that are low income (particularly those in the lowest income quintile); mostly singles and lone parents; live in single detached, older homes, with mortgage; and seniors. With this information and context, we discuss how existing policy supports alleviate energy poverty and how the CleanBC plan can be expected to interact with energy poverty.

Notably, while Canada has an official poverty line, there is no official measure of energy poverty,[2] which is a correlate of income-related poverty. B.C. has implemented a poverty-reduction strategy, with four guiding principles: affordability, opportunity, reconciliation, and

[1] Due to data limitations, we are unable to comment on energy poverty in rural and remote communities or Indigenous communities.

[2] There are numerous energy poverty concepts and definitions in Europe; Castaño-Rosa et al. (2019) provide an overview.

social inclusion (Province of British Columbia, 2019); affordable energy services directly relate to these principles.

Energy poverty is the subject of research in both developing and developed country contexts. Most relevant to us is the European Union Energy Poverty Observatory (n.d.), which collates research, indicators, and data on energy poverty for European Union countries. Recent work in the U.K. considered the potential for higher natural gas heating costs to push more households into energy poverty, and subsequent health and mortality impacts (Crossley & Zilio, 2018; Hernández, 2016). Related work looks at the efficacy of policy measures to alleviate energy poverty in the U.K. through the Winter Fuel Payment program for seniors (Beatty et al., 2014). Specific to Canada, most work is from think tanks or NGOs (Consumers' Association of Canada (Manitoba) Inc., 2017; Green et al., 2016; Lee et al., 2011; Maynes, 2008). Lee et al., Green et al., and Rezaei (2017) describe households' energy expenditure and characterize energy poverty and households' vulnerabilities to price changes. Lee et al. and Rezaei specifically look at British Columbia, using a single year of data (2009 and 2011, respectively) to examine energy poverty. In addition, Lee et al. and Green et al. use a definition of energy poverty of households that spend 10% or more of their income on energy sources. Rezaei notes that this definition comes from Boardman (2010, 2012), who examined energy poverty in the U.K.; the threshold of 10% was two times the national median of energy expenditure's share of income, and is unlikely to be appropriate in a Canadian context. We use seven different indicators to characterize energy poverty in B.C., both for comparability to past work and because each type of indicator has strengths and weaknesses.

The paper proceeds as follows. First, we discuss how to define energy poverty, drawing on definitions from academic research. We then present seven indicators from past work for measuring energy poverty in B.C., modifying these where necessary to match the data we have available to us. We also discuss indicators previously used to define energy poverty in Canada and B.C. to contextualize our choices in previous Canadian work. Second, we characterize energy use and energy poverty in B.C., using the seven indicators and three aggregate indicators. We follow with a discussion of expenditure on transportation. Third, we discuss existing policy supports to alleviate energy poverty and discuss the potential distributional consequences of the CleanBC plan. We conclude with recommendations for policy-makers in B.C.

Defining Energy Poverty and Energy Affordability

There are numerous definitions and approaches to measuring energy poverty. Here, we briefly review the approaches and their pros and cons, drawing on existing academic literature. (A full description of indicators with strengths and weaknesses is presented in Appendix A1.) We focus on work examining energy poverty in the developed world, as that is most relevant for our analysis. We abstain from discussing qualitative measures of energy poverty (such as self-reported housing conditions like thermal comfort or surveys on households' perceptions) as we

do not have data on these indicators. Following the brief literature review, we present indicators we have chosen for characterizing energy poverty in B.C., along with a brief description of their strengths and weaknesses. We then discuss definitions used in extant work examining energy poverty in Canada to provide context for our choice of indicators.

Definitions From Literature

The first definition of energy poverty is generally attributed to Boardman (1991), who defined U.K. households as "fuel poor" if their expenditure on energy services exceeds 10% of total income, which was twice the median fuel-expenditure-to-income ratio (Boardman, 2012). The definition became commonly used, with little-to-no acknowledgement of the rationale behind the 10% threshold. Importantly, this measure is a relative one, based on a snapshot in time of income levels and prices. Romero et al. (2018) criticize the measure due to its sensitivity to energy prices, the arbitrary selection of a 10% threshold, and its ability to capture "high-income households with … excessive energy consumption" (p. 100).

More complex and less arbitrary measures have been proposed over time. Closest to the 10% threshold are 2M-type indicators, where thresholds are defined as twice the median or twice the mean of either household expenditure on energy or the ratio of household expenditure on energy to income (Castaño-Rosa et al., 2019). These indicator types address some problems with the 10% threshold: keeping its simplicity while removing the arbitrariness of the threshold and ensuring high-income households are not misidentified as energy poor. However, these measures are relative, and identification of a given household as energy poor will depend on the distributions of expenditure and income. While still a relative measure, the hidden energy poverty indicator identifies households with "abnormally low" energy expenditure, using a threshold of households with expenditure below half the median energy expenditure (Betto et al., 2020; Castaño-Rosa et al., 2019). This indicator is meant to identify households that are low income and have to choose between energy use and other necessities. However, it will misidentify households without energy costs (renters with utilities included, condo owners) as being in energy poverty unless the definition is modified to include income.

Moore (2012) proposes a minimum income standard (MIS) indicator, where households are defined as energy poor if energy costs are greater than household income less housing costs and the minimum income standard. The benefit of this approach is that it explicitly accounts for socio-economic factors (household size, type, location) in identification of energy poverty. The main drawback is it requires definition of an MIS, which is complex and potentially contentious. The MIS itself may be an arbitrary choice, lessening the value of this type of indicator (Castaño-Rosa et al., 2019). Moore argues that an MIS-based measure of energy poverty is a "more accurate and consistent measure of a household's ability to afford fuel costs" (p. 22), as it shows whether households have sufficient residual income to meet energy costs after minimum household expenses. Romero et al. (2018) note a weakness of this approach if the MIS is incorrectly measured or insufficient to cover all household needs, and suggest a modification involving three conditions (see Table A1 in Appendix A).

A related approach is the after-fuel-cost poverty (AFCP) indicator, whereby households are defined as energy poor if household income, less housing and energy expenditure, is below a minimum acceptable income (Castaño-Rosa et al., 2019). This approach focuses on household income after expenses compared to a minimum income threshold, and is based on the MIS indicator.

The low-income high-cost (LIHC) metric is the most complex, as households must satisfy two conditions to be defined as energy poor. Households must have (a) energy expenditure above average, such as a national median level, and (b) income after their energy expenditure below an income threshold. Proposed by Hills (2012), it became England's measure of energy poverty in 2013 (Department for Business, Energy & Industrial Strategy, 2020).[3] The LIHC is a dual indicator, identifying the number of households with low income and high energy costs, as well as the depth of energy poverty for households classified as being in energy poverty, where depth is the difference between actual expenditure and the threshold. Importantly, the Hills method relied on modelled[4] median energy expenditure for the first threshold, rather than actual median expenditure. Romero et al. (2018) proposed a slightly modified version of the LIHC, lowering the second threshold by comparing household income after energy expenditure to median income after energy expenditure. Moore (2012) criticizes the LIHC indicator as "excessively complex and not transparent" (p. 25), masking the effect of fuel price changes on energy poverty, and ignoring the role of energy efficiency and housing stock in determining actual expenditure and energy poverty. Romero et al. note that the LIHC is an indicator based on two relative measures, making time trends difficult to interpret.

Table A1 in Appendix A outlines the strengths and weaknesses of these various measures. Not surprisingly, there are trade-offs associated with the use of each to measure energy poverty. Relative measures, such as the 2M and Romero et al. LIHC approaches, present energy inequality rather than energy poverty. However, indicators using household energy expenditure relative to a threshold allow for identification of an "energy poverty gap," which is useful for defining the depth of energy poverty. Relative measures are also difficult to compare across time periods, as energy prices and incomes change. Data availability is also a challenge. The U.K. methodology is the most advanced, as it compares households' energy expenditure to the modelled expenditure necessary for households to achieve an "adequate level of warmth" (Department for Business, Energy & Industrial Strategy, 2020, p. 2). However, this requires detailed data on household characteristics to construct modelled energy expenditure and to match households to modelled expenditure per household type. Data limitations have prevented the use of the U.K. indicator in other contexts; instead, researchers rely on relative measures that compare household expenditure to median expenditure—or household expenditure shares to median expenditure shares (Hills, 2011, 2012; Mohr, 2018;

[3] Northern Ireland, Scotland, and Wales kept the 10% indicator (Department for Business, Energy & Industrial Strategy, 2020).

[4] Energy requirements are modelled based on household size, dwelling type and energy efficiency and fuel mix, and energy prices.

Robinson et al. 2018)—or indicators that define energy poverty as relative to a minimum required income (Moore, 2012; Robinson et al., 2018; Romero et al., 2018). Not surprisingly, energy poverty research in Europe finds the choice of energy poverty definition matters for results on the depth and breadth of energy poverty (Hills 2011, 2012; Legendre & Ricci, 2015; Moore, 2012; Romero et al., 2018). Importantly, the indicators discussed above only include in-home energy use (excludes transportation), so in many instances they may under-measure the energy cost burden on households.

Indicators to Describe Energy Poverty in B.C.

As each indicator has its strengths and weaknesses, we do not feel it is appropriate to choose a specific indicator to describe energy poverty in British Columbia. Instead, we present the indicators made possible by the data we have available: the 2017 Survey of Household Spending (SHS) public use microdata file (PUMF) and public data tables from the SHS (which present averages).[5] The overlap of households within all indicators will present a potential lower bound of energy poverty in B.C.

Notably, all the measures described below focus solely on in-home energy use. We define "energy expenditure"[6] as expenditure on electricity, natural gas, and other fuels for principal accommodation (we omit energy expenditure for secondary residences).

A potential omission in the definitions of energy poverty described above is that many of them rely on energy expenditure relative to income. Poterba (1989) notes that income year to year is variable and is less so over longer time horizons. Moreover, consumption-smoothing suggests that expenditure provides "a more accurate measure of lifetime resources" (p. 325) compared to annual income. This is a challenge when evaluating energy poverty, as it is useful to identify households that are energy poor based on current income as well as those persistently energy poor based on lifetime income/consumption. In addition, using current income as a measure may mischaracterize those with high wealth (savings) and low income as being "energy poor."

Indicator 1: income-based 10% threshold

Description: A household is in energy poverty if

$$\frac{household\ energy\ expenditure}{household\ income} > 0.1$$

where energy expenditure is in-home energy use and income is total household net income after taxes and transfers.[7] Net household income includes earned income, investment income, government transfer payments, and other income (such as scholarships or RRSP withdrawals) for the reference person, their

[5] Due to COVID-19, we are unable to use detailed SHS data matched to tax-filer data and so are more limited in our analysis.

[6] Specifically, in the SHS PUMF, we define household energy expenditure as HH_EE = SH032 + SH033 + SH034.

[7] Specifically, in the SHS PUMF, we define household net income with the variables: HHNetInc = HHTotInc - TX001.

spouse, and others in the household. We include this indicator for comparability to other work on energy poverty in B.C., namely Green et al. (2016) and Rezaei (2017).

Strengths: simple; easy to use; identifies energy expenditure inequality; fixed threshold and target; commonly used metric.

Weaknesses: sensitivity to energy prices; arbitrary threshold; misclassifies high-income households with high energy consumption as energy poor; compares households of unequal size.

Indicator 2: expenditure-based 10% threshold

Description: A household is in energy poverty if

$$\frac{household\ energy\ expenditure}{household\ total\ expenditure} > 0.1$$

where energy expenditure is in-home energy use and total household expenditure is total consumption.[8]

Strengths: simple; easy to use; identifies energy expenditure inequality; fixed threshold and target; accounts for lifetime consumption-smoothing.

Weaknesses: sensitivity to energy prices; arbitrary threshold; compares households of unequal size.

Indicator 3: income-based twice national median

Description: A household is in energy poverty if

$$\frac{household\ energy\ expenditure}{household\ income} > 2 * median(\frac{energy\ expenditure}{income})$$

We use the national[9] median energy-expenditure-to-income ratio, and equivalize median energy expenditure and income by household size. We include this indicator for comparability to other work on energy poverty in B.C., namely Rezaei (2017) and CUSP (2019).

Strengths: simple to calculate; threshold definition related to distribution of income and expenditure; avoids problems of static measures not adjusting to changing circumstances; accounts for different household sizes having different energy costs. Household income is net incomes, as in Indicator 1.

Weaknesses: Identifies relative, not absolute, energy poverty; sensitive to energy prices; sensitive to low reported incomes; identifies energy inequality; does not describe

[8] Specifically, in the SHS PUMF, we define total household expenditure using the variable TC001.

[9] B.C. has the lowest mean and median energy expenditure shares across Canada. As overall energy expenditure is lower due to climate, this could understate the level of energy poverty in B.C.

severity/depth of energy poverty; arbitrary, fixed threshold; difficult to compare year to year.

Indicator 4: modified Hills (2012) LIHC

Description: A household is in energy poverty if two conditions are satisfied:

$$HH\ energy\ expenditure\ >\ median\ equivalized\ energy\ expenditure$$

AND

$$HH\ income\ -\ (rent\ +\ mortgage)\ -\ median\ equivalized\ energy\ expenditure\ <\ MBM$$

We are forced to modify the Hills (2012) LIHC as we do not have access to modelled energy expenditure for households in B.C. (or in Canada). Therefore the first condition compares household energy expenditure to median equivalized energy expenditure, rather than modelled. In the second condition, we replace $0.6 \times median\ after\ housing\ costs\ equivalized\ income$ (the U.K. poverty line) with the Vancouver market basket measure (MBM). We use national median equivalized energy expenditure in both conditions. Household income is net income, as in Indicator 1. Also different with this indicator is that income is adjusted for rent and mortgage but not other shelter costs.

Strengths: Corrects 10% threshold by including income threshold and energy expenditure; attenuates impact of price fluctuations; measures depth of energy poverty via gap from energy cost threshold; accounts for different household types having different energy costs;

Weaknesses: complex and not transparent; does not identify households where reducing energy costs will alleviate energy poverty; difficult to identify cause of changes to indicator over time; setting energy expenditure threshold at median ignores effect of energy efficiency; median fuel cost threshold may be too high; difficult to compare year to year.

Indicator 5: Moore (2012) minimum income standard (MIS)

Description: A household is in energy poverty if

$$HH\ energy\ expenditure\ >\ HH\ income\ -\ housing\ costs\ -\ equivalized\ MBM$$

This can be rewritten as:

$$HH\ income\ -\ HH\ housing\ costs - HH\ energy\ expenditure\ < equivalized\ MBM$$

which is the after-fuel-costs energy poverty measure.

We use the Statistics Canada MBM for the minimum income standard, as this is B.C.'s official poverty line. We use the Vancouver 2017 MBM (2018 base), as Vancouver is the highest MBM level in B.C. (and Canada) and the SHS PUMF does not have geolocational data for households.[10] (See

[10] We use the Vancouver MBM threshold for all provinces in our analysis as it is the highest MBM threshold in Canada and allows for comparisons across Canada based on the same measure of minimum income.

Table B4

in Appendix B for MBM values by household size.) We define housing costs as rent, mortgage, repairs, insurance and water for households' principal residence.[11]

Strengths: simple; includes concept of poverty and costs of shelter and food in measuring energy poverty; accounts for household size in energy poverty measurement; absolute measure of energy poverty; allows for a scale of energy poverty (determined by reduction in MIS living costs to afford energy costs).

Weaknesses: requires identification of minimum income (see Petit & Tedds, 2020c); sensitive to MIS definition; does not describe severity/depth of energy poverty.

Indicator 6: Romero et al. (2018) MIS

Description: A household is in energy poverty if

$$\begin{aligned} &HH\ energy\ expenditure \\ &\quad > HH\ income - housing\ costs \\ &\quad - [equivalized\ MBM - mean(eq.energy\ expenditure) - mean(housing\ costs)] \end{aligned}$$

We can rewrite this as

$$\begin{aligned} &HH\ income - equivalized\ MBM \\ &\quad < HH\ energy\ expenditure - mean(energy) + HH\ housing\ expenditure \\ &\quad - mean(housing\ expenditure) \end{aligned}$$

This rewritten relationship expresses energy poverty as deviations from mean energy expenditure and mean housing costs. As with Indicator 5, we use the MBM for a minimum income standard, and national mean energy expenditure and housing costs, equivalized by household size.

Strengths: includes concept of poverty and costs of shelter and food in measuring energy poverty; accounts for household size in energy poverty measurement; absolute measure of energy poverty; allows for a scale of energy poverty (determined by reduction in MIS living costs to afford energy costs).

Weaknesses: more complex than Moore (2012) MIS method; requires definition of minimum income; sensitive to choice of MIS; false negative if housing costs are large; does not describe severity/depth of energy poverty.

Indicator 7: hidden energy poverty

Description: A household is in energy poverty if

$$HH\ energy\ expenditure < 0.5 \times median(equivalized\ energy\ expenditure)$$

We use national median equivalized energy expenditure. Note we modify the HEP definition from Castaño-Rosa et al. (2019), using median equivalized energy

[11] Specifically, in the SHS PUMF, we define housing costs as HC = SH002 - SH032 - SH033 - SH034.

expenditure rather than median energy expenditure. This is to account for different household sizes having different energy use and expenditure patterns.

Strengths: simple; identifies households with low income and low energy expenditure (choice between heating and eating); identifies depth of energy poverty relative to threshold; accounts for different household sizes; comparable over time.

Weaknesses: households that do not pay utilities (renters, condo owners) will be misidentified as in energy poverty; arbitrary threshold; sensitive to energy prices.

Definitions Previously Used in Canada or B.C.

As noted above, the majority of work examining energy poverty in Canada is from think tanks and NGOs. To place our analysis in this context, we briefly describe the methods, data and approaches.[12]

The most common approach to measuring energy poverty in Canada is to apply the Boardman (1991) definition: households are energy poor if they spend more than 10% of their income on energy. This is the approach taken by Kelly (2007), Maynes (2008), McEachern and Vivian (2010), Lee et al. (2010), and Green et al. (2016) (Table 1).

Maynes (2008) also considers a 5% energy-expenditure-to-income ratio as average Canadian expenditure on energy was 3.1% of income in 2006. Rezaei (2017), in the first academic study of energy poverty in B.C. (and in Canada), explores two measures of energy poverty. The first is household energy-expenditure-to-income ratio is greater than 5.8%, twice the national median of the ratio in 2011. The second definition is an adaptation of the Hills (2012) method, augmenting the first threshold with whether households' income is below the low-income cut-off (LICO). The definition of energy is consistent across these works and with the research described above, including only in-home energy use. The exceptions are Maynes (2008) and Green et al. (2016). Maynes expanded the definition of "energy burden" to include expenditure on water, fuel and electricity. Green et al. compare energy poverty, using the standard definition of energy expenditure and in-home use plus gasoline expenditure, using the 10% threshold for both. As far as we are aware, the work of Green et al. is the only research that expands energy use to include fuels used in transportation.

Characterizing Energy Poverty and Energy Affordability in B.C.

In this section we analyze the available data, first exploring characteristics of household energy expenditure in British Columbia—compared to the rest of Canada, by income quintile, and household size—followed by a detailed analysis of the various energy poverty indicators outlined in the previous section.

For this analysis we rely primarily on public use microdata files from Statistic Canada's Survey of Household Spending. While this allows us to consider many demographic aspects of household spending, unfortunately the spatial granularity of the data is limited to the province

[12] We note that Mirnezami (2014) argues energy poverty is not an issue in Canada.

level. In future work we wish to explore the intraprovince heterogeneity between urban and rural communities.

Table 1

Energy Poverty Indicators Previously Used in Canada and B.C.

Paper	Jurisdiction examined	Measure of energy poverty	Years examined	Data source
Kelly (2007)	B.C.	energy expenditure >= 10% of after-tax income	2002	Survey of Household Spending, custom tabulations
Maynes (2008)	Canada	energy expenditure >= 5% of after-tax income OR energy expenditure >= 10% of after-tax income	1997 to 2006	Survey of Household Spending public use microdata files
McEachern and Vivian (2010)	B.C.	energy expenditure >= 10% of after-tax income	2007	Survey of Household Spending public use microdata files
Lee et al. (2011)	B.C.	energy expenditure >= 10% of total income	2009	Survey of Household Spending
Green et al. (2016)	Canada and provinces	energy expenditure >= 10% of total expenditure Consider in-home energy expenditure and gasoline expenditure in addition to standard in-home definition	2010 to 2013	Survey of Household Spending, custom tabulations
Consumers' Association of Canada (Manitoba) Inc. (2017)	Canada and provinces	Self-reported	2016	Focus groups
Rezaei (2017)	B.C.	energy-expenditure-to-income ratio > 5.8% (twice national median) OR household income < LICO	2011	Survey of Household Spending public use microdata files
CUSP (2019)	Canada and provinces	energy expenditure > 6% of after-tax household income (identified as roughly twice national median)	2016	2016 census, custom tabulations

Characteristics of Household Energy Expenditure

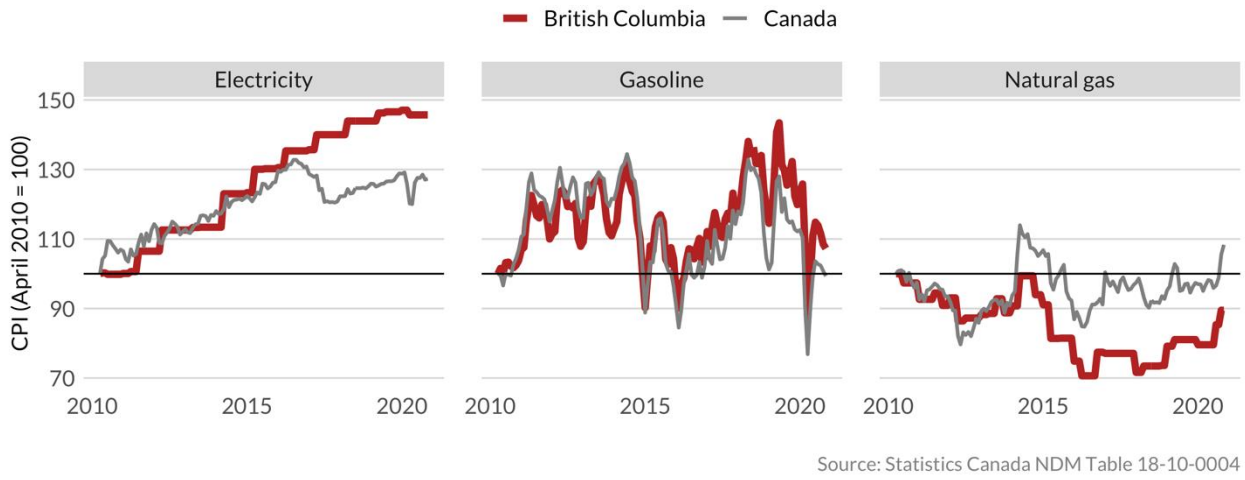
Price Inflation

The core components of energy spending in B.C. vary greatly in their respective price growth. Figure 1 shows the consumer price index for electricity, gasoline and natural gas over the past 10 years in B.C. and the rest of Canada. We highlight three key features of the data:

- First, while B.C. is among the provinces with low electricity costs in Canada (Hydro-Quebec, 2018), consumer electricity prices have risen more steeply in B.C. compared to the rest of Canada. Of note, the large drop in Canadian electricity prices in 2017 stems largely from Ontario's Fair Hydro plan to subsidize electricity rates (Ontario Energy Board, 2017).
- Second, changes in gasoline prices in B.C. largely follow movements in the rest of Canada, reflecting reasonably well-integrated petroleum markets across the country. More recently, however, B.C. gasoline prices began to diverge higher than the rest of Canada as delivery to and production in the Lower Mainland remains limited.
- Third, B.C. has experienced deflation in natural gas prices, with prices falling over the 10-year period while the rest of Canada remains flat. This broadly reflects low natural gas prices in Western Canada due to abundant supply, both locally and in typical delivery locations in the United States, and egress constraints depressing prices in the producer regions. B.C. natural gas production grew over this 10-year period to 5.3 billion cubic feet per day from 2.9 (Canada Energy Regulator, 2019).

Figure 1

Energy Price Inflation in B.C. and Canada, 2010–2020



Energy Expenditures

Using Statistics Canada Survey of Household Spending data and the Household and the Environment Survey, we highlight what British Columbians spend on energy and how they consume it and related products compared to the rest of Canada.

Gasoline is the largest household expenditure on energy products in B.C. and the rest of Canada (Figure 2). Within energy for the home, electricity is the largest energy expenditure in

B.C., followed by natural gas. “Other fuels”, i.e. heating oil, play a small role in B.C. yet remain an important source of home heating in other parts of Canada, namely the Atlantic provinces.

Differences in energy consumption (in GJ per household) by province are shown in Figure 3. There is a clear west–east divide on the usage of natural gas vs. heating oil. These differences manifest in our cross-province energy poverty metrics, with significantly higher costs in the Atlantic provinces. B.C. energy consumption, overall, is lower than the Canadian average.

Figure 2

Average Annual Expenditure by Commodity, B.C. and the Rest of Canada, 2017

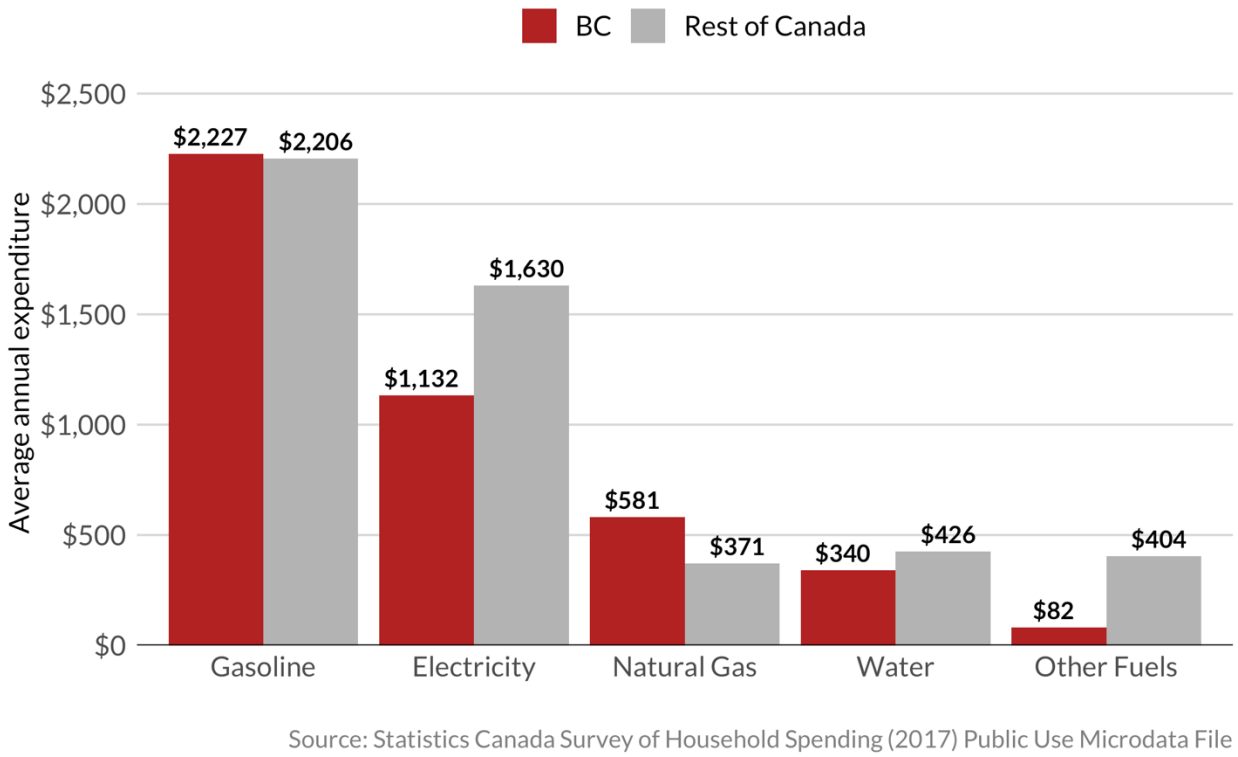


Figure 3

Energy Consumption by Energy Type Across Canada, 2015

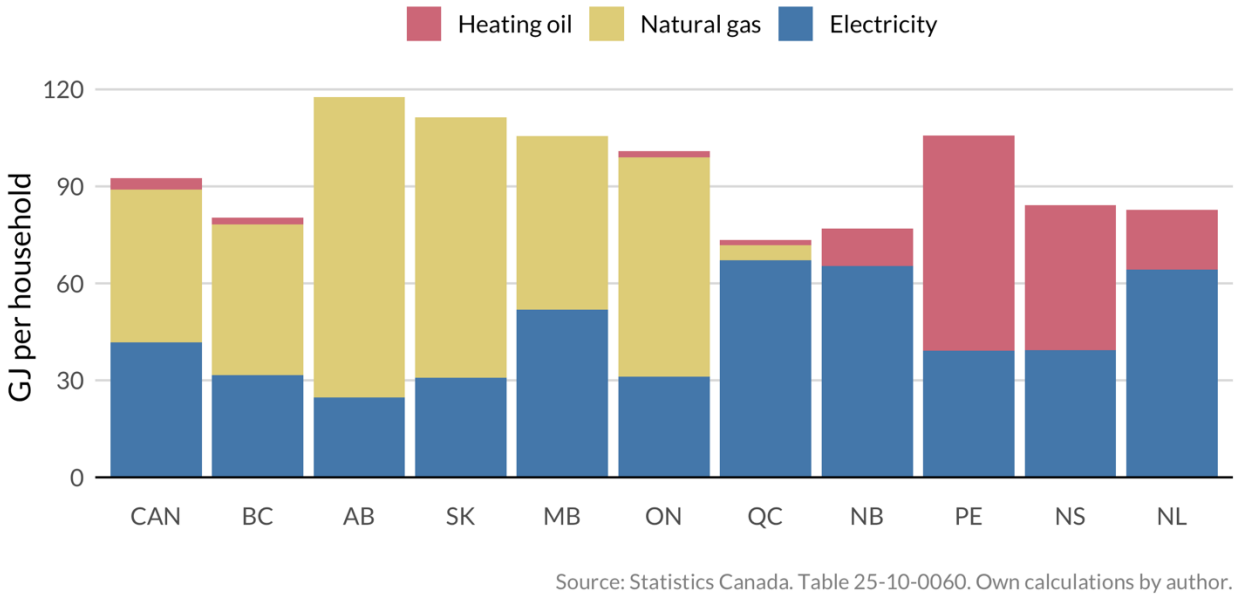
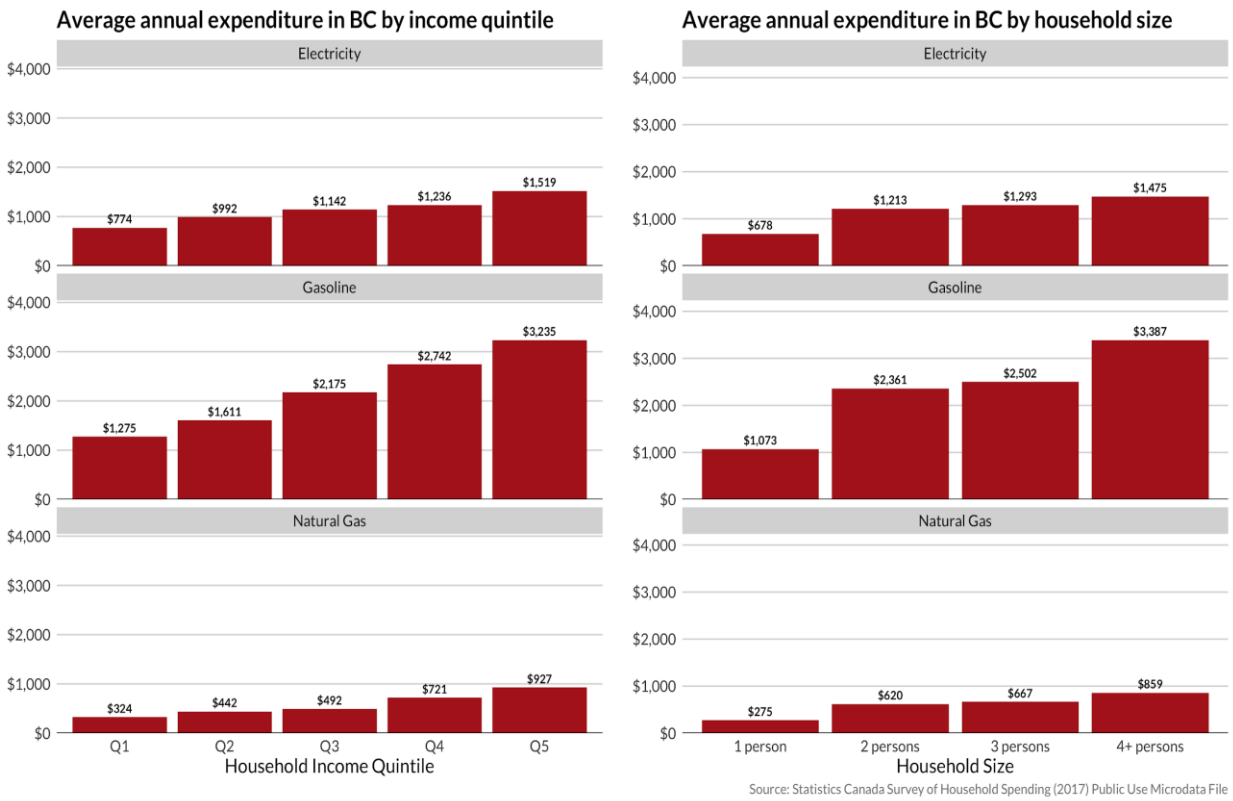


Figure 4 explores important heterogeneity in energy expenditure. We consider two dimensions: household (after-tax and transfers) income quintiles and household size.

Figure 4

Energy Expenditure in B.C. by Income Quintile and Household Size, 2017



Expenditures are, unsurprisingly, increasing in both income quintile and household size.[13] We note, however, that the degree of progressivity differs across commodities. Gasoline and natural gas expenditures roughly triple between the first and fifth income quintiles, whereas electricity has a much flatter profile, with expenditures roughly doubling from first to fifth quintile. A similar pattern exists along the household size dimension, with gasoline and natural gas much more sensitive to household size than electricity. Of note on household size is that there is a much larger expenditure gap between one- and two-person households than there is between two- and three-person households, and three- and four-person households. This likely arises from differences in dwelling types.

As noted above, presenting energy expenditure as a share of income may overstate the distributional differences in energy expenditure, as household income is variable year to year but more stable over longer time horizons (Poterba, 1989). Moreover, household income does not necessarily reflect household wealth, and so households with low income and large savings could be mischaracterized as being energy poor.

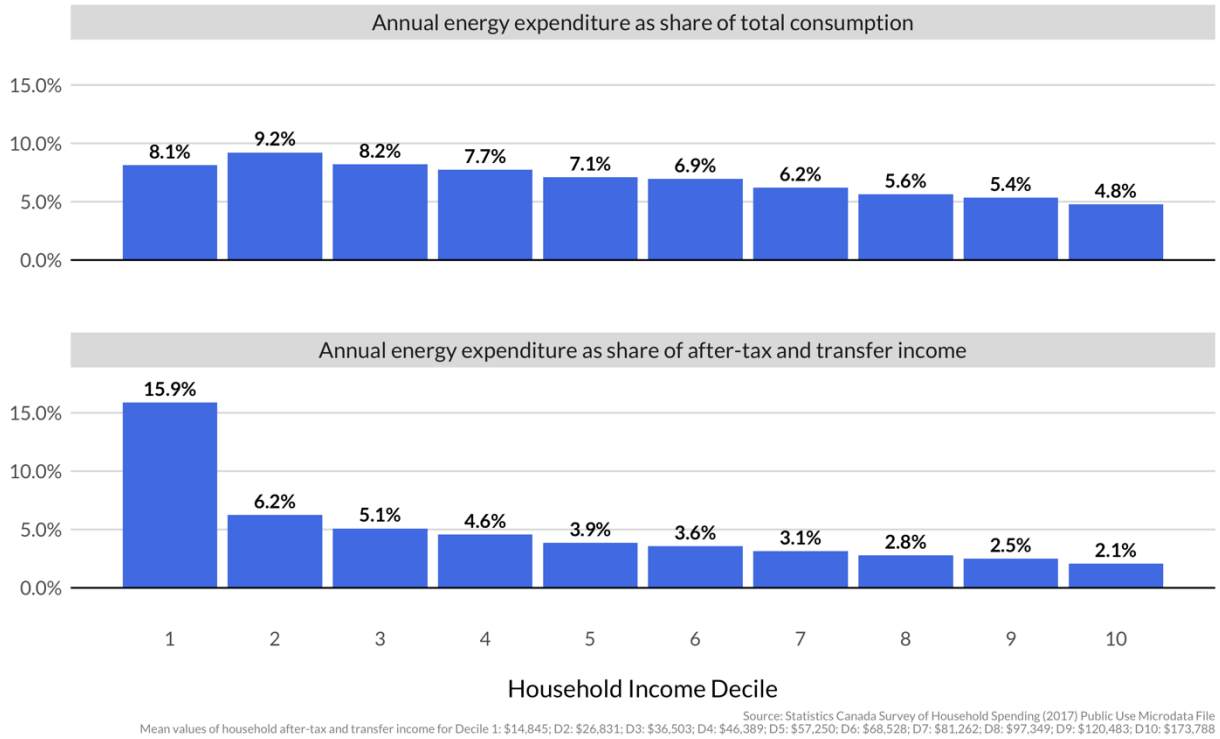
Figure 5 presents 2017 energy expenditure as a share of total consumption and as a share of total income after taxes and transfers by income decile. Notably, energy expenditure as a share of consumption is highest for the second decile and tapers as incomes increase, suggesting a budget constraint faced by decile 1 and a potential move to larger or less energy-

[13] The household after-tax and transfers income quintiles upper cut-offs are as follows: Q1 < $33,275; Q2 <$55,100; Q3 <$77,025; Q4 <$106,650; Q5: >$106,650.

efficient housing with an increase in income. The stark difference between decile 1 and decile 2 when energy expenditure is presented as a share of income suggests those in decile 1 face a binding budget constraint.

Figure 5

Annual Energy Expenditure as Share of Total Consumption and Household Income by Income Decile, 2017



Note: Energy expenditure includes electricity, natural gas, fuel oil and other fuels, and second home energy. Income deciles are total household income, after taxes and transfers.

Energy Poverty Indicators in B.C.

In this section we apply the various energy poverty indicators to the data outlined earlier. We analyze each indicator in turn, looking across various income and demographic sub-types, with conclusions following based on the overlap of our results.

Indicator 1: 10% Income Test

While only 5% of B.C. households spend more than 10% of after-tax and transfer income on energy, there are clear distributional differences (Figure 6). In comparison to other provinces, this share is below average. However, within B.C., almost 20% of households within the lowest income quintile can be considered in energy poverty. This statistic is clearly correlated with household size and type, as single-person and lone-parent households have

shares more than double the B.C. average. Interestingly, although a drawback of this indicator is that it can falsely identify households with high income and high-energy expenditure as being energy poor (see the section “Definitions from Literature,” above and Appendix B), a very small share of households in quintiles 3 and 4 (1.1% and 0.4% respectively), and none in quintile 5, are categorized as energy poor.

Indicator 2: 10% Expenditure Test

Interestingly, 8.6% of households in B.C. allocate more than 10% of consumption to energy (Figure 7). This is the lowest in Canada (which could be a function of more temperate climates in B.C.).

Comparing shares across the income distribution in B.C., we see non-zero shares of households in energy poverty in the fourth and fifth income quintiles, suggesting this indicator may be misclassifying high-income households with excessive energy expenditure as being energy poor. A second interesting feature of the income distribution is that the share of energy-poor households is lower in the first quintile compared to the second. This may suggest lowest-quintile houses face the trade-off between energy expenditure and other necessities, or that higher incomes are associated with larger or less energy efficient homes. The tapering in households with energy expenditure as a share of total expenditure above 10% from the second to fifth quintile suggests improving energy efficiency may offset increased expenditure. This tapering could also be a function of energy expenditure increasing less than total consumption as incomes increase (see

Figure 8). Notably, the prevalence of energy poverty increasing with dwelling age is consistent with the energy efficiency argument.

The prevalence of energy poverty is highest in households of single persons, couples with no children, and couples with other persons. This is correlated with age, as the modal age group of couples with no children is 65–74, while the modal age group of couples with children is 30–54. We see the prevalence of energy poverty is strongly correlated with age of the SHS respondent. Moreover, average incomes of couples-with-children households are higher, which would support higher overall expenditure, leading to lower shares of energy-poor households in this group. Finally, the large spike in consumption shares for “owned without mortgage,” is also correlated with age. Specifically, 85% of households who own without a mortgage have a reference person 55 or older, whereas only 28% of households who own with a mortgage have a reference person aged 55 or older.

Together, this indicator suggests energy poverty is most prevalent in lower-income seniors’ households living in single detached homes. We also note that seniors are more likely

Figure 6

Indicator 1: Distribution of Household Energy Expenditures as Share of After-tax Income, 2017

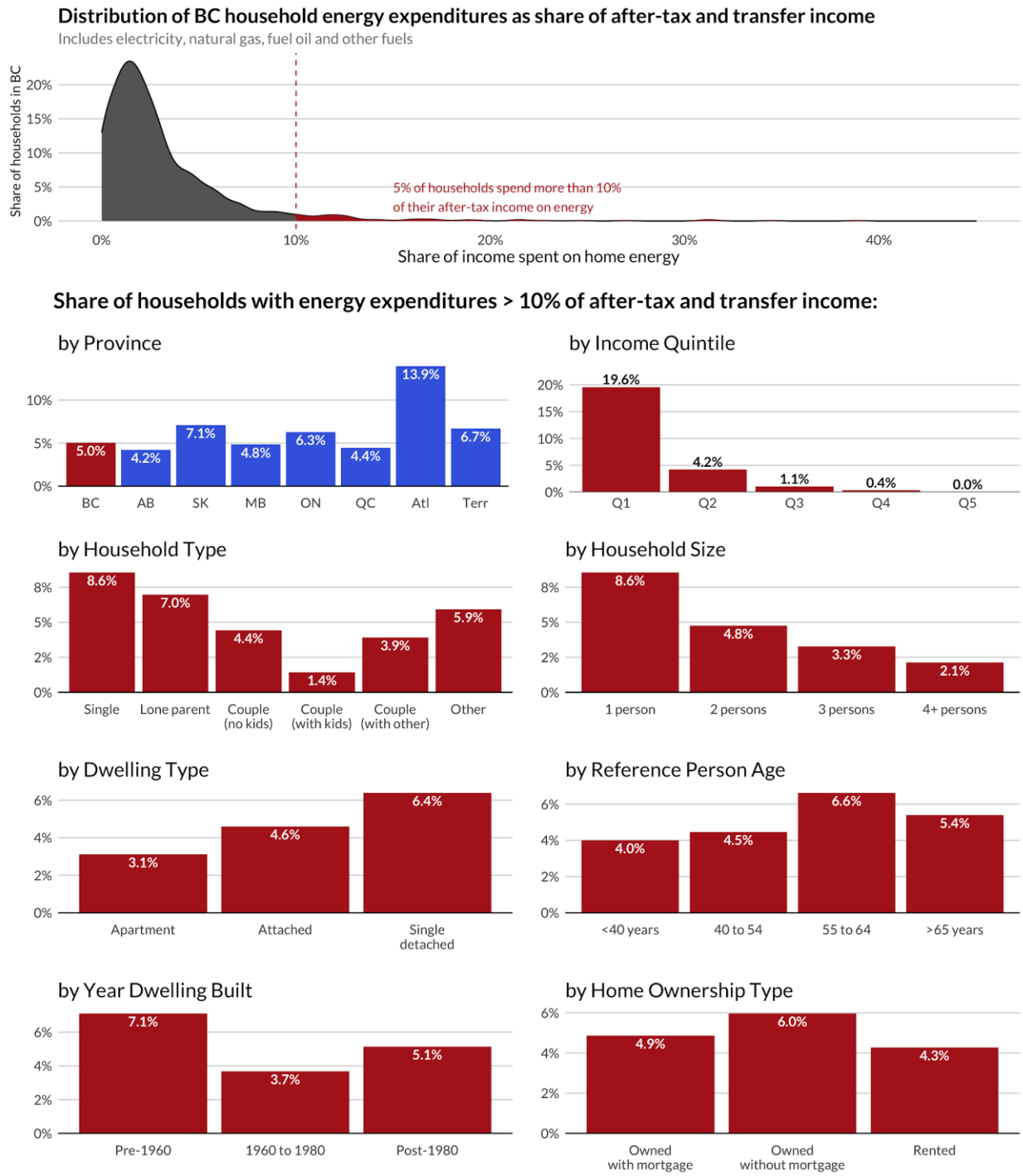


Figure 7

Indicator 2: Distribution of Household Energy Expenditures as Share of Total Consumption, 2017

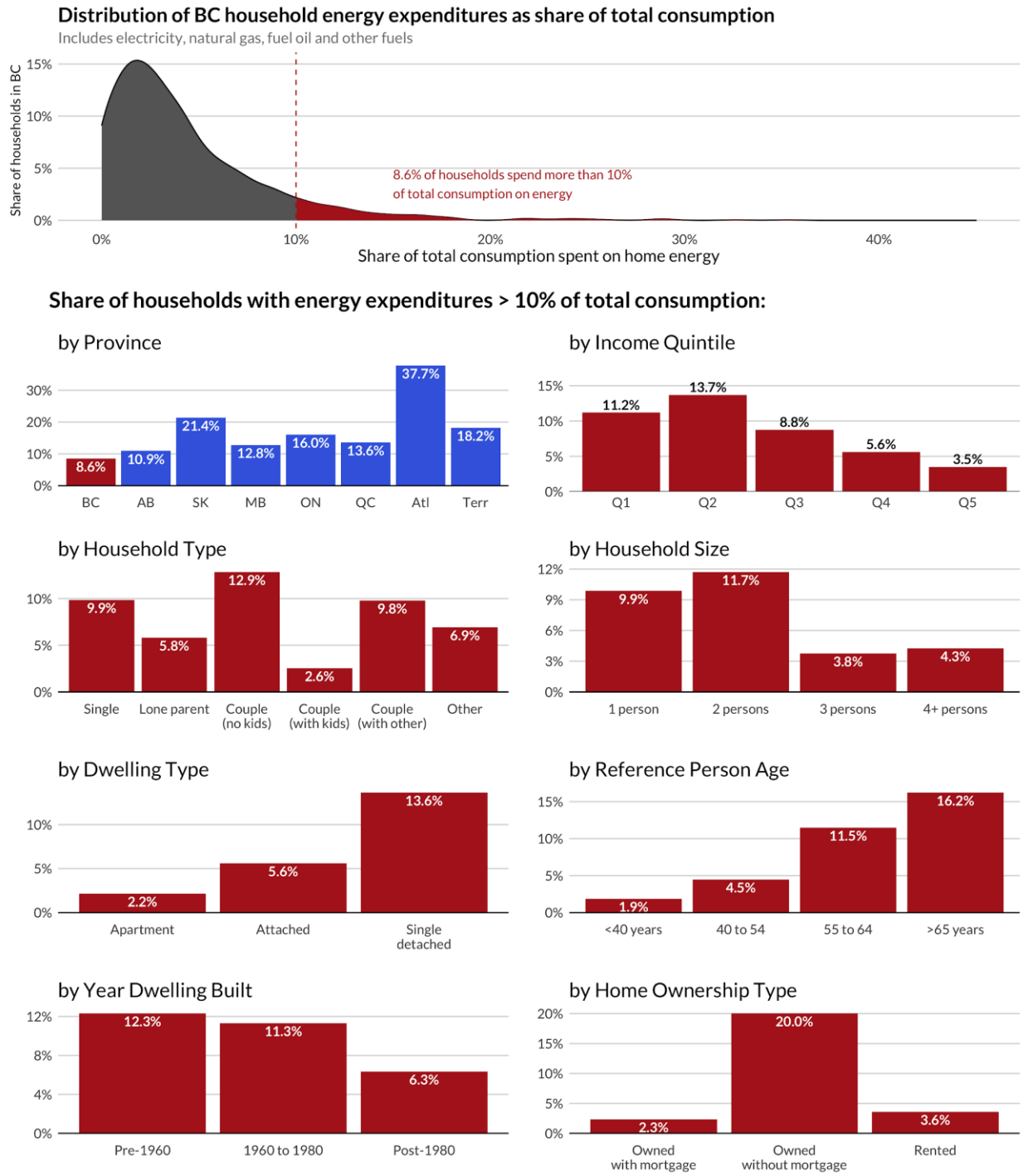
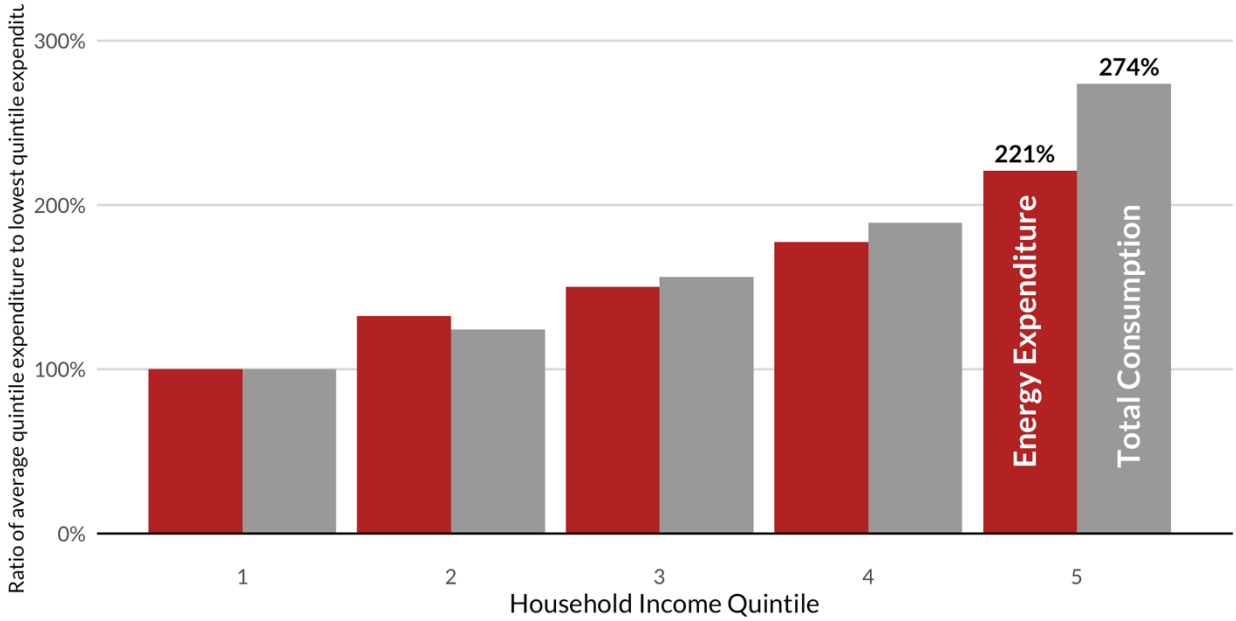


Figure 8

Energy Expenditures and Total Consumption Indexed to Lowest Quintile



to spend the majority of their time in the home, which likely contributes to their higher energy expenditure and probability of being classified as energy poor.

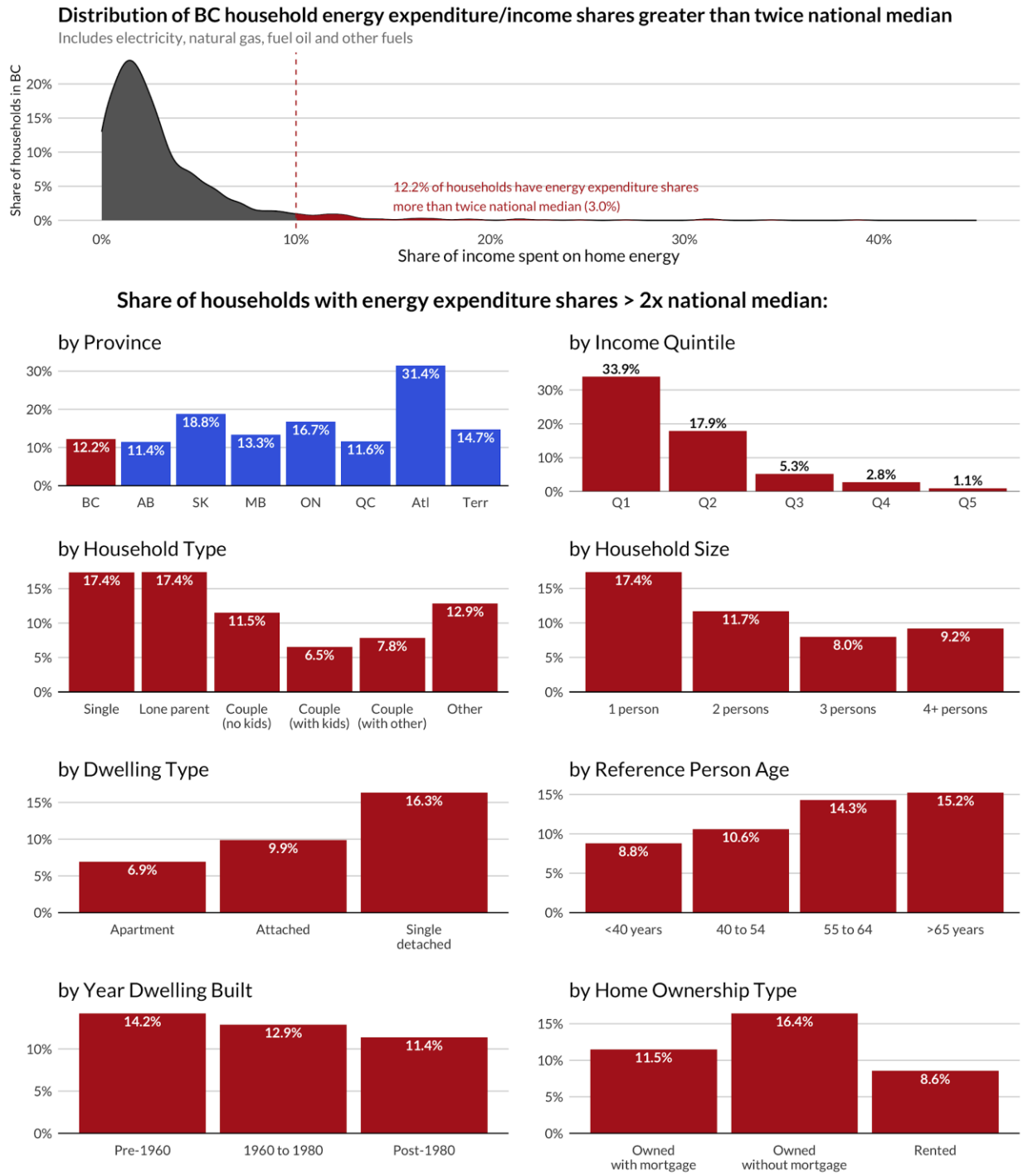
Indicator 3: Income-based twice national median

Indicator 3 compares to Indicator 1 in that it considers home energy expenditure shares relative to after-tax and transfer income (Figure 9). However, the proportion of flagged households is significantly higher than with Indicator 1 since the national median share of income spent on energy is 3%, making the eligibility cut-off 6% for this indicator relative to the former's 10%. We chose the national median, rather than provincial median, to reflect energy poverty probabilities are lower in B.C. than in the rest of Canada. This could be due to multiple factors, including societal norms of conservation, building construction codes, and, most likely, the province's relatively favourable climate requiring less home energy for heating and cooling.

Despite relatively lower energy expenditure shares of income in B.C., 12% of B.C. households are flagged as being in energy poverty. This indicator also identifies high proportions of energy-poor households in the two lowest quintiles. A small share of households in quintiles 3 through 5 are flagged as energy poor, suggesting this indicator captures some households with higher incomes and excessive energy consumption. Single-person and lone-parent households are most likely to be classified as energy poor, followed by "other," which is households with more than one person who are related or not related. As with Indicator 2, there is a clear correlation between dwelling type, age of dwelling, and the reference person's age with the share of households identified as being in energy poverty.

Figure 9

Indicator 3: Distribution of Household Energy Expenditure/Income Shares Relative to Twice National Median, 2017



Indicator 4: Low-Income High-Cost

Indicator 4 is the only two-part energy poverty test we use. It identifies households as being energy poor when their expenditure is above the national median (equivalized for household size) and removes the potential for false positives via an income test. The income test compares household income, less minimum shelter costs and national median equivalized energy expenditure to the B.C. poverty line (the MBM). With this indicator, 6.4% of households in B.C. are defined as being in energy poverty, the second-lowest proportion across the provinces and territories and below the mean of 8.5% (

Figure 10).

By quintile, 17.5% of households in the lowest income quintile and 9.5% in the second-lowest quintile are flagged as energy poor.[14] A small proportion of households in quintile 3 (3.2%) and quintile 4 (1.8%) are defined as energy poor, and this indicator avoids false positives in the highest income quintile. The results for quintile 4 are likely households with high rents or mortgages and high energy expenditure.

This indicator identifies lone-parent households (9.3% of households) as most likely to be energy poor, followed by couples with other related or non-related persons (7.8%), and single-person households (7.5%). Unlike several other indicators, couples without children (4.9%) are least likely to be energy poor. By household size, one-person (7.5%) and four-or-more person households (8.5%) have the highest proportion of energy-poor households. The income test (the MBM) and median energy expenditure are equivalized by household size, suggesting the latter result is households tipped below the poverty line by shelter expenses.

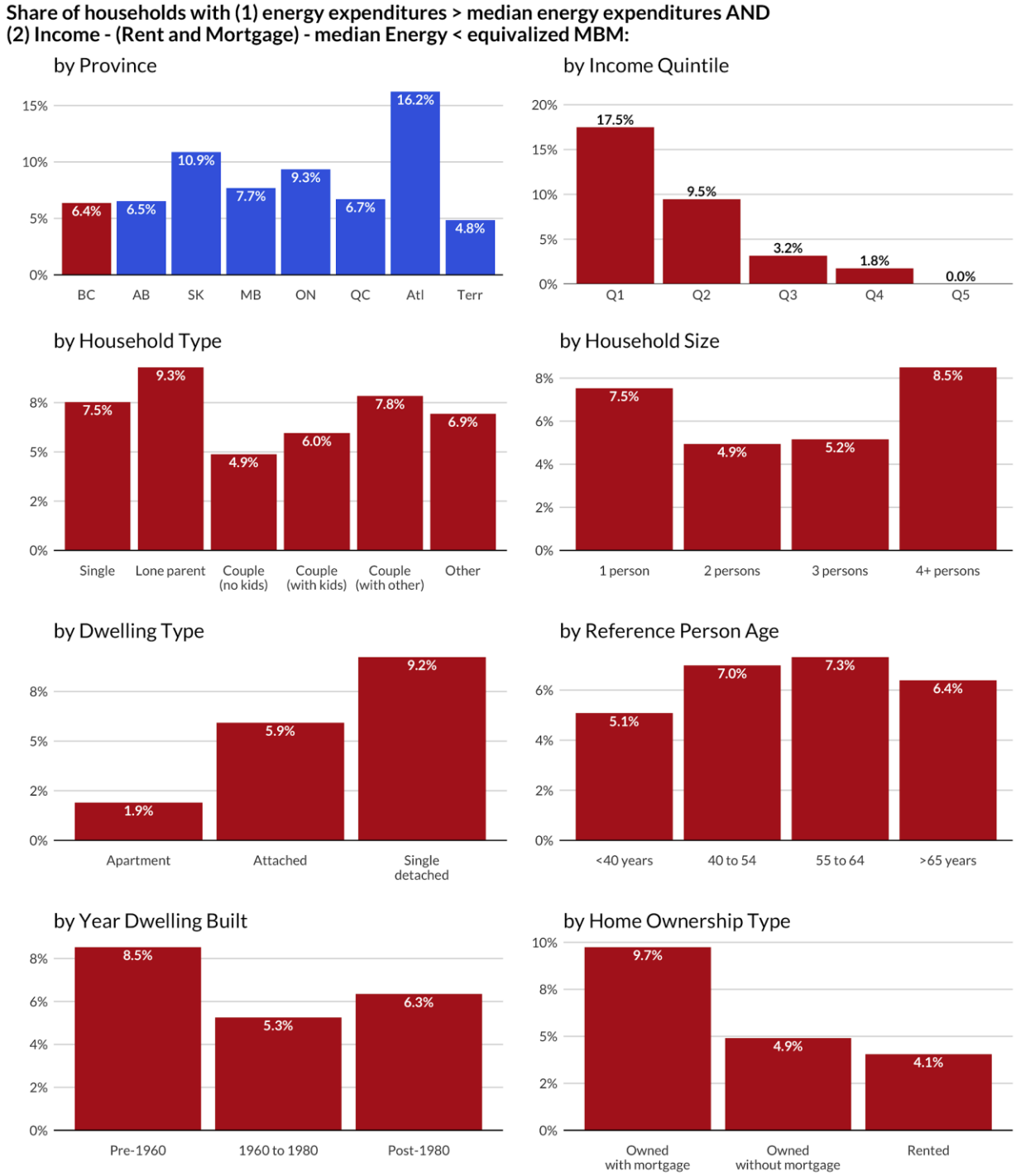
The share of households flagged as energy poor is increasing in dwelling type size, an expected result as energy expenditure is generally highest for single detached homes. There is a large increase moving from households in an apartment that are in energy poverty (1.9%) to attached homes (5.9%) and to single detached homes (9.2%). This suggests shelter costs play an important role in whether a household is defined as being energy poor with this indicator. The proportions by home ownership type corroborate this result; households with a mortgage (9.7%) are most likely to be classified as energy poor, followed by households that own without a mortgage (4.9%), and renters (4.1%).

Interestingly, energy poverty shares are increasing in age, with a slight decrease at the highest age category. All together, Indicator 4 identifies as energy-poor older households (with or without a mortgage) and younger households (particularly singles and lone-parent households) that have high shelter costs and low incomes.

[14] The quintile income cut-off for the lowest income quintile is income below $33,275, and for quintile 2 is income below $55,100. The MBM thresholds range from $23,750 for a one-person household to $57,001 for a six-person household. There may be households that match the second condition of this indicator but are not classified energy poor because their energy expenditure is below the national equivalized median.

Figure 10

Indicator 4: Distribution of Households With Low Incomes and High Energy Costs, 2017



Indicator 5: Moore Minimum Income Standard

Indicator 5 defines a household in energy poverty if its income net of housing costs and energy expenditure is less than a minimum income (in this case, the MBM). Its purpose is to determine if a household is in poverty after fuel and housing costs. An alternative way of thinking about this indicator is that it identifies households as energy poor when their income is insufficient to cover energy expenditure after accounting for shelter costs and a minimum income. The indicator is, of course, sensitive to the choice of value for a minimum income; we use the MBM as it is B.C.'s official poverty line (Figure 11).

Under this measure, 35% of B.C. households are in energy poverty, which is slightly above the average of all provinces and territories. The results by quintile are stark, with 96% of households in the lowest quintile and 50% in the second quintile flagged as energy poor. This suggests that many households in the two bottom quintiles are budget constrained and forgoing other consumption to manage in-home energy expenditure. This indicator does identify some households in quintiles 4 and 5 as being energy poor, suggesting it is susceptible to false positives when households have high incomes and high housing and energy costs.

The high share of one-person households classified as energy poor is also striking in contrast to the other household sizes. The MBM for a one-person household in Vancouver is $23,750; many lowest-quintile households have income after shelter costs that are below this value, and so these households are classified as energy poor as a by-product of being in poverty. Type of household matters here as well; single and lone-parent households and those of other related or non-related groups are twice as likely to be classified as energy poor compared to households that are couples. Another interesting feature of this indicator is that it identifies young persons, elderly persons, renters, and those living in apartments as most likely to be energy poor.

An important feature of this indicator is that higher shelter costs lower the left-hand side of the comparison. As the MBM includes a minimum shelter cost (including in-home energy use), this identifies households where energy expenditure is high relative to the minimum embodied in the MBM. These households may benefit from energy efficiency improvements and are at risk of energy price increases, further lowering quality of life.

Figure 11

Indicator 5: Distribution of Households With Income After Energy Expenditure Below the B.C. Poverty Line, 2017

Indicator 6: Romero et al. minimum income standard

Indicator 6 again compares energy expenditure to income after housing costs; adjusting income after housing costs to make it relative to minimum income and average housing expenditure (Figure 12). This method increases the value of the calculation on the right-hand side of the comparison (relative to Indicator 5), making a positive determination of energy poverty less likely.

With this metric, 15% of B.C. households are classified as being in energy poverty, slightly above the average of 13.9% across all provinces and territories. Examining the results by income quintile, we see the indicator classifies almost 60% of lowest-quintile households as energy poor, but only 12% of households in quintile 2. A few quintile 3 and quintile 4 households are classified as energy poor, suggesting their housing costs are above average or their energy expenditure is unusually high.

Household type and household size corroborate the results by income quintile: single, lone-parent, and “other” household types have the highest incidence of energy poverty. This is not surprising, as all else equal a single or lone-parent household is more likely to be low income due to a single household income. Energy poverty incidence is also highest among households in apartments, those renting, and with a reference person who is relatively young.

Altogether, this indicator captures households that are lower income and likely vulnerable due to poverty. The results by year dwellings were built and home ownership type also suggest the indicator captures some lower-income seniors households. The minor differences in energy poverty incidence by year dwellings were built suggest there may be a role for energy efficiency improvements alleviating energy costs. However, as households in the newest homes have a similar energy poverty incidence to those built between 1960 and 1980, the problem is likely poverty and vulnerability rather than high energy costs. Moreover, the high incidence of energy poverty among renters suggests energy efficiency programs are unlikely to effectively address energy poverty.

Figure 12

Indicator 6: Distribution of Households With Income After Energy and Housing Costs Below the B.C. Poverty Line, 2017

Indicator 7: Hidden Energy Poverty

Indicator 7 identifies households with very low energy expenditure, or less than half of median national energy expenditure, equivalized for household size (Figure 13). It is intended to identify households that are low income and have to choose between energy use and other necessities. With this indicator, B.C. has the highest prevalence of energy poverty in Canada at 34.9%. This may reflect that climate in B.C. warrants lower energy use and that energy prices are lower than the Canadian average.[15] This indicator shows that more households in B.C. spend less than half the national median compared to other provinces, but they are not necessarily unable to afford energy. This indicator is likely better in situations where energy use is similar across jurisdictions. Moreover, as noted above, this indicator can misidentify households without energy costs (renters with utilities included, condo owners) and those with highly energy-efficient homes as in energy poverty. This is likely why 15% of households in quintile 5 and 27% of those in quintile 4are identified as energy poor, and why there is very little difference in energy poverty rates based on dwelling age.

Similar to other indicators, the households with high shares of energy poverty are single individuals, lone parents, and “other,” each around 50% of households. As we equivalize median energy expenditure by household size, this likely reflects lower energy expenditure in B.C. and true affordability challenges for some of these households. This is supported by the high proportions of households that are in an apartment (71%) or that rent (68%), and those that have a young reference person (less than 40 years old; 52%).

Surprisingly, this indicator has a higher share of households that are in the newest types of dwellings (post-1980) classified as energy poor (36%) compared to earlier vintages (pre-1960 and 1960–1980 are both 33%). Again, this likely captures households in more energy-efficient homes.

While results of this indicator should be treated with caution, it does appear to identify households in energy poverty that are young, small in size, lower income, and renting. The indicator also misclassifies households that are high income and low-energy expenditure.

[15] B.C. has the third-lowest average residential electricity prices in Canada (Hydro-Quebec, 2019) and the third-lowest natural gas prices in Canada (Canada Energy Regulator, 2018).

Figure 13

Indicator 7: Distribution of Household Energy Expenditure Relative to Half the National Median, 2017

Characterizing Energy Poverty and Energy Affordability in B.C.

In this section we compare the results from the different energy poverty indicators to characterize the breadth and depth of energy poverty in B.C. Table 2 presents the results for each indicator by income quintile (Table B1 in Appendix B presents a comparison by all household characteristics.) This can be used as a first pass at evaluating the appropriateness of each indicator for measuring energy poverty in B.C. There are substantial differences in the overall energy poverty rates by indicator, ranging from a low of 5% of households (Indicator 1, 10% income share) to a high of 35% (Indicators 5 and 7).

Notably, all indicators except for Indicator 1 (energy expenditure share of income greater than 10%) and Indicator 4 (low-income high-cost) have false positive results for the highest income quintile. This is particularly a problem with Indicator 7 (hidden energy poverty), which measures energy expenditure relative to half the national median. B.C.'s relatively milder climate leading to overall lower levels of in-home energy expenditure is likely behind this result. All indicators have false positives for quintile 4, though most are very low shares of households.

The indicators that identify relatively high proportions of households in energy poverty in the two lowest quintiles are Indicators 5 (Moore MIS/after-fuel costs), 6 (Romero et al. MIS), and 7 (hidden energy poverty). Most striking is Indicator 5, with 96% of households in quintile 2 and 50% of households in quintile 2 in energy poverty.

Table 2

Share of Households Defined as Energy Poor by Quintile and Indicator, 2017

Indicator	Q1	Q2	Q3	Q4	Q5	Overall
1: 10% of income	19.6%	4.2%	1.1%	0.4%	0.0%	5.0%
2: 10% of consumption	11.2%	13.7%	8.8%	5.6%	3.5%	8.6%
3: Income share twice national median	33.9%	17.9%	5.3%	2.8%	1.1%	12.2%
4: Low-income high-cost	17.5%	9.5%	3.2%	1.8%	0.0%	6.4%
5: Moore MIS/after-fuel costs	96.2%	49.5%	8.8%	5.6%	1.8%	35.1%
6: Romero et al. MIS	64.0%	18.9%	3.9%	2.8%	2.8%	18%
7: Hidden energy poverty	54.5%	40.4%	36.8%	27.4%	15.4%	34.9%

Given the significant differences in the results of these energy poverty indicators, we propose a minimum bound for energy poverty in B.C. is the share of households that are identified by multiple indicators. Somewhat surprisingly, no households were flagged as energy poor by all seven indicators; we interpret this as inconsistencies between definitions. For example, Indicator 7 defines a household as energy poor when it has excessively low expenditure (less than half the national median), whereas other indicators rely on energy expenditure or expenditure shares being higher than national medians.

Figure 14 presents the distribution of households that are flagged as energy poor by at least six indicators, Figure 15 presents results for households flagged by at least five indicators, and

Figure 16 presents results for households flagged by at least four indicators.

Figure 14 shows that a very small proportion (0.8%) of households in B.C. meet the energy poverty definition for six indicators. These households are low income, small, and most likely to be seniors living in an old home. Notably, for all these households flagged by six of the seven indicators, the omitted indicator is always Indicator 7.

Lessening the stringency of our minimum bound of energy poverty to households flagged by five or more indicators (Figure 15), the proportion of households in B.C. increases to 3.9%. As that is still lower than the lowest share of households by individual indicator (5%, based on Indicator 1, see Table 2), this aggregate indicator may still be too stringent. However, this aggregate measure of energy poverty captures far more households in the two lowest income quintiles (roughly quadrupling the share compared to

Figure 14) as well as a small proportion of households in the middle income quintile. Lone parents are now classified as energy poor, and the negative relationship between household size and energy poverty is clearer. More younger households are identified as energy poor, as well as those renting and in apartments. Age of dwelling matters less, though the fact that the highest proportions of energy-poor households are in dwellings built before 1960 and those that are newer (built post-1980) suggests that energy efficiency improvements could be important in alleviating energy poverty for the former, whereas shelter costs are behind the latter.

Lessening the stringency of our aggregate definition further (Figure 16), we see the proportion of households defined as energy poor increases to 6.7%. Again, the proportion is low relative to most of the individual indicators presented in Table 2. However, many more households in the lowest two income quintiles are defined as energy poor—increasing to 24.8% in quintile 1 and 8.1% in quintile 2—without a change in the proportion of households in quintile 3. Single and lone-parent households remain the dominant household type in energy poverty, and the age distribution flattens somewhat (though the proportion of over 65 households roughly doubles). Other patterns from Figure 15 remain similar.

Together, these indicators and aggregate definitions suggest energy poverty in B.C. is most commonly found in households that are low income (particularly those in the lowest income quintile); mostly singles and lone parents; live in single detached, older homes, with a mortgage; and seniors. These results are consistent with overall poverty trends identified by Petit and Tedds (2020c).

Figure 14

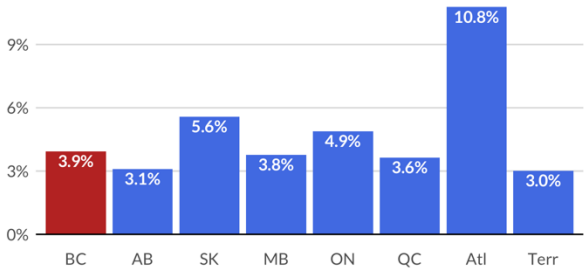
Share of Households Defined as Energy Poor by at Least Six Indicators, 2017

Figure 15

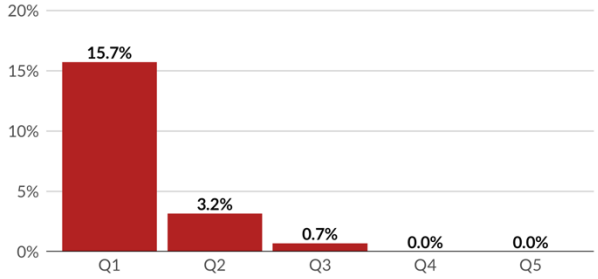
Share of Households Defined as Energy Poor by at Least Five Indicators, 2017

Share of households flagged as energy poor by five or more indicators:

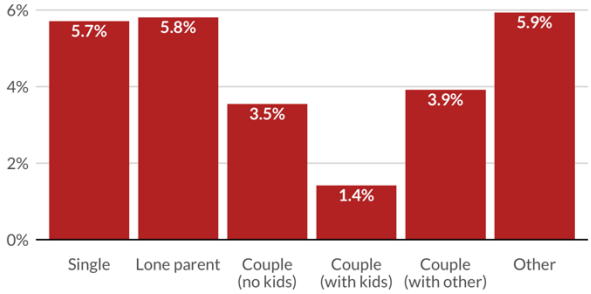
by Province



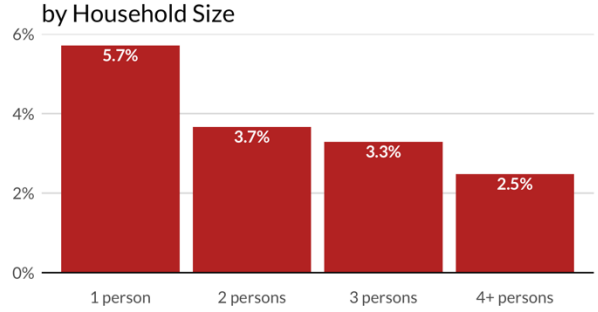
by Income Quintile



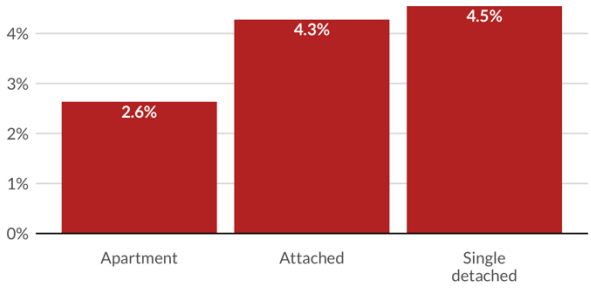
by Household Type



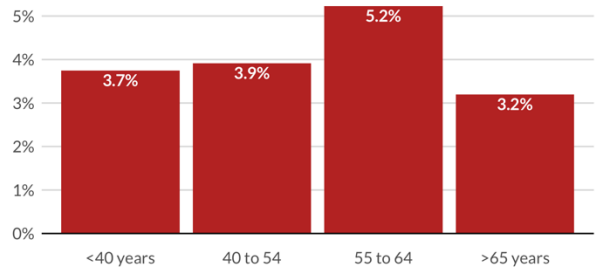
by Household Size



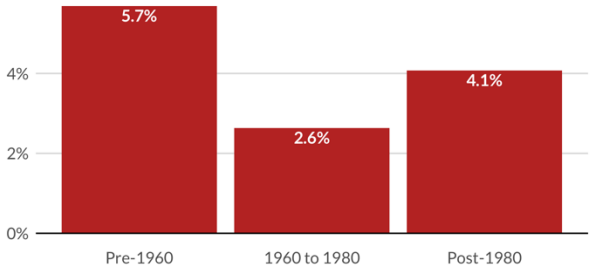
by Dwelling Type



by Reference Person Age



by Year Dwelling Built



by Home Ownership Type

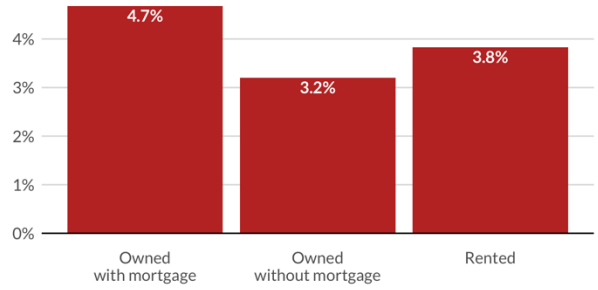


Figure 16

Share of Households Defined as Energy Poor by at Least Four Indicators, 2017

Gasoline Expenditure

The energy poverty measures analyzed above focus on home energy expenditures—electricity, natural gas, and heating oil. They do not include the largest energy-related expenditure for Canadian households: gasoline.

This is purposeful, for several reasons. First, for comparability to international metrics, home energy expenditure is the standard unit of analysis. Second, while lack of ability to afford gasoline clearly leads to hardship, it is the inability to provide adequate climate control in the household that has been shown to be directly related to adverse mortality rates (Chirakijja, 2019). Lastly, the data on household gasoline expenditure is far more limited within the Statistics Canada Survey of Household Spending.

Nevertheless, in this section we provide a brief summary of gasoline expenditure in relation to the distribution of gasoline spending, as this is often a focus for both policy-makers and the public. Figure 17 presents average household gasoline expenditure by income quintile, highlighting the positive relationship between income and gasoline spending, similar to other home energy types.

Figure 17

B.C. Household Gasoline Expenditure by Income Quintile, 2017

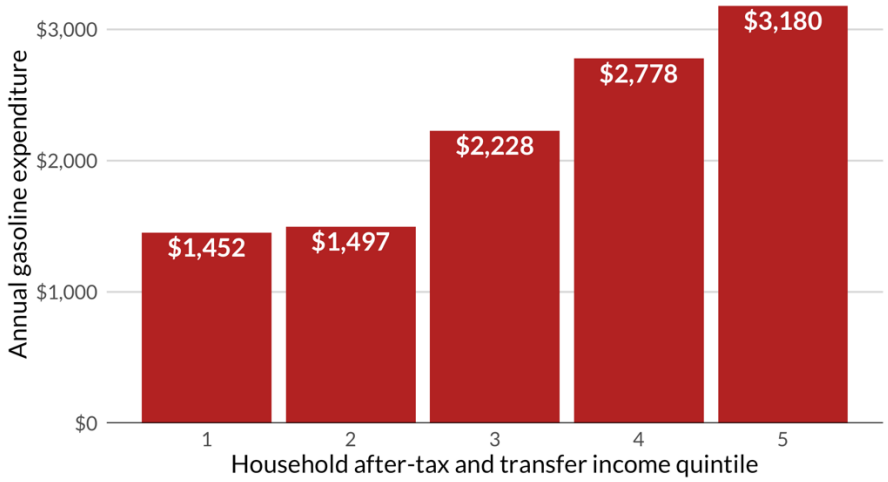


Figure 18 examines the share of both income and consumption spent on gasoline. Similar to home energy expenditures, the profile of consumption shares is relatively flat, whereas the share of income spent on gasoline spikes for those in the lowest income quintile. However, looking more closely within quintiles, we see that there is significant heterogeneity in this burden. Within the lowest quintile, over 50% of all households reported no gasoline expenditure in 2017, suggesting this large share of households in the lowest income quintile do not own vehicles (Figure 19). This has important policy implications, as reducing gasoline prices

is often a focus of policy-makers and the public, yet the beneficiaries of such action may not be felt by many in the lowest income quintile.[16]

Figure 18

B.C. Household Gasoline Expenditure Shares of Income and Consumption by Income Quintile, 2017

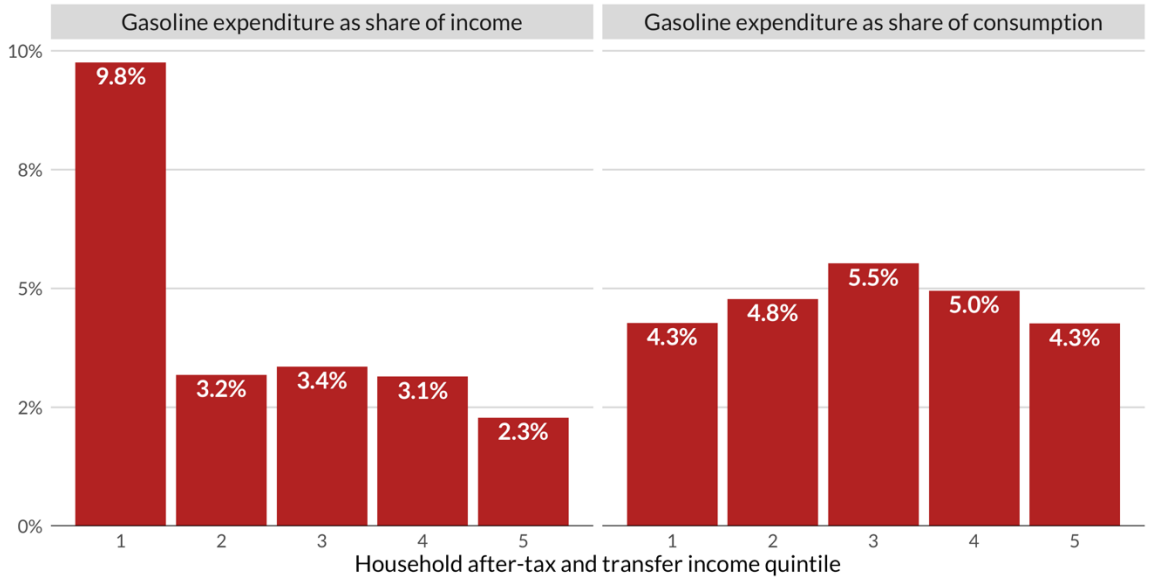
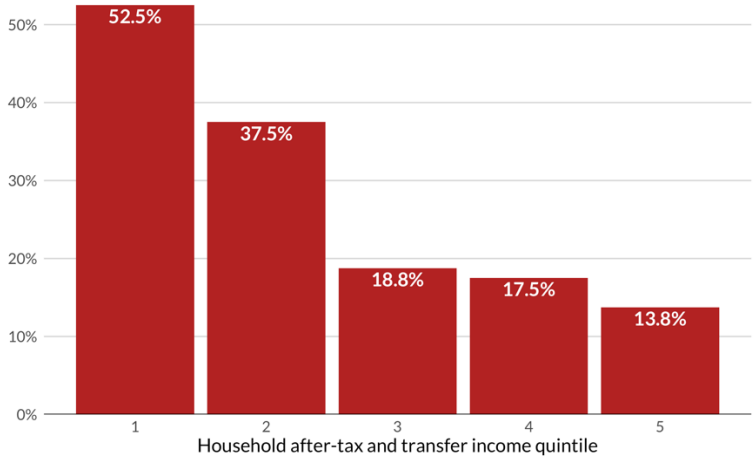


Figure 19

Share of B.C. Households Recording Zero Gasoline Expenditure, 2017



Policy Supports Specific to Energy for Lower-income Households

[16] Unfortunately, we cannot present a similar chart for households' expenditure on public transit, as the SHS PUMF aggregates public transportation, including within the variable local public transit, sightseeing tours, taxi and limousines, and transportation by airplane, etc.

In this section we briefly discuss existing policy supports in B.C. that fully or partially address energy poverty, and then turn to the expected consequences of the CleanBC plan that are specific to energy use.

Energy Poverty Policy Supports in B.C.

There are few policy supports in B.C. devoted to addressing the issue of energy poverty and energy affordability. We have identified nine, classified into general supports, supports for in-home energy use, and supports for transportation; these are briefly described in

Table 3. Notably, five of these policy supports are through BC Hydro.

The general policy support is B.C.'s Climate Action Tax Credit (CATC), a means-tested non-taxable benefit. As noted by Petit and Tedds (2020e), the CATC combined with other income supports is an important source of income for those with little or no income. Winter et al. (2019) demonstrate that emissions pricing is regressive, though the choice of revenue-recycling mechanism is key. As the CATC is means-tested, it alleviates some of the distributional concerns regarding energy poverty exacerbated by rising carbon taxes. However, as Petit and Tedds (2020e) note, the CATC and other refundable tax credits also address regressivity of the tax system and may be better suited to addressing the broader issue of poverty in B.C. rather than energy poverty specifically.

Policy supports related to in-home energy use are all provided through BC Hydro. This includes two programs for improving energy efficiency and energy conservation, a crisis fund for households with bills in arrears, and options for expenditure smoothing via payment plans. We also include the COVID-19 crisis fund, as it provides bill forgiveness for households without income due to COVID-19. The energy efficiency and conservation program is means-tested, so it is designed for lower-income households at risk of energy poverty. As an older home is a correlate of being defined as energy poor, this is likely an important program for reducing household energy expenditure. However, mobile homes are not eligible for furnace or insulation upgrades (BC Hydro, n.d.-f), which may exclude a proportion of lower-income and energy-poor households from important conservation opportunities. Households in apartments and condos are also ineligible for fridge upgrades (BC Hydro, n.d.-f), again excluding a group we identify as energy poor. Another gap in these programs is that households may receive furnace, fridge, and insulation upgrades, but there is no provision for ineligible households to receive loans or other supports (such as a payment plan on the utility bill) to self-fund home upgrades and spread the costs out over time.

Table 3

Policy Supports Addressing Energy Poverty in B.C.

Type of energy use	Program	Program summary and eligibility
General	Climate Action Tax Credit	- Refundable, non-taxable tax credit, delivered quarterly with federal GST rebate or delivered annually if credit less than $40 - Means-tested - Adjusted for family size - 2019 tax year benefit: $154.50 each for tax filer and partner (or the first child in a single parent family); $45.50 each for all other children

In-home energy use	BC Hydro Customer Crisis Fund	- Apply online or through Service BC; application evaluated within 21 days of receipt
		- For accounts with overdue amounts facing disconnection
		  o Outstanding balance $1000 or less
		  o Demonstrated attempt to make bill payments
		  o May need to demonstrate financial need
		- Demonstrate life event in last 12 months causing temporary financial crisis
		- Eligible once per year per account holder
		- Grant up to $600 (electrically heated homes) or up to $500 (non-electrically heated homes)

	BC Hydro COVID-19 Relief Fund	- Provides up to three months of bill credit based on average consumption
		  o Requires proof of eligibility (EI, CERB, or B.C. Emergency Benefit)
		  o Household member must have stopped working due to COVID
		  o Maximum of one COVID Relief Fund bill credit per household
		- Defer bill payments or arrange flexible payment plans for those still working

	BC Hydro Energy Conservation Assistance Program	- Apply online or to BC Hydro or FortisBC - Means-tested and adjusted for household size; requires proof of income for each household member - Available to renters with landlord's consent - Free home "energy coaching" and energy-efficient product installation by energy coach (e.g., LED bulbs) - Some homes qualify for advanced energy-efficient products (e.g., furnace upgrade, insulation) - Also available to non-profit housing providers and Indigenous communities (not means-tested)

	BC Hydro Energy Saving Kit	- Apply online or by phone - Means-tested; adjusted for household size - Kit (e.g., LED bulbs, weather stripping) with instructions

	BC Hydro Other Bill Help	- Defer bill payment (apply online or by phone)
		- Payment plans (annual bill smoothing or catch-up payment plans)
		- Alternative to security deposit:
		  o proof of creditworthiness, or
		  o account guarantee by another customer, or
		  o advance initial payment

Transportation	BC Bus Pass Program	- Available to low-income seniors and persons with disabilities (PWD) - Means-tested (on income assistance or low income and not eligible for income assistance) - Seniors (60 or older): $45 per year admin cost - PWD: cash transfer of $52 (transportation supplement) as part of disability assistance
	Federal Excise Gasoline Refund	- Apply via paper to Canada Revenue Agency - Must have qualifying disability, certified by medical professional - Claims less than $200 must be submitted every six months, no later than one month after the end of the six-month period - Claims over $200 can be submitted any time, but no more than one per month - Receipts not required but must be kept for audit purposes

	Fuel Tax Refund for Persons with Disabilities (B.C.)	- Register online or by paper
		- Must have qualifying disability, certified by medical professional
		- Refund of up to $500 per year for internal combustion engine vehicle
		  o Refund application must include fuel receipts
		  o Fuel purchase receipts must be within four years of application receipt
		  o Minimum refund $10
		  o Refund application initiated by applicant
		- Discount on vehicle insurance for electric vehicles

Sources: BC Hydro (n.d.-a through h), Canada Revenue Agency (2019), Government of British Columbia (n.d.-a through f), Petit and Tedds (2020b).

BC Hydro's payment plans help insulate households from fluctuations in energy bills, and the crisis funds address one-off events. However, these programs do not help households that are persistently challenged by energy expenditure and other shelter costs. These are households identified by Indicators 4, 5, and 6, where necessaries of life push households below the B.C. poverty line. BC Hydro is not likely to be the appropriate vehicle for addressing this type of energy poverty, but we flag it as a gap in existing policy supports, and further indication that existing income supports in B.C. are insufficient to truly address poverty (Petit & Tedds 2020b, 2020e).

Of the three policy supports for transportation, two are for gasoline tax rebates to persons with disabilities (PWD). The remaining one is a bus pass program for low-income seniors and PWD. As the adequacy of supports for PWD are addressed elsewhere (see Petit & Tedds, 2020d), we will not comment further beyond noting that as carbon taxes increase, PWDs may be differentially affected. To the extent PWDs receive the CATC, they may be insulated from the cost increase.[17]

However, as we outlined in earlier, while gasoline is the largest share of energy expenditure for B.C. households, large proportions of households in the bottom two income quintiles did not purchase any gasoline in 2017, suggesting that affordability of public transit may matter far more for transportation, making the BC Bus Pass Program relevant to our discussion of energy poverty. Petit and Tedds (2020a) discuss in detail the bus pass program, including its interactions with other tax-delivered benefits. Notwithstanding these concerns, as we show above, low-income seniors are a group at risk of energy poverty, and the presence of this program can be considered important for addressing transportation energy poverty. All of our energy poverty indicators above are based strictly on in-home energy use, and so we are likely understating the true level of energy poverty in B.C. An important consideration for the Government of British Columbia is to potentially expand the bus pass program to all low-income households.[18] This could alleviate some of the budget constraints faced by low-income households for shelter and transportation costs, and help address in-home energy poverty.

The CleanBC Plan and Expected Future Impacts on Households' Energy Expenditure

The CleanBC plan outlines numerous regulatory and policy actions that will change energy use in B.C. These government actions are directed at households (which will impose direct costs) and industry (which will impose indirect costs on households). In Table 4 we outline CleanBC initiatives and the likely effect on B.C. households, as well as distributional consequences.

CleanBC includes a pledge that making the policy and regulatory changes "cannot leave anyone behind" (Government of British Columbia, 2019, p. 5). As we show above (Figure 2 and

Figure 4 explores important heterogeneity in energy expenditure. We consider two dimensions: household (after-tax and transfers) income quintiles and household size.

Figure 4), gasoline and electricity are the two highest sources of household energy expenditure. However, in-home energy expenditure varies across the income distribution, and 52% of households in the lowest income quintile had no gasoline expenditure in 2017 (Figure 17). This shows that the CleanBC initiatives devoted to in-home energy use vs. transportation will have very different distributional impacts. The energy efficiency programs in CleanBC will

[17] We also note there are efficiency arguments against increasing the fuel tax rebates to account for the carbon tax, as it eliminates the incentive provided by the carbon tax to change behaviour.

[18] For example, the City of Calgary has a means-tested low income monthly pass and means-tested yearly passes for seniors (see Calgary Transit, n.d-a.; n.d.-b). The City of Edmonton and the City of Toronto also have means-tested regular and senior bus pass programs.

likely improve energy affordability; the distributional consequences will depend on whether these programs are means-tested. The household transportation initiatives are likely to be regressive, with the exception of expanding public transit. Increased electrification to meet changing energy demand will require careful consideration of rate design, given electricity is the largest share of in-home energy expenditure. Finally, the CATC is the only CleanBC policy to directly address the budget constraint faced by energy-poor households, but it may be better suited to address overall poverty when combined with other tax credits (Petit & Tedds, 2020e).

Table 4

Selected CleanBC Initiatives and Expected Effect on Households

Area	Initiative	Expected effect	Distributional consequences
Emissions price	Carbon tax increases to $50 per tonne by 2021	Increased costs of emissions-intensive goods and services; lowered consumption	Regressive
	Rebates for lower income and remote households (CATC)	Higher income; increased consumption	Progressive
Transportation	Phase out internal combustion engine (ICE) vehicles/phase in zero-emissions vehicles (ZEVs)	May increase or decrease value of existing ICE stock	Unknown; larger impact likely on remote communities
	ZEV incentive program	Subsidy to households	Likely regressive (expect more uptake from higher-income households)
	Expand network of ZEV charging stations	Network effect lowers cost of operating ZEVs	Unknown; potentially regressive, depending on capital cost recovery formula (higher-income households more likely to benefit)
	Increasing low-carbon fuel standard	Likely increases cost of gasoline and diesel (Ragan et al., 2016)	Unknown; potentially regressive within households with ICE vehicles
	Increasing ICE vehicle emissions standards in 2025	Improves emissions-intensity of ICE vehicles, reducing fuel use	Likely regressive (Levinson, 2019)
	Make public transit more accessible and affordable	Increase public transit use.	Likely progressive
Increased electrification	Implicit in CleanBC	Increased investment in generation; higher electricity costs	Likely regressive
Remote communities	Funding to retrofit homes and buildings, develop renewable heating systems, and implement renewable energy projects to offset diesel	Less emissions-intensive energy and lower energy use	Unknown; limited details

Buildings	Change building codes to make buildings more energy efficient	Increase cost of new buildings	Likely regressive (may price lower-income households out of new home/unit market)
	Increased energy efficiency standards for home appliances	Increase cost of new appliances	Likely regressive
	Energy efficiency programs for existing building stock	Subsidy to homeowners	Likely regressive
		Rebates and direct installations for lower-income households, including low-interest financing	Progressive
		Subsidy to multi-unit residential owners	Unknown; potentially regressive if updates to units are costly and reflected in rent

Conclusions and Recommendations

The CleanBC plan includes a pledge that making the policy and regulatory changes necessary to reduce B.C.'s emissions—and meeting B.C.'s emissions reduction targets—"cannot leave anyone behind" (Government of British Columbia, 2019, p. 5). However, not leaving anyone behind requires first understanding who is "left behind" by the current policy environment.

Above, we characterized energy poverty in B.C. with several indicators of energy poverty found in the literature, using 2017 Survey of Household Spending public use microdata files. We find that energy poverty in B.C. is most commonly found in households that are low income (particularly those in the lowest income quintile); mostly singles and lone parents; live in single detached, older homes, with a mortgage; and seniors.

Compared to the rest of Canada, B.C. tends to have a smaller share of households identified as energy poor. This could be due to differences in societal norms toward conservation, differences in building codes, or most likely, a considerably warmer climate requiring less overall energy use. This suggests that while poverty levels remain an area of concern in B.C. given high shelter costs, energy is less of a focal point of concern than in the rest of the country.

In terms of energy types, electricity is the largest in-home energy expenditure in B.C., and given the CleanBC goal of increased electrification, we can expect this share to increase over time. As the electricity system in B.C. evolves, cost pressures will mean electricity tariff design will remain a focus for the foreseeable future. We highlight electricity expenditures to reinforce the importance of considering distributional consequences in rate design.

We briefly explore gasoline expenditure, despite the focus of the energy poverty analysis being on in-home energy expenditures. We do so because much of the CleanBC policies focuses on the transportation sector. Our analysis highlights that while the lowest income quintile households do spend a significantly higher share of their income on gasoline, within that

quintile expenditures are extremely heterogeneous, with roughly one-half of lowest quintile households having zero gasoline expenditures. Policies to reduce cost impacts on drivers will thus poorly target many of the lowest income households. In contrast, a focus on making public transit service more affordable is likely to have a more beneficial impact to the lowest income quintile. We note that B.C. has a reduced-fare bus pass for seniors, and while we find seniors make up a large share of households flagged as energy poor, age remains a blunt instrument with which to target those most in need. A low-income reduced-fare transit pass is worthy of consideration.

As a recommendation arising from our analysis, we encourage the development of a separate category within the MBM for energy expenditure. This improves comparisons across households in terms of flagging which households are at risk of energy poverty.

Lastly, we note limitations of our study in not having sufficiently granular spatial data with which to examine energy poverty along urban/suburban/rural and geographic dimensions. Liddell et al. (2012) argue that accounting for regional disparities in energy use and energy expenditure is important for measuring energy poverty and setting poverty-reduction targets. We acknowledge that more work is required to identify areas of rural, northern, and remote communities that likely face significantly greater energy poverty than our provincially aggregated data suggests.

References

BC Hydro. (n.d.-a). *COVID-19 Relief fund*. https://app.bchydro.com/accounts-billing/bill-payment/ways-to-pay/covid-19-relief-fund.html

BC Hydro. (n.d.-b). *COVID-19 Relief fund for residential customers*. https://app.bchydro.com/accounts-billing/bill-payment/ways-to-pay/covid-19-relief-fund/residential.html

BC Hydro. (n.d.-c). *Customer crisis fund*. https://app.bchydro.com/accounts-billing/bill-payment/ways-to-pay/customer-crisis-fund.html

BC Hydro. (n.d.-d). *Customer service rules for our customers*. https://app.bchydro.com/accounts-billing/bill-payment/customer-service-rules.html

BC Hydro. (n.d.-e). *Free energy saving kit*. https://www.bchydro.com/powersmart/residential/savings-and-rebates/savings-based-on-income/free-energy-savings-kit.html

BC Hydro. (n.d.-f). *Free product installation and energy coaching*." https://www.bchydro.com/powersmart/residential/savings-and-rebates/savings-based-on-income/free-product-install-and-advice.html

BC Hydro. (n.d.-g). *Free upgrades for non-profit housing providers and Indigenous communities*. https://www.bchydro.com/powersmart/residential/savings-and-rebates/savings-based-on-income/non-profit-aboriginal-housing-upgrades.html

BC Hydro. (n.d.-h). *Trouble paying your BC Hydro bill?* https://app.bchydro.com/accounts-billing/bill-payment/ways-to-pay/bill-help.html

Beatty, T. K., Blow, L., Crossley, T. F., & O'Dea, C. (2014). Cash by any other name? Evidence on labeling from the UK Winter Fuel Payment. *Journal of Public Economics*, *118*, 86–96.

Beck, M., Rivers, N., Wigle, R., & Yonezawa, H. (2015). Carbon tax and revenue recycling: Impacts on households in British Columbia. *Resource and Energy Economics*, *41,* 40–69.

Betto, F., Garengo, P., & Lorenzoni, A. (2020). A new measure of Italian hidden energy poverty. *Energy Policy, 138,* 111237.

Boardman, B. (1991). *Fuel poverty: From cold homes to affordable warmth*. Belhaven Press.

Boardman, B. (2010). *Fixing fuel poverty: Challenges and solutions*. Routledge.

Boardman, B. (2012). Fuel poverty synthesis: Lessons learnt, actions needed. *Energy Policy*, *49,* 143–148.

Böhringer, C., Rivers, N., Rutherford, T., & Wigle, R. (2015). Sharing the burden for climate change mitigation in the Canadian federation. *Canadian Journal of Economics*, *48*(4), 1350–1380.

Calgary Transit. (n.d.-a). *Fares and passes*. http://www.calgarytransit.com/fares-passes

Calgary Transit. (n.d.-b). *Low income monthly pass*. http://www.calgarytransit.com/fares-passes/passes/low-income-monthly-pass

Canada Energy Regulator. (2018, July 26). *Market snapshot: What is in your residential natural gas bill?* https://www.cer-rec.gc.ca/nrg/ntgrtd/mrkt/snpsht/2018/07-04rsdntlntrlgsbll-eng.html

Canada Revenue Agency. (2019). *XE8 application for refund of federal excise tax on gasoline*. Retrieved May 29, 2020, from https://www.canada.ca/en/revenue-agency/services/forms-publications/forms/xe8.html

Carbone, J., & Rivers. N. (2017). The impacts of unilateral climate policy on competitiveness: evidence from computable general equilibrium models. *Review of Environmental Economics and Policy*, *11*(1), 24–42.

Castaño-Rosa, R., Solís-Guzmán, J., Rubio-Bellido, C., & Marrero, M. (2019). Towards a multiple-indicator approach to energy poverty in the European Union: A review. *Energy and Buildings, 193*, 36–48.

Chirakijja, J., Jayachandran, S., & Ong, P. (2019). *Inexpensive heating reduces winter mortality.* National Bureau of Economic Research working paper, No. w25681.

Consumers Association of Canada (Manitoba) Inc. (2017). *Tackling energy poverty*. http://www.cacmanitoba.ca/data/uploads/tackling-energy-poverty-research-report.pdf

Crossley, T. F., & Zilio, F. (2018). The health benefits of a targeted cash transfer: The UK winter fuel payment. *Health Economics*, *27*(9), 1354–1365.

CUSP [Canada Urban Sustainability Practitioners]. (2019, October). *Energy Poverty in Canada: a CUSP Backgrounder*. https://energypoverty.ca/backgrounder.pdf

Department for Business, Energy & Industrial Strategy. (2020). *Fuel poverty methodology handbook*. U.K. Government.https://www.gov.uk/government/publications/fuel-poverty-statistics-methodology-handbook

Djidel, S., Gustajtis, B., Heisz, A., Lam, K., Marchand, I., & McDermott, S. 2020. *Report on the second comprehensive review of the market basket measure*. Statistics Canada. https://www150.statcan.gc.ca/n1/pub/75f0002m/75f0002m2020002-eng.htm

Environmental Reporting BC. 2019. *Trends in greenhouse gas emissions in B.C. (1990–2017)*. State of Environment Reporting, Ministry of Environment and Climate Change Strategy.

EU Energy Poverty Observatory. (n.d.). *About the observatory*. https://www.energypoverty.eu/about/about-observatory

Government of British Columbia. 2019. *CleanBC*. https://blog.gov.bc.ca/app/uploads/sites/436/2019/02/CleanBC_Full_Report_Updated_Mar2019.pdf

Government of British Columbia. (n.d.-a). *Apply for a fuel tax refund for persons with disabilities.* Retrieved May 29, 2020, from https://www2.gov.bc.ca/gov/content/taxes/sales-taxes/motor-fuel-carbon-tax/fuel-tax-refund/apply-for-refund

Government of British Columbia. (n.d.-b). *BC bus pass program*. https://www2.gov.bc.ca/gov/content/transportation/passenger-travel/buses-taxis-limos/bus-pass

Government of British Columbia. (n.d.-c). *BC bus pass for seniors and others*. https://www2.gov.bc.ca/gov/content/transportation/passenger-travel/buses-taxis-limos/bus-pass/people-with-disabilities

Government of British Columbia. (n.d.-d). *Climate action tax credit*. https://www2.gov.bc.ca/gov/content/taxes/income-taxes/personal/credits/climate-action

Government of British Columbia. (n.d.-e). Fuel tax refund for persons with disabilities. https://www2.gov.bc.ca/gov/content/taxes/sales-taxes/motor-fuel-carbon-tax/fuel-tax-refund

Government of British Columbia. (n.d.-f). *Transportation supplement/BC bus pass for people receiving disability assistance.* https://www2.gov.bc.ca/gov/content/transportation/passenger-travel/buses-taxis-limos/bus-pass/seniors

Green, K. P., Jackson, T., Herzong, I., & Palacios, M. (2016). *Energy costs and Canadian households: How much are we spending?* Fraser Institute.

Hernández, D. (2016). Understanding “energy insecurity” and why it matters to health. *Social Science & Medicine*, *167*, 1–10.

Hills, J. (2011, October). *Fuel poverty: The problem and its measurement*. CASE Report 69. Centre for Analysis of Social Exclusion.

Hills, J. (2012, March). *Getting the measure of fuel poverty: Final report of the fuel poverty review*. CASE Report 72. Centre for Analysis of Social Exclusion.

Hydro-Quebec. (2019). *Comparison of electricity prices in Major North American cities–rates in effect April 1, 2019*. https://www.hydroquebec.com/data/documents-donnees/pdf/comparison-electricity-prices.pdf

Imbert, I., Nogues, P., & Sevenet, M. (2016). Same but different: On the applicability of fuel poverty indicators across countries—insights from France. *Energy Research and Social Science*, *15*, 75–85. https://doi.org/10.1016/j.erss.2016.03.002

Kelly, L. (2007). *Affordable energy: Diversifying DSM programs in BC: A discussion paper*. https://www.bcuc.com/Documents/Proceedings/2008/DOC_18821_C10-2-1_Attachment_3_Clean-Copy.pdf

Lee, M., Kung, E., & Owen, J. (2011). *Fighting energy poverty in the transition to zero-emission housing: A framework for BC*. Canadian Centre for Policy Alternatives.

Legendre, B., & Ricci, O. (2015). Measuring fuel poverty in France: Which households are the most fuel vulnerable? *Energy Economics, 49,* 620–628.

Levinson, A. (2019). Energy efficiency standards are more regressive than energy taxes: Theory and evidence. *Journal of the Association of Environmental and Resource Economists*, *6*(S1).

Levinson, A., & Silva, E. (2019). *The electric gini: Income redistribution through energy prices.* NBER working paper no. 26385. https://ssrn.com/abstract=3472820

Liddell, C., Morris, C., McKenzie, S. J. P., & Rae, G. (2012). Measuring and monitoring fuel poverty in the UK: National and regional perspectives. *Energy Policy*, *49*, 27–32. https://doi.org/10.1016/j.enpol.2012.02.029

Maynes, C. (2008). *Time for action: Tackling energy poverty in Canada through energy efficiency*. Green Communities Canada. https://www.healthyenvironmentforkids.ca/resources/time-for-action-background-paper.

McEachern, M., & Vivian, J. (2010). *Conserving the planet without hurting low-income families: Options for fair energy-efficiency programs for low-income households*. Conserving-planet-without-hurting-low-income-families-April2010-FINAL.pdf (uvic.ca)

Mirnezami, S. R. (2014). Electricity inequality in Canada: Should pricing reforms eliminate subsidies to encourage efficient usage? *Utilities Policy, 31*, 36–43.

Mohr, T. M. (2018). Fuel poverty in the US: Evidence using the 2009 residential energy consumption survey. *Energy Economics, 74*, 360–369.

Moore, R. (2012). Definitions of fuel poverty: Implications for policy. *Energy Policy*, *49*(October), 19–26. https://doi.org/10.1016/ j.enpol.2012.01.057

Murray, B., & Rivers, N. 2015. British Columbia's revenue-neutral carbon tax: A review of the latest "grand experiment" in environmental policy. *Energy Policy*, *86*, 674–683.

Ontario Energy Board. (2017). *The Fair Hydro Act, 2017.* https://www.oeb.ca/newsroom/2017/fair-hydro-act-2017

Petit, G. & Tedds, L. M. (2020a). *Interactions between income and social support programs in B.C.* Research paper commissioned by the Expert Panel on Basic Income, British Columbia.

Petit, G. & Tedds, L.M. (2020b). *Overview of system of income and social support programs in British Columbia.* Research paper commissioned by the Expert Panel on Basic Income, British Columbia.

Petit, G. & Tedds, L. M. (2020c). *Poverty in British Columbia: Income thresholds, trends, rates, and depths of poverty.* Research paper commissioned by the Expert Panel on Basic Income, British Columbia.

Petit, G. & Tedds, L. M.. (2020d). *Programs-based overview of income and social support programs for working-age persons in British Columbia*. Research paper commissioned by the Expert Panel on Basic Income, British Columbia..

Petit, G. & Tedds, L. M. (2020e). *Systems-level reforms to B.C.'s income and social support programs along basic income lines.* Research paper commissioned by the Expert Panel on Basic Income, British Columbia..

Poterba, J. (1989). Lifetime incidence and the distributional burden of excise taxes. *American Economic Review*, *79*(2), 325–330.

Preston, I., White, V., Blacklaws, K., & Hirsch, D. (2014). *Fuel and poverty: A rapid evidence assessment for the Joseph Rowntree Foundation*. Centre for Sustainable Energy. https://www.cse.org.uk/downloads/reports-and-publications/fuel-poverty/Fuel_and_poverty_review_June2014.pdf

Province of British Columbia. (2019). *TogetherBC: British Columbia's poverty reduction strategy*. https://www2.gov.bc.ca/assets/gov/british-columbians-our-governments/initiatives-plans-strategies/poverty-reduction-strategy/togetherbc.pdf

Ragan, C., Beale, E., Boothe, P., Cappe, M., Dahlby, B., Drummond, D., Elgie, S., Hodgson, G., Lanoie, P., Lipsey, R., Olewiler, N., & St-Hilaire, F. (2016). *Course correction: It's time to rethink Canadian biofuel policies*. Ecofiscal Commission. Course Correction: It's Time to Rethink Canadian Biofuel Policies (ecofiscal.ca)

Rezaei, M. (2017). *Power to the people: Thinking (and rethinking) energy poverty in British Columbia, Canada*. [Doctoral dissertation]. University of British Columbia.

Rivers, N. (2013). The distribution of costs of a carbon tax on Canadian households. *Canadian Tax Journal*, *60*(4), 899–915.

Rivers, N., & Schaufele, B. (2015). Salience of carbon taxes in the gasoline market. *Journal of Environmental Economics and Management*, *74,* 23–36.

Robinson, C., Bouzarovski, S., & Lindley, S. (2018). “Getting the measure of fuel poverty”: The geography of fuel poverty indicators in England. *Energy Research and Social Science* 36, 79–93.

Romero, J. C., Linares, P., & López, X. (2018). The policy implications of energy poverty indicators. *Energy Policy,* 115, 98–108.

Statistics Canada. (n.d.). Table 11-10-0066-01 market basket measure (MBM) thresholds for the reference family by market basket measure region, component and base year

Winter, J., Dolter, B., & Fellows, G. K. (2019). *Carbon pricing costs for households and revenue recycling options in Canada*. [Working paper]. https://jenniferwinter.github.io/website/Winter_Dolter_FellowsSept2019.pdf

Yamazaki, A. (2017). Jobs and climate policy: Evidence from British Columbia’s revenue-neutral carbon tax. *Journal of Environmental Economics and Management*, *183,* 197–216.

Yip, C. M. (2018). On the labor market consequences of environmental taxes. *Journal of Environmental Economics and Management*, *89,* 136–152.

Appendix A

Energy Poverty Indicators

Table A1

Strengths and Weaknesses of Energy Poverty Indicators

Indicator	Energy Poor if	Strengths	Weaknesses
10% threshold	Ratio of household energy expenditure to income greater than 0.1: $$\frac{household\ energy\ expenditure}{household\ income} > 0.1$$	- Simple calculation - Understandable - Versatile/easy to use - Identifies energy expenditure inequality - Fixed threshold and target	- Sensitive to energy prices - Sensitive to low reported incomes - Arbitrary, fixed threshold - No relationship to household income or circumstances (no mechanism to exclude wealthy households) - Identifies energy inequality, not poverty - Does not describe severity/depth of energy poverty
U.K. pre-2013 10% threshold	Ratio of modelled energy costs (required use multiplied by price) to income greater than 0.1: $$\frac{modelled\ energy\ costs}{household\ income} > 0.1$$ Can also be written as (where i refers to different energy types): $$\frac{\sum_i\ required\ energy\ use_i \times price_i}{household\ income} > 0.1$$	- Simple calculation - Understandable - Relies on modelled energy needs rather than expenditure - Responsive to changes in prices, income, energy efficiency - Modelled energy costs a national weighted average	- Required energy costs complex to calculate - Modelled energy costs a national weighted average - Arbitrary, fixed threshold - Does not account for differing household sizes - Sensitive to price changes - Sensitive to low reported incomes - Sensitive to temperature used in modelling required energy use - Does not identify depth of energy poverty

Hills (2012) low-income high-cost (LIHC)	Two conditions satisfied: 1. household energy expenditure (*HH_EE*) greater than median equivalized modelled energy expenditure (*M_EE*) $$HH\_EE > median\ (equivalized\ M\_EE)$$ AND 2. household income less housing (rent and mortgage) less energy expenditure is less than 0.6 median national household income plus median equivalized modelled energy expenditure $$HH\_Income - housing - HH\_EE < 0.6 \times median(income) + median(equivalized\ M\_EE)$$	- Corrects 10% threshold by including income threshold and energy expenditure - Relative thresholds that vary over time attenuates impact of price fluctuations - Measure of energy poverty based on individual households' position relative to thresholds - Measures depth of energy poverty via gap from energy cost threshold - Gap provides measure of severity of energy poverty - Acknowledges different household types have different energy costs - Uses official U.K. poverty line - Modelled energy expenditure based on expected energy use captures households where actual energy expenditure is low because of poverty	- Complex and not transparent - Does not identify households where reducing energy costs will alleviate energy poverty - Difficult to identify cause of changes to indicator over time - Setting energy expenditure threshold at median ignores effect of energy efficiency - Requires calculation and modelling of median energy expenditure - Median fuel cost threshold may be too high - Relative measure that changes over time; difficult to compare year to year
Romero et al. (2018) LIHC	Two conditions satisfied: 1. household energy expenditure greater than median energy expenditure (*EE*) $$household\ energy\ expenditure > median\ EE$$ AND 2. household income less energy expenditure less than 60% of median household income less mean energy expenditure $$HH\_Income - HH\_EE < 0.6 \times [median(income) - mean(EE)]$$	- Simplifies data requirements relative to Hill (2012) - Consistency on RHS and LHS of second condition	- Relative measure; measures energy inequality - Relies on median expenditure to calculate energy poverty - Relative measure that changes over time - Difficult to compare year to year
Moore (2012) minimum income standard (MIS)	Household energy expenditure (*H_EE*) greater than household income less housing costs less equivalized minimum income standard (MISeq.): $$H\_EE > HH\_Income - housing - MISeq$$ This can be rewritten as: $$HH\_Income - housing - HH\_EE < MISeq$$	- Includes concept of poverty and costs of shelter and food in measuring energy poverty - Accounts for household type, size and location in energy poverty measurement - Absolute measure of energy poverty - Allows for a scale of energy poverty (determined by reduction in MIS living costs to afford fuel costs)	- Requires identification of minimum income (see Petit & Tedds, 2020c) - Sensitive to MIS definition - Does not describe severity/depth of energy poverty

Romero et al. (2018) MIS	Household energy expenditure (*H_EE*) greater than household income less housing costs less equivalized minimum income standard (MISeq.) plus mean energy expenditure plus mean housing costs: $H\_EE > HH\_Income - HH\_housing - [MISeq - mean(EE) - mean(housing)]$ This can be rewritten as: $HH\_Income - MISeq < HH\_EE - mean(EE) + HH\_housing - mean(housing)$	- Aggregates individual MIS to household-level to measure HH energy poverty - Acknowledges different household types have different energy costs	- More complex than Moore (2012) MIS method - Requires definition of minimum income - Equivalized MIS is national population-weighted average of Spanish minimum income allowance - Sensitive to choice of MIS - False negative if housing costs are large
Romero et al (2018) modified MIS	Three conditions satisfied: 1. household income less household energy expenditure greater than equivalized non-energy MIS $HH\_Income - HH\_EE > nonenergyMISeq$ AND 2. household income greater than equivalized MIS $HH\_Income > MISeq$ AND 3. household energy expenditure greater than energy component of equivalized MIS $HH\_EE > energy\ MISeq$	- Conditions 1 and 2 distinguish between “energy poor”’ and “income poor” households - Condition 3 identifies households in energy poverty due to high bills	- Complex - Requires energy expenditure component of MIS
2M Type 1 (Castaño-Rosa et al., 2019)	Household energy expenditure greater than two times mean national household energy expenditure: $HH\_EE > 2 \times mean(EE)$	- Simple to calculate - Avoids problems of static measures not adjusting to changing circumstances -	- Mislabels higher-income households with “excessive” energy expenditure as energy poor - Sensitive to energy prices

2M Type 2 (Castaño-Rosa et al., 2019)	Household energy expenditure greater than two times median national household energy expenditure: $$HH\_EE > 2 \times median(EE)$$		- Sensitive to low reported incomes - Arbitrary, fixed threshold - No relationship to household income or circumstances (no mechanism to exclude wealthy households)
2M Type 3 (Castaño-Rosa et al., 2019)	Ratio of household energy expenditure to income greater than two times the national mean ratio: $$\frac{household\ energy\ expenditure}{household\ income} > 2 \times mean\left(\frac{energy\ expenditure}{income}\right)$$	- Simple to calculate - Threshold definition related to distribution of income and expenditure - Avoids problems of static measures not adjusting to changing circumstances	- Mean sensitive to outliers in data - Identifies relative, not absolute, energy poverty - Sensitive to energy prices - Sensitive to low reported incomes - Identifies energy inequality, not poverty - Does not describe severity/depth of energy poverty - Arbitrary, fixed threshold - Relative measure that changes over time; difficult to compare year to year
2M Type 4 (Castaño-Rosa et al., 2019)	Ratio of household energy expenditure to income greater than two times the national median ratio: $$\frac{household\ energy\ expenditure}{household\ income} > 2 \times median\left(\frac{energy\ expenditure}{income}\right)$$		
After fuel-cost poverty (AFCP)	Household income less housing and energy expenditure less than equivalized MIS: $$HH\_Income - housing - HH\_EE < MISeq$$	- Equivalent to Moore (2012) MIS - Identifies households that are vulnerable but not necessarily defined as energy poor by other definitions - Adjusts for different household types having different energy costs and incomes	- Requires definition of MIS
Hidden energy poverty (HEP)	Household energy expenditure less than half the national median: $$HH\ energy\ expenditure < 0.5 \times median(energy\ expenditure)$$	- Identifies households with low income and low energy expenditure (choice between heating or eating)	- Households that do not pay utilities (renters, condo owners) will be misidentified as in energy poverty

Sources: Adapted from Hills (2011, 2012), Preston et al. (2014), Imbert et al. (2016), Romero et al. (2018,) and Castaño-Rosa et al. (2019).

Appendix B

Supplementary Tables

Table B1

Share of B.C. Households Defined as Energy Poor by Indicator, 2017

	Indicator 1: 10% income share	Indicator 2: 10% expenditure share	Indicator 3: Income share > 2x median	Indicator 4: LIHC	Indicator 5: Moore MIS	Indicator 6: Romero MIS	Indicator 7: Hidden energy poverty
Overall	**5.0%**	**8.6%**	**12.2%**	**6.4%**	**35.1%**	**18.0%**	**34.9%**
By income quintile							
Quintile 1	19.6%	11.2%	33.9%	17.5%	96.2%	64.0%	54.5%
Quintile 2	4.2%	13.7%	17.9%	9.5%	49.5%	18.9%	40.4%
Quintile 3	1.1%	8.8%	5.3%	3.2%	21.4%	3.9%	36.8%
Quintile 4	0.4%	5.6%	2.8%	1.8%	7.4%	2.8%	27.4%
Quintile 5	0.0%	3.5%	1.1%	0.0%	0.7%	0.0%	15.4%
By household type							
Single	8.6%	9.9%	17.4%	7.5%	49.1%	27.3%	50.6%
Lone parent	7.0%	5.8%	17.4%	9.3%	55.8%	31.4%	48.8%
Couple (no kids)	4.4%	12.9%	11.5%	4.9%	22.0%	9.5%	26.6%
Couple (with kids)	1.4%	2.6%	6.5%	6.0%	28.7%	12.5%	22.7%
Couple (with other)	3.9%	9.8%	7.8%	7.8%	23.5%	7.8%	21.6%
Other	5.9%	6.9%	12.9%	6.9%	50.5%	32.7%	49.5%
By household size							
1 person	8.6%	9.9%	17.4%	7.5%	49.1%	27.3%	50.6%
2 persons	4.8%	11.7%	11.7%	4.9%	27.7%	13.9%	31.1%
3 persons	3.3%	3.8%	8.0%	5.2%	32.4%	16.4%	29.1%
4+ persons	2.1%	4.3%	9.2%	8.5%	32.3%	14.2%	25.2%

By reference person age							
<40 years	4.0%	1.9%	8.8%	5.1%	42.8%	24.1%	51.9%
40 to 54	4.5%	4.5%	10.6%	7.0%	28.8%	16.5%	32.4%
55 to 64	6.6%	11.5%	14.3%	7.3%	30.3%	16.7%	26.5%
>65 years	5.4%	16.2%	15.2%	6.4%	36.9%	14.5%	27.5%
By dwelling type							
Apartment	3.1%	2.2%	6.9%	1.9%	47.8%	28.0%	71.3%
Attached	4.6%	5.6%	9.9%	5.9%	39.5%	19.1%	39.5%
Single detached	6.4%	13.6%	16.3%	9.2%	25.6%	11.5%	11.4%
By year built							
Pre-1960	7.1%	12.3%	14.2%	8.5%	39.8%	20.4%	33.6%
1960 to 1980	3.7%	11.3%	12.9%	5.3%	35.8%	16.8%	33.4%
Post-1980	5.1%	6.3%	11.4%	6.3%	33.5%	17.8%	35.9%
By ownership							
Owned with mortgage	4.9%	2.3%	11.5%	9.7%	29.2%	16.6%	24.4%
Owned without mortgage	6.0%	20.0%	16.4%	4.9%	23.0%	7.5%	15.6%
Rented	4.3%	3.6%	8.6%	4.1%	54.5%	30.6%	67.6%

Table B2

Household Income Quintiles (Net Income After Tax and Transfers)

Quintile	Income Lower Bound	Income Upper Bound
Q1 (lowest)	$0	$33,275
Q2 (lower middle)	$33,275	$55,100
Q3 (middle)	$55,100	$77,025
Q4 (upper middle)	$77,025	$106,650
Q5 (highest)	$106,650	

Source: Own calculations from 2017 SHS PUMF. We define household net income after taxes and transfers with the variables: HHNetInc = HHTotInc - TX001.

Table B3

Market Basket Measure Square Root Equivalence Scale

Family size	Square root scale	Multiply the threshold value by
1	1.0	0.5
2	1.4	0.7
3	1.7	0.9
4	2.0	1.0
5	2.2	1.1
6	2.4	1.2

Source: Table 5 of Djidel et al. (2020).

Table B4

2008 and 2018 Base Market Basket Measure Threshold for Vancouver by Family Type, 2017 Current Dollars

Family size	2008-base threshold value	2018-base threshold value
1	20,099.50	23,750
2	28,139.30	33,250
3	36,179.10	42,750
4	40,199.00	47,501
5	44,218.90	52,251
6	48,238.80	57,001

Source: Modified from Table E1 of Djidel et al. (2020) and Statistics Canada (n.d.)

Table B5

Count of B.C. Dwelling Types by Year Built, 2017 SHS PUMF

	Single detached	Attached	Apartment
Pre-1960	131	36	44
1960 to 1980	213	64	103
Post-1980	360	204	271

Source: 2017 SHS PUMF.

Table B6

Count of B.C. Dwelling Ownership Types by Year Built, 2017 SHS PUMF

	Owned with mortgage	Owned without mortgage	Rented
Pre-1960	52	70	89
1960 to 1980	123	119	138
Post-1980	338	280	217

Source: 2017 SHS PUMF.