Measuring Building Quality of First Nation Owned Housing in British Columbia

by

Kear Porttris
Bachelor of Engineering, University of Victoria, 2017

Business Human Resources Diploma,
Saskatchewan Institute of Applied Science and Technology, 2008

A Thesis Submitted in Partial Fulfillment
of the Requirements for the Degree of

MASTER OF APPLIED SCIENCE

in the Department of Civil Engineering

Supervisory Committee

Measuring Building Quality of First Nation Owned Housing in British Columbia

by

Kear Porttris
Bachelor of Engineering, University of Victoria, 2017

Business Human Resources Diploma,
Saskatchewan Institute of Applied Science and Technology, 2008

Supervisory Committee

Dr. Christopher Kennedy, Civil Engineering Supervisor

Dr. Phalguni Mukhopadhyaya, Civil Engineering Co-Supervisor

Abstract

On-Reserve housing might be the most contentious, complicated issue faced by First Nations people in Canada. First Nations have unique relationships with the Canadian Government and face historical and on-going challenges. One of these many challenges is the growing gap between adequate housing need and availability. First Nations people face higher rates of overcrowding, exposure to mould, and living in poorly constructed or maintained homes. Housing has been studied from many angles by government and academics alike, from policy and planning to homelessness and health, but very few studies clearly quantifies the quality of On-Reserve housing. Most of the numbers used in studies, in both the grey literature and open research, draw from statistical information or self-reporting surveys. This information is helpful in a broad analysis but it lacks details that could be used for setting concrete strategic priorities and policies for building new housing and/or renovating existing stock.

The objective of this research is to identify the differences between First Nation homes and non-First Nation homes in British Columbia (BC) using housing information provided by Natural Resources Canada (NRCan). This data is available from the submission of home energy assessment data. Non-invasive procedures and professional experience is used to estimate many of the parameters used in these assessments. A home's air changes per hour at a pressure of 50 kPa, ACH_{50}, was chosen as the value for home quality through this research. ACH_{50} is the only consistently measured parameter during home energy assessments. The information from NRCan represents 693 homes owned by First Nations between climate zones 4 and 7A and 127,295 homes owned by non-First Nations between climate zones 4 and 7B.

The results of this research show that most First Nation homes were situated in climate zone 5, while most non-First Nation homes were in climate zone 4. Assuming that all the First Nation housing data is on reserve, a methodology was created to allocate the home data to individual First Nation communities in BC. This allowed 515 homes to be isolated into 25 First Nation communities, where other factors were compared to the data. Examining the aggregate data, First Nation homes faired better than non-First Nation homes in terms of ACH_{50} and ceiling insulation levels, but the analysis is more nuanced

than the data presents. The number of homes that were isolated by First Nation community as well as the history and current situation of On-Reserve housing must be considered in the analysis. Socioeconomic factors (i.e. unemployment rates, average total income, and annual band revenues) did not seem to significantly impact the quality of homes on reserve, but the remoteness of a community did have a negative impact on the quality of a home. This research is useful in identifying some key aspects of First Nation and non-First Nation housing in BC but the analysis recognizes a gap in the data which requires a more critical and holistic evaluation to identify how this information relates to the current housing situation First Nations people continue to face.

Table of Contents

Supervisory Committee ii
Abstract iii
Table of Contents v
List of Tables vi
List of Figures vii
Acknowledgments viii
Dedication ix
Chapter 1 – Objective Statement & Introduction 1
Objective Statement 1
Introduction 1
Chapter 2 – Literature Review / Background 9
2.1 Social Science Research 9
2.2 Health related 11
2.3 Mould in First Nation Housing 12
2.4 Indigenous Architecture and Design 15
2.5 Housing 17
Chapter 3 – Data & Methodology 25
3.1 Home Energy Assessment Data 25
3.2 Identifying Data for First Nations Communities 29
3.3 Statistical Tests 40
Chapter 4 – Results 48
4.1 Air Changes per Hour Comparisons 48
4.2 Socioeconomic Comparisons 53
4.3 Ceiling Insulation Comparisons 57
Chapter 5 – Discussion 61
Chapter 6 – Conclusion 80
Bibliography 82
Appendix A - Graphs 91

List of Tables

Table 1: Annual Net Migration Rates of Registered Indians by Area of Residence, 1966-1971 to 2001-2006 [3] 4
Table 2: Self Reporting of dwelling requirements by year 21
Table 3: Number of Homes in British Columbia by Climate Zone Based on NRCan Home Energy Assessment Data 31
Table 4: Indigenous Communities Identified through the NRCan Data 34
Table 5: Unemployment Rates, Average Total Household Income and Total Annual Band Revenues for Each Identified First Nation Community [77] 37
Table 6: Geographic and Environmental Classifications [78] 38
Table 7: Remoteness and Environmental Indices [78] 39
Table 8: Statistical tests conducted during investigation of building energy performance in Indigenous communities in British Columbia 40
Table 9: Regression and Statistical Analysis for Figures 4 through 11 60
Table 10: ACH_{50} by Climate Zone for Aboriginal and Non-Aboriginal Homes in BC 51
Table 11: Size of Homes in BC 56
Table 12: Ceiling Insulation Levels by Climate Zone and Ownership Type 57
Table 13: Average Ceiling Insulation Values (RSI) and the Number of Aboriginal Homes That Met the BC Building Code Standards for Ceiling Insulation 59
Table 14: Overall Age of Homes for Aboriginal and non-Aboriginal Owned Homes in BC Organized by the Build Year of the Homes 62
Table 15: Overall ACH_{50} Values 63
Table 16: Canadian Off-Grid Community Data [86] 70

List of Figures

Figure 1: Energy Use by End Use in Canada, 2013 [8] 6
Figure 2: Presence of Mould or Mildew in the Home, by Self Reporting [33] 14
Figure 3: Percentage of First Nations Adults Reporting if there has been Mould or Mildew in their home within the past 12 Months, by remoteness [32] 14
Figure 4: Condition of Homes and Need for Repairs, Regional Health Survey 2008/10 [33] 22
Figure 5: Number of Homes Built and Renovated Between 2005 and 2012 [52] 22
Figure 6: Approximate Climate Zones of British Columbia by Heating Degree Days [73] 29
Figure 7: Percent of Indigenous and Non-Indigenous Homes by Climate Zone in British Columbia based on NRCan Home Energy Assessment Data 30
Figure 8: Population Density and First Nation Communities in BC with Corresponding Climate Zone Approximation 31
Figure 9: ACH_{50} of all non-Indigenous Homes for Homes Built Between 1850-2018 49
Figure 10: ACH50 by Build Year of All Indigenous Homes 50
Figure 11: ACH_{50} by Climate Zone for Aboriginal and Non-Aboriginal Homes in BC .. 51
Figure 12: Building ACH_{50} vs Community Remoteness Index (logarithmic scale) 52
Figure 13: Air Changes per Hour vs Percent of Homes Assessed in Each Indigenous Community 53
Figure 14: ACH vs Average Total Income (All Persons with Income), Indigenous Communities 54
Figure 15: ACH vs Unemployment Rate for BC First Nation Communities 55
Figure 16: ACH vs Annual Total Band Revenues 55
Figure 17: Size of Homes in BC 56
Figure 18: Ceiling Insulation Levels by Climate Zone and Ownership Type 58
Figure 19: Ceiling Type by Ownership Type 58
Figure 20: ACH50 by Build Year Trendlines of Indigenous and non-Indigenous Homes 62
Figure 21: Percentage of First Nations adults reporting their dwellings in need of repairs, by remoteness [34] 68
Figure 22: Maslow's Hierarchy of Needs [88] 73
Figure 23: Proportion of Individuals Living in Crowded Homes On-Reserve by Region between Census Years 2001, 2006 and 2011 [82] 78
Figure 24: ACH50 of all non-Indigenous Homes for Homes Built Between 1778-2018 92
Figure 25: ACH50 by Build Year of All Indigenous Homes 93
Figure 26: ACH50 by Build Year Trendlines of Indigenous and non-Indigenous Homes 94
Figure 27: Population Density in BC by Dissemination Area [75] 95
Figure 28: Figure a overlapped by climate zone map [73][75] 96
Figure 29: Map of First Nation Communities in BC [76] 97
Figure 30: Figure c overlapped by Climate Zone Map [74][76] 98
Figure 31: Indigenous Communities Identified in the Data 99

Acknowledgments

This work could not have been made possible without the support of my family, particularly my parents. In the chaos, which is my life, they were there ensuring that other things were taken care of so that I was able to complete this work.

I would also like to acknowledge the patience and tenacity of my supervisor, Dr. Christopher Kennedy. His guidance through this process has been pivotal in my success.

Dedication

I would like to dedicate my thesis to the next generation of Indigenous STEM (science, technology, engineering, and mathematics) professionals and researchers. There currently is not enough of you out there. Let's change that.

Chapter 1 – Objective Statement & Introduction

Objective Statement

There is a considerable amount of research that evaluates Indigenous housing for both on-reserve and urban housing. This research aligns with various social science, policy or political topics surrounding this type of housing where statistical census data or qualitative data is presented through the research or reports. This research undertakes a quantitative comparison of housing data between Aboriginal and non-Aboriginal owned homes in British Columbia (BC). Using the quantitative comparisons from these data, differences between these home types will be evaluated.

Introduction

Canada's Aboriginal Peoples face immense challenges due to colonization. Although these challenges vary, there is a considerable amount of overlap between the causes and effects of the diverse issues. One of these issues, and perhaps the most contentious and complicated, is on-reserve housing. The home is the center and foundation for a family and families are the center and foundation for communities. Sadly, the system that supports housing on reserve is broken and has negatively affected Status Indians for over a century. The media often reports on the difficulties of housing on reserve but the contributing factors faced by housing providers, housing managers, administrative staff, government(s) and community members are nearly impossible to quantify in five-minute news stories.

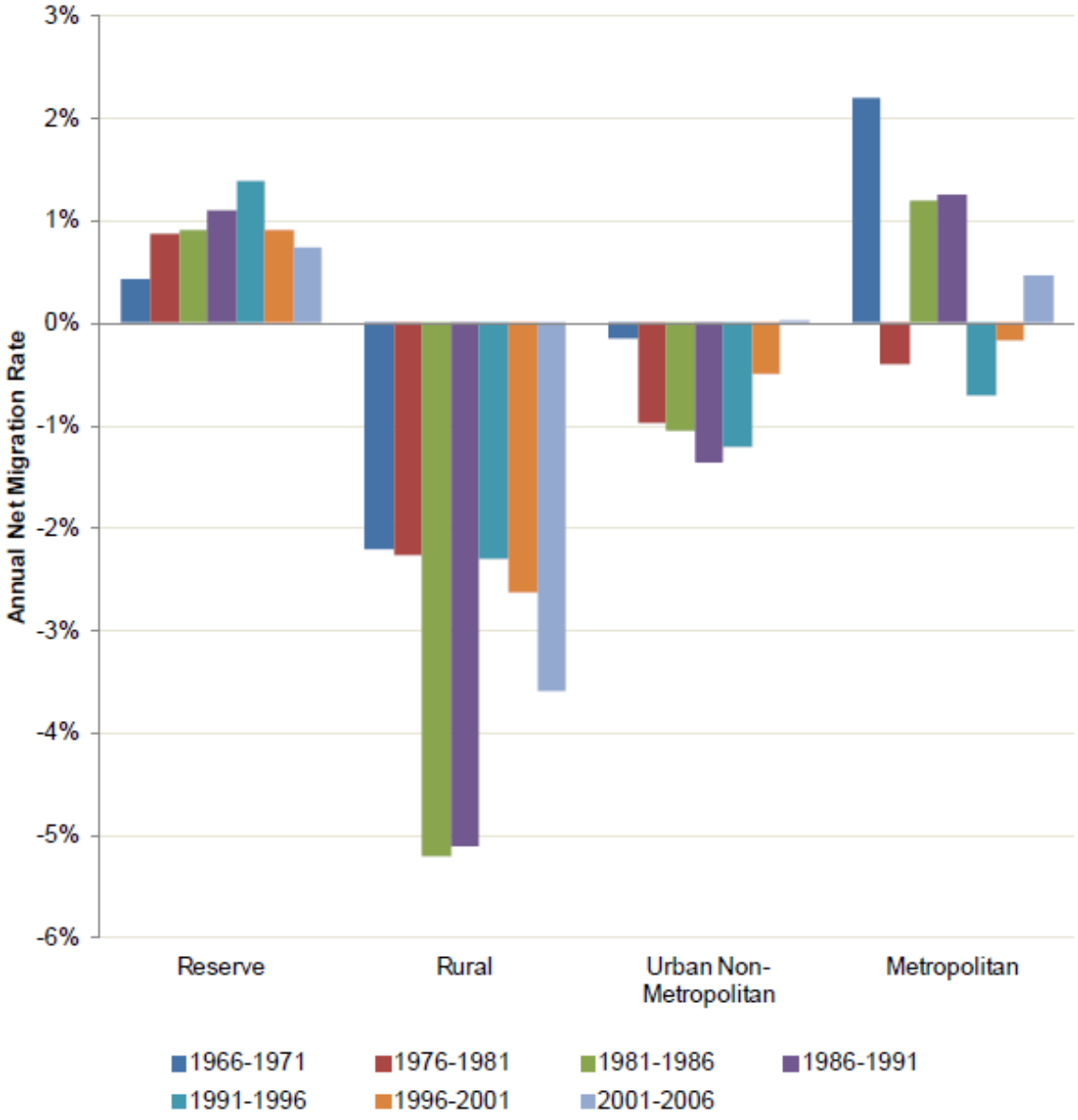
This research presents the situation of Indigenous People in Canada, from a perspective of technical housing information based on an analysis of BC housing data sourced from

Natural Resources Canada (NRCan). The NRCan data was separated into two datasets based on home ownership type, Aboriginal-owned and all non-Aboriginal owned homes. Much of the statistical and academic information presented may include numbers for Indigenous people generally, but all the data analysis of the NRCan data is assumed to be First Nation housing on reserve and, thus, the methodology is only associated with First Nation communities.

Colonization imposed a way of life onto Indigenous People in Canada which forced Indigenous people onto land that they could not own and where their everyday lives were managed by the colonial government [1]. A similar approach toward Indigenous Peoples was used in the United States, New Zealand, and Australia. These imposed systems create a complex relationship between Indigenous Peoples and Settler Canadians, where Status Indians in Canada are wards of the state. This is further complicated as governments and government departments often disagree on roles, responsibilities, and jurisdiction on topics like housing, education, health, and social services meant to support Indigenous people in Canada. This is a result of multiple agencies handling similar portfolios and compounded by the inefficiencies of bureaucracy, ultimately creating dysfunction and negativity for the Indigenous people that these systems and services are meant to serve. The Indian Act (the "Act") implemented in 1876 governed the everyday life of Status Indians and other Indigenous people in Canada. The Act created Indian Reserves and forced Status Indians to live on relatively small pieces of land under the control of the Federal government. The Act limited Indigenous people's access and involvement with Canadian society, which formed clear differences between Indigenous and non-Indigenous people in Canada. There are vast amounts of statistical information

available for Indigenous people and much of this data is presented in this research. Through treaties and the Indian Act, a fiduciary duty (i.e. a trust type legal responsibility) was established by the Crown for Indigenous people. One of the many requirements under the Act was that Status Indians required permission from the local Indian agent to leave the reserve. They were required to present documentation if they left their reserve, or else they could be arrested. Fortunately, this is no longer the case and Status Indians are legally able to come and go from the reserve as they please. Currently, approximately 44.2% of all First Nations with Indian status live on reserve [2] and there is continual, positive influx of First Nations people moving to reserves [3], see Table 1 below. Also, the growth rate for the Canadian Aboriginal population was 20.1% and 22.9% for First Nations people between 2006 and 2011, approximately four times that of the Canadian non-Aboriginal population during that period [4]. This indicates that the challenges faced by Indigenous people and communities will only grow if they are not addressed.

Table 1: Annual Net Migration Rates of Registered Indians by Area of Residence, 1966-1971 to 2001-2006 [2]



There are several common issues that all on-reserve housing faces but the two that could be addressed from a technical perspective are mould and building quality. Mould growth is a result of temperatures and moisture levels in a favourable range, often associated with poor building quality and design, lack of building maintenance and/or

overcrowding. Overcrowding is defined as exceeding the Nation Occupancy Standards (NOS), which has a number of age and family related criteria for people sharing a home. A simple breakdown of NOS is that kids can share rooms, teens of different genders require separate bedrooms, and couples can share a room. Considering NOS, overcrowding affects 23.1% of First Nation people [5] and 11.4% of all Indigenous people in Canada. In comparison, only 4% of non-Indigenous Canadians experience overcrowding [6]. Overcrowding may be linked to family size, where First Nations living on-reserve generally have larger families (3.7 persons per household) than Canadians (2.5 persons per household) [7].

Because humans produce water vapour through respiration, more people in a single home requires higher levels of moisture management considerations in a building's design and maintenance. A building's design and maintenance directly affect mould growth. For example, if a building has improper ventilation then excessive moisture levels cause greater potential for mould growth on or within the building envelope. Improper building envelope design, either through inadequate vapour and water barriers or low levels of insulation, can cause moisture to build up within the wall cavity and provide an ideal environment for mould growth. Making considerations for either mould or building quality dually supports both of these common issues while also improving building energy efficiency.

Home energy efficiency is generally dependent on three factors: the building envelope, the appliances and technology used in the home, and user behaviour. Figure 1 below shows the home energy use of a home in Canada in 2013, showing that space heating is the primary demand for energy in the home. Poor building energy performance is linked

to building quality because a home will require more space heating if the design is not appropriate for the local climate. Canada used centrally designed homes that provided standardized homes to First Nations communities [8] that often did not fit the climate where they were located nor were they designed for comfort or to accommodate the

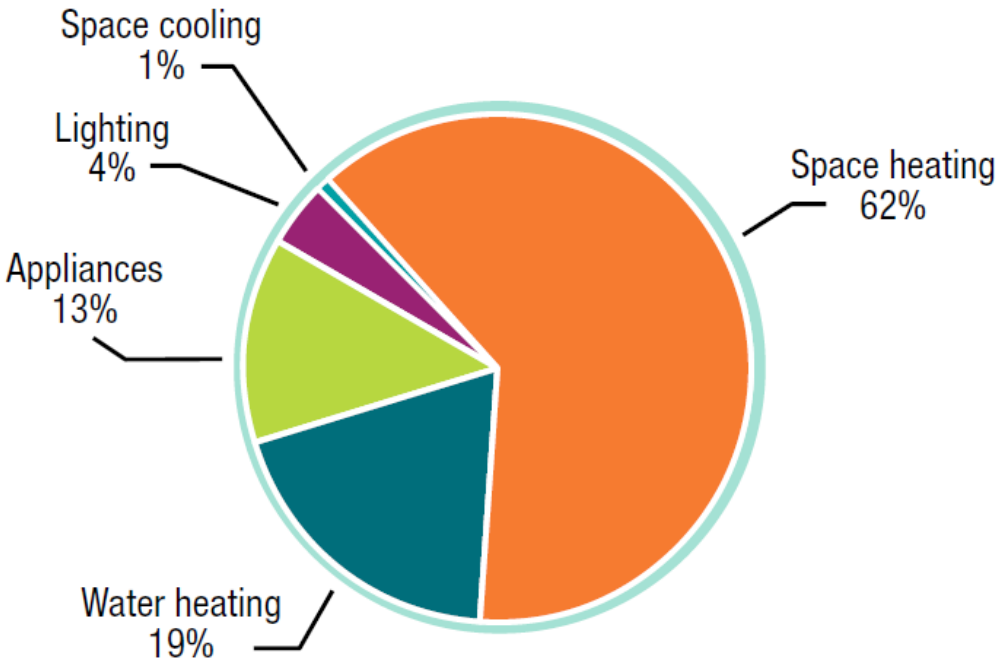


Figure 1: Energy Use by End Use in Canada, 2013 [8]

families they sheltered. Housing was controlled by the Canadian government and has been an on-going legacy of colonialism for First Nation communities. As technology and building policy changed and Canadian homes became more energy efficient, but on-reserve homes continued to suffer from poor building quality.

This research focuses on the technical analysis of housing data that is available through NRCan. A literature review of the research shows that the majority of existing literature is largely focused on socioeconomic, political, or policy related matters. The grey literature that focuses directly on reserve housing is often in disagreement and estimates

often differ substantially between findings from First Nation organizations and the Canadian government. Broad statements are made about quality or need rather than verifiable technically gathered data. Furthermore, there is considerable information available that shows Indigenous people's health is not as good as other Canadians but the findings do not conclusively connect health outcomes to housing related challenges that Status Indians face, as health is also multi-dimensional.

NRCan provided housing data for all homes in BC, housing data was made available for 127,988 homes. NRCan gathers this data directly from homeowners who complete professional home energy audits. The housing data was analyzed in aggregate and by climate zone. Statistical information and regression analysis were performed. Although, NRCan provides an exceptional amount of information to use and analyze, in order to protect the privacy of homeowners, the only identifying information provided was the evaluation identification number, city and first three characters of the postal code. Consequently, there was no easy or immediate way to associate home data to specific First Nation communities. A methodology was then developed to identify and separate the data for all the First Nation owned homes into communities, assuming all the data for First Nation owned homes was on-reserve. Once communities were identified, community information was retrieved from the Indigenous Services Canada (ISC) website through their First Nations profile database. The ISC information is gathered from Statistics Canada ("Stats Can") or submitted from the First Nation directly and made publicly available online. Air changes per hour (ACH), specifically at a pressure of 50 pascals (ACH_{50}), was used as the deciding factor for quality of the home. ACH_{50} is the only consistently, objectively measured parameter in all the home energy assessment

information. The other housing parameters are gathered through non-destruction or non-invasive inspections by a home energy advisor, who is often an experienced building professional who makes an educated guess on the various parameters from the available information. Ceiling insulation was also evaluated but not to the same extent as ACH_{50}. Some of this data, information, analyses and results are well known and/or well understood by researchers and industry professionals but much of it has not been quantified explicitly using this type of housing information.

Chapter 2 – Literature Review / Background

The urban Indigenous population in Canada increased by 83.8% over the period of 1996-2006 [10]. Though this trend continues, this research specifically analyzes on-reserve housing. The unique jurisdictional situation of on-reserve housing significantly impacts the daily lives of Status Indians and has been a challenge for more than 100 years. Most of the housing research available focuses on social science, anthropology, economics, and health, but fails to address technical analyses of housing design or quality, with the exception of a limited amount of self-reported information. There is an abundant amount of research out there that documents Indigenous housing and its interface between health and the social challenges from Canada, the United States, Australia, and New Zealand. Indigenous inclusion and research seem to be a little more developed in Australia and New Zealand than in Canada but the grey literature that is available from the Canadian Government provides significant breadth and depth on the topic of housing.

2.1 Social Science Research

There is a broad spectrum of research focused on Indigenous housing ranging from discrimination against Indigenous people seeking housing to urban Indigenous population considerations to policy development. Racism toward Indigenous people been studied and documented, as demonstrated in Motz's study on housing discrimination of Indigenous postsecondary students in Canada [11]. Evans et al performed a participatory study asking about the experiences of Indigenous peoples with social and health services in the Okanagan Valley [12]. Anderson does an in-depth empirical evaluation on urban

Indigenous populations in the prairies [13]. Anderson focuses on demographics, affordability, income, migration from and to reserves, amongst other statistics. These types of studies are very common and provide specific and general analyses of the position of Indigenous people in Canada.

Sociological and political science research has been the approach of some housing research making these perspectives more readily available in the literature. Zavisca1 and Gerber suggest that housing status be considered a key independent factor impacting sociological research rather than loosely connecting it to other factors [14]. Monk spotlights that First Nation communities are becoming increasingly responsible for on-reserve housing without corresponding supports or redress for the historical challenges that have created the "housing crisis". She argues that reconceptualizing housing can make housing a tool for decolonization and self-determination [15] rather than a burden. Durbin assessed the failed response to on-reserve housing through the Kelowna Accord and makes suggestions on a more productive approach for dialogue in future deliberations [16]. The Kelowna Accord was an agreement between First Nations and multiple levels of government from across Canada to address long standing First Nations issues, with particular focus on housing. The agreement was not ratified before the Harper Conservative government came into power in 2006, and was then abandoned. These sociopolitical arguments help frame the dialogue through roots in social and political discourse rather than technical aspects of housing.

There are a handful of researchers that focus on the policy and intersection of urban Indigenous peoples, homelessness, and urban planning. Walker has done extensive research on urban planning and identified that 49% of the nearly one million Indigenous people in Canada during 2001 lived in urban centers [17][18][19]. By 2016, the population had

grown to 1.67M and about 900,000 of those Indigenous Canadians lived in urban areas [20]. Porter and Barry study the impacts of land sovereignty and land justice by including Indigenous communities in city planning exercises [21]. Urban Indigenous considerations are becoming more common as cities grow and the impacts to Indigenous communities and people become more apparent, especially considering that Indigenous people are overrepresented among the homeless in Canada, Australia and Aotearoa/New Zealand [22][23][24], where much of the perspective has been focused on policy and culturally appropriate approaches to these populations. This type of policy research, which includes Indigenous people as part of the solution process, is important in creating effective policy that includes Indigenous perspectives.

2.2 Health related

The socioeconomic and health status of Indigenous People in Canada, the United States, Australia, and New Zealand have narrowed or widened over time [25]. Links between housing and health can and are made through some research and grey literature. Health research shows that marginalized groups are generally not as healthy as other populations. Broader subjects, such as housing, need to be included to fully understand the impacts on health [26]. This cannot be truer than it is for Canada's Indigenous people. The Community Wellness Index indicates that 96 of the bottom 100 Canadian communities are First Nations [27], inferring that physical and mental health are intimately interwoven with the quality of housing and housing conditions that these peoples face on reserve. General health research shows that mental health worsens with persistent housing problems [28] while improvements to a home's structure can be associated with improvements in mental health [29]. Children who grow up in an

overcrowded home experience lasting affects of this on their socioeconomic status and wellbeing into adulthood [30]. Robson found that inadequate housing negatively impacts health concerns across the spectrum from tuberculosis to shigellosis to mental health and suggests on-reserve housing is a risk to Indigenous people [31][32]. This is further supported by Carrièr et al whose research shows First Nations people were significantly more likely than non-Indigenous people to be treated for respiratory tract infections and asthma, even when housing conditions, household income and residential location were taken into account [33]. It is well known that Indigenous people in Canada live shorter and harder lives than other Canadians.

2.3 Mould in First Nation Housing

The Regional Health Survey found that over-crowding is linked with various negative outcomes: mould, unintentional injuries, transmission of infectious disease, mental health problems, family tension, accelerated home usage, and violence [34]. Although, mould is a known challenge for Indigenous communities, the full scope of health problems associated with mould need to be assessed and more extensive field data on mould growth in on-reserve housing is required [35] before any conclusions can be firmly drawn. For instance, Figure 2 below shows that half the respondents said there was mould in their homes and for those that self-reported fair/poor health status the majority stated they had mould in their home. On this assertion, the Office of the Auditor General recommended, "Indian and Northern Affairs Canada, Canada Mortgage and Housing Corporation, and Health Canada, in consultation with First Nations, should develop a comprehensive strategy and action plan to address the problem of mould on reserves." However, this was not achieved [36], as none of the above-mentioned agencies had acted

on the recommendations nor taken on the responsibility to develop a strategy from their 2003 report, as documented in their 2011 report.

Mould can be found nearly anywhere there is favourable levels of moisture and temperature as well as a food source. In a home it can lead to higher rates of degradation of building components while having negative health impacts on the residents of the home. Problematic moisture stems from deficiencies in housing conditions, including structural damage to the building envelope, overcrowding, and insufficient use of ventilation systems and other moisture-control and maintenance strategies [35]. Lawrence and Martin explore the challenges of First Nation communities faced with mould and suggest that substandard housing is a major contributor [37]. Homes were built using centrally designed housing plans which did not account for the vastly different climates across Canada [38] which contributes to the notions of substandard housing design. Overcrowding is also a major contributor to mould growth, as more water vapour from human respiration leads to higher relative humidity and potential for mould. The Senate committee report regarding On-Reserve housing indicates that mould can be found in homes within two years after it is built. First Nation families on reserve have limited housing choices and alternatives, which results in families living in mould contaminated homes that have already been condemned [38]. Figure 3 below shows the differences in mould or mildew presence in the home between urban, rural and remote communities, increasing from urban settings.

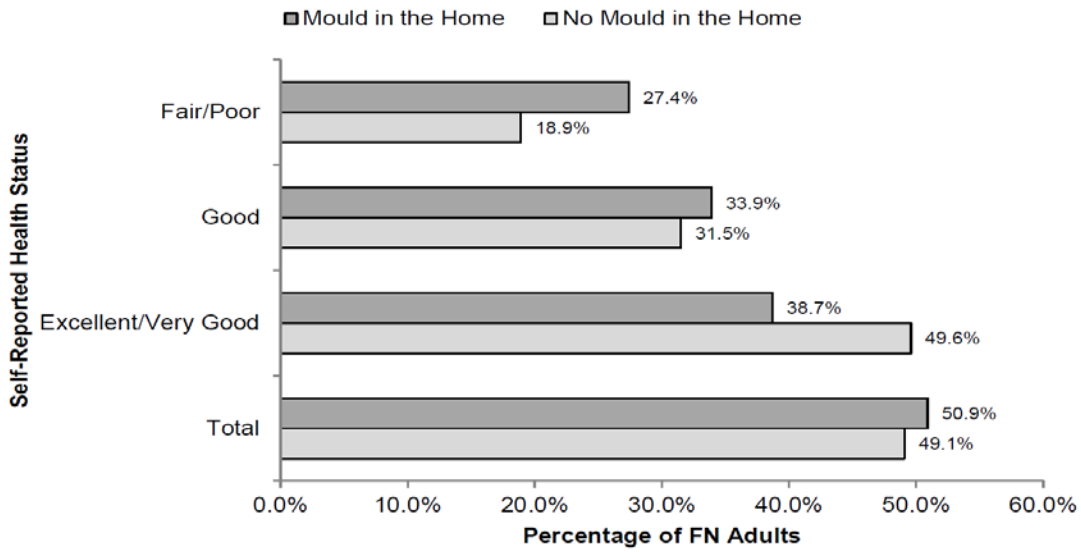


Figure 2: Presence of Mould or Mildew in the Home, by Self Reporting [33]

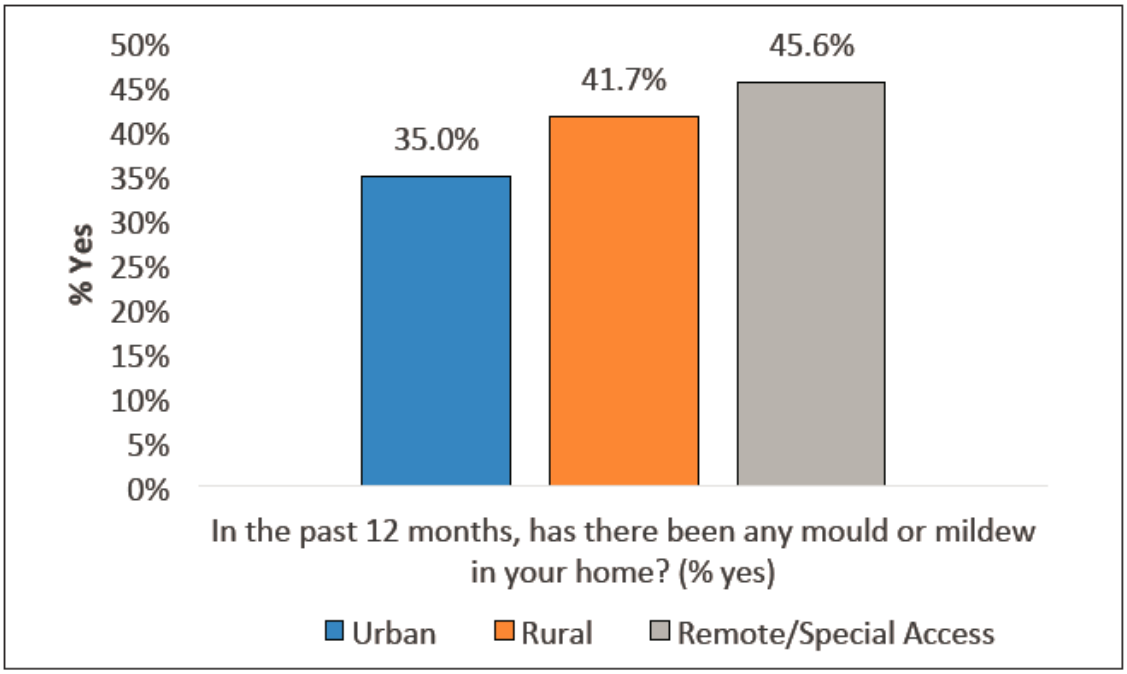


Figure 3: Percentage of First Nations Adults Reporting if there has been Mould or Mildew in their home within the past 12 Months, by remoteness [32]

Statistics and health informatics are important and accurate tools for aligning and identifying health information about Canada's population. Stats Can found that First Nations

people are significantly more likely than non-Indigenous people to be hospitalized for respiratory tract infections and asthma, at rates triple the general population for those living on reserve and double for off-reserve Indigenous people. Although housing conditions are related to rates of hospitalization for respiratory tract infections and asthma, additional factors must be considered. In this case, the study suggested household income between Indigenous and non-Indigenous people could be a more important factor [33].

2.4 Indigenous Architecture and Design

Indigenous perspectives in design from an architectural perspective is also readily studied. *Our Voices: Indigeneity and Architecture*, assembled by Rebecca Kiddle, Luugigyoo Patrick Stewart and Kevin O'Brien, is a "first of its kind" collaboration across the USA, Canada, Australia and New Zealand to bring perspectives and stories that focus on Indigeneity design, placemaking and planning [39]. *The Handbook of Contemporary Indigenous Architecture* by Grant et al uses a similar approach to present the cross-section of architecture and Indigenous culture and also shares stories from design professionals and scholars from Australia, Canada, the United States and New Zealand [40]. Costa states that "designers are fundamentally disconnected from the users" and the needs of building projects must reflect the People, place and history they serve, helping to further define Indigenous Architecture [41]. For many years Indigenous people were not living in homes that represented them or met their needs. This resurgence in Indigenous design is not a novel concept but the consideration for Indigenous people in their homes has been a contentious topic for so long that the body of work supporting it is growing rapidly.

The approach to modern Indigenous housing is constantly evolving and primarily focuses on culturally appropriate housing design, often aligning with greener building

practices that help address some of the historical challenges of past housing. Appropriateness is identified as a means of fostering identity, sense of ownership, and responsibility for the home, according to Kyser [42][43]. A study by researchers at the University of Victoria explored an integrated approach with the Haisla Nation for designing homes in their community, centred on direct interaction with the stakeholders [44]. Deane and Smoke found that collaborative design activities produced "significantly different" home designs from the conventional model [45]. Geoff Taylor developed a framework to approach housing with the Tla-o-qui-aht and Ahousaht First Nations that focuses on affordable homes and green building practices while addressing their distinct cultural needs [46]. The Penticton Indian Band created the Eco Sage Project where they built five high efficiency homes in a culturally appropriate way and incorporated the natural cycles in the systems of the home in order to reduce heating and pollution in their community while connecting to the "timeless and traditional ways of building, which relate to the movement of the sun, natural breezes and the Indigenous landscape" [47]. These specific community approaches to housing have produced great work, but they focus on the broader design aspects of housing and do not thoroughly investigate the technical aspects of existing housing.

BC Housing's recent approach to funding on-reserve housing includes recommendations from planning to design [48]. The Canadian Mortgage and Housing Corporation (CMHC) research showcases how some Indigenous communities designed homes to their needs and preference while also using local materials to construct their homes on reserve [49]. The use of local materials is recommended for appropriate housing, especially in remote areas, and an Earthship design model proposed by Stephanie Kelly takes this a step further to suggest using upcycled and donated materials and volunteer labour [50]. There is no lack of supporting

research for more inclusion with Indigenous people to ensure their homes are appropriate to them.

2.5 Housing

Urban housing needs and proactive policy development as they relate to Indigenous People often focuses on urban housing. Belanger demonstrates how ownership is a positive measure for urban Indigenous populations but there is still a considerable shortfall in federal funding support for homelessness and urban Indigenous housing [51]. Considering that homeownership on reserve is severely limited, this type of research is not often directly applicable to on-reserve populations. Other research states that a third of the Canadian Indigenous population live in inadequate, unsuitable or unaffordable housing, whereas the non-Indigenous population for the same considerations is 18%. The same report states that Métis and Non-Status Indians are more likely to become homeowners than Status Indians and Inuit [52]. Walker focuses much of their research on urban planning and believes that Aboriginal urban housing needs will only be rectified by pairing it with the common pursuit of adequate and affordable housing for all Canadians [53]. Although urban Indigenous housing is an important topic, it is faced with significantly different jurisdictional and funding challenges compared to on-reserve housing.

Indigenous housing has been intricately explored by governments and the grey literature shows significant depth[1] [38][54]. CMHC has also performed regular evaluations of on-reserve programs with multiple reports between 1987 and 2017 [55][56] and "Research on Aboriginal Housing" had over 100 papers and reports between 1957 and 2011 [57]. Neegan Burnside also developed a report on housing management training programs in 2004 [58]. The Canadian Aboriginal Aids Network even provides some work on an informal discussion

paper [59]. Graham and Motsi's policy brief found that the Federal Government spent $3 billion on First Nation Housing between 1997-2006, creating over 19,000 new dwellings and reducing overcrowding by 7%, but homes requiring major repairs increased by 8% to 44% in that same period, where the national average for homes requiring major repairs was 7% [60]. They further identify that First Nation housing challenges are a political problem with three key factors: (1) political will, (2) community support, and (3) managerial and technical capacity. The authors then provide an argument for improved governance and capacity through an accreditation regime that would increase the administrative capacity of First Nation housing providers by setting standards and providing support through associations to access benefits and resources as needed. Much of this research and information is based around policy, management and financial shortcomings of the system but do not offer much information on the technical design needs of the current housing situation. The majority of the data continues to be statistical or self reported values and responses.

The federal government's on-reserve housing policy only used to provide funding for renovations and new construction, not for maintenance or administrative supports. This changed in 1996 when ISC broadened the policy to include more in their funding allocations [61]. The legacy from the previous policy still has an impact on the way Status Indians interact with their homes, particularly since this is a voluntary policy that communities must opt into in order to benefit from the new policy [15]. There are also considerable bureaucratic issues working with government agencies where funding is complex and roles between agencies, namely ISC and CMHC, are not clear [62] and continued to be a problem documented by the Senate report more than a decade later [38]. This adds even more difficulties for Indigenous communities to access support through the government. Under the administration of CMHC and ISC, the Public Policy Forum created a recommendation report from "round table" discussions with Aboriginal community members and housing staff. This

report identified five common themes that are evident in most, if not all, the literature on Canadian Indigenous housing on reserve [63]:

1. Include First Nations in the conversation – include community members, Chief and Council, First Nations and government representatives.
2. Acknowledge and address democratic and political challenges between First Nations and the government.
3. Build greater capacity and flexibility into First Nations initiatives.
4. Review and re-think First Nations housing models and funding – there should be no one-size-fits-all model.
5. Explore the creation of a First Nations-led organization(s) with responsibility for on-reserve housing.

Some of these initiatives and actions are taking place. For example: the First Nations Housing and Infrastructure Council in BC is committed to taking on the responsibility of administering housing and infrastructure funding and support for First Nation communities across BC. Likewise, Indigenous Services Canada introduced their "New Approach for Housing Support in British Columbia" that applies a better model to leverage funding, develop housing plans, policy and management in First Nation communities. Although these changes show progress and provide optimism, change is a very slow process in the face of historic challenges and bureaucratic systems.

Lack of complete and conflicting information about housing need and supply makes it difficult to develop solutions in an effective way [64]. In 2015, the Standing Senate Committee on Aboriginal Peoples released an interim report that reviewed numbers from 2011 where the Assembly of First Nations (AFN) said the shortfall in housing was 85,000 units while the federal government estimated the same shortfall between 35,000-40,000 units

[38]. AFN published a fact sheet in 2013 that stated 107,627 housing units were required as of March 2013 where the Canadian Government stated that 130,197 new housing units would be needed between 2010-2031 with approximately another 10,000 units needing some sort of renewal or renovations [65]. The First Nations Market Housing Fund (FNMHF) was established in 2008 to provide financial backing to enable mortgage lending on reserve. It was projected that the FNMHF would be directly supporting the construction of 25,000 homes over ten years but, as of December 2013, the FNMHF had enabled the construction of only 55 homes [38]. One of the goals of the 10 Year First Nations National Housing and Related Infrastructure Strategy is to "identify funding needs, collect consistent and standardized data and review and analyze existing data in order to provide a comprehensive picture of housing and related infrastructure needs in First Nations." However, this seems difficult because there are unclear roles and responsibilities in many of the government agencies to have and provide this information [66]. It is difficult to address policy measures for housing when there is this lack of information and methodology in identifying housing need.

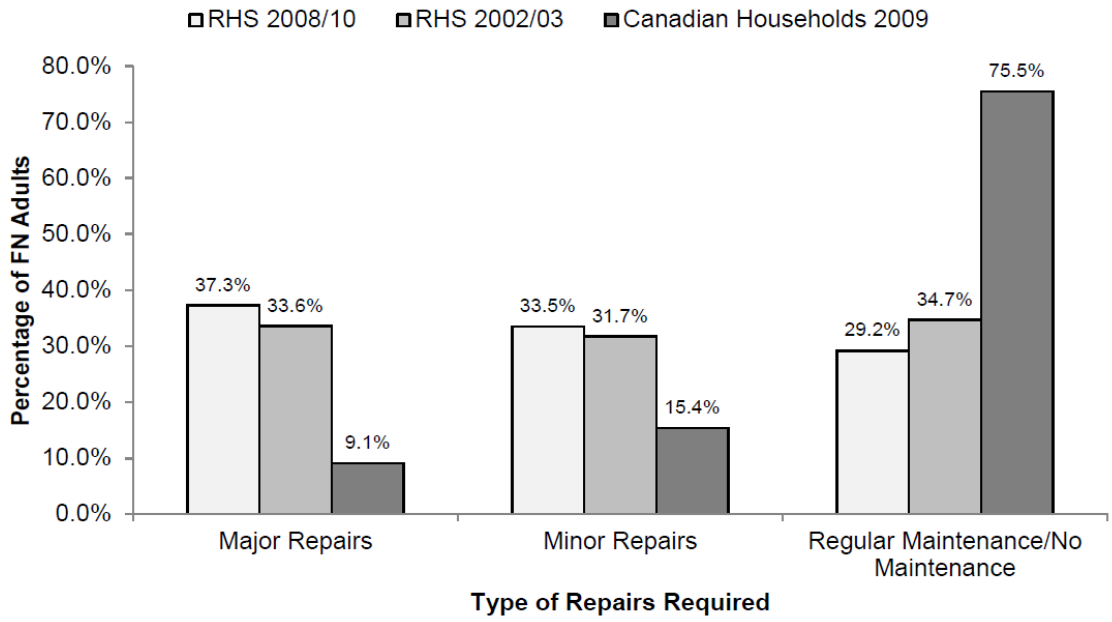
There is considerable statistical data that represents housing related information, specifically on houses needing repair or maintenance, where much of the findings are based around the subjectively collected data through self-reporting and not verified or collected by a qualified professional. This poses questions around consistency and accuracy because it is subjectively reported, presenting a challenge to use this information as a technical measure. Table 2 and Figure 4 present information from the Regional Health Survey as well as the findings from the BC Office of Housing and Construction Standards. If the need for regular maintenance is increasing then what kind of metrics are being used to track the quality of renovations and improvements in renovations? ISC's own evaluation of on-reserve housing shows that renovations outpace new builds in communities [52] (see Figure 5). There is a

lack of good information on spending and results of that spending [62] which makes this analysis problematic in addressing the ongoing issues of maintenance and home repair.

Table 2: Self Reporting of dwelling requirements by year

	DWELLINGS	PERCENTAGE			
		2002/03[&]	**2007**	**2008/10[&]**	**2016[+]**
DWELLINGS REQUIRE REGULAR MAINTENANCE ONLY	38,320*	34.7%[&]	50.5%*	29.2%[&]	44.0%[+]
DWELLINGS REQUIRE MINOR REPAIRS ONLY	26,630*	31.7%[&]	31.1%*	33.5%[&]	31.8%[+]
DWELLINGS REQUIRE MAJOR REPAIRS	13,925*	33.6%[&]	18.4%*	37.3%[&]	24.2%[+]

*[64]
&[33]
+[5]



*Canadian Households 2009 from Survey of Household Spending (SHS) 2009 (Statistics Canada, 2010).

Figure 4: Condition of Homes and Need for Repairs, Regional Health Survey 2008/10 [33]

Figure 3: Number of Houses Built and Renovated Between 2005 and 2012[34]; and the Proportion Adequate between 2005 and 2014[35]

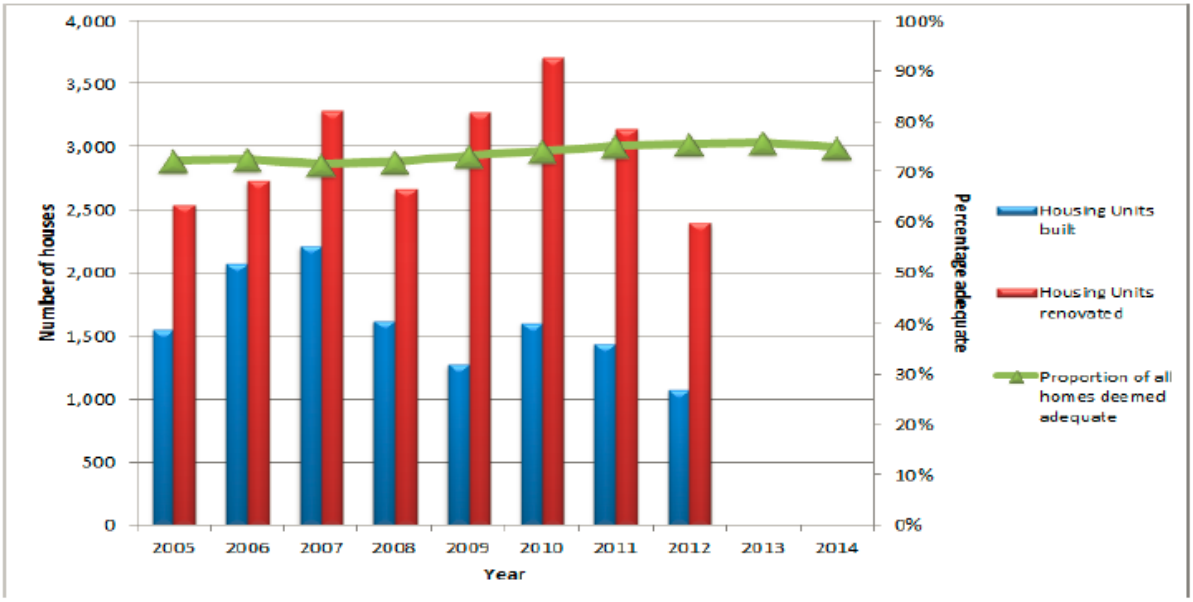


Figure 5: Number of Homes Built and Renovated Between 2005 and 2012 [52]

The Aboriginal Housing Management Association (AHMA) released their National Housing Strategy Recommendations on October 21, 2016. One of its recommendations is to define and measure housing in different ways to ensure key performance indicators take a broader account of impacts from stable housing [67]. Many of AHMA's recommendations are based on better management and planning for housing but do not mention technical aspects of the homes, instead focusing on the culture and appropriateness. Although these recommendations may help build homes, it will not address technical needs of housing nor how some of the challenges faced by First Nation communities are fundamentally a result of the shortfall on quantitative data.

The lack of detailed technical research sticks out in the available research. Boles studied five sample homes in Washagamis Bay First Nation and recommended developing greater capacity for indoor air quality and energy efficiency evaluations while also keeping an inventory of existing home data [68]. Communities are starting to become more savvy and practical where information is being development by Indigenous organizations that make housing information more accessible for Indigenous communities. One such guide is the *New Housing Guide* created by Coastal First Nations, an alliance of eight Nations living on British Columbia’s North and Central Coast and Haida Gwaii, that provides simple guidelines and costing information to help housing managers make decisions [69]. A year prior, a similar guide was developed by Dylan Heerema with more technical guidelines, developed with BC Hydro and the Great Bear Initiative (GBI) [70]. In this work, existing building energy performance was estimated using utility consumption data, several different building standards were explored, and design recommendations for eight common issues for these communities were presented. This research focused on technical design recommendations and exploration of available technologies, approximating energy savings,

and building methods to meet these communities' needs rather than a deep dive on current building stock. This is the closest technical information available to address baseline issues but is light on technical baseline data that can be used to measure or create key performance for homes going forward.

Chapter 3 – Data & Methodology

This section explains the data and methods used to identify and separate the information between non-Indigenous and Indigenous communities. The aggregated quantitative housing data was provided by NRCan, which is gathered from home energy audit submissions of HOT2000 simulation software data from British Columbia. Community census data was gathered from each community's profile, available on ISC's website. Due to privacy considerations and limitations in the modelling software, the NRCan data did not provide enough information to associate individual housing data to specific communities. This information was then analyzed through a detailed methodology to cross reference geographical information, with other considerations, to identify which housing data belonged to specific Indigenous communities in the area. The building information, although very plentiful, only specifies the housing type as "Aboriginal Owned" or "non-Aboriginal Owned," and given that Métis and Inuit have no settlements or reserves in BC all the housing data is assumed to be from First Nation reserves in the context of this research. It is also difficult to compare building quality given the type of information provided in the housing data and choosing the right parameter to signify housing quality was imperative, and daunting. Calculated ACH_{50} was chosen as the measure for home quality. All the housing data was provided in digital spreadsheet format and statistical analysis was performed using Microsoft Excel.

3.1 Home Energy Assessment Data

NRCan has a significant amount of data on Canadian homes. Some of this data has been collected through home energy assessments and EnerGuide Home Evaluations

where Canadian homeowners have hired a professional home energy advisor (HEA) to evaluate their home's energy efficiency. HEAs are independent contractors who use "NRCan's official marks, trademarks, and software under a licencing agreement" [71][72] and are hired by homeowners to perform these building assessments. During these assessments, the HEA investigates many components of the home, performs a blower door test and evaluates the energy use of the home using HOT2000 software. HOT2000 is an energy simulation software developed by NRCan to generate EnerGuide Ratings and energy use estimates for residential homes and small buildings. HOT2000 provides estimates on building energy use and uses building information as inputs parameters. EnerGuide Ratings for Homes is merely a rating scale between 0-100 that is used to quantify how energy efficient a house is using the HOT2000 analysis. There have been several funding programs that have encouraged and/or required homeowners to engage HEAs to access government funding for home renovations. Currently, there is a program offered through CleanBC Better Homes with funding from BC Hydro, Fortis, the Province of BC and Canadian Government. HEAs are often only responsible for the home energy audits and submission of the data to NRCan if a EnerGuide Rating is desired. This process has helped build the database of building information that is held and managed by NRCan.

HEAs use a combination of experience and building knowledge to gather necessary building information for accurate building assessments and effective building modelling through HOT2000. Some examples of the information gathered by the HEA are:

- Building Orientation
- Location of home
- Total square footage and heights of the building
- Building occupancy
- Types and sizes of installed windows and doors
- Heating, ventilation, and air-conditioning (HVAC) equipment
- Types of home, foundation and ceiling types, building shape and number of storeys
- Domestic water heating equipment
- Wall thicknesses and materials used to construct the building's envelope (exterior and interior)
- Insulation levels in the walls, foundation, and attic/ceiling

HEAs use non-destructive and non-invasive methods during their investigations and directly measure the "airtightness" of a home by performing a blower door test. The blower door test creates a 50 pascals (Pa) pressure difference between the interior and the exterior of the building and measures the volume of air that flows through the apparatus. This flow is then used to calculate ACH of the building. The blower door test is the only consistently measured objective data in these assessments, given that the non-destructive investigations used to gather the other building information limits the accuracy of the data, especially those of the building's envelope (e.g. insulation levels in walls, foundations and some types of ceiling types, type of framing used, air and vapour barriers used, etc.), as many of the components are concealed behind drywall and other finishing materials. All the collected information is input into HOT2000, which calculates home energy use information and related reports. If the client so chooses, the information is then submitted to NRCan. This HOT2000 information was requested for homes in BC during the spring of 2019 and provided by NRCan shortly after in the form of raw

information, presented in electronic spreadsheets separated by climate zone and ownership types (Aboriginal owned and non-Aboriginal owned).

The quantitative measure used to differentiate climate zones is Heating Degree Days (HDD). HDD is a unit that signifies the level of heating demand required over the year by tracking the days and degrees required for heating to a standard temperature. The National and BC Building Codes use HDD to identify the required levels of insulation in buildings and isolating the data by these parameters was seen to be appropriate for this research. That being said, the difference in climate regions (i.e. coastal, inland and mountain regions) are substantial and building homes in each region will have specific building practices that will differ despite sharing the same climate zone. For example, the way a home is built in Haida Gwaii (formerly, Queen Charlotte Islands) will require design features for high volumes of rainfall and high wind considerations. In Kamloops, snowfall is more of a concern and in Victoria earthquake load calculations affect building structure and envelope considerations. Figure 6 below shows the various climate zones in BC.

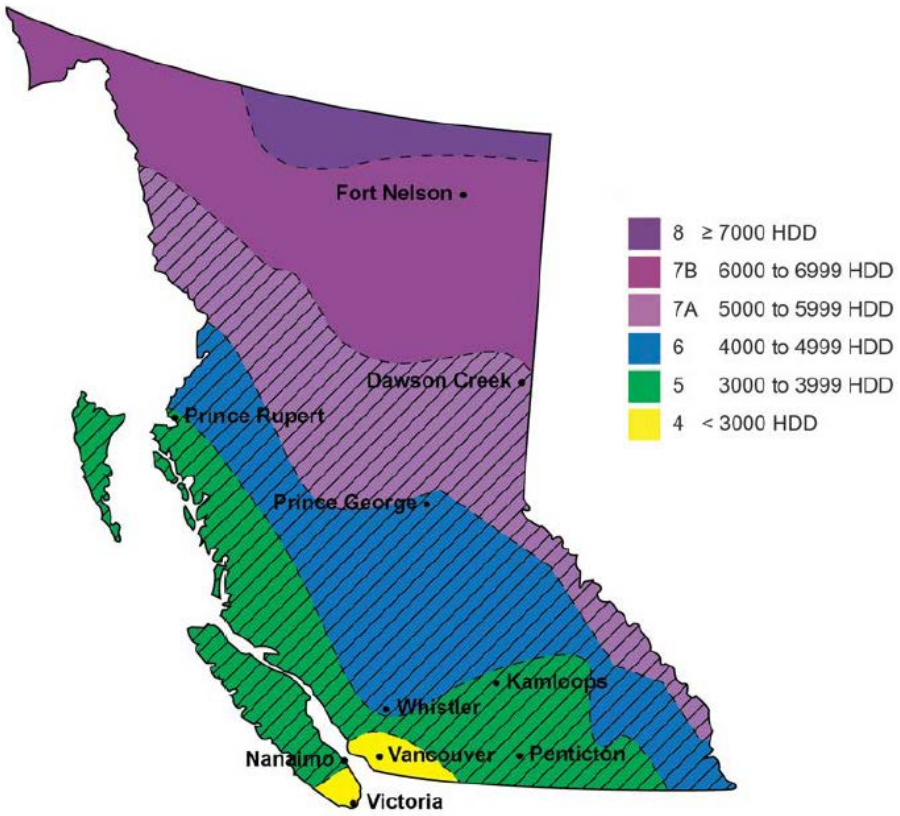
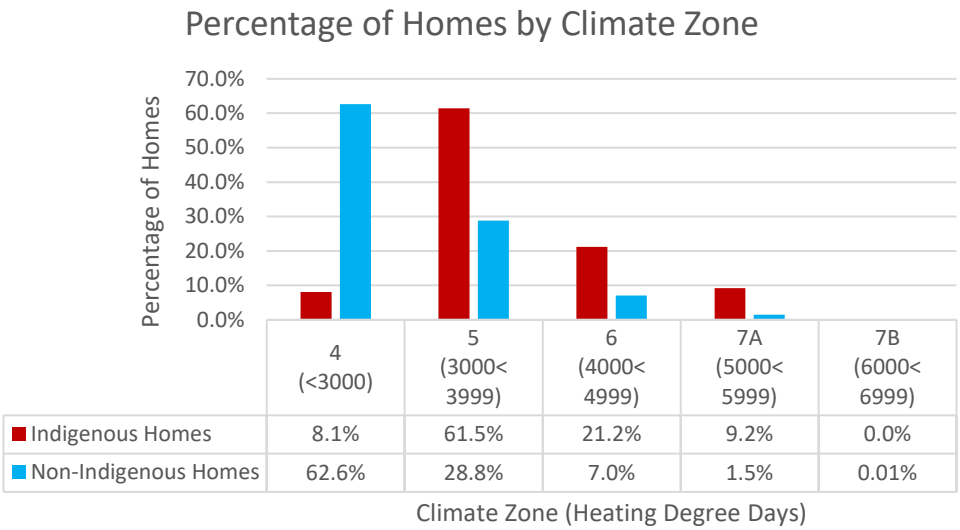


Figure 6: Approximate Climate Zones of British Columbia by Heating Degree Days [73]

3.2 Identifying Data for First Nations Communities

The NRCan data was separated in two datasets, First Nation owned and non-First Nation owned homes, where both datasets were organized by climate zone. The data represents 127,988 homes in BC, the vast majority of which (127,295) are non-First Nation owned homes. The ratio of the two ownership types is approximately 185:1. Table 3 shows the total number of homes in each climate zone and Figure 7 represents those values as percentages by climate zone and ownership type. For non-First Nation homes this shows that most of the data, 91.4%, is gathered from homes in climate zones four and five, which likely correlates to the BC population statistics: in 2016 nineteen of the top

twenty-six cosmopolitan municipal areas in BC were within these two climate zones [74]. Figure 8 (a) and (b) show the population density of areas throughout BC and the overlapping climate zones of that data. For the Indigenous homes, the majority of the housing data is from climate zones five and six, representing 82.7% of the First Nation housing data. Figure 8 (c) and (d) show the locations of First Nation communities across BC and the overlapping climate zones. These two data sets show how the population of both ownership types are spread out according to the population and community information available. Although there are likely other factors that affect the way in which this information is spread, this is a good indicator of the likelihood of where this data came from.

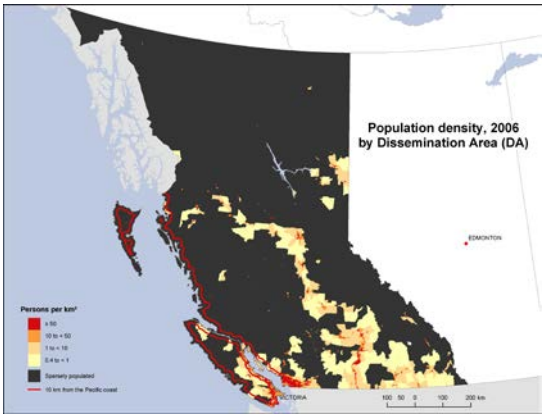


	4 (<3000)	5 (3000< 3999)	6 (4000< 4999)	7A (5000< 5999)	7B (6000< 6999)
Indigenous Homes	8.1%	61.5%	21.2%	9.2%	0.0%
Non-Indigenous Homes	62.6%	28.8%	7.0%	1.5%	0.01%

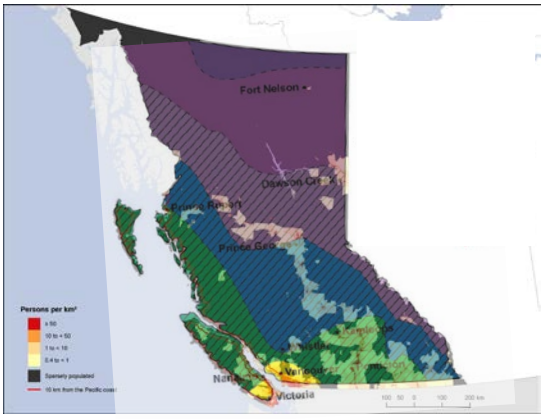
Figure 7: Percent of Indigenous and Non-Indigenous Homes by Climate Zone in British Columbia based on NRCan Home Energy Assessment Data

Table 3: Number of Homes in British Columbia by Climate Zone Based on NRCan Home Energy Assessment Data

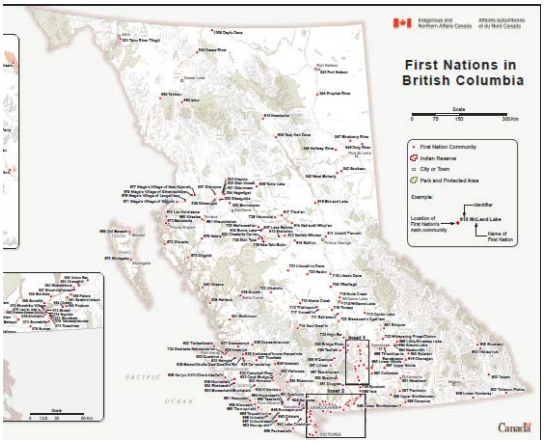
		Climate Zone (HDD)					
		4 (<3000)	5 (3000< 3999)	6 (4000< 4999)	7A (5000< 5999)	7B (6000< 6999)	**Totals**
Indigenous	Homes	56	426	147	64	-	**693**
Non-Indigenous	Homes	79722	36684	8949	1922	18	**127,295**



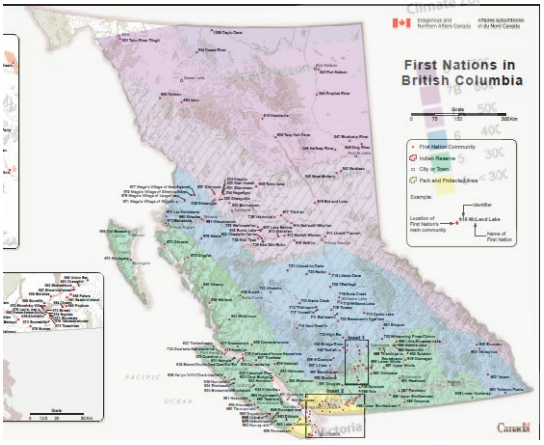
(a)



(b)



(c)



(d)

Figure 8: Population Density and First Nation Communities in BC with Corresponding Climate Zone Approximation

(a) Population Density in BC by Dissemination Area [75],
(b) Figure a overlapped by climate zone map [73][75],
(c) Map of First Nation Communities in BC [76], and
(d) Figure c overlapped by Climate Zone Map [74][76]

Because the focus of this research was to compare Indigenous housing to non-Indigenous housing, information was provided by NRCan in two separate spreadsheets, First Nation and non-First Nation owned. Ownership type in the HOT2000 software is limited to eight choices through a dropdown menu with the following options:

- Private
- Corporate
- Aboriginal
- Special Projects (Aboriginal)
- Special Projects (non-Aboriginal)
- Federal Housing
- Provincial Housing
- Municipal Housing

Due to privacy considerations for homeowners, specific ownership information in the data is limited to whether the home is Aboriginal-owned or not. Many First Nation communities face nuanced and unique challenges with on-reserve housing and the data does not readily allow for a separation of that information. Although this data specifies that it is Aboriginal owned, it does not say whether it is owned by a community or by an individual or if it is on-reserve or off-reserve. This is important information considering there is often a drastic difference with housing and infrastructure built on reserve compared to that built off reserve, as building codes, regulations and jurisdictions differ between the land types these homes are built on. The only identifying information in the data is the evaluation identification number, the city the home is located and the first three digits of the postal code. Though this helps identify where in BC the information is

from it does not give the details necessary to directly compare the differences between housing in Aboriginal communities and non-Aboriginal communities.

Given the lack of identifying information in the data, a procedure was created to isolate and identify which communities the Indigenous Housing data could belonged to, making the following assumptions:

- Data belonged only to BC First Nation communities
- Significant consideration for the location of a community's most populated reserve and other reserves was taken, gathering information from various sources (e.g. community's website, ISC's community profile page)
- Data belonged to communities where identified appropriate reserves were near the location of each data point
- Postal code charts were used to isolate location in formation, and
- Where First Nation communities were very close to each other, it was deemed to be inconclusive that the data point belonged to any of the communities.

It was assumed that the information only belonged to First Nations and did not make any considerations for Métis or Inuit, as neither of those Peoples have settlements or registered lands in BC. Using the location information, the city and first three letters of the postal code, nearby First Nation communities were identified using local maps, Google Maps, postal code maps, Canada Federal Lands maps (in the form of KMZ file), information available through ISC, the Indigenous communities' website and other relevant information sources. Figure 8 (c) shows how close many of these communities are geographically and when multiple communities were in close proximity to a data point, and it was not clear which community it belonged to, the point was not isolated nor

associated with any First Nation community. The data was separated into individual communities, Table 4 below shows the communities and number of homes identified through the data in each community, allowing for a specific analysis of other community information and comparing it to the housing quality data. 515 homes were isolated into 25 communities using this method.

Table 4: Indigenous Communities Identified through the NRCan Data

COMMUNITY	CLIMATE ZONE	NUMBER OF HOMES	PERCENT OF TOTAL ON-RESERVE HOMES
OSOOYOOS	5	129	25.0%
PENTICTON	5	111	21.6%
AQ'AM	6	59	11.5%
MUSQUEAM	4	26	5.0%
WUIKINUXW	5	23	4.5%
KWADACHA	7A	19	3.7%
LOWER KOOTENAY	6	14	2.7%
LOWER NICOLA	5	14	2.7%
HESQUIAHT	5	13	2.5%
SNUNEYMUX	5	13	2.5%
HAIDA	5	13	2.5%
UPPER SIMILKAMEEN	5	12	2.3%
T'SOUKE	4	11	2.1%
PACHEEDAHT	4	9	1.7%
TOBACCO PLAINS INDIAN BAND	6	9	1.7%
BURNS LAKE BAND	7A	8	1.6%
TAKLA NATION	7A	8	1.6%
MOWACHAHT/MUCHALAHT BAND	5	7	1.4%
AHOUSAHT	5	5	1.0%
LHEIDLI T'ENNEH	6	3	0.6%
WESTBANK	5	3	0.6%
CHEMAINUS FIRST NATION (STZ'UMINUS FIRST NATION)	4	2	0.4%
SQUAMISH	4	2	0.4%
KAMLOOPS	5	1	0.2%
UCLUELET	5	1	0.2%
TOTAL ISOLATED DATA POINTS	-	515	74.3%

COMMUNITY	CLIMATE ZONE	NUMBER OF HOMES	PERCENT OF TOTAL ON-RESERVE HOMES
TOTAL UNCLASSIFIED		178	25.7%

It was imperative to isolate the points by communities in order to access and compare community specific information. Community information is available through each community's online profile, on ISC's First Nation Profiles website, and by accessing census or statistical information through Statistics Canada. To prevent any of the census data from being traced to an identifiable person in the communities the data was limited in the following ways, as noted on each of webpages presenting this information on First Nations' profiles through the ISC website [77]:

- For some metrics, no available data was available for communities with less than 40 individuals;
- Income information was not available for communities with less than 250 individuals or 40 households; and,
- In certain geographic areas random rounding (either up or down to multiples of 5 or 10) or data suppression was used.

Although there is a significant amount of information available through ISC, many First Nation communities in BC are small, meaning average household income data was unavailable for many of the communities. Fortunately, the aggregate data (i.e. unemployment rate and total annual band revenues) was available for almost all the communities. Due to the above considerations all data was recorded from the First Nations' Profiles to provide a consistent approach to the available information. The total band revenues were averaged from the years that were available, mostly from 2013

through 2019. The *First Nations Financial Transparency Act* (FNFTA) required First Nation communities to publish various financial documents online and this information was accessed for the analysis. The following is an account of the Nations who did not have complete financial data available through the ISC website:

- Wuikinuxw Nation

  Audited financial statements for 2018 and 2019 were not available

- Haida Nation

  All Haida Nation housing information was aggregated as the Nation has undisputed control over their territories, with no overlapping claims with other Nations. The Haida Nation consists of two villages, Skidegate and Old Massett, and because both communities share similar remoteness indices and only a single home from Old Masset, the decision was made to not isolate the housing data. Therefore, no community information was collected or compared.

- Westbank First Nation

  Westbank First Nation became a self-governing Nation by signing a treaty agreement with the Canadian Government on May 6, 2004 meaning it is no longer governed by the Indian Act and is not required to submit documents to satisfy the FNFTA.

- Ucluelet Nation

  Ucluelet First Nation became a self-governing Nation, together with other Maa-nulth First Nations, by signing a treaty agreement with the Canadian Government on July 22, 2008 meaning it is no longer governed by the Indian Act and is not required to submit documents to satisfy the FNFTA.

Table 5 below shows the collected data for each community's unemployment rate, average total household income and total annual band revenues:

Table 5: Unemployment Rates, Average Total Household Income and Total Annual Band Revenues for Each Identified First Nation Community [76]

COMMUNITY	UNEMPLOY-MENT RATE IN COMMUNITY (%)	AVERAGE TOTAL HOUSEHOLD INCOME ($)	TOTAL ANNUAL BAND REVENUES ($M)
OSOOYOOS	12.7	32,806	$13.9
PENTICTON	12.4	33,053	$15.8
AQ'AM	13.6		$6.8
MUSQUEAM	9	47,354	$35.5
WUIKINUXW	25		$5.3
KWADACHA	26.9	22,075	$19.1
LOWER KOOTENAY	16.7		$7.4
LOWER NICOLA	24	23,564	$18.3
HAIDA			
HESQUIAHT	40		$4.8
SNUNEYMUX	21.2	22,553	$23.4
UPPER SIMILKAMEEN	40		$4.7
T'SOUKE	13		$4.1
PACHEEDAHT	28.6		$7.8
TOBACCO PLAINS INDIAN BAND	0		$4.6
BURNS LAKE BAND	0		$5.2
TAKLA NATION	40		$9.4
MOWACHAHT/MUCHALAHT BAND	33.3		$5.8
AHOUSAHT	23.5	16,353	$15.7
LHEIDLI T'ENNEH	30		$7.7
WESTBANK	8.2	37,049	
CHEMAINUS FIRST NATION (STZ'UMINUS FIRST NATION)	20.4	17,214	$16.3
SQUAMISH	12.7	28,281	$88.1
KAMLOOPS	8.8	55,675	$28.4
UCLUELET	13.3	24,579	

Communities were also evaluated for their remoteness. The remoteness factor used to analyze the data consists of two values: the geographic classification and the environmental classification [78][79]. These values are used by ISC to calculate and

allocate funding to First Nation communities across Canada. The geographic zone identifies a classification value that corresponds to a community's proximity and accessibility to the nearest service centre, which is a community where suppliers, material and equipment and skilled and semi-skilled labour are readily available, and where at least one financial institution as well as provincial and federal services are available [78]. Zone 4 communities (i.e. remote communities) also contain sub-zones to further analyze the degree of remoteness in these communities. The environmental classification value is governed by the community's latitude. Table 6 below has the classification values and descriptions for each. Together these numbers provide an alphanumeric code that can be used to identify the appropriate remoteness and environmental indices for various government funding [78]. For example, Ahousaht has a geographic zone classification of 4, sub zone 1 and environmental classification of B. Its remoteness factor is 4-B-1, which produces a remoteness index of 0.45. These remoteness indices were then used to analyze average ACH_{50} of homes in the identified First Nation communities in the data.

Table 6: Geographic and Environmental Classification Codes for First Nation Communities Used by Indigenous Services Canada [78]

Geographic Classification		Environmental Classification	
Zone 1	First Nations located within 50 km of a service centre	A	Geographic location < 45° latitude

Zone 2	First Nations located 50 to 350 km of a service centre	B	45° latitude > geographic location < 50° latitude
Zone 3	First Nations located over 350 km from a service centre	C	50° latitude > geographic location < 55° latitude
Zone 4	First Nations with either air, rail or boat access to the service centre	D	55° latitude > geographic location < 60° latitude
Sub-Zones of Zone 4		E	60° latitude > geographic location < 65° latitude
0	Distance < 50 km from service centre		
1	50 km > distance < 160 km from service centre	F	Geographic location > 65° latitude
2	160 > distance < 240 km from service centre		

Table 7: Remoteness and Environmental Indices Used by Indigenous Services Canada [77]

BAND CLASSIFICATION Derivations	REMOTENESS INDEX						ENVIRONMENTAL INDEX					
	A	B	C	D	E	F	A	B	C	D	E	F
Zone 1	0.00	0.08	0.12	0.20	0.25	0.29	0.00	0.40	0.60	1.00	1.30	1.60
Zone 2	0.10	0.18	0.22	0.30	0.35	0.40	0.00	0.40	0.60	1.00	1.30	1.60
Zone 3	0.40	0.48	0.52	0.60	0.66	0.72	0.05	0.47	0.68	1.10	1.42	1.73
Zone 4 - SPECIAL ACCESS (S.A.) Sub-zones												
0	0.10	0.18	0.22	0.30	0.44	0.59	0.00	0.40	0.60	1.00	1.30	1.60
1	0.35	0.45	0.50	0.60	0.66	0.72	0.20	0.68	0.92	1.40	1.76	2.12
2	0.45	0.55	0.63	0.74	0.81	0.87	0.40	0.96	1.24	1.80	2.22	2.63
3	0.65	0.75	0.82	0.95	1.03	1.10	0.60	1.24	1.56	2.20	2.68	3.16
4	0.80	0.92	1.00	1.04	1.23	1.30	0.80	1.52	1.88	2.60	3.15	3.68
5	0.95	1.10	1.18	1.35	1.44	1.53	1.00	1.80	2.20	3.00	3.60	4.20
6	1.10	1.25	1.35	1.65	1.75	1.85	1.20	2.08	2.52	3.40	4.06	4.72

All this community information and NRCan data was analyzed and evaluated and the results are showcased in the following chapter.

3.3 Statistical Tests

All the data was broadly analyzed for each of the non-Aboriginal and Aboriginal owned homes datasets. This analysis was completed using Microsoft Excel, providing averages, minimums, maximums, and standard deviation, for much of the data. Specific focus was given to ACH_{50}, ceiling insulation, and age of building, with Table 8 showing the exploratory variables against dependent variables. T-values for the compared data were calculated using Microsoft Excel's *T.Test* function for all data. For Climate Zone 8 no Indigenous home data was available; therefore, no comparisons were made. For much of the data there were multiple values for certain components (e.g. total energy consumption, insulation levels, ACH_{50}, etc.) because values were measured and/or evaluated more than once (e.g. prior to and post renovations). Multiple readings were required for some funding programs where the HEA was required to perform an initial analysis and provide recommendations for home energy upgrades then perform second assessment after renovations or improvements were completed, noting improvements on their final report. The data values used in the analyses within this thesis are the pre-renovation values, providing a more accurate representation of the original building design and performance and the regression analysis is shown in Table 9.

Table 8: Statistical tests conducted during investigation of building energy performance in Indigenous communities in British Columbia (1)

DEPENDENT VARIABLE	EXPLANATORY VARIABLES
AIRTIGHTNESS (ACH_{50})	Build Year of all non-Indigenous Homes
	Build Year of all Indigenous Homes
	Community Remoteness Index
	Percent of Homes Assessed in Each Indigenous
	Unemployment Rate in Each Indigenous Community

	Average Total Income (All Persons with Income), Indigenous Communities
	Annual Total Band Revenues
	Build Year Trendlines of Indigenous and non-Indigenous Homes

Chapter 4 – Results

The following section discusses the results of the statistical analyses of the data, primarily measured against ACH_{50} and Ceiling Insulation. ACH_{50} is used as a measure of building quality and, as previously mentioned, is the only reliably measured housing parameter in the data. The following graphed information represents ACH_{50} vs Build Year of Homes (both home ownership types), Community Remoteness Index (Indigenous homes only), Percentage of Homes Assessed in the Community (Indigenous homes only), and against some socioeconomic factors (Unemployment Rate, Average Total Household Income, and Total Band Revenues). The results show that there is a strong relationship between Remoteness Index and ACH_{50} (for Climate Zone 5, where the majority of the Indigenous home data is collected) and weaker correlations between ACH_{50} and the socioeconomic factors, stated above.

4.1 Air Changes per Hour Comparisons

Airtightness in homes measured against the build year of homes for both home ownership types are shown in Figure 9 and Figure 10, showing that airtightness clearly improves with the build year of the homes for both ownership types. For non-Aboriginal homes this represents over 125,000 homes across climate zones 4 to 7B and spanning more than 150 years: the oldest home in this dataset was built in 1778 with the newest being built in 2018. These homes also show a considerable spread of ACH_{50} values, ranging from 0.43 ACH_{50} to 55.91 ACH_{50}. The data has information for 693 Aboriginal owned homes, representing climate zones 4 to 7A, build dates spanning from 1965 to 2018, and ACH_{50} values ranging from 1.26 ACH_{50} to 36.18 ACH_{50} values. The scattering

of the data is expected, as build quality, home maintenance and building envelope integrity will vary considerably between individual homes, but the trend clearly indicates a downward trend in ACH_{50} against build year. The statistical analysis of both graphs show relevance with considerably low P-values and strong R^2 values.

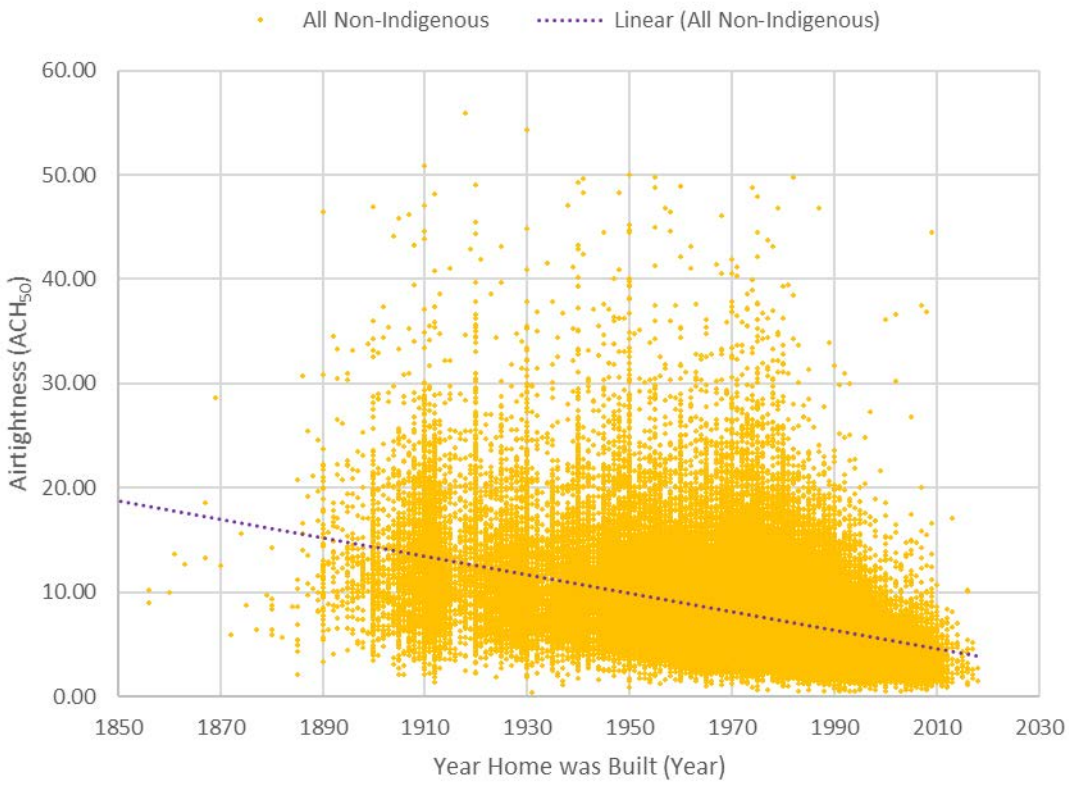


Figure 9: ACH_{50} of all non-Indigenous Homes for Homes Built Between 1850-2018

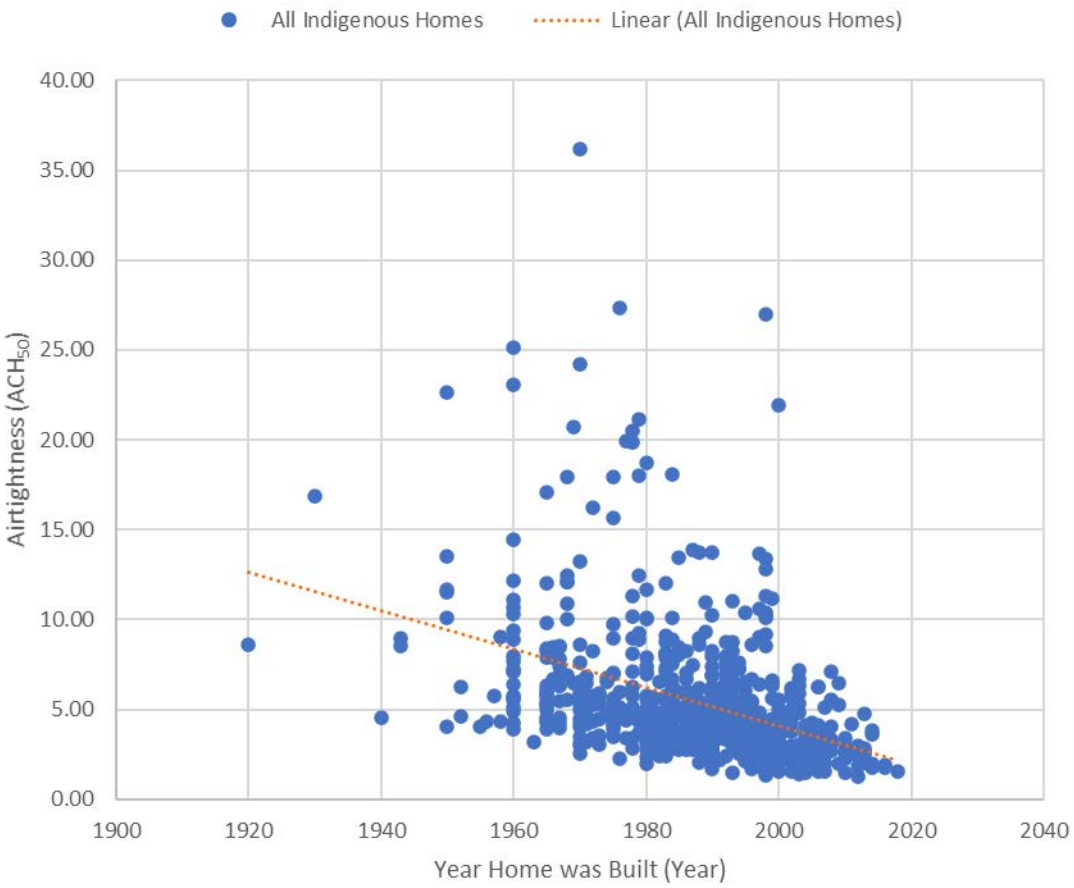


Figure 10: ACH50 by Build Year of All Indigenous Homes

When comparing the aggregate data for both datasets, namely the average and maximum $ACH_{50,}$ it appears that the Aboriginal owned housing is of better quality than the non-Aboriginal homes. Average ACH_{50} for Aboriginal Owned homes were nearly 2.5 ACH better than that of non-Aboriginal owned homes, which were 5.47 ACH_{50} and 7.99 ACH_{50}, and even more pronounced for maximum values of ACH_{50}, 36.18 ACH_{50} and 55.19 ACH_{50}. Figure 11 and Table 10 below show these comparisons explicitly, where the minimum ACH_{50} of the non-Aboriginal owned housing is the only value that beats out the Aboriginal housing data, where non-Aboriginal homes had nearly Passive House level minimums (ACH performance requirement for Passive House is 0.3 ACH_{50}), with

the lowest value being 0.43 ACH compared to Aboriginal housing with a minimum ACH value of 1.26 ACH_{50}.

Table 9: ACH_{50} by Climate Zone for Aboriginal and Non-Aboriginal Homes in BC

	Air Changes per Hour (ACH_{50})					
CLIMATE ZONE	**4**	**5**	**6**	**7A**	**7B**	**Overall**
ABORIGINAL MINIMUM	2.03	1.26	1.59	1.42		1.26
ABORIGINAL AVERAGE	6.84	5.07	6.21	5.30		5.47
ABORIGINAL MAXIMUM	21.12	27.02	36.18	19.90		36.18
NON-ABORIGINAL MINIMUM	0.43	0.45	0.63	0.63	3.58	0.43
NON-ABORIGINAL AVERAGE	8.74	6.85	6.31	6.38	7.67	7.99
NON-ABORIGINAL MAXIMUM	55.91	50	40.94	43.18	23.86	55.91

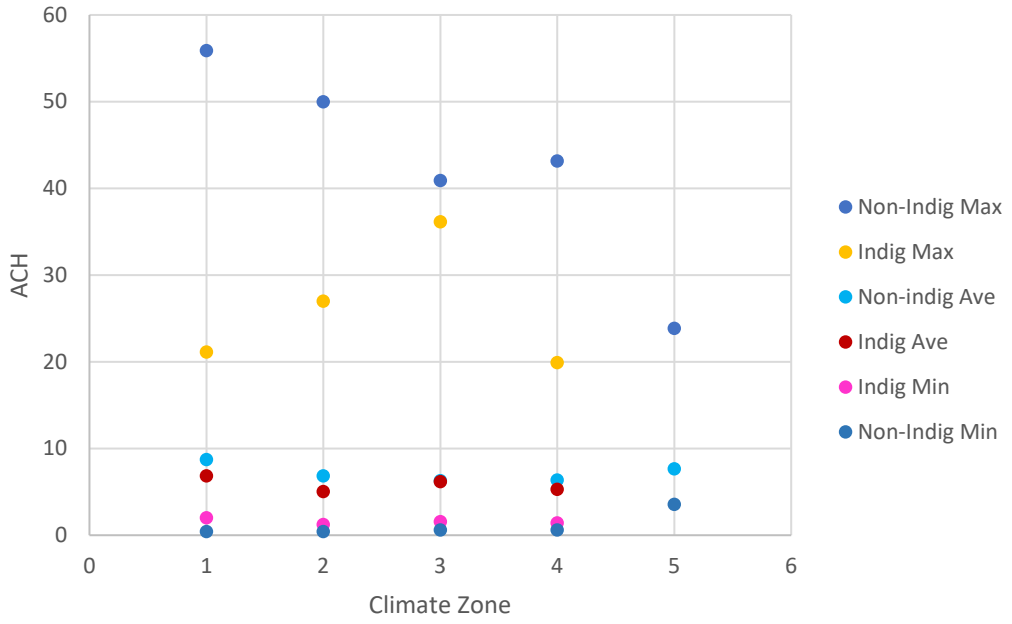


Figure 11: ACH_{50} by Climate Zone for Aboriginal and Non-Aboriginal Homes in BC

The ACH_{50} data for each of the 24 identified nations was averaged for each of the communities (see Figure 12 below). This average was then plotted against the remoteness factor of each community, as stated above. For all the communities except those in the

3000-3999 HDD climate zone, ACH_{50} decreases as remoteness increases. Although this may be counterintuitive, there are very few homes in each of those Climate Zones. In Climate Zone 5, where the majority of the Indigenous housing data is situated, the data indicates that homes in more remote areas are less airtight than those closer and more accessible to service centres. Regression analysis was completed for climate zone 5 only with P-value and R^2 values of 2.01E-16 and 0.18. This could be due to many factors that will be explored further in the discussion section.

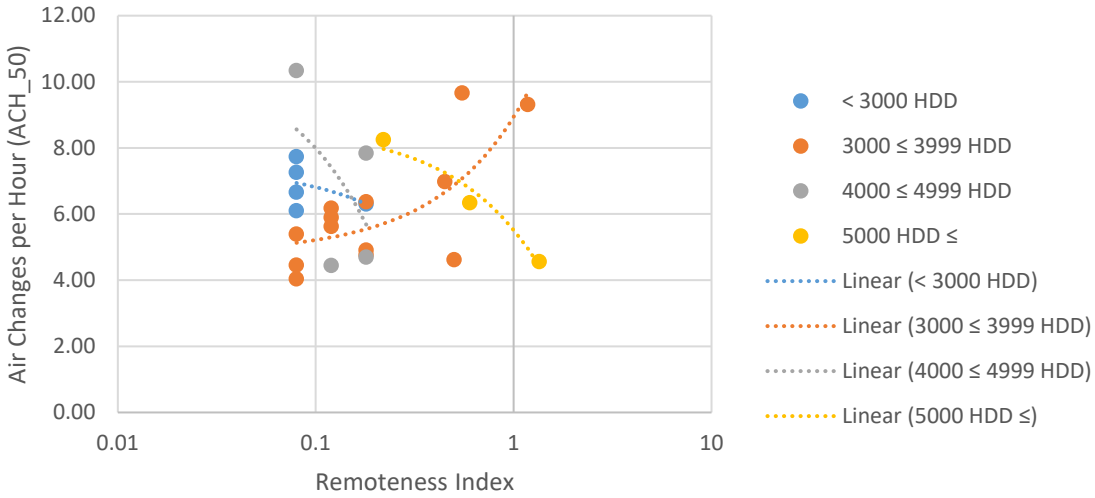


Figure 12: Building ACH_{50} vs Community Remoteness Index (logarithmic scale)

From the identified First Nation communities, the percent of homes was calculated using the available NRCan data measured against the census data for each community and then compared to the average air changes per hour for each community (see Figure 13 below). Communities with more available housing data had significantly higher ACH_{50} values. More data will be available as more homes are tested and this results in a

more robust dataset and, thus, greater average values. Considering that on-reserve housing is plagued with many challenges, such as lower quality building, this data reflects a truer view of the communities as more collected information results in a more representative dataset. Although there are some communities with considerably low ACH_{50}, these likely do not reflect the state of housing throughout the whole community and the regression analysis of this data may suggest that more factors impact this information.

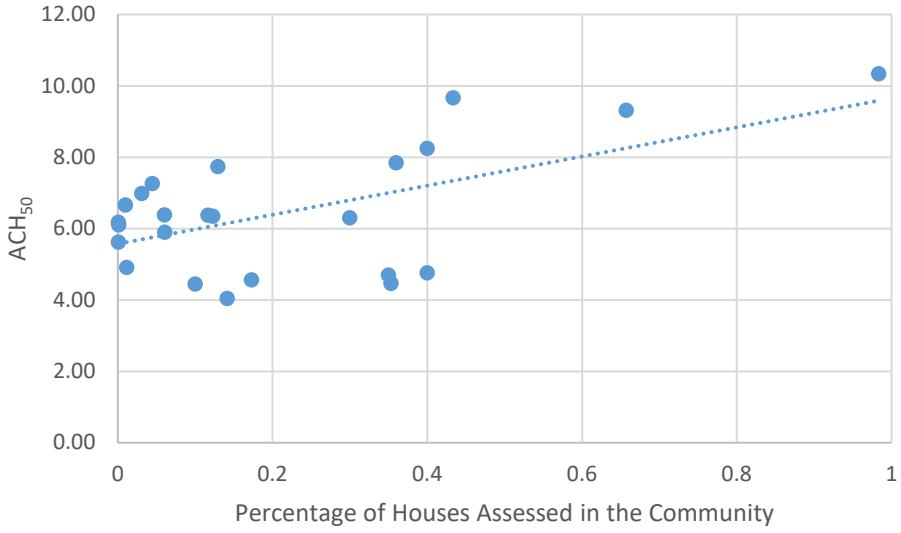


Figure 13: Air Changes per Hour vs Percent of Homes Assessed in Each Indigenous Community

4.2 Socioeconomic Comparisons

Building quality, using ACH_{50}, was then measured against socioeconomic information and band related data, specifically:

- Average Total Income of All Persons with Income
- Unemployment Rate
- Total Band Revenues

The socioeconomic data and band information is all available through each Nation's Profile on Indigenous Services Canada's website. Measuring home quality against this data shows trendlines are essentially flat (see Figure 14 to Figure 16 below), suggesting there is little to no correlation between these factors and quality of homes, which is further supported by the regression analysis in Table 9. In Figure 16, communities with higher band revenues show more homes below or near the trendline while there is a much higher spread on ACH_{50} values on the bands with lower revenues. Home ownership and socioeconomic factors are sometimes considered with housing quality (home maintenance, aesthetics or cleanliness, etc.), where Zavisca and Gerber found most studies focus on homeownership in the United States and Western Europe [14], and these results may show little correlation between these factors and the quality of homes.

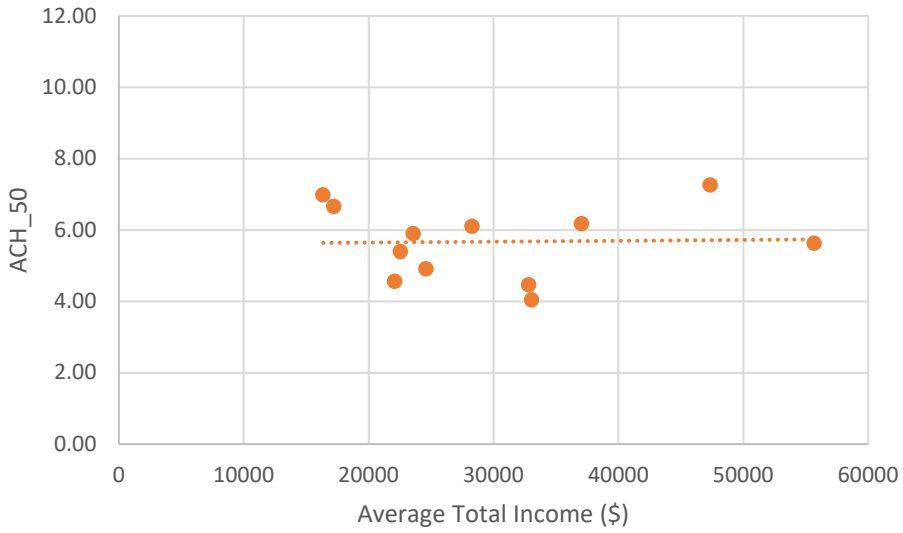


Figure 14: ACH vs Average Total Income (All Persons with Income), Indigenous Communities

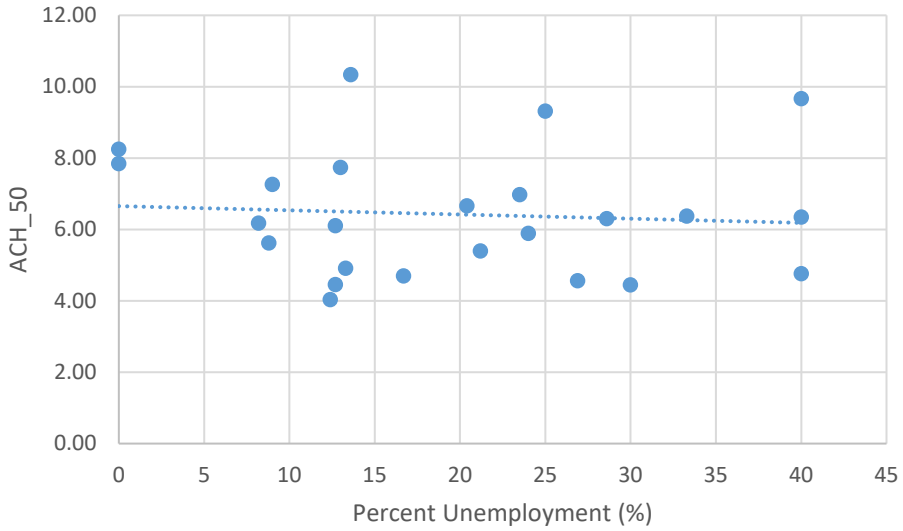


Figure 15: ACH vs Unemployment Rate for BC First Nation Communities

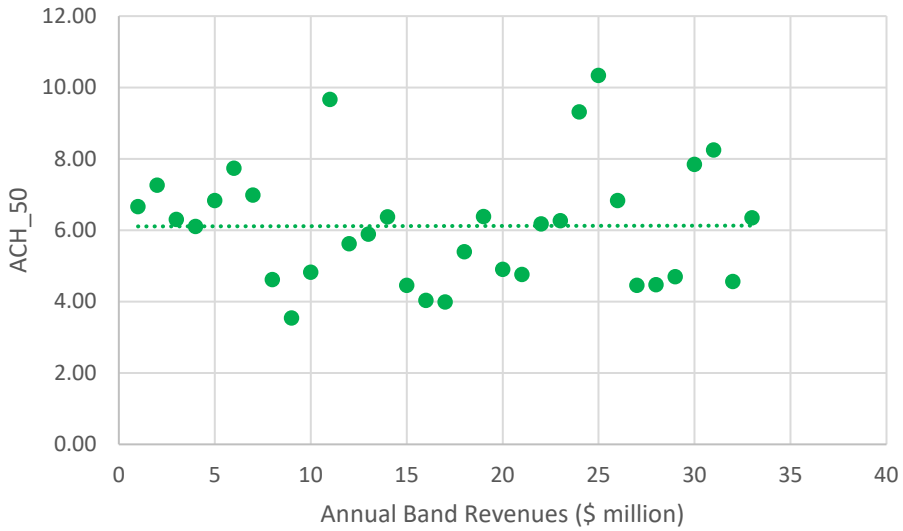


Figure 16: ACH vs Annual Total Band Revenues

Home size differences demonstrate that non-Indigenous homes exhibit a much larger max size and significantly higher average floor area (p-value of 2E-138). The average Aboriginal home is 168.15m^2 (1,808.3ft^2) compared to 229.59m^2 (2,471.3ft^2) for non-Aboriginal homes, which is a difference of approximately 61.44m^2 (661.3ft^2). The

highest points of the floor area range are the most notable, with the largest home being 366m^2 amongst the Aboriginal homes and 2,188m^2 for non-Aboriginal homes. Table 11 and Figure 17 have the detailed information below with the statistical information in Table 13.

Table 10: Size of Homes in BC

	Floor Area of Homes (m^2)					
CLIMATE ZONE	**4**	**5**	**6**	**7A**	**7B**	**Overall**
ABORIGINAL MINIMUM	59.1	40	43	67		40
ABORIGINAL AVERAGE	177.34	167.86	166.33	159.51		168.15
ABORIGINAL MAXIMUM	354.3	366	323	240		366
NON-ABORIGINAL MINIMUM	25	30.8	40.3	24.2	58	24.2
NON-ABORIGINAL AVERAGE	236.27	166.08	153.09	203.2	189.19	229.59
NON-ABORIGINAL MAXIMUM	2188	1598.7	538.9	932.2	277.2	2188

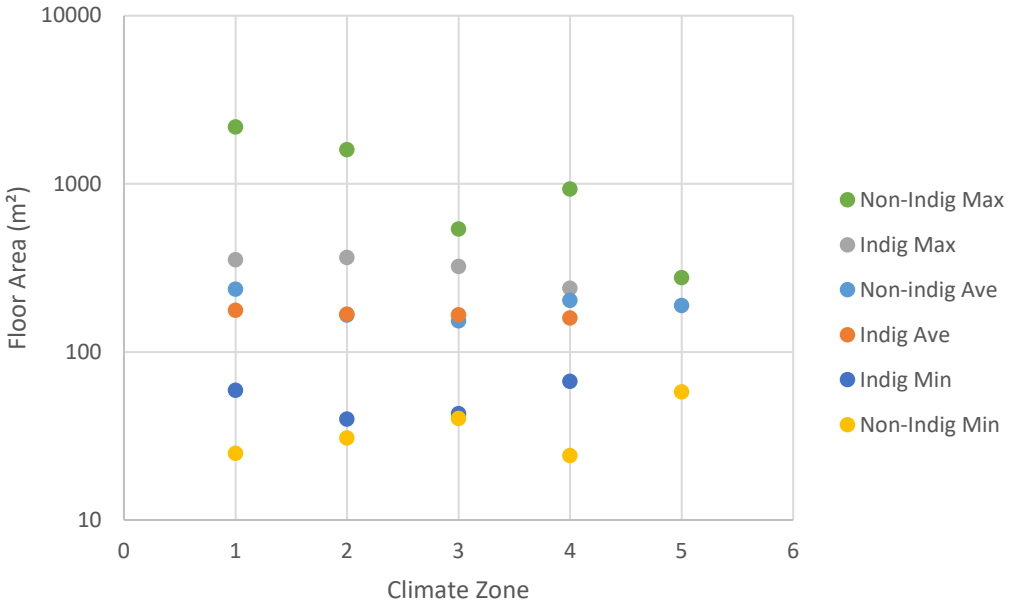


Figure 17: Size of Homes in BC

4.3 Ceiling Insulation Comparisons

The ceiling insulation comparisons for both ownership types show similar results to that of ACH_{50}, suggesting that the average Aboriginal house is significantly better insulated (p-value 5.51E-77). Table 12 below shows the minimum, average and maximum values for ceiling insulation for Aboriginal and non-Aboriginal homes separated by climate zone and the Aboriginal homes have higher averages and minimums in every climate zone while having much lower maximum values across all climate zones. Table 13 below presents the statistical information for this data. The vast majority of homes use gable type construction rather than flat roofs, with small percentages of mixed roofing types on the homes. Figure 19 shows that 83.1% of Aboriginal owned homes use gable construction while 66.8% of non-Aboriginal homes use gable construction, but have nearly double the proportion of flat roof houses than Aboriginal homes.

Table 11: Ceiling Insulation Levels by Climate Zone and Ownership Type

	RSI Values					
CLIMATE ZONE	**4**	**5**	**6**	**7A**	**7B**	**Overall**
ABORIGINAL MINIMUM	2.06	0.36	0.23	1.99		0.23
ABORIGINAL AVERAGE	4.13	5.01	4.21	5.50		4.81
ABORIGINAL MAXIMUM	6.27	8.77	8.8	9.09		9.09
NON-ABORIGINAL MINIMUM	0	0	0	0.21	1.56	0
NON-ABORIGINAL AVERAGE	3.34	3.98	3.93	3.95	3.58	3.57
NON-ABORIGINAL MAXIMUM	15.12	14.09	15.15	13.88	7.04	15.15

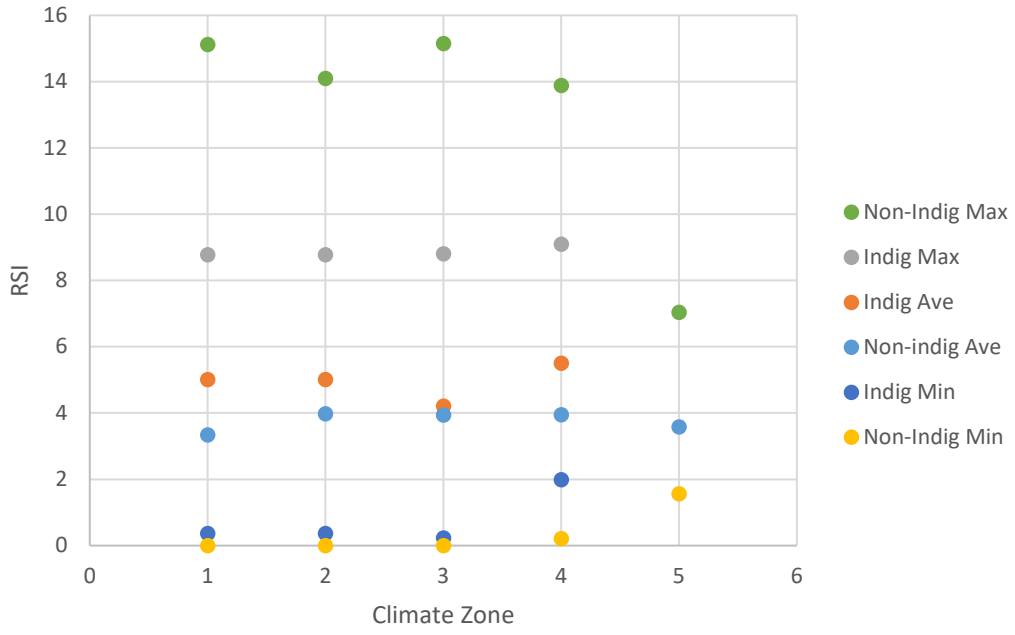


Figure 18: Ceiling Insulation Levels by Climate Zone and Ownership Type

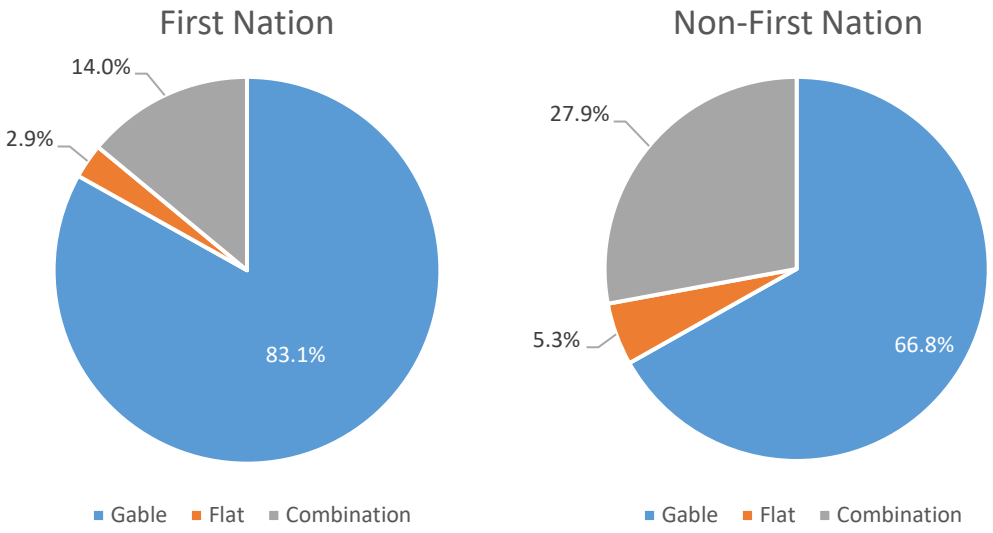


Figure 19: Ceiling Type by Ownership Type

Very few of the Aboriginal owned homes met the BC Building Code (BCBC) standard code, as can be seen in Table 13, where only 14 homes had insulation levels that met or

exceeded the BCBC ceiling insulation. The BCBC standards, specifically Table 9.36.2.6, were referenced in this section because BCBC 2018 adopted the standards directly from the National Building Code (NBC) 2015. Figure 20 below shows the requirements for insulation levels of the building envelope components (ceiling, walls and floors over unheated spaces) with considerations for roof construction type and if the home uses a heat recovery ventilation system (HRV). There are slight differences in the insulation levels needed for each level, but ultimately only 2% of Aboriginal owned homes met this standard.

Table 12: Average Ceiling Insulation Values (RSI) and the Number of Aboriginal Homes That Met the BC Building Code Standards for Ceiling Insulation

CLIMATE ZONE	4			5			6			7A		
CEILING TYPE	Gable	Flat	Mixed	Gable	Flat	Mixed	Gable	Flat	Mixed	Gable	Flat	Mixed
COUNTS	49	2	5	362	11	53	139	3	5	57	5	2
MEETS CODE REQUIREMENTS	0	0		9	2		3	0		0	0	
AVERAGE	4.21	3.93	3.38	5.07	4.66	4.69	4.29	0.59	4.05	5.70	3.91	3.89
BC BUILDING CODE STANDARDS FOR BUILDINGS, EXTRACTED FROM TABLE 9.36.2.6-A OF THE BCBC CEILING INSULATION MINIMUM REQUIREMENTS [80]												
BUILDING WITH HEAT RECOVERY VENTILATION	6.91	4.67		8.67	4.67		10.43	5.02		10.43	5.02	
BUILDING WITHOUT HEAT RECOVERY VENTILATION	6.91	4.67		6.91	4.67		8.67	5.02		10.43	5.02	

Table 13: Regression and Statistical Analysis for Figures 4 through 11

FIGURE	NAME	R^2	ADJUSTED R^2	N	COEFFICIENT	Y-INTERCEPT	T-STAT	P-VALUE	LOWER 95% CI	UPPER 95% CI
9	**ACH_{50} non-Ind vs Year of Home**	-0.20296	-0.20295	127295	-0.08947	182.4961	-180.038	0	-0.08947	-0.08754
10	**ACH_{50} by Build Year of All Indigenous Homes**	-0.15946	-0.15825	693	-0.10652	217.1404	-11.4496	6.49E-28	-0.12479	-0.08825
TABLE 11	**Size of Homes in BC**						-31.616	2E-138	-1.96327	1.96327
TABLE 12	**Ceiling Insulation Levels by Climate Zone and Ownership Type**						21.0672	5.51E-77	-1.96336	1.96336
12	**Building ACH_{50} vs Community Remoteness Index (logarithmic scale) - 3000-3999 HDD *only averages***	0.098244	0.041884	18	0.371297	4.822507	1.320285	0.205317	-0.22487	0.967467
	All points	0.180054	0.177649	343	1.271348	2.553222	8.653371	2.01E-16	0.982366	1.56033
13	**Air Changes per Hour vs Percent of Homes Assessed in Each Indigenous Community**	0.066993	0.024584	24	2.42239	5.988941	1.256852	0.221988	-1.57468	6.419464
14	**ACH vs Average Total Income (All Persons with Income), Indigenous Communities**	0.000797	-0.09912	12	2.44E-06	5.598837	0.089301	0.930606	-5.8E-05	6.34E-05
15	**ACH vs Unemployment Rate for BC First Nation Communities**	-0.00624	0.038936	24	-0.01173	6.653941	-0.37154	0.713789	-0.07719	0.053738
16	**ACH vs Annual Total Band Revenues**	0.035545	-0.01268	22	-0.01843	6.794229	-0.85855	0.400763	-0.0632	0.026344

Chapter 5 – Discussion

First Nation housing is a multi-layered subject. This research uses a technical approach in analyzing housing data with other information to assess relatable factors impacting First Nation housing in BC. Although many trends within the housing data are intuitive or support what is anecdotally known, there is very little technical research available to verify what is generally accepted as the status quo, namely that on-reserve housing is not built equal to off-reserve housing. The following section will discuss the findings of this research and expand on some of the factors affecting the research and the Indigenous communities in general, beginning with the ages of the homes, ACH_{50} and some of the challenges with the data and collected information.

The analysis began with home quality by build year. Although the downward trend in Figure 21 is evident (i.e. home quality improves with the build year of the home) this should not be surprising. Building codes improve over time as more effective building materials, technology and construction practices are used in the industry resulting in better construction of homes. The slopes in Figure 21, although very similar, shows Aboriginal homes improving more quickly than non-Aboriginal homes. This is an excellent sign, that Aboriginal housing is outpacing non-Aboriginal homes, but there are other considerations that need to be explored, which will be discussed in more detail below.

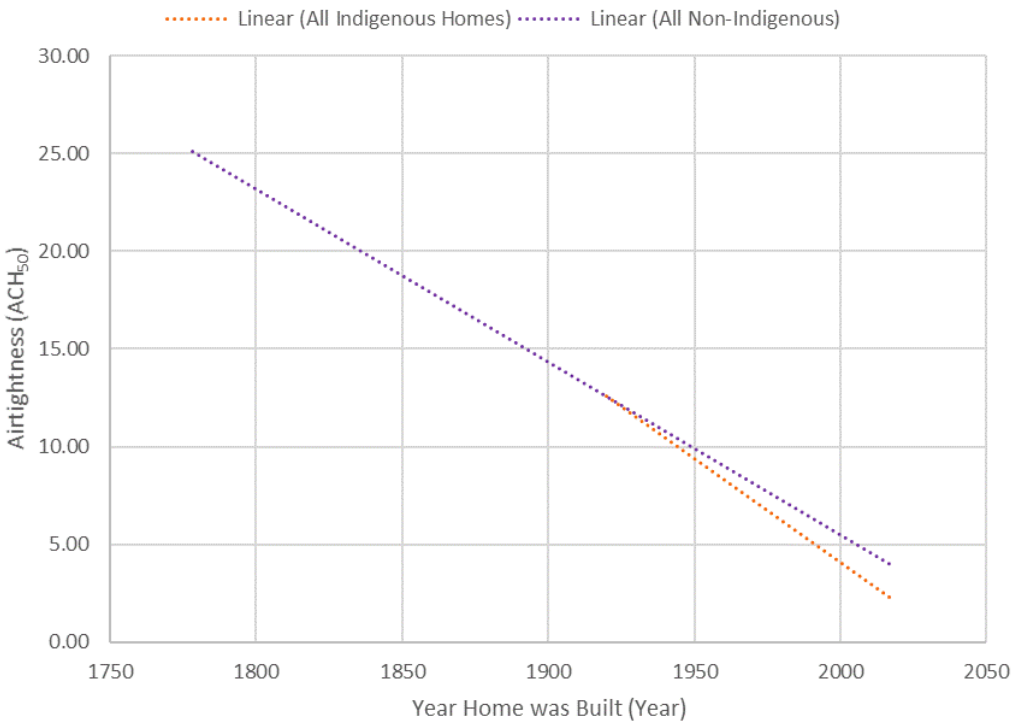


Figure 20: ACH50 by Build Year Trendlines of Indigenous and non-Indigenous Homes

After analyzing both datasets, the difference in the available data paints a picture that is well-known by professionals working in Indigenous housing: houses built on reserve do not last as long. Table 14 below shows that the average age of Aboriginal homes are 15 years younger than non-Aboriginal homes. There is also a

Table 14: Overall Age of Homes for Aboriginal and non-Aboriginal Owned Homes in BC Organized by the Build Year of the Homes

	ABORIGINAL OWNED	NON-ABORIGINAL
OLDEST	1920	1778
AVERAGE	1987	1972
NEWEST	2018	2018
VARIANCE	208.45	447.72
T-STAT	-27.84	
P(T<=T) 2-TAILED	9.121E-116	
T CRIT. TWO-TAIL	1.96	

noticeable and significant difference in the oldest homes between each dataset (1920 is the oldest build year for Aboriginal homes and 1778 is the oldest for non-Aboriginal homes). On-reserve houses do not last as long, and only have an average lifespan of about 15 years opposed to 35 years for typical homes off-reserve [81]. This difference in lifespan is reflected in the average age of homes in the data, where even the limited information available for Aboriginal owned homes shows an age difference in the homes as 15 years. The high demand for and on Aboriginal housing, with factors of overcrowding and poor build quality, also make the presence of older homes on reserve limited. Again, although the aggregate information may not be surprising, this analysis objectively supports the qualitative findings of the grey literature where shorter life expectancy of homes in Indigenous communities is well known and often attributed to overcrowding, inadequate construction and lower levels of maintenance [35][38][49][55][62][81][82].

Comparing the overall ACH_{50} values of both datasets shows an unexpected result: the Aboriginal housing seems to have better build quality than the non-Aboriginal housing. The Aboriginal housing has lower averages and maximum ACH_{50} values than the non-Aboriginal, with the following values:

Table 15: Overall ACH_{50} Values

	ABORIGINAL OWNED	NON-ABORIGINAL
LOWEST	1.26	0.43
AVERAGE	5.47	7.99
HIGHEST	36.1776	55.91
VARIANCE	14.83	17.28
T-STAT	17.15	
P(T<=T) 2-TAILED	2.47E-55	
T CRIT. TWO-TAIL	1.96	

This goes against what is expected, as on-reserve building practices have been generally challenged by poor build quality, poor geographically designed buildings, and underfunding. The government has identified underfunding as a known issue through the recommendations made by the Standing Committee on Aboriginal Peoples [83]. Even though these numbers are counter intuitive, this could be explained by the relatively low number of Aboriginal homes that the data represents, only 693 homes in total. There are many factors that go into on-reserve community housing, and therefore individual factors are weighed to choose which homes should be prioritized for home energy assessments and related funding. There are funding programs available to support housing construction and renovations all with varying parameters, eligibilities, and criteria to support Indigenous housing projects, for renovations and new builds. The Residential Rehabilitation Assistance Program (RRAP), for example, is a funding program offered through the CMHC that provides up to $60,000 for renovations on an existing home on reserve but requires a home assessment, not necessarily done by an HEA, as part of the application process. The challenge with RAPP is that to receive the full reimbursement monies, all repairs need to be completed on the home before CMHC will release funding. This creates a situation where homes that require renovations costing more than the $60,000 cap do not get assessed nor apply for funding and only homes that require relatively minor repairs apply to the program. As a result, homes in the poorest condition do not get assessed, skewing any data that is gathered through these assessments by excluding poorer quality houses. It is also likely that the Aboriginal-owned dataset has more representation for homes in relatively good condition and not necessarily the worst homes, as it may not provide value for a community to have an HEA assess a home in

poor and very poor condition. Considering this, the data may be skewed by not showing the worst homes in the data for Aboriginal communities. It is also important to consider the assumption that all the Aboriginal housing data is from on-reserve housing, but the data and analysis may represent off-reserve housing and housing that is built to the BC Building Code or regional standards. The average home in the Aboriginal dataset is more than a decade newer than those of the non-Aboriginal homes, which significantly impacts the comparison of the numbers, as considerations for building materials and standards may still show improved build quality, even considering the challenges of on-reserve housing.

A significant challenge for building on reserve lands is that these lands are under federal jurisdiction, thus provincial jurisdiction and related building codes do not apply, while the National Building Code is the main governing building law. The National Building Code did not have prescriptive standards on insulation or energy efficiency till 2015. This lack of guiding policy has allowed the building of homes that do not provide quality buildings and are a direct factor in shortened lifespans and poor building quality of on-reserves houses. First Nation communities can remedy this by implementing their own building bylaws, either adopting the BC Building Code or creating their own building code, but there can be significant challenges around government structure and internal capacity to build such laws effectively. There is also a lack of oversight in the building process, namely the lack of on-reserve building inspectors and personnel to ensure builders and developers are actually building to a defined code or applicable bylaws. Costa et al found similar challenges with Indigenous communities in the United States and recommends using an independent third-party building inspector for building

inspection oversight the way that any metropolitan community would do [84]. A typical municipality has building inspectors on staff and charges fees to ensure they have operational support on building. Many First Nation communities lack the proper resources, both human and financial, to ensure building inspections are completed on buildings. This is further exacerbated when much of the construction funding in a community is allocated for infrastructure related projects but there may not be core funding for building inspectors as housing falls outside that type of funding [85]. These types of jurisdictional issues have had deep impacts on Indigenous communities and creates greater challenges in remote communities where resources can be even more scarce. Many communities use building inspectors and hire capable and responsible building professionals to support this work, but jurisdictional issues will continue to negatively impact First Nation communities, particularly because of their strenuous relationships and histories with the federal government.

Working within remote communities has many challenges (e.g. increased cost of materials, limited availability and diversity of materials, limited access to skilled tradespeople, limited professional oversight and construction review, increased transportation and logistics costs, etc.) and professionals and governments struggle to provide similar levels of service as metropolitan areas. There is significant evidence and professional support for costing information through resources like the RS Mean Construction Cost Estimating Guides and Software where costs are indexed against specific metropolitan centres, but little has been done to quantify through research how the quality of the built environment, specifically housing, differs with remoteness. In response to this, ISC provides additional funding and Northern and Remote Communities

can access community grants to help support infrastructure projects that would otherwise be extremely challenging or impossible to move forward without additional funding allocations.

Within the data, Climate Zone 5 shows a clear increase in ACH_{50} as Remoteness Index increases (see Figure 12). This Climate Zone is also where 82.7% of all the Indigenous data is represented from the NRCan information, which, after breaking out this data by climate zone which ultimately represents two thirds of the overall Aboriginal data, includes 14 communities. The other climate zones only have between three and five First Nation communities represented in the data and should not be considered representative of broader communities in BC. The fact that this information shows that housing quality, measured as ACH_{50}, decreases with the remoteness of a community ($R^2 = 0.18$; P-Value = 2.01E-16; n = 343) further supports the difficulties remote Indigenous communities face and quantifies a gap that exists between remote and urban communities.

The challenges of remote communities were also studied through Phase 3 of the Regional Health Survey of 2018. Figure 22 below shows that First Nation adults in remote or special access communities reported 37.9% of their homes needed major repairs [34], while urban homes showed that only 21.8% of homes needed major repairs. Most urban homes, 41.6%, only showed a need for regular maintenance. If homes in remote communities show greatest need for major repairs that would help explain the increase in ACH_{50} with increasing Remoteness Index in results. The other challenges that remote communities face is that they are not able to provide the same level of service, even if they have the jurisdiction to do so. For instance, no municipalities or First Nation communities are able to enforce building code standards because there are no inspectors

readily available and the cost and logistics of bringing inspectors into the community are very high and seen as impractical for most builders. As a result, many homes and buildings are constructed without proper code considerations or by building professionals, rather using handymen and/or regular people building what they want or need. This will lead to greater inabilities to complete major repairs and continue the trend of poor building quality in remote areas. There may not be a practical fix for this as the main barriers are on logistics, which ultimately lead to higher costs and burden on residents in these areas.

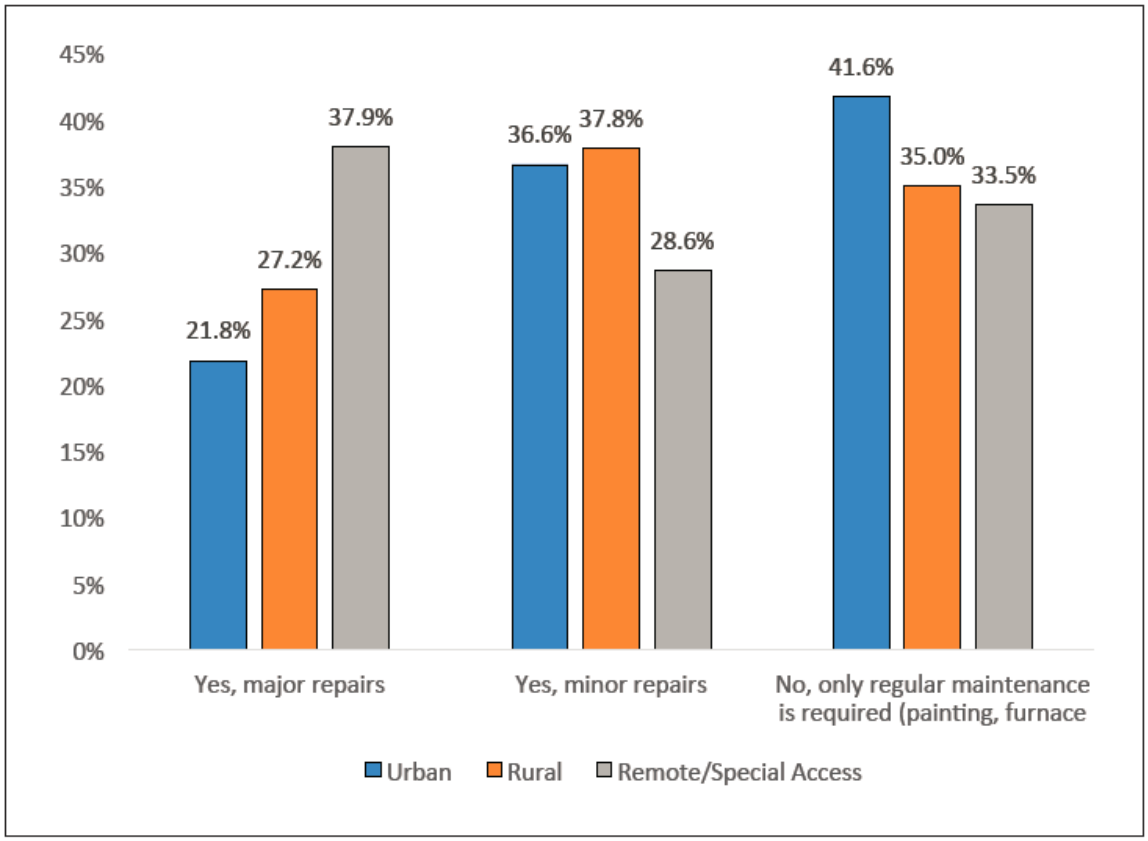


Figure 21: Percentage of First Nations adults reporting their dwellings in need of repairs, by remoteness [34]

Energy security is another challenge that remote communities face, as most remote communities in BC are powered solely by diesel. When the Status of Remote/Off-Grid Communities in Canada report was released, August 2011, 86 Off-Grid communities existed in BC, 25 Indigenous and 61 non-Indigenous and only three had renewable energy systems to supplement their diesel systems, all of which were within Indigenous communities [86]. Across Canada, the majority of remote off-grid communities are Indigenous, 170 of 292 with approximately 126,861 Indigenous people represented within those communities which represented about 9% of Canada's Indigenous population at that time. Understanding how housing is controlled and affected in remote Indigenous communities will enable these communities to approach energy and housing solutions more effectively for their People.

Another interesting finding within the report is that most of the Indigenous communities had complete information on their energy infrastructure and demand, with overall energy generation capacity and demand information (see Table 16 below). This information is likely due to the robust infrastructure gathered and maintained through ISC, as much of the energy infrastructure in Indigenous communities would have been funded by ISC and provided minimal ongoing operational funding. This type of information gathering is extremely useful in supporting these communities so that broader community policy and maintenance can be guided by this information and administrators and staff could effectively create Key Performance Indicators, benchmarks and objective goal setting. Many of the non-Indigenous communities are not necessarily able to take a community approach, as the Canadian approach is based on individual

ownership and a community approach may be more challenging to attain under a cultural model that is based on the independence and autonomy of its community members.

Table 16: Canadian Off-Grid Community Data [85]

	Total Number of Settlements		Sites with Energy Information		Available Data (%)	
	Indig	Non-Indig	Indig	Non-Indig	Indig	Non-Indig
BC	25	61	15	34	60.0%	55.7%
AB, SK & MB	5	5	5	3	100.0%	60.0%
ON	25	13	25	25	100.0%	23.1%
QC	19	25	16	3	84.2%	12.0%
NL	16	12	14	12	87.5%	100.0%
NWT	33	5	28	1	84.8%	20.0%
NU	26	0	25	0	96.2%	-
YT	21	1	10	0	47.6%	0.0%
Overall	170	122	138	78	81.2%	63.9%

A major challenge of this housing research was the lack of identifying information in the data to associate it with specific Indigenous communities. The eight ownership types do not catch the spectrum of housing ownership that should include on-reserve, off-reserve, privately owned or band-owned housing. More ownership types would enable greater efficiency and effectiveness in analyzing this data for on-reserve populations. This lack of information is also seen as a challenge in health statistics for Indigenous people in Canada, since more detailed information could reduce errors and biases in the analysis [87]. More specific housing information could also encourage communities to submit more information to NRCan and/or provide greater incentives through government initiatives to encourage more data gathering in communities. Communities value the information provided by HEAs and some businesses thrive on providing the home assessment and renovation services, but submitting their housing information to

NRCan does not always match a community's needs. One such company is Community Power, who have HEAs, building professionals, and researchers on staff supporting communities across BC. Community Power houses much of the home data for the Nations rather than submitting it to NRCan for an EnerGuide Rating, as they have proprietary software that can be customized to fit a community's needs (e.g. animal licensing can be built into the software along with housing information). Also, a community may not see the value in submitting the data to NRCan and often have concerns surrounding the access and use of their data once it is submitted to an outside agency, as research and data has negatively impacted many Indigenous people in Canada in the past.

Indigenous communities should be encouraged to share their home energy data, since more information provides a better picture of on-reserve homes and communities. Similar to the housing data, communities could use this data with the broader data to effectively track and develop housing plans and strategies. This data analysis would also help build data for aggregated analysis and allow for more solid recommendations on approaches to housing supports. But data access and use that reflect a community's personal and cultural needs requires a respectful and transparent approach that must be built into NRCan's processes to protect and build a relationship with the communities who submit information. Increasing the volume of data will allow for a more robust and representative analysis of the data where a broader spectrum of homes will be able to show the good and the bad, not just the moderate to great homes. Figure 13 shows that ACH_{50} increases as a greater percentage of homes are assessed within the community. This shows that as more community information is gathered, more balanced information

is available and can likely lead to greater policy development and support for communities.

Many communities have limitations on funding and financial choices which often results in plans that will maximize value for the community. As previously explained, some incentive and renovation programs depend on home energy assessments to leverage funding and construction dollars for home renovations. This is a significant challenge for housing departments where a housing manager may engage a HEA to perform services on a home that only requires some renovations but is in relatively good condition overall, something that may be indicative of the low ACH_{50} values for communities with low percentages of completed home assessments. Complete assessments do not provide value for homes requiring substantial renovations or are at the end of their lifespan, so a housing manager will choose not to complete assessments on these homes. This approach to data gathering then skews the data, providing information and values that only represent homes that are in relatively good condition. Under the funding and program constraints that First Nation housing managers are under this is a reasonable and effective approach but limits what is available through the NRCan system, thus limiting the effectiveness of decisions that the broader, aggregated information can support. The methodology used to segregate the data into specific communities is then able to be compared to other community information. This provides a broader analysis into the data but is ultimately flawed as the detail of the data does not provide specific parameters that could easily be analyzed for greater impacts on policy development and/or act as key performance indicators for funding programs.

There are multiple needs models used to explain human desire and motivation. Maslow's Hierarchy of Needs, Figure 23 below, places physiological needs (e.g. food, air, water, and shelter) as the first requirement for humans to attain before exploring other levels in the spectrum, literally creating the foundation for people to build themselves up. Having a reliable, stable living situation is a key factor of succeeding in life, but the way housing is intertwined with community and federal on-reserve policy affects the way Indigenous people living in community interact with their dwellings. Also, considering the complex relationship that people have with housing and how different populations

Figure 22: Maslow's Hierarchy of Needs [88]

treat their homes is something to keep in mind (e.g. someone who is on social assistance will be home throughout the day and interact with their home's housing systems in a way that is very different from someone who is working full-time). Anecdotally, there are different explanations for reasons why on-reserve housing is so different, often hearing

that home ownership, or rather the lack thereof, results in poor home conditions and maintenance of housing on reserve (i.e. “pride in ownership”). The multidimensional aspects of on-reserve housing is not the focus of this research but examining some community factors and how they might affect housing quality was explored, a multi dimensional approach is encouraged by Zavisca and Gerber as much of their research is focused on homeownership [14]. When ACH_{50} was compared to Total Income and Unemployment census data and Annual Band Revenue, the trendlines were essentially flat, showing very little correlation between housing quality and these factors. This suggests that none of these factors affect the measured housing data in the studied communities, using ACH_{50} as the indicator for housing quality. The Standing Committee on Aboriginal Peoples report "noted a strong correlation between the quality of housing and the economic situation of the First Nation community and its members" [38], but this assertion was not supported by the data that was analyzed. The comment that "where the community had own-source revenue, or high employment levels, the housing was much more likely to be very similar to what one would see in the rest of Canada" may also be skewed in the data as the majority of home types were detached homes but some on-reserve housing can be a hybrid of housing types (e.g. permanent dwellings built around a mobile homes trailer is a common home type in Indigenous communities). Because on-reserve housing is multidimensional and complex, a deeper dive into other factors that affect housing is required to look at the nuanced nature of housing and how it affects people in community. This would require a multi-disciplinary approach to research to look at the human, administrative, technical, policy and governmental approach to housing, not an easy or straightforward undertaking.

Housing funding is an ongoing challenge for most First Nation communities as reserve lands are technically owned by the Federal Government, making it difficult to borrow money to build anything on-reserve. This has created a dependency on grant funding for housing on-reserve, either through CMHC or other federal agencies, where chronic underfunding for housing has further plagued on-reserve communities. Historically, housing funding and support from the federal government has not met the need of building on reserve because funding allocations are formula based rather than needs based, creating a gap between what the funding will cover and the actual costs of building. Kyser found that modesty requirements also put restrictions on housing funding that further limits a community's ability to meet their needs [42]. On top of this, housing funding can often be oversubscribed and limit how much funding is ultimately provided to each community. Although some First Nations can self-fund some of their community's infrastructure, many depend solely on government funding. If that funding is limited, then sometimes a disreputable contractor is used for a building project which negatively impacts the project and/or ultimately compromises the design, materials or construction of a home.

Some communities have had success with housing programs by taking a multi-faceted approach to housing. The Penticton Indian Band, for instance, has created a system that allows their members to first build capacity as renters and grow into being homeowners, where the band provides a mortgage for them to buy/build a home on reserve. This approach has a well-developed housing program that tracks renters and essentially upgrades them into better, more expensive homes with greater and greater responsibility for bills and utilities until they are approved to access the band's mortgage program.

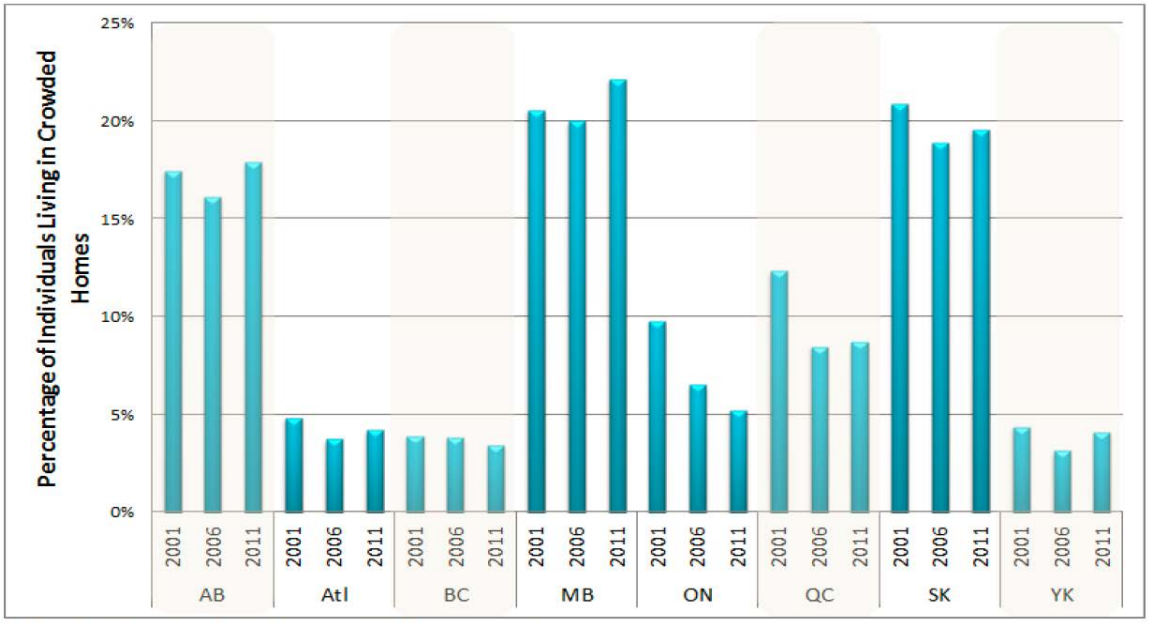
Through this program, Nation members must have a good track record before they can move up the program. Renters who are not responsible tenants (e.g. do not pay rent or damage the property) are denied housing for a period of time before they can reapply. So far the band has not had any mortgages fall into default [89]. This program takes a business approach to housing, while integrating education and social work aspects into the program, while many other communities have difficulties separating the business of housing from the need and relationality of their community. The First Nations Market Housing Fund is another resource for First Nation communities to work with participating banks to provide mortgages for their members, where the mortgages are backed by the band and ministerial loan guarantees; but as presented above this program has not shown much success. Broader provincial funding programs are also becoming more available where the BC Government, through BC Housing, has recently started providing on-reserve housing funding, the first provincial government to do so in Canada. BC Housing has dedicated "$550 million over 10 years to support the building and operation of 1,750 new units of social housing for projects on- and off-reserve" [90]. These types of solutions ultimately put the risk on the band for housing, though, because if the borrower defaults on their mortgage the band is responsible for the balance of the money owing.

Overcrowding of homes continues to be a challenge for Indigenous communities, where overcrowding can be more than 20% in some communities compared to the national average of approximately two percent [82]. The National Occupancy Standard (NOS) is used as the basis of overcrowding and defines that a household requires a number of bedrooms as follows:

- A maximum of two persons per bedroom.
- Household members, of any age, living as part of a married or common-law couple share a bedroom with their spouse or common-law partner.
- Lone-parents, of any age, have a separate bedroom.
- Household members aged 18 or over have a separate bedroom - except those living as part of a married or common-law couple.
- Household members under 18 years old of the same sex share a bedroom - except lone-parents and those living as part of a married or common-law couple.
- Household members under 5 years old of the opposite sex share a bedroom if doing so would reduce the number of required bedrooms. This situation would arise only in households with an odd number of males under 18, an odd number of females under 18, and at least one female and one male under the age of 5.

Overcrowding has many different challenges on its own but when considering the technical aspects of a home with increased occupancy levels the home requires more ventilation to reduce relative humidity of the home environment. If the home was designed for a certain occupancy level or lacks proper ventilation, then the increased humidity level may increase the likelihood of mould growth. This problem is magnified if the home is not maintained or cleaned regularly. The housing data does not address or support the notion of overcrowding, but this should be taken into consideration, since the average occupancy of the data is 3.66 with roughly 34% of the homes having 3 occupants and the other 66% having 4 and no more than 4 occupants in any of the homes within the data. BC recognizes and addresses that overcrowding is a challenge for Indigenous populations across Canada, and therefore has very low levels of overcrowding compared

to other provinces across Canada (see Figure 24 below). Detail in the data also does not show if overcrowding is a challenge for the assessed homes. This is another aspect showing how the data may be skewed to only include certain households or the possibility of some information not being included by the HEAs' analysis. As part of this information gathering, overcrowding considerations may be useful to include so moisture and humidity considerations could be included in the HOT2000 simulations, not just energy related information. Several challenges with gathering this data are privacy and sensitivities around social situations of families and how the NOS may not align with what is acceptable or required in some Indigenous communities.



** Note that the national rate has consistently been around two percent.*

Figure 23: Proportion of Individuals Living in Crowded Homes On-Reserve by Region between Census Years 2001, 2006 and 2011 [82]

The NBC was first created in 1941. It was adopted in BC in 1973 and was reworked into the BC Building Code (BCBC) in 1980. The building codes were mainly focused on

building safe, stable structures to minimize environmental risk factors for building occupants, and did not have any provisions for energy efficiency in their inception, delegating regional insulation and other standards to municipalities. The BCBC did not have any insulation considerations till 1994 and the NBC did not have any energy efficiency requirements till the 2015 edition of the code was introduced. Energy efficiency guidelines were introduced as an appendix to the NBC, through the Model National Energy Code for Buildings, in 1997 [91][92].

Chapter 6 – Conclusion

The situation of on-reserve housing may be dismal at times but it is showing some very great progress and opportunity going forward. Though Housing conditions have seen limited long-term improvement over the decades, the Canadian Government is becoming more proactive in the way they are working with Indigenous communities [81] and Indigenous communities are becoming more savvy and effective in delivering housing programs in their communities. Indigenous communities have an opportunity that many other communities do not: a centralized administration that collects and manages detailed housing information that can be used to develop KPIs and technical strategies to create more robust outcomes for communities.

The objective of this research was to identify the differences between Aboriginal owned homes and non-Aboriginal owned homes in BC using housing information provided by NRCan. The information from NRCan represents 693 homes owned by Aboriginal people between climate zones 4 and 7A and 127,295 homes owned by non-Aboriginal people between climate zones 4 and 7B. ACH_{50} was chosen as the value for home quality as it is the only consistently measured parameter during home energy assessments.

The results of this research show that 82.7% of Aboriginal homes were situated in climate zones five and six while 91.4% of non-Aboriginal homes were in climate zones four and five. Assuming that all the First Nation housing data is on reserve, a methodology was created to allocate the home data to individual First Nation communities in BC. This allowed 515 homes to be isolated into 25 First Nation communities, where other factors were compared to the data. Examining the aggregate

data, Aboriginal homes faired better than non-Aboriginal homes, in terms of ACH_{50} and ceiling insulation levels, but the analysis is more nuanced than the data presents. The number of homes that were isolated by First Nation community as well as the history and current situation of on-reserve housing must be considered in the analysis. Socioeconomic factors (unemployment rates, average total income, and annual band revenues) did not seem to significantly impact the quality of homes on reserve, but the remoteness of a community did have a negative impact on the quality of a home. Aboriginal housing is also younger than non-Aboriginal housing by 15 years which reflects the reality that on-reserve housing does not last as long as housing off reserve.

This research is useful in identifying some key aspects of Aboriginal and non-Aboriginal housing in BC but the analysis recognizes a gap in the data which requires a more critical and holistic evaluation to identify how this information relates to the current housing situation First Nations people continue to face.

Bibliography

[1] United Nations General Assembly, "Report of the Special Rapporteur on Adequate Housing as a Component of the Right to an Adequate Standard of Living, and on the Right to Non-Discrimination in this Context: Note by the Secretary General", Seventy-fourth session, July 17, 2019.

[2] Canada, "Housing Conditions of Aboriginal People in Canada: Census of Population, 2016". Statistics Canada. 2017.

[3] Canada, "Aboriginal Migration and Urbanization in Canada, 1961-2006," Aboriginal Affairs and Northern Development Canada, 2013, Accessed: November 8, 2020. [Online]. Available: https://www.aadnc-aandc.gc.ca/DAM/DAM-INTER-HQ-AI/STAGING/texte-text/rs_re_brief_AMU-PDF_1375449942901_eng.pdf

[4] A. Turner et al, "Aboriginal Peoples in Canada - First Nations People, Métis and Inuit: National Household Survey, 2011". Statistics Canada, 2013. Accessed: November 8, 2020. [Online]. Available: https://www12.statcan.gc.ca/nhs-enm/2011/as-sa/99-011-x/99-011-x2011001-eng.cfm

[5] Statistics Canada, "Census in Brief: The housing conditions of Aboriginal people in Canada," [Online] Available: https://www12.statcan.gc.ca/census-recensement/2016/as-sa/98-200-x/2016021/98-200-x2016021-eng.cfm (Accessed on April 19, 2020)

[6] K. Kelly-Scott, K. Smith and Canada, "Aboriginal Peoples: Fact Sheet for Canada". Statistics Canada, 2015.

[7] National Collaborating Centre for Aboriginal Health, "Housing as a Social Determinant of First Nations, Inuit and Métis Health". Prince George, BC: National Collaborating Centre for Aboriginal Health. 2017.

[8] Libraries and Archives Canada, Department of Indian Affairs, RG 10, Letter to Colonel H.M. Jones, Director, Indian Affairs Branch, Ottawa from P.E. Moore, M.D. Director, Indian and Northern Health Services, 27 September 1960, volume 6856, file 901/29-2, part 4

[9] Natural Resources Canada, *Energy Fact Book, 2016-2017,* Cat. No. M136-1E (Print) ISSN 2291-9066, 2018.

[10] Canada Mortgage and Housing Corporation, "2006 Census Housing Series: Issue 13 – On-Reserve Housing Conditions". Ottawa, 2011

[11] T.A. Motz, C.L. Currie, "Racially-motivated housing discrimination experienced by Indigenous postsecondary students in Canada: impacts on PTSD symptomology and perceptions of university stress," Public Health, Volume 176, Pages 59-67, ISSN 0033-3506, https://doi.org/10.1016/j.puhe.2018.12.011, 2019

[12] M. Evans, K. White and L. Berg, ""They think you're lying about your need": The impact of appearances on health and social service access for aboriginal people in Canada," Canadian Journal of Native Studies, vol. 34, (1), pp. 55, 2014.

[13] A. B. Anderson 1939, "Home in the City: Urban Aboriginal Housing and Living Conditions". London; Toronto; Buffalo; University of Toronto Press, 2012.

[14] J. R. Zavisca and T. P. Gerber, "The Socioeconomic, Demographic, and Political Effects of Housing in Comparative Perspective," Annual Review of Sociology, vol. 42, (1), pp. 347-367, 2016.

[15] L. Monk, University of Victoria (B.C.). School of Environmental Studies and University of Victoria (B.C.), "Decolonizing Home: A Re-Conceptualization of First Nations' Housing in Canada," 2013.

[16] A. Durbin, "Canada's Response to the On-Reserve Housing Crisis: A Study of the Kelowna Accord," Pimatisiwin: A Journal of Aboriginal and Indigenous Community Health 7(2), pp 181-200, 2009

[17] R Walker, "Searching for Aboriginal/indigenous self-determination: urban citizenship in the Winnipeg low-cost-housing sector," Canada, Environment and Planning A, volume 38, pages 2345-2363, 2006

[18] R Walker, M Barcham "Indigenous-Inclusive Citizenship: The City and Social Housing in Canada, New Zealand, and Australia," Environment and Planning A: Economy and Space.42(2):314-331. doi:10.1068/a41314, 2010

[19] R. C. Walker, "Interweaving Aboriginal/Indigenous Rights with Urban Citizenship: A View from the Winnipeg Low-Cost Housing Sector, Canada," Citizenship Studies, vol. 10, (4), pp. 391-411, 2006.

[20] K. Wilson, "Pulling Together: Foundations Guide. Victoria, BC: BCcampus," 2018.

[21] L. Porter 1973 and J. Barry, Planning for Coexistence?: Recognizing Indigenous Rights through Land-use Planning in Canada and Australia. 2016.

[22] J Anderson, D Collins, "Prevalence and causes of urban homelessness among indigenous peoples: a three-country scoping review," Hous.Stud. 29, 959–976, 2014.

[23] D Collins, Homelessness in Canada and New Zealand: a comparative perspective on numbers and policy responses," Urban Geogr. 31, 932–952, 2010.

[24] D Belanger, O Awosoga, G Weasel Head, "Homelessness, urban aboriginal people, and the need for a national enumeration, Aborig. Policy Stud. 2, 4–33, 2013

[25] M Cooke, F Mitrou, D Lawrence et al, "Indigenous well-being in four countries: An application of the UNDP'S Human Development Index to Indigenous Peoples in Australia, Canada, New Zealand, and the United States," BMC Int Health Hum Rights 7, 9; https://doi.org/10.1186/1472-698X-7-9, 2007.

[26] A Naomi, "The Embodiment of Inequity: Health Disparities in Aboriginal Canada," Canadian Journal of Public Health, Vol. 96, SUPPLEMENT 2: Reducing Health Disparities in Canada (MARCH/APRIL 2005), pp. S45-S61 Published by: Canadian Public Health Association, 2005

[27] P. C. Webster, "Housing triggers health problems for Canada's First Nations," The Lancet (British Edition), vol. 385, (9967), pp. 495-496, 2015.

[28] D. J. Pevalin et al, "The impact of persistent poor housing conditions on mental health: A longitudinal population-based study," Preventive Medicine, vol. 105, pp. 304-310, 2017.

[29] C. Liddell and C. Guiney, "Living in a cold and damp home: frameworks for understanding impacts on mental well-being," Public Health (London), vol. 129, (3), pp. 191-199, 2014; 2015.

[30] C. D. Solari and R. D. Mare, "Housing crowding effects on children's wellbeing," Social Science Research, vol. 41, (2), pp. 464-476, 2012.

[31] R. Robson, "Suffering an excessive burden: housing as a health determinant in the First Nations community of northwestern Ontario," Canadian Journal of Native Studies, vol. 28, (1), pp. 71, 2008.

[32] L. Larcombe et al, "Housing conditions in 2 Canadian First Nations communities," International Journal of Circumpolar Health, vol. 70, (2), pp. 141-153, 2016;2011.

[33] G. M. Carrière, R. Garner and C. Sanmartin, "Housing conditions and respiratory hospitalizations among First Nations people in Canada," Health Reports, vol. 28, (4), pp. 9-15, 2017.

[34] First Nations Information Governance Centre, "First Nations Regional Health Survey (Rhs) 2008/10," 2012.

[35] M. Optis et al, "Mold growth in on-reserve homes in Canada: the need for research, education, policy, and funding," Journal of Environmental Health, vol. 74, (6), pp. 14-21, 2012.

[36] Office of the Auditor General, "2011 June Status Report of the Auditor General of Canada – Chapter 4 – Programs for First Nations on Reserves," Ottawa, 2011.

[37] R. Lawrence and D. Martin, "Moulds, moisture and microbial contamination of First Nations housing in British Columbia, Canada," International Journal of Circumpolar Health, vol. 60, (2), pp. 150, 2001.

[38] Standing Senate Committee on Aboriginal Peoples, "Housing on First Nation Reserves: Challenges and Successes." 2015. [Online]. Available: www.parl.gc.ca

[39] R. Kiddle, P. Stewart and K. O'Brien, "Our Voices: Indigeneity and Architecture," Canada: ORO Editions, 2018

[40] E. Grant et al, The Handbook of Contemporary Indigenous Architecture. 2018. DOI: 10.1007/978-981-10-6904-8.

[41] W. Dalla Costa, "Indigenous futurity and architecture: Rewriting the urban narrative," Architecture Australia, vol. 109, (2), pp. 56-58, 2020

[42] Johann Kyser, "Sustainable Aboriginal Housing in Canada," Housing Services Corporation, December 2011

[43] Johann F. Kyser, "Improving Aboriginal Housing: Culture and Design Strategies," M Thesis, Environmental Design, UCalgary, Calgary, AB, Canada, 2012

[44] T MacTavish, M Marceau, M Optis, K Shaw, P Stephenson and P Wild, "A participatory process for the design of housing for a First Nations Community," Journal of Housing and the Built Environment, Vol. 27, No. 2 (June 2012), pp. 207-224, Springer, 2012.

[45] L Deane, E Smoke, "Designing Affordable Housing with Cree, Anishinabe, and Métis People," Canadian Journal of Urban Research; 19, 1; ProQuest pg. 51, Summer 2010.

[46] G. Taylor et al, Assessment of Sustainable and Cultural Housing Design in the Clayoquot Sound First Nations: A Decision Framework for Residential Housing Developments. 2011.

[47] Penticton Indian Band, "Eco Sage Project Page," pib.ca/?page_id=1448 (Accessed April 19, 2020).

[48] BC Housing, "Interim Guide to Indigenous Housing Development and Design," September 2018

[49] L. Hardess, R. C. McDonald and D. Thomas, "Aboriginal Housing Assessment: Community Design Needs and Preferences and the Application of Local Materials." 2004.

[50] S Kelly, “Mother Earthship: Alternative Solutions to Canada's First Nation Housing Crisis," M Thesis, Journalism, UBC, Vancouver, BC, Canada, 2015.

[51] Y Belanger, G Weasel Head, O Awosoga, "Housing and Aboriginal People in Urban Centres: A Quantitative Evaluation," Aboriginal Policy Studies, Vol 2, no.1, pp4-25, 2012.

[52] Canada. Aboriginal Affairs and Northern Development Canada. Evaluation, Performance Measurement and Review Branch, Final Report - Impact Evaluation of the Urban Aboriginal Strategy. 2011.

[53] R Walker, "Aboriginal Self-determination and Social Housing in Urban Canada: A Story of Convergence and Divergence," Urban Studies. 45(1):185-205. 2008. doi:10.1177/0042098007085107

[54] Catherine Palmer & Associates Inc, Aboriginal Housing in British Columbia Community Engagement Sessions: Summary Report. 2008.

[55] Canada, Canadian Mortgage and Housing Corporation, Canada, "Evaluation of CMHC on-Reserve Housing Programs: Summary Report," 1987.

[56] Canada, Canadian Mortgage and Housing Corporation, Canada, "Evaluation of CMHC on-Reserve Housing Programs: Summary Report," 2017

[57] Canadian Mortgage and Housing Corporation, Research on Aboriginal Housing, [Online] Available: https://iportal.usask.ca/action.php?sid=538872931&url=http://caid.ca/CMHCResAboHou2011.pdf&action=go&id=25264

[58] M. Gareau et al, An Examination of First Nations Housing Management Training Programs. 20043-024. 2004.

[59] Canadian Aboriginal Aids Network, "Aboriginal Housing in Canada: An Informal Background Discussion Paper," 2010.

[60] J. Graham and G. Motsi, "How to Improve First Nations Housing," 2008.

[61] Canada, "On-Reserve Housing Policy Impact Assessment 1996-2000," Department of Indian Affairs and Northern Development, Community Infrastructure and Housing Directorate, October 2000

[62] Office of the Auditor General, "Report of the Auditor General of Canada to the House of Commons. Chapter 6: Federal Government Support to First Nations – Housing on Reserves," Ottawa, 2003

[63] Public Policy Forum, "Bringing New Voices to the Table: Rethinking on-Reserve Housing in Canada," 2016.

[64] British Columbia. Ministry of Aboriginal Relations and Reconciliation, British Columbia. Office of Housing and Construction Standards and Catherine Palmer

& Associates Inc, Comprehensive Needs and Capacity Assessment of Aboriginal Housing in British Columbia. 2007.

[65] Assembly of Fist Nations, "Fact Sheet – First Nation s Housing On-Reserve," June 2013

[66] Assembly of First Nations, Chiefs Committee on Housing and Infrastructure, Indigenous Services Canada, Canada Mortgage and Housing Corporation, Employment and Social Development Canada, "DRAFT: 10 Year First Nations National Housing and related Infrastructure Strategy," July 4, 2018

[67] Aboriginal Housing Management Association, "AHMA National Housing Strategy Recommendations," October, 2016.

[68] B Boles, "Cost-effective indoor air quality and energy efficiency recommendations for First Nations housing: final report." Canada: N. p., 2001.

[69] Coastal First Nation, "New Housing Guide," June 2017

[70] D Heerema, "Technical Guideline Development for High Performance Coastal First Nations Housing," April 22, 2016.

[71] Natural Resources Canada, "EnerGuide energy efficiency home evaluations," [Online] Available: https://www.nrcan.gc.ca/energy-efficiency/energuide-canada/energuide-energy-efficiency-home-evaluations/20552

[72] Canada, "Tools for industry professionals," [Online] Available: https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-homes/professional-opportunities/tools-industry-professionals/20596

[73] Homeowner Protection Office, "Illustrated Guide - Energy Efficiency Requirements for Houses in British Columbia." British Columbia: Province of British Columbia, 2015.

[74] Canada, "Population Density, 2006 by Dissemination Area (DA) Map," [Online] Available: https://www12.statcan.gc.ca/census-recensement/2006/as-sa/97-550/vignettes/m1bc-eng.htm (Accessed May 20, 2002)

[75] Statistics Canada, "Focus on Geography Series, 2016 Census," [Oniline] Available: https://www12.statcan.gc.ca/census-recensement/2016/as-sa/fogs-spg/Facts-cma-eng.cfm?LANG=Eng&GK=CMA&GC=933&TOPIC=1) (Accessed May 10, 2020).

[76] Indigenous and Northern Affairs Canada, "Maps," [Online] Available: https://www.aadnc-aandc.gc.ca/eng/1100100021015/1100100021021 (Accessed April 1, 2020)

[77] [Online] Available: https://fnp-ppn.aadnc-aandc.gc.ca/fnp/Main/Search/SearchFN.aspx?lang=eng

[78] Canada, "Band Classification Manual," INAC, Ottawa, ON, Canada, March 2000.

[79] Canada, "First Nation Profiles," Indigenous and Northern Affairs Canada, [Online] https://fnp-ppn.aadnc-aandc.gc.ca/fnp/Main/Search/SearchFN.aspx?lang=eng (Accessed January 3, 2020)

[80] National Research Council Canada et al., "The British Columbia Building Code 2018," Ministry of Forests and Range and Minister Responsible for Housing. Victoria, B.C. 2018.

[81] S. Olsen 1955 et al, "Making Poverty: A History of on-Reserve Housing Programs," 1930-1996. 2016.

[82] INAC, "Evaluation of On-Reserve Housing Project Number: 1570-7/15108," January 2017.

[83] Canada, "On-Reserve Housing and Infrastructure: Recommendations for Change, Committee Business," Senate, 41st Parliament, 2nd Session, June 2015.

[84] W. D. Costa, K. Parrish and B. Arviso, "Unique features of conducting construction activities within tribal communities," in Construction Research Congress pp. 233-242. 2018.

[85] Canada, , "Evaluation of the 1996 On-Reserve Housing Policy – Report February 2008, Evaluation, Performance Measurement and Review Branch Audit and Evaluation Sector" Indian and Northern Affairs Canada, 2008.

[86] Government of Canada, "Status of Remote/Off-grid Communities in Canada," August 2011

[87] J. Smylie and M. Firestone, "Back to the basics: Identifying and addressing underlying challenges in achieving high quality and relevant health statistics for

indigenous populations in Canada," Statistical Journal of the IAOS, vol. 31, (1), pp. 67-87, 2015.

[88] E Hopper, "Maslow's Hierarchy of Needs Explained," February 2020. [Online] https://www.thoughtco.com/maslows-hierarchy-of-needs-4582571

[89] Tabitha Eneas, “Overview of Affordable Housing Programs,” presented at the AFOA BC Conference, Kelowna, BC, Canada, June 13, 2018

[90] BC Housing, "Indigenous Housing Fund - Program and Proposal Process," [Online] Available: https://www.bchousing.org/projects-partners/Building-BC/IHF

[91] T Frappé-Sénéclauze and J MacNab, "Evolution of Energy Efficiency Requirements in the BC Building Code, Pacific Institute for Climate Solutions," Pembina Institute, July 2015.

[92] Office of Housing and Construction Standards, British Columbia Government, "History of British Columbia Building Regulations," September 29, 2015

Appendix A - Graphs

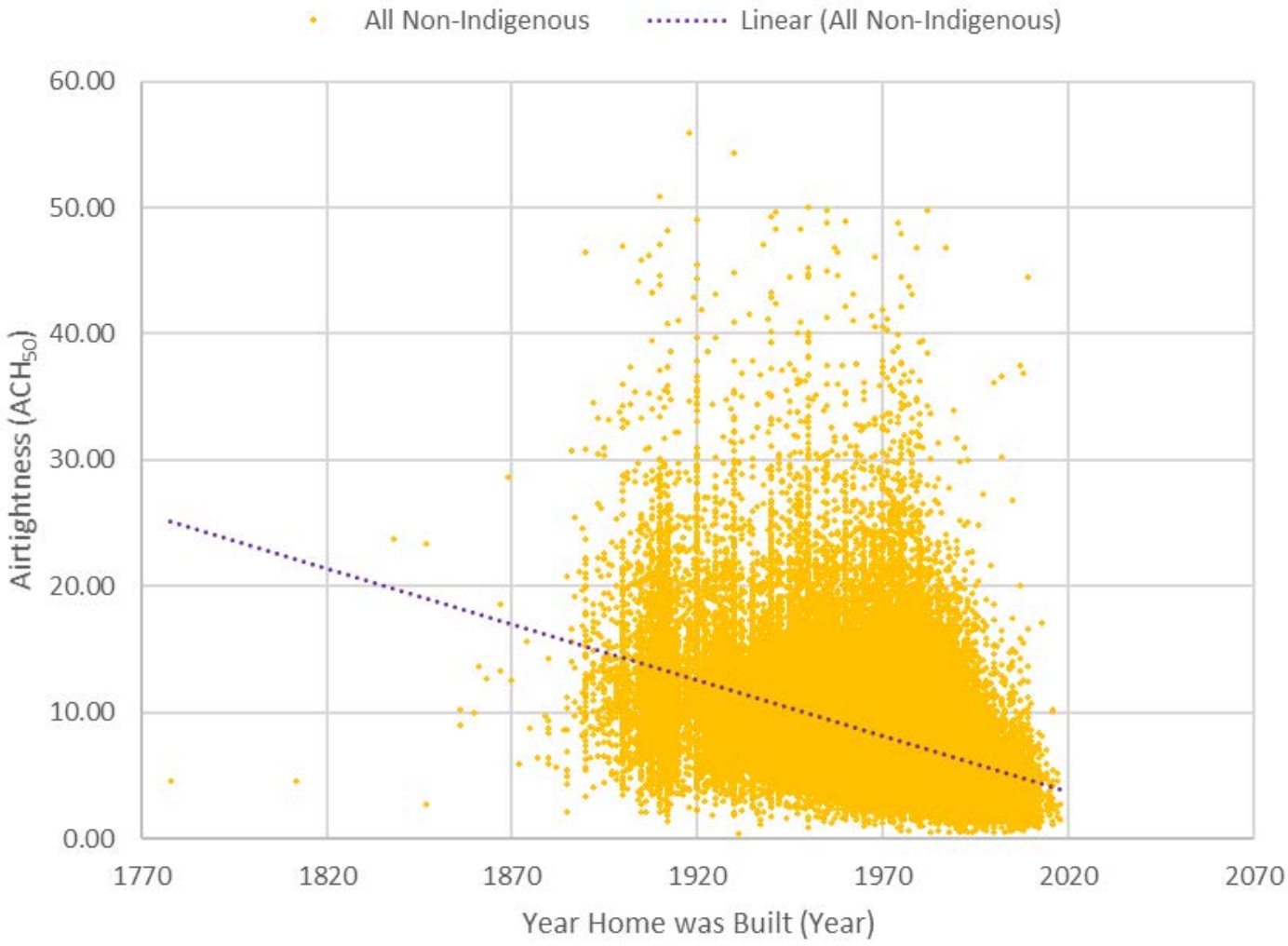


Figure 24: ACH50 of all non-Indigenous Homes for Homes Built Between 1778-2018

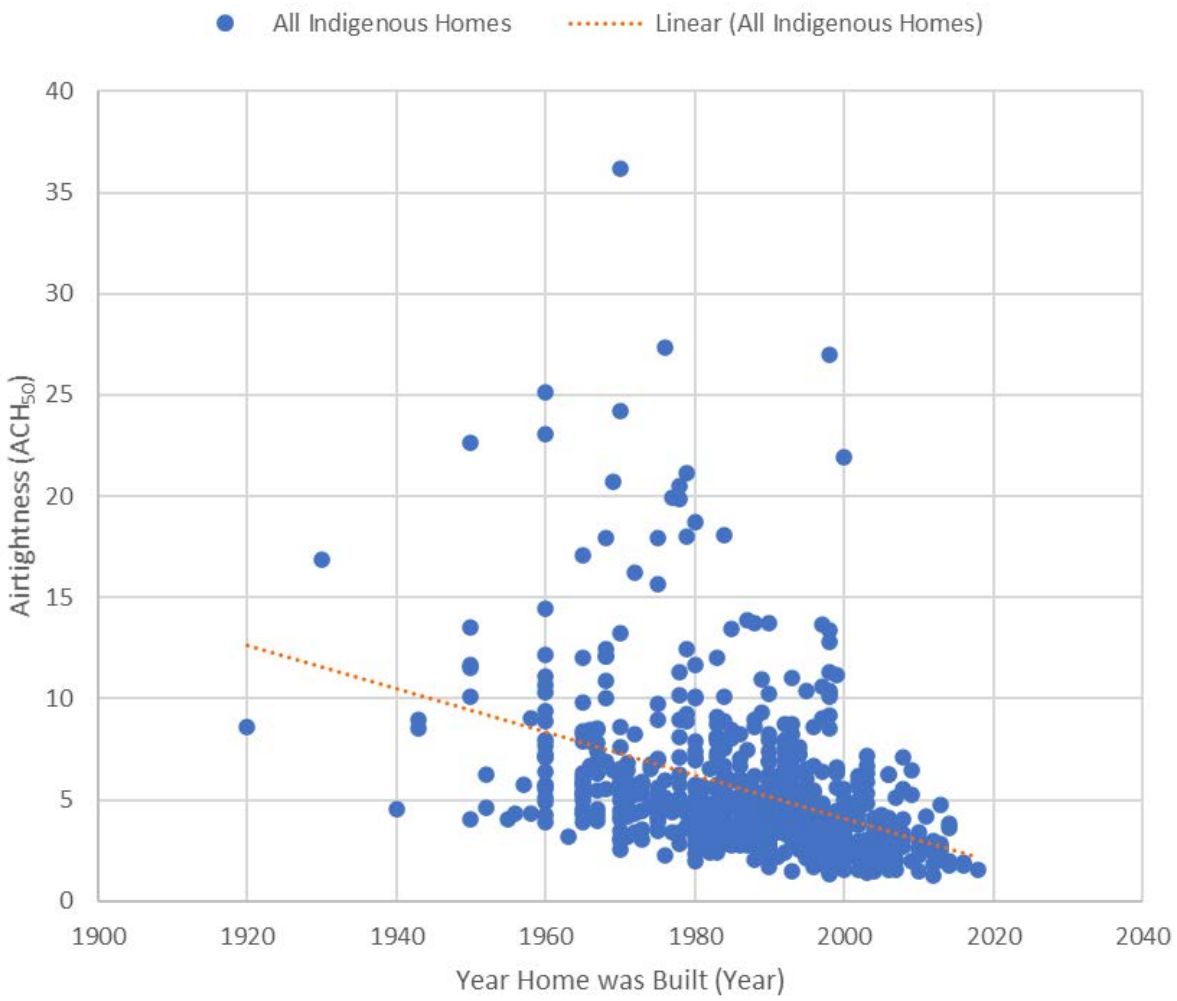


Figure 25: ACH50 by Build Year of All Indigenous Homes

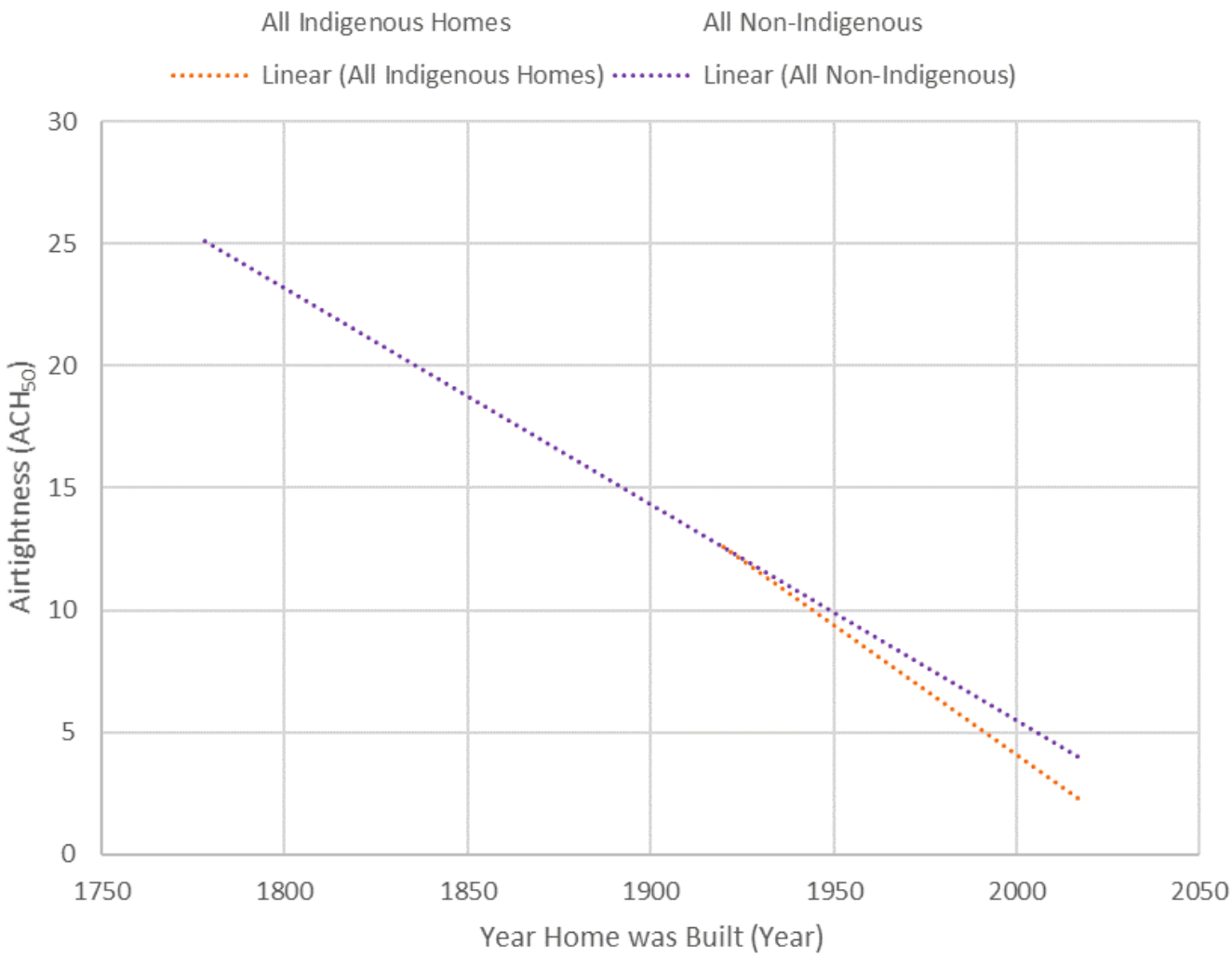


Figure 26: ACH50 by Build Year Trendlines of Indigenous and non-Indigenous Homes

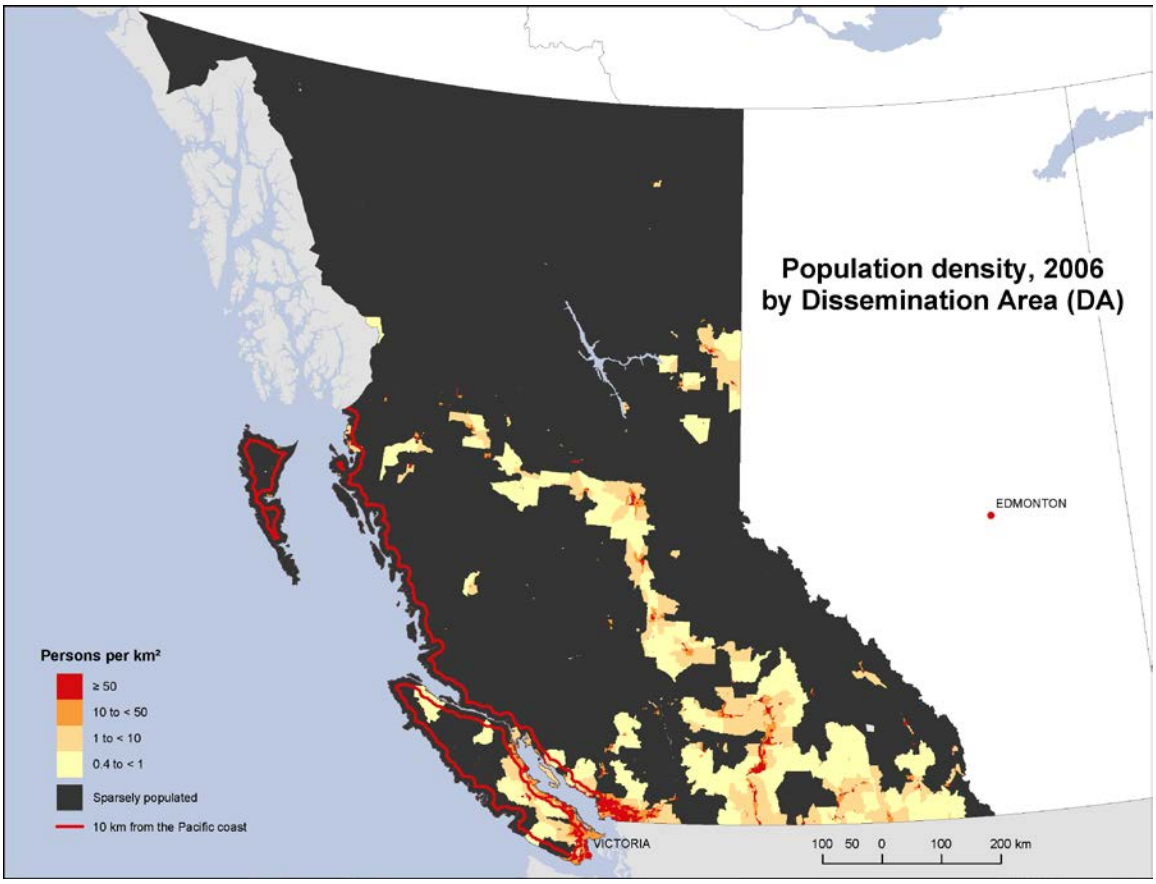


Figure 27: Population Density in BC by Dissemination Area [75]

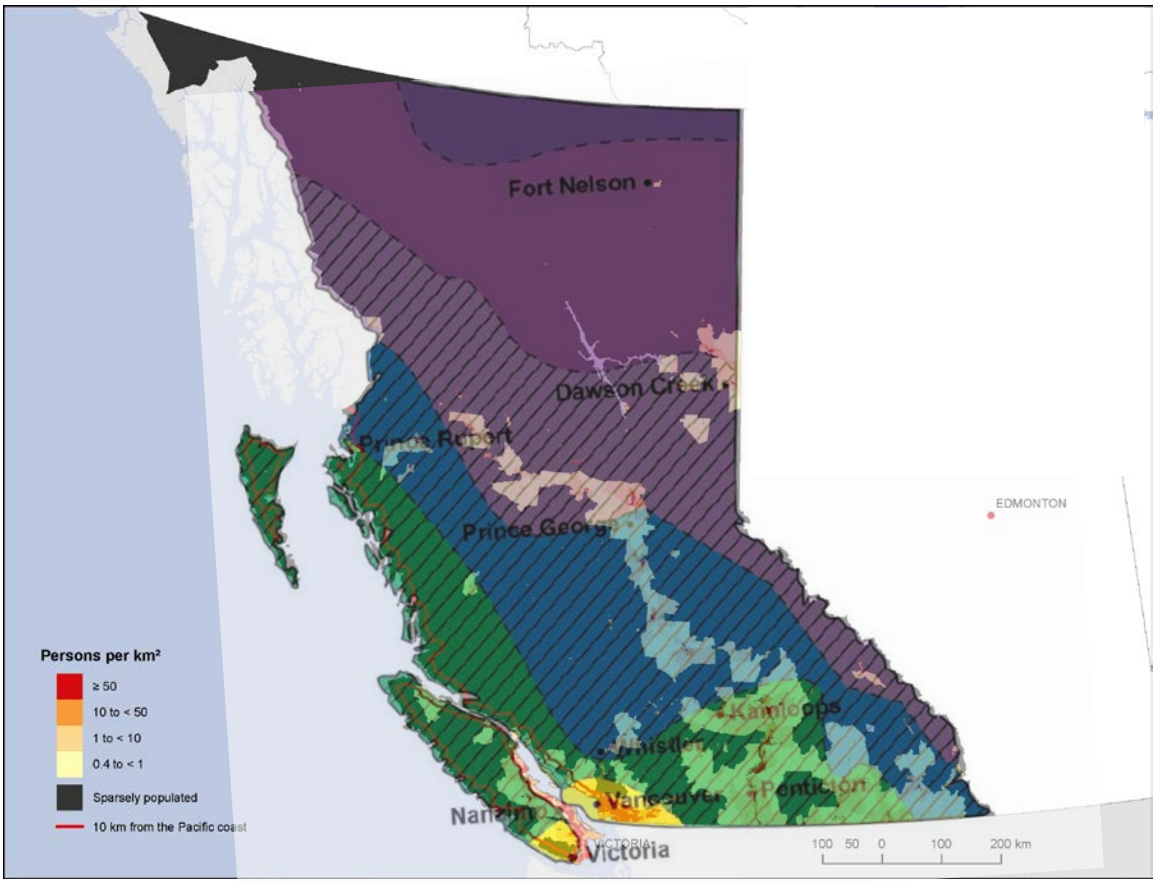


Figure 28: Figure a overlapped by climate zone map [73][75]

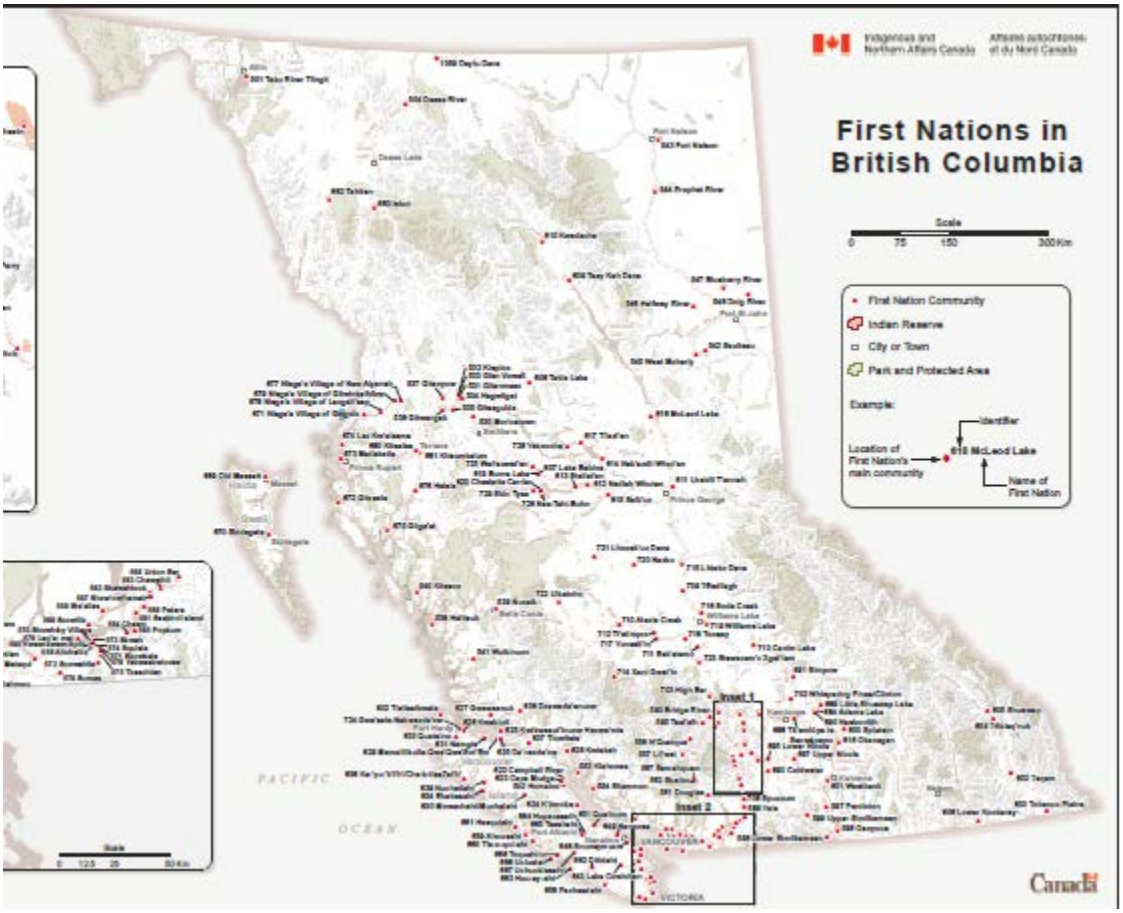


Figure 29: Map of First Nation Communities in BC [76]

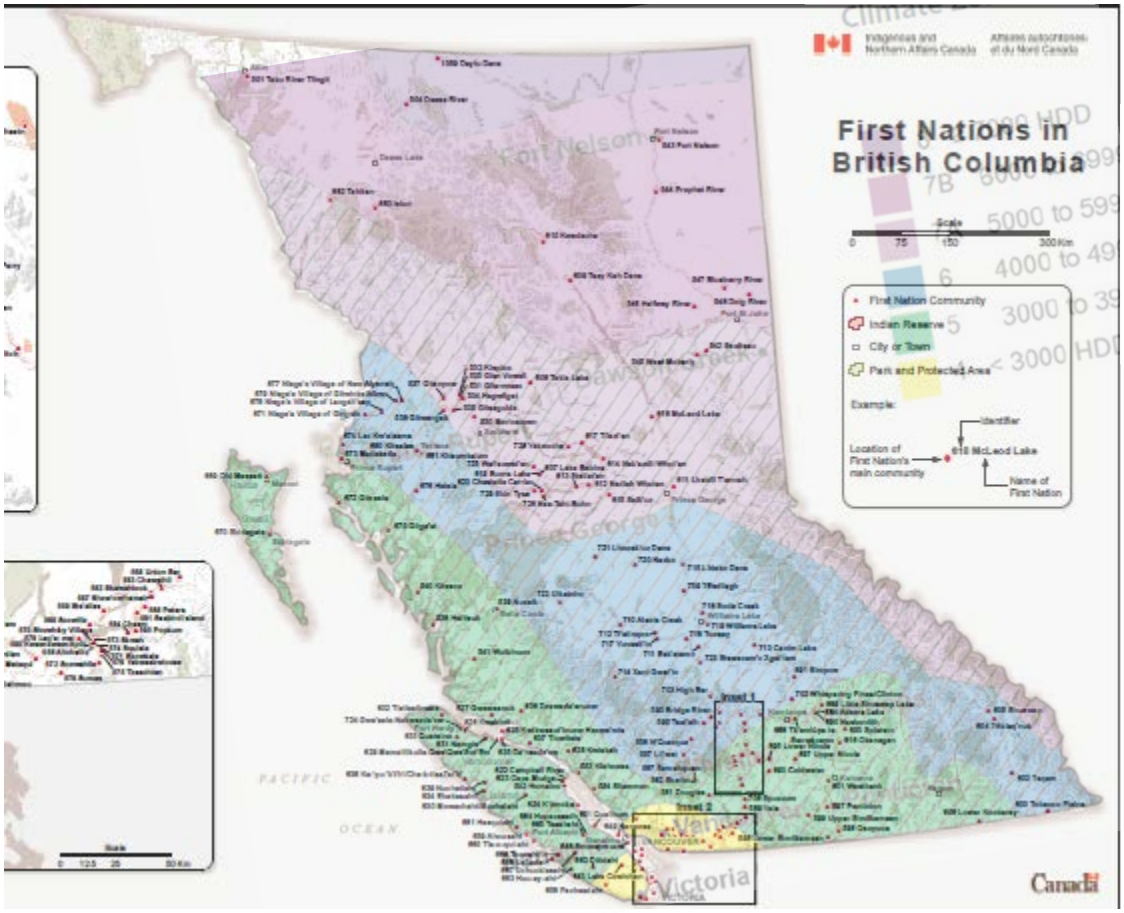


Figure 30: Figure c overlapped by Climate Zone Map [74][76]

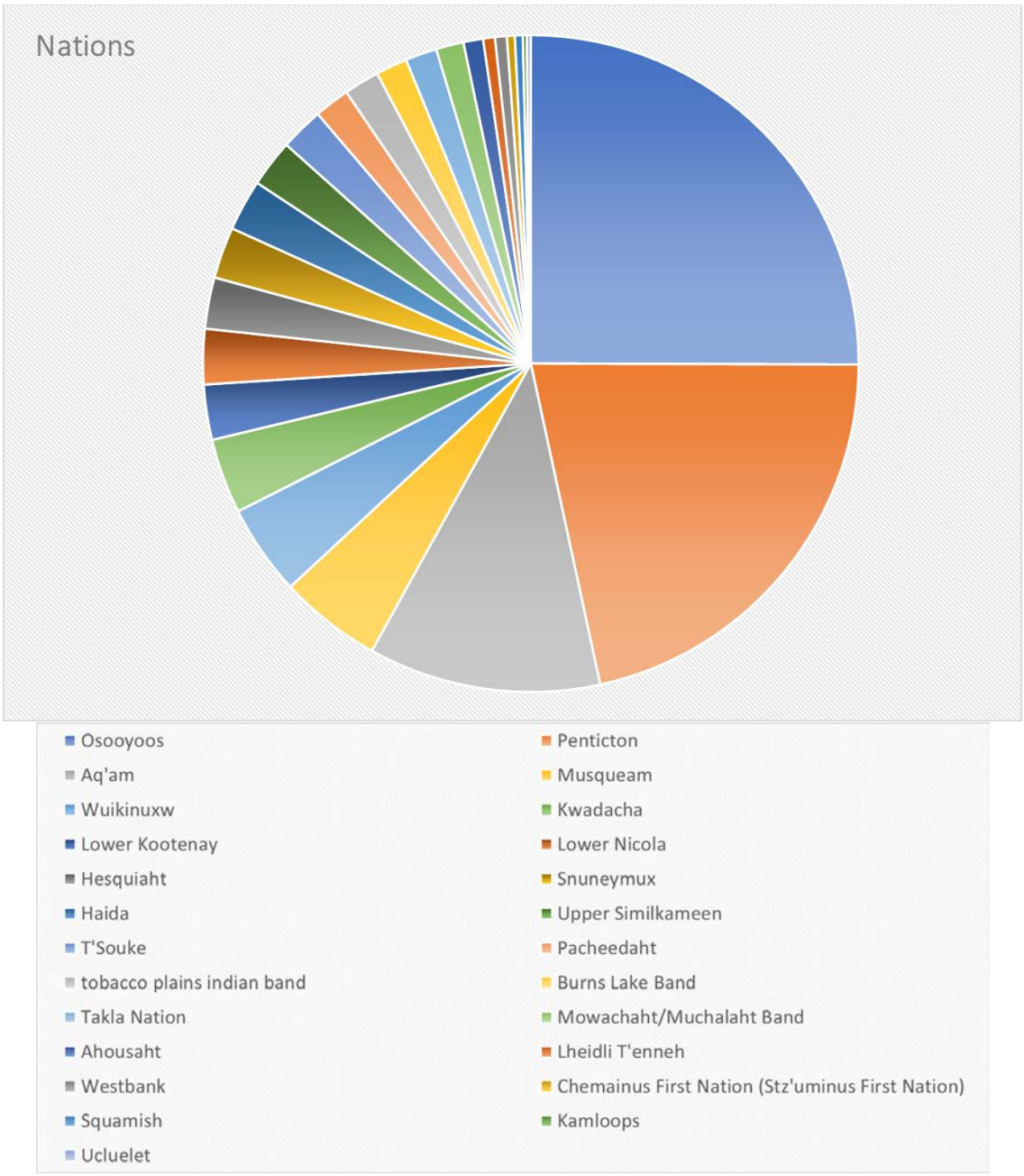


Figure 31: Indigenous Communities Identified in the Data