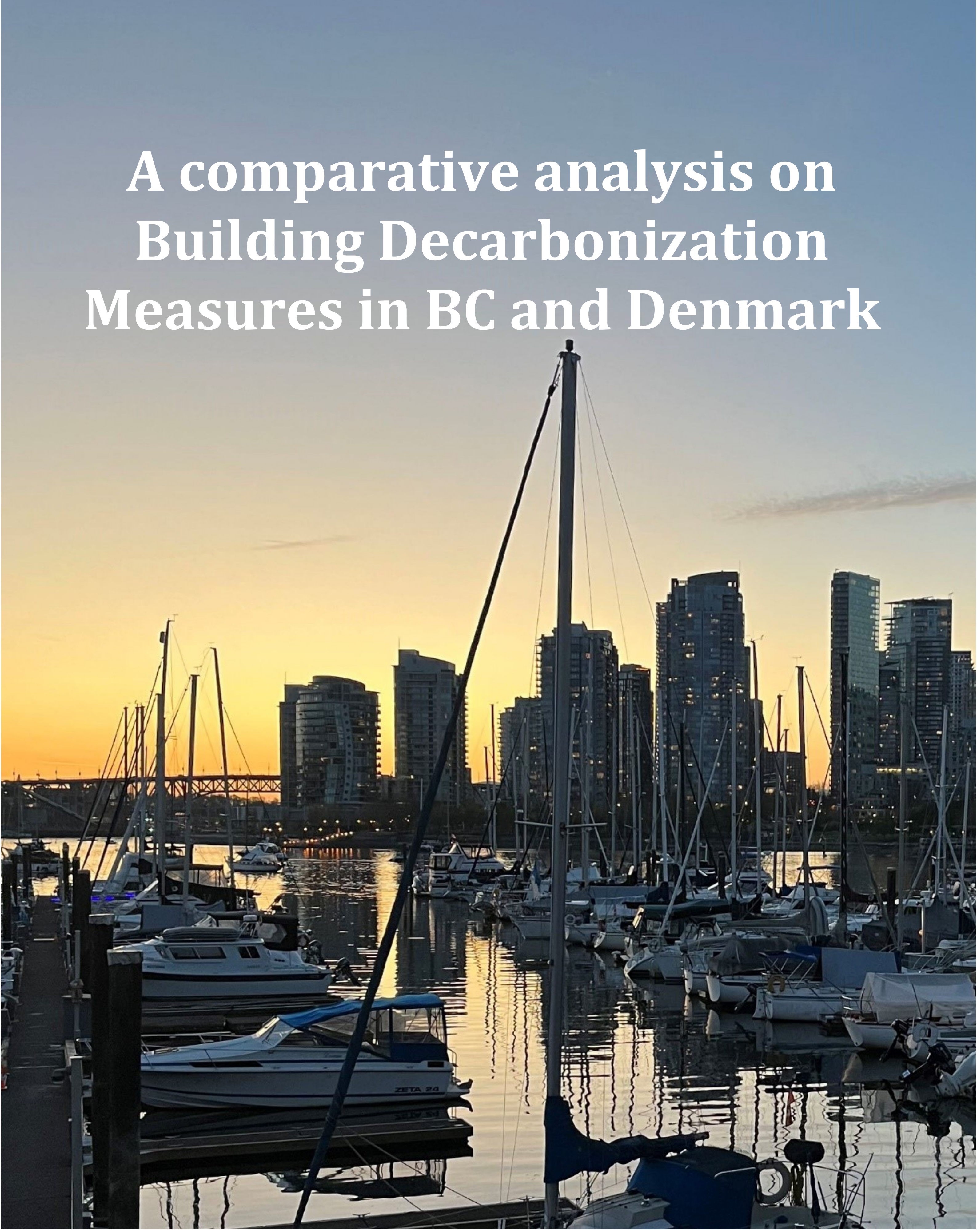
A comparative analysis on Building Decarbonization Measures in BC and Denmark



Danish Energy Agency

VANCOUVER ECONOMIC COMMISSION

Copyright

Disclaimer

This analysis is prepared for the Danish embassy in Toronto and is based on articles and data found in existing materials. No new data collection has been carried out and data from this analysis should not be used for other analysis.

Acknowledgements

Vancouver Economic has provided great input to this analysis, as well as the Danish embassy of Toronto. The analysis is produced in May 2023.

Contacts

Anne Svendsen, Senior advisor, Danish Energy Agency, ansv@ens.dk

Credits

Cover photo by Anne Svendsen.

Inputs from Vancouver Economic commission and the Danish Trade Council in Toronto

Foreword

We are pleased to provide an introduction to this report from the Danish Energy Agency (DEA) comparing building decarbonization and energy efficiency strategies in British Columbia (B.C.) and Denmark. This project was initiated as follow-up to the Vancouver delegation that came to Copenhagen in 2022 as part of a learning tour jointly organized by the Danish Trade Council and the Vancouver Economic Commission (VEC). Since then, thanks to the generous support of the DEA's Global Centre for Co-operation, British Columbian and Danish buildings experts have been able to continue to engage with one another and compare policies between the two jurisdictions as a way of identifying further areas for collaboration.

The report, which follows here, was the result of the tireless work of Anne Svendsen from DEA, with input and support from the Built Environment Branch from BC's Ministry of Energy, Mines, and Low Carbon Innovation and Peter Sun from the Vancouver Economic Commission. Additionally, the guidance of Jeppe Fredslund, former Danish Consul General in Toronto and now at the U.S. Embassy as Head of Trade and Regional Director, and his entire team at the Toronto Consulate.

British Columbia and Denmark are two jurisdictions both deeply committed to combating climate change, and are increasingly aligned in both our approaches and the challenges we face in doing so.

British Columbia was one of the first jurisdictions in the world to bring forward a price on carbon in 2008 and has continued to build on that landmark policy with a variety of other policy and regulatory interventions, most recently, the CleanBC Roadmap to 2030. Within the buildings sector specifically, BC's pioneering approach to building decarbonization began with a focus on energy efficiency through the provincial electricity utility and most recently with the Zero Carbon Step Code to phase-in net zero construction across the whole province.

The Kingdom of Denmark has adopted a comprehensive strategy focusing on energy efficiency and green innovation. They have heavily invested in wind energy, with wind power contributing significantly to their electricity generation. Denmark's work to advance widespread heat pump adoption in both new and existing buildings and decarbonize their vast networks of district heating and energy systems is inspiring and was a key part of our desire to stay engaged with Danish leaders after the trip in 2022.

This DEA report focuses on laying out the key aspects of both of our approaches to building decarbonization, where both BC and Denmark recognise that there are significant environmental, economic, and social benefits to be gained from. The broad parameters of each jurisdiction's approaches are laid out, including key regulations, policies, and programs, with some specific instances of comparison in terms of performance measures used. It closes with some thoughts about how and where we might continue to work together – work that VEC, the Trade Council, and the Province are keen to support.

British Columbia — Ministry of Energy, Mines and Low Carbon Innovation

Nat Gosman EMLI, August 2023

Danish Energy Agency

VANCOUVER ECONOMIC COMMISSION

Executive summary

The impact of climate change is strongly visible today with increased number of wildfires, heat waves and rising sea levels. Within this global climate context, the urban built environment plays an important role, with buildings alone responsible for at least 38%[1] of global energy-related Greenhouse Gas (GHG) emissions. Reducing carbon emissions in the building sector is an international task and it is therefore relevant to share knowledge and information among countries on how to reduce the carbon emissions from the building sector.

This analysis is looking at the actions taken in the country of Denmark and the Province of British Columbia in Canada to reduce GHG emissions in the building and construction sector. Both the Ministry of Energy, Mines, and Low Carbon Innovation (EMLI) in British Columbia (BC), Canada and the Ministry of Climate and Energy in Denmark have set some very ambitious targets for bringing down carbon emissions. Denmark has developed a climate target of 70% reduction of the greenhouse gas (GHG) emissions by 2030 compared to 1990, and British Columbia has set a climate target of 40% reduction by 2030 compared to 2007.

Buildings and the construction industry in Denmark and BC account for a large proportion of GHG emissions. In Denmark the emissions from the building sector is about 30 % of the total emissions and in BC about 13%. The large difference is due to that Denmark no longer have a large industry sector. Both jurisdictions have initialized plans to reduce emissions[2, 3].

Strict requirements in building codes and other related regulations are important measures to ensure buildings with low energy consumption in addition to fostering a healthy and comfortable space for building users. This analysis shows that both Denmark and BC are among some of the most ambitious in the world in regards to this.

Both Denmark and BC have implemented innovative measures for achieving these targets. There are different approaches and ways of implementing the measures, and there is great opportunity to learn from each other.

The analysis has identified some of the measures used in both Denmark and BC to reduce the energy consumption in buildings:

- Strict building codes for new and existing buildings
- Funding schemes and loaning mechanisms for energy efficient renovation of existing buildings
- Energy labeling systems/home rating systems
- Support for installing heat pumps in homes
- Focus on District energy as a fossil free and efficient heating method
- Training of installers
- Support for Energy efficient research

In the following, the analysis will go deeper into the different measures and policies applied in Denmark and BC respectively.

---

1 Source: United Nations Environment Program 2020 Global Status Report for Buildings and Construction

2 Clean BC Roadmap to 2030: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_roadmap_2030.pdf

3 Danish building industry suggestions for action in the construction sector: https://www.danskindustri.dk/siteassets/di-byggeri/analyse-og-politik/klima-energi-og-baredygtighed/climate-partnership-construction-report-march-2020-bat-kartellet-1.pdf

Danish Energy Agency

VANCOUVER ECONOMIC COMMISSION

Table of Contents

Danish Energy Agency

VANCOUVER ECONOMIC COMMISSION

Figures

Abbreviations

BC	British Columbia
COP	Coefficient of Performance
CHP	Combined Heat and Power
DEA	Danish Energy Agency
EMLI	British Columbia Ministry of Energy, Mines, and Low Carbon Innovation
EPC	Energy Performance Certificate
GDP	Gross Domestic Product
GHG	Greenhouse Gas
LCA	Life Cycle Analysis
MEPs	Minimum Energy Performance Standards for buildings or installations
TC	Trade Council
VEC	Vancouver Economical Commission

1. INTRODUCTION

This analysis has been developed to provide a comparative analysis of energy policy and regulations in the building sector within British Columbia (BC) and Demark. This is the result of an ongoing collaboration between the Danish Energy Agency (DEA), the Danish embassy in Toronto, the British Columbia Ministry of Energy, Mines, and Low Carbon Innovation (EMLI), and the City of Vancouver’s economic development agency, the Vancouver Economical Commission (VEC).

The analysis focuses on energy efficiency and carbon reductions in buildings and looks at where initiatives have been taken to secure a more energy efficient building sector, and how effective these measures have been.

The analysis is built up by the following process: After a brief contextual background in section 2, Section 3 provides an overview of the regulatory and financial energy efficiency measures implemented in the building sector in Denmark. In Section 4, the analysis looks at the energy efficiency measures introduced in BC in the building sector. Therefore, if you are interested in the Danish situation, you can start at section 3 and if you are more interested in the situation in BC please go to section 4. Section 5 concludes with general observations from the analysis.

2. BACKGROUND

BC and Denmark both see improved energy efficiency in buildings as a critical path towards the green transition, while also a way to achieve the climate targets.

The building sector in both BC and Denmark consists mostly of existing homes and buildings. The annual construction rate for new homes and buildings in both Denmark and BC is only about 1-1.5%. The greatest challenge and the greatest potential for energy savings and carbon reductions therefore lies in the renovation and retrofitting of existing homes and buildings. Both Denmark and BC have similar challenges on how to increase the energy renovation rate and the implementation of new energy efficient technologies in existing homes and buildings.

Each government is currently developing long-term renovation plans to improve energy efficiency in existing buildings - both residential and commercial. These plans are expected to increase the demand for more energy efficient solutions in the future.

BC released a new provincial Zero Carbon Step Code in 2023, which will induce forthcoming regulations on standards for high-efficiency equipment (to require sale and installation of equipment with a minimum coefficient of performance (COP) of 1 or greater, where a COP of 1 means a 100% efficient system) and future regulations on utilities. BC will soon be entering its most ambitions actions on decarbonizing buildings.

In 2023, Denmark has introduced new requirements for including embedded carbon from building materials into the building code as one of the first countries in the world. The requirement is to make a Life-Cycle-Analysis of the building project including embedded/ embodied carbon of the building materials. This is a rather new concept within the building market, where it is a measure of the emissions resulting from the entire life cycle of a building project including manufacturing of the building materials, the transportation of material to the building site, installation, operation if the building, maintenance, and disposal.

In both jurisdictions, the focus is not only on energy efficiency but also on more holistic approaches that includes other non-energy aspects such as healthy buildings, good indoor climate for the building users, reducing noise, increased value of the homes and the buildings and reduce energy poverty.

3. ENERGY EFFICIENCY IN THE BUILDING SECTOR IN DENMARK

Approximately 50 years ago, Denmark was almost entirely dependent on imported oil and coal from other countries for producing electricity and heating for the country. During the international oil crisis in the 70's, Denmark began its green transition. Integrating economic growth with ambitious green policies has been Denmark's trademark for decades. From 1980, Denmark has managed to decouple the economic growth from the overall energy consumption. The Danish GDP has in the period increased by 100 per cent, while the Danish energy consumption has only increased by 6 per cent, and water consumption has decreased by 40 per cent. This proves that it is possible to create economic growth independently from energy consumption. Looking at the build area for both homes and buildings, Fig. 1 illustrates how this value has increased by 60% since 1975 and that the energy consumption for heating buildings has decreased by 20% in the same period, indicating that the heating of homes and buildings has become much more efficient in Denmark.

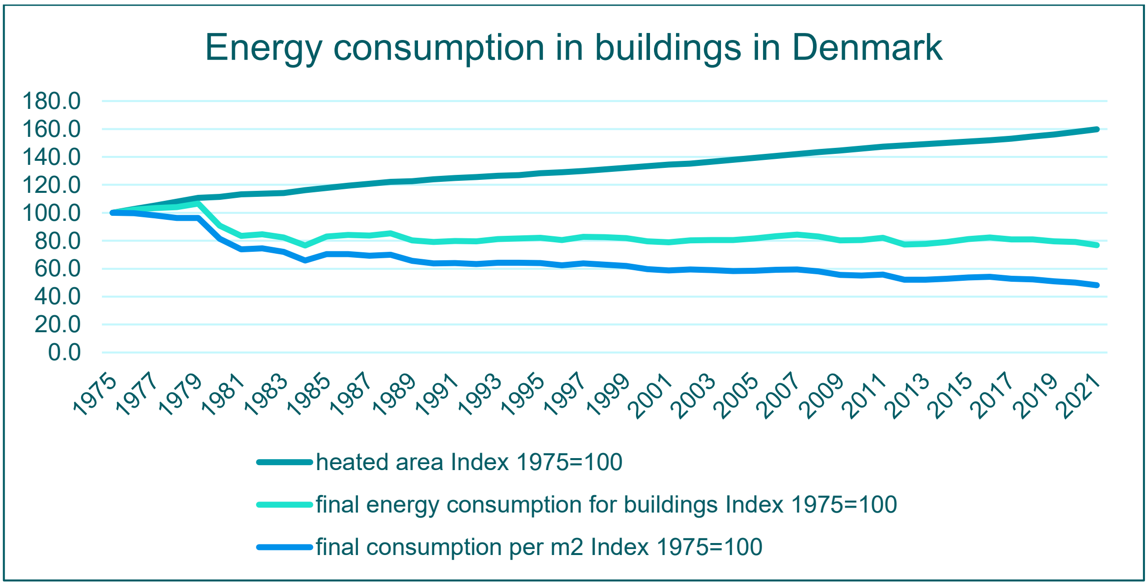


Figure 1 Heated area and energy (1975 = index 100), Source: Danish statistic

3.1 The Danish climate targets

The Danish Climate Act was approved by the Danish government in December 2019 and in 2020 the overall climate target for all sectors were laid out as: climate neutrality by 2045; to be independent of fossil fuels by 2050 and even to reach a negative level of carbon emissions by 2050 (110% compared to 1990). Furthermore, the GHG emissions shall be reduced by 70% in 2030 compared to 1990. The strategy to achieve climate neutrality and the 70% reduction in GHG is to increase the share of renewable energy in the electricity grid, to extend the amount of buildings connected to the district heating network and to replace oil and gas boilers with heat pumps. In 2022, the share of renewable energy from the electrical grid was 52% for the whole year, although some days with good wind, the utility achieved over 100% RE[4].

[4] https://ens.dk/sites/ens.dk/files/Statistik/energy_in_denmark_2021.pdf

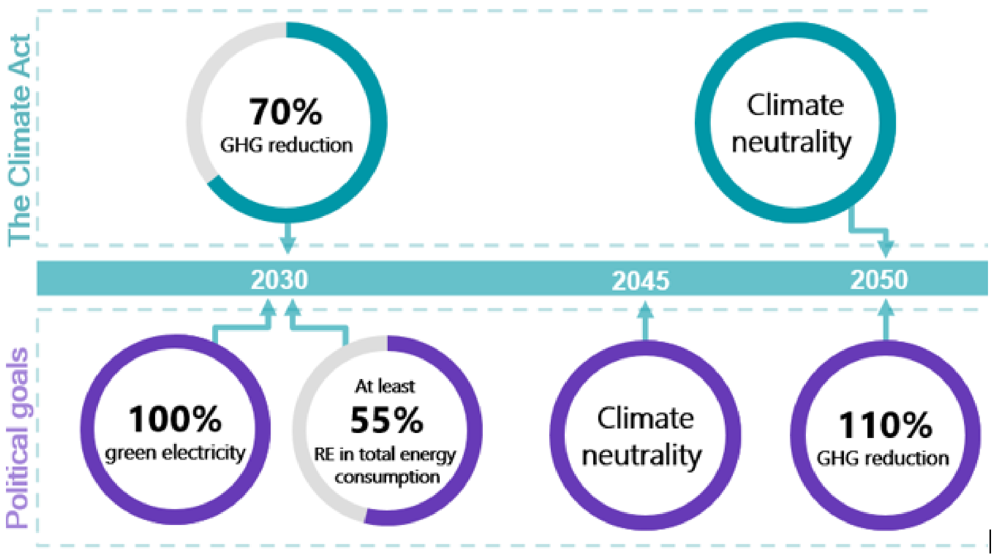


Figure 2 The Danish Climate targets

3.2 The Climate action Plan on buildings

In 2020, the first Danish Climate Action Plan was presented with a focus on electrifying heating of private homes and on encouraging house owners to renovate their building with the goal of improving energy efficiency. In the climate action plan, the focus is on the following measures:

- **Subsidy for replacing oil-fired boilers**

  A subsidy of DKK 20 million (approx. $4 million CAD) has been granted yearly between 2021-2024 annually for house owners converting their oil- or gas boiler to heat pumps. The subsidy is for buildings located outside the collective heating network (district heating). The building owner can receive up to approx. $5,300 CAD (the costs of installing an air-to-water heat pump is about $23,500 CAD).

- **Heat pumps on subscription / Heat-as-a-Service (HaaS)**

  To lower the initial cost of buying a heat pump, private households can purchase a subscription service for the heat from a heat pump company. The company installs, maintain, owns and operates the heat pump and the homeowner pay a monthly fee and pays according to the consumption of energy (heat) and not for the electricity consumption for the heat pump. If agreed the house owner can, after a period, buy back the heat pump[5].

- **Reduced tax on electricity for homes with heat pumps**

  If a home is registered by the municipality having a heat pump as the major heating installation it is possible to pay the minimum tax on electricity (the tax on energy is generally very high in Denmark). An annual consumption under 4,000 kWh per household is set at the normal price, while all electricity consumption over 4,000 kWh is at a reduced price.

  The normal electricity tax is about 0.89 DKK/kWh ($0.17 CAD/kWh), but with a heat pump installed it is reduced to 0.21 DKK/kWh ($0.04 CAD7kWh) for all consumption over 4,000 kWh/year. It was planned that the electric heating tax should fall to approx. 0.16 DKK/kWh ($0.03 CAD/kWh) in 2021, and it has by 2023 been reduced to 0.08DKK/kWh ($0.02 CAD/kWh). On top of this is the raw electricity price (consumption and distribution).

[5] More information on Heat as a Service: https://ens.dk/sites/ens.dk/files/Globalcooperation/final_ens_heatpump_as_a_service_print.pdf

- **Subsidy scheme for energy efficient renovation of buildings,**

  A subsidy of DKK 200 million ($40 million CAD) has been granted yearly between 2021-2024 annually to support energy efficiency renovation in buildings. A requirement is that an energy performance certificate is made for the house; it is then possible to get a subsidy for the measures mentioned in the energy performance certificate. The subsidy scheme is favourising the homes with the poorest energy performance certificate.

- **Support for digitalization in the building industry**

  A national strategy has been developed in order to assure open source and the possibility of sharing data in the different phases of a building process from design to construction to maintenance[6].

  The recommendations in the strategy falls within the following topics:

  1. Better utilization of digital tools
  2. Open formats and common standards
  3. Better utilization of data
  4. Digital competences for the entire value chain
  5. More sustainable construction through digitalization

- **Improvement of the user friendliness of the Energy Performance Scheme/Energy Labeling Scheme.**

  Denmark has been using Energy Performance Certificates since 2006. This scheme has been improved so that it is easier to understand for homeowners and other stakeholders like banks and financial institutions. Especially the layout, the language, and the way the measures are presented in the certificate/energy plan to the house owner have been improved in order to increase the user-friendliness of the Energy Label.

3.3 Energy efficiency in the building sector in Denmark

One of the important reasons for the energy savings achieved in the building sector in Denmark is due to a long and strategic work on the building code. The Danish Building Code, which is covering all the regions in Denmark (one climate zone with approx. 3,000 heating degree days), sets stringent energy performance standards for the construction of new buildings and homes as well as for major renovation of existing buildings and homes. In the Danish building code, there are stringent requirements for the level of insulation, the airtightness of the building, the energy consumption for ventilation and heating. There are also requirements for minimum efficiencies of the technical installations (heating, production of hot water, ventilation and cooling). The building code is up for revision every 5 year. Another important pillar is the energy performance certificate system, which is mandatory for all new buildings and homes and for buildings and homes being sold or rented out. The energy performance certificate system for existing buildings and homes allows potential buyers or tenants of a home or a building to assess the overall energy efficiency before buying a certain property.

In addition to these measures, financial incentives and support programs are available for homeowners, who wish to improve the energy efficiency of their homes. This includes funding for upgrading the level of insulation and replacement of old windows and doors with energy-

[6] Danish Strategy for digitalization: https://en.digst.dk/media/27861/national-strategy-for-digitalisation-together-in-the-digital-development.pdf
Strategy for digitalization in the building sector: https://im.dk/Media/638040252338597742/ny-final-303837-strategi-for-digitalt-byggeri-final-a.pdf

efficient windows and doors. It is also possible to get low-interest loans from financial institutions specifically for the purchase and installation of renewable energy systems such as heat pumps or solar panels.

Some of the specific measures that have helped Denmark reduce its energy consumption in the building sector are listed here:

- Regular and continuous improvements to building codes (both for new and existing buildings), including performance checks of technical installations and most recently, the introduction of LCA calculations (introduced as a requirement in the Danish Building Code on January 1st 2023). LCA-calculation includes CO_2 emissions and energy consumption from production and procurement of building materials, transportation of building materials to the site, construction and operation of the building over 50 years. For now, disposal of building materials is not included in the calculation due to lack of data. For buildings and homes under 1,000 m^2 (approx. 10,000 sq. feet), the requirement is to make the calculation and for buildings and homes over 1,000 m^2, there is a limit of 12 kg CO_2/m^2 per year over 50 year. Builders and developers must show compliance of this in order to get a building permit. The municipalities have the responsibility for checking compliance.
- Improvements to the building code are announced and discussed with the building industry several years before they come into force
- Energy Performance Certificates (EPC) or energy labeling scheme for new and existing building (the EPC consists both of a label for the building based on an energy demand calculation, suggestions for energy saving measures and an energy action plan)
- Specific energy saving requirements for public buildings
- Subsidies for phasing out oil and gas boilers in private homes and replacing them with heat pumps
- Subsidies for renovation of existing homes and multi-family buildings
- Ensuring quality in the supply chain through training and capacity building (training of installers and certification scheme for heat pump installers)
- Communication campaigns to house owners and One-stop-shop for consumers (digital platform: https://sparenergi.dk/)
- Campaigns for municipalities, introduction on energy management in public buildings, subsidies for the renovation of public buildings like schools, sports facilities etc.
- Danish Knowledge Center with specific information for installers (digital platform, https://byggeriogenergi.dk/)
- Focus on digitalization in the building sector (planning, construction, operation, and demolition as well as collection of energy data)
- Financial support to energy efficient renovation of low income housing
- Support for research in e.g. improved efficiencies for installations, high efficiency heat pumps, and materials with low CO_2 levels

3.4 Heating of Danish buildings

The international energy crisis in 1973/74 made it evident that saving energy was critical both to decrease the dependency of imported fuels, and to reduce consumer-heating costs. Therefore, a decision was made by the Danish government to expand the fuel-efficient combined heat and power (CHP) systems to a number of cities in Denmark.

Prior to 1979, there was no law to regulate the heat supply in Denmark. Most heat consumers had small oil-fired boilers or other forms of individual heating. In some areas of the larger cities, there were heating networks but there could also be buildings with individual heating in the same areas. In order to fulfil its policy goals, Denmark passed its first heat supply law in 1979. The law contained regulations regarding the form and content of heat planning in Denmark and marked the beginning of a new era in public heat planning. Today, the heating sector in Denmark is a highly developed and innovative industry that has made significant strides in reducing carbon emissions and transitioning to renewable energy sources. The heating sector plays a crucial role in achieving the climate goals. Today, more than 65% of Danish households are heated by district heating in the form of hot water distributed into radiators in both homes and buildings. In larger cities, this figure is up to 98 % of all buildings being heated by district heating. The majority of the heat generated in a district heating system comes from biomass, waste, and geothermal sources.

The heating strategy from the Danish Energy Agency (DEA) is to expand the district heating network to areas and buildings, where it is financially viable and to encourage owners of gas- and oil boilers in individual homes to convert to heat pumps - mainly air to water or ground source to water. Even though the switching from oil or gas boilers to heat pumps is going smoothly, it is estimated that there are still more than 200,000 homes that still use oil or gas boilers. The target from the Danish Energy agency is approximately 28,000-30,000 conversions of existing oil or gas equipment per year in order to reach the climate targets.

3.5 The Danish building stock and energy consumption in buildings

Almost half of the number of dwellings in Denmark are single-family houses, about 39% are multi-family buildings and 15% are semi-detached houses. The split can be seen in the following figure.

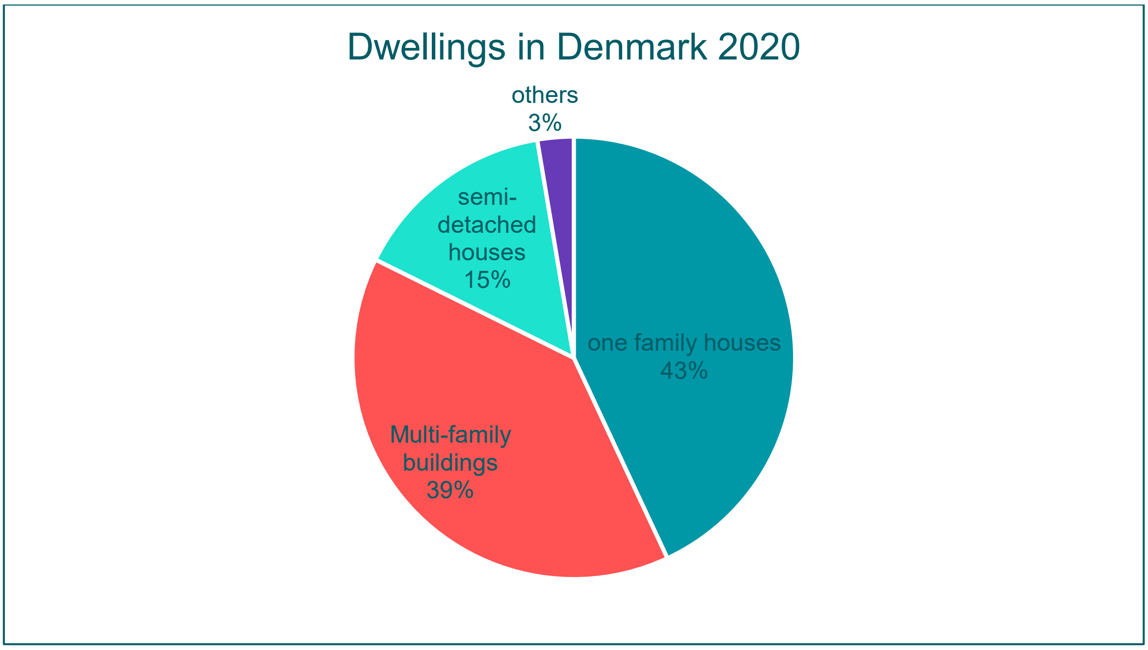


Figure 3 Split of the private building stock in Denmark, Source: Danish Statistics

Of the single-family houses, the largest part has been constructed in the 1970's before energy requirements in the building code were introduced. There is therefore still a very large potential for achieving energy savings by renovating these buildings. It is estimated, that the saving potential is between 15-30 % in existing buildings depending on the year of construction and when the installations were replaced or upgraded. Some buildings are difficult to upgrade and the costs may be very high, for example old buildings, whereas for newer buildings it may be easier and less costly to upgrade.

The population of Denmark is about 5.8 million and the number of dwellings is about 2.7 million, giving about 2.2 person per dwelling. The average number of heating degree days is around 3000 (at 17 degrees Celsius).

As can be seen from figure 4, the energy consumption in dwellings, has been reduced with about 9 % over the last 15 years. In the same period the number of dwellings has increased about 7 %.

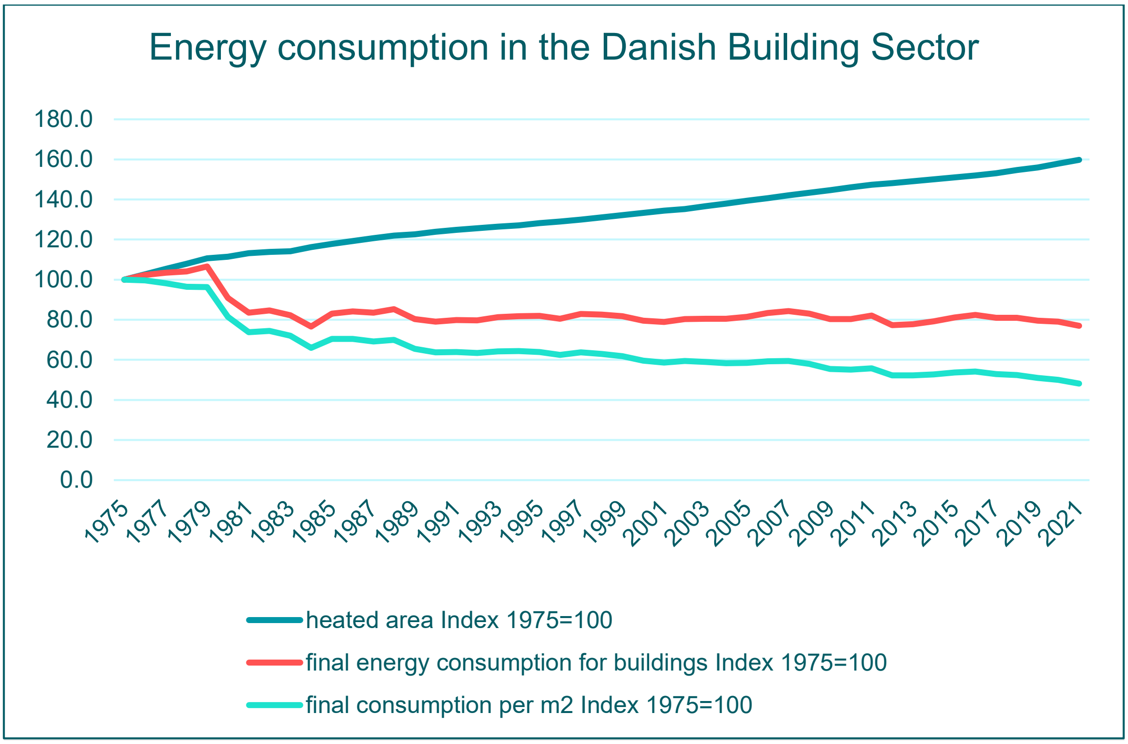


Figure 4 Development in energy consumption and the heated area since 1975. Source: Danish Statistics

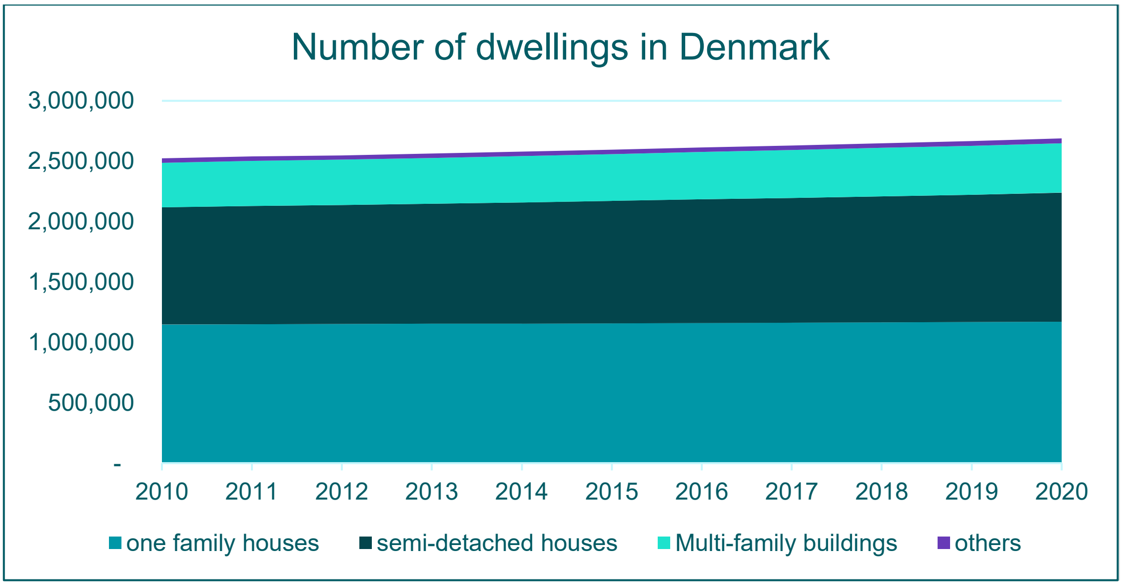


Figure 5 Number of dwellings, source Danish Statistics

The energy consumption according to year of construction and type of building can be seen in figure 6. As illustrated, the highest energy consumption is in single family buildings constructed before the seventies where the energy requirements were first introduced in the building code. There is a relatively large potential for energy savings by renovating this part of the building stock.

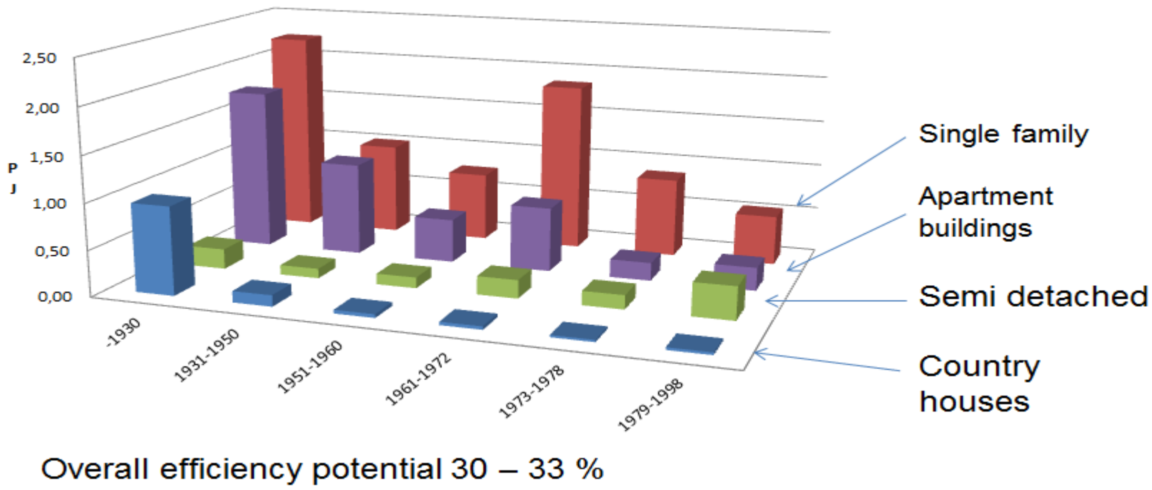


Figure 6 Energy consumption in private buildings according to type and the year of construction

3.6 The Danish Building Code

In line with the increased requirements, the Danish building industry has developed significantly over the last decades. New technologies for regulating room temperatures, better windows, better insulation and more efficient heating and ventilation systems have been developed. New buildings are much more energy efficient than existing, but since new buildings only constitute a very small part of the total building stock in Denmark, the highest energy saving potential is in the existing buildings. A central element in achieving energy savings is to focus on efficiency first and then to look at the opportunity for decarbonizing the building by using renewable energy. For existing buildings, the aim is to encourage the home and building owners, who are going to renovate, to also include energy efficient measures in the renovation, and see it as an opportunity to increase the value of the building and improving the indoor air quality and the comfort.

The first Danish building code with requirements for energy was implemented in 1979, and was a prescriptive code with requirements for maximum U-values for walls, floors, roofs and windows. Since then, the requirements have been made increasingly more ambitious so that the energy consumption for a house built today is about 70% lower than in 1979.

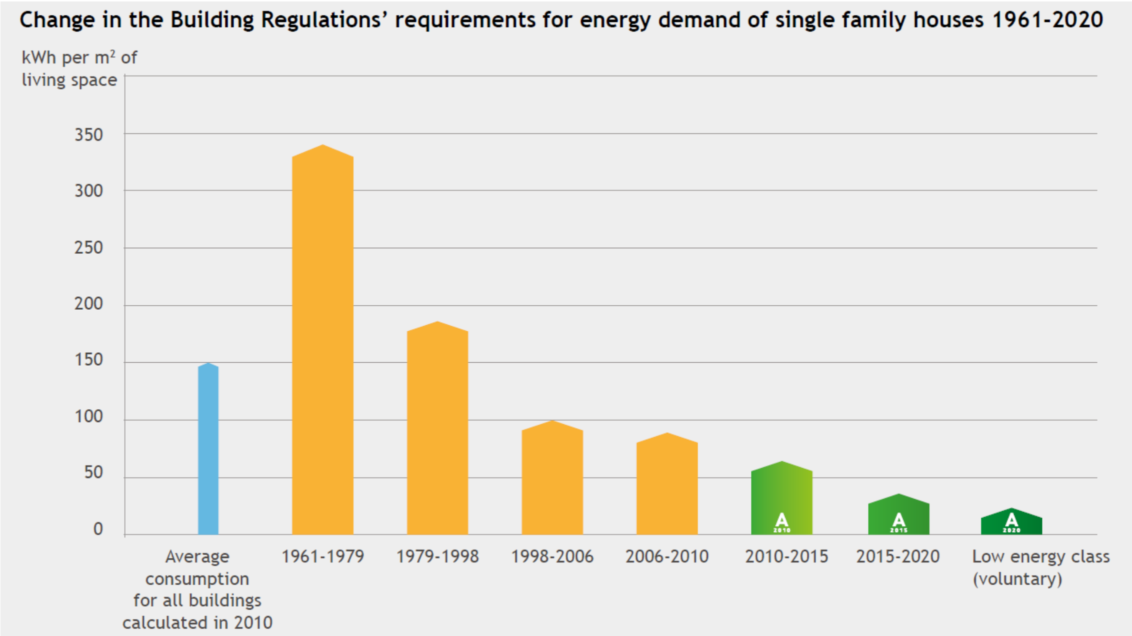


Figure 7 Energy Requirements in the Building Code.

In 2008, the Danish building code was changed into a performance based code including performance-based requirements in the form of an "energy frame". The energy frame (calculated energy demand for the entire building per heated area per year using provided parameters like weather data, indoor temperatures, occupancy and internal loads) is calculated using:

- The U-values for the building envelope (roof, floor, walls, windows and doors)
- The building orientation and shading of windows, the weather zone
- Minimum efficiency of the heating and hot water installations
- Minimum efficiency of ventilation system (fan efficiency, heat exchanger efficiency)
- Losses in the heating and hot water system (losses from pipes, valves, hot water tanks)
- Losses from ventilation system (ducts, heat exchanger)
- The heat-accumulating properties of the building
- The internal loads from occupants and installations (pre-defined)
- Losses from replacing air for ventilation
- Natural ventilation and airtightness of the building
- Solar radiation though windows and roof lights

Positive energy gains shall also be included in the calculation:

- Energy from solar heating and solar cells (PV)
- Heat pumps
- Condensing boilers
- Natural ventilation (also referred to as free cooling)

The building code is revised every five years reflecting technological developments taking place in the construction industry. The code is valid in all regions and municipalities in Denmark for all homes and building heated to more than 15°C and with permanent occupation. Whenever changes are made to the building code, it is preceded by an extensive stakeholder consultation process with several stakeholders from the building and construction industry to ensure ambitious but realistic changes. The changes are announced several years before they come into force, in order for the industry to adapt, develop new solutions and invest in the necessary production equipment. In this way, the building code is also used as a means to spur innovation in the industry.

The current Danish building code is from January 2023. Buildings exempt from following the code include barns, churches and non-heated industrial buildings like warehouses etc. The current code contains regulations regarding the testing of the actual performance of the installations when the building or the retrofit is completed (heating, ventilation and lighting).

The Danish building code is also valid for major renovation of existing buildings with prescriptive requirements for maximum U-Values as long as the costs of the measure is lower than the cost of energy saved over the lifetime of the building element. The building code ensures that the existing building stock continuously becomes more energy efficient and that energy measures are implemented at the most cost-effective time, namely in connection with other non-energy-related renovations.

If a component of the building envelope is completely replaced, maximum requirements apply for the U-value of the new building element.

Maximum U-values allowed by renovation of an existing building (larger projects) can be seen in table 1.

Building element	New houses and buildings	Retrofitting of existing houses and buildings
Roof	0.2 W/m²K/R-28.39	0.12 W/m²K/R-47.32
Walls	0.3 W/m²K/R-18.93	0.18 W/m²K/R-31.55
Floors	0.2 W/m²K/R-28,39	0.10 W/m²K/R-56,79
Windows	Energy balance at 0 kWh/m² per year or more	The heat balance must be positive (the energy that goes through the window must be bigger that the energy going out of the window)
Doors without glass	1.4 W/m²K	
Door with glass	1.50 W/m²K or energy balance at 0 kWh/m² per year	
Roof lights	1.4 W/m²K	
Energy frame for residential Buildings (lighting is not included)	30.0 kWh/m² per year + 1,000 kWh per year/heated area of building	*See also note voluntary codes for renovation of residential buildings*
Energy frame for non-residential buildings (lighting is included)	41.0 kWh/m² per year +1,000 kWh per year /heated are of the building	The calculated energy demand must be reduced with 30.0 kWh/m² per year. *See also note on voluntary codes for renovation of non-residential buildings*

Table 1, Requirements in the Danish Building code to the building envelope

Notes on the voluntary codes for renovation of residential buildings (home, multi-family buildings etc), energy demand for heating, ventilation, cooling and hot water:

- *Voluntary code 1: 52.5 kWh/m² per year + 1,650 kWh per / heated area of the building.*
- *Voluntary code 2: 110.0 kWh/m² per year + 3,200 kWh per / heated area of the building.*

Notes on voluntary codes for renovation of non-residential buildings (offices, schools, institutions and other buildings), energy demand for heating, ventilation, cooling hot water and lighting:

- *Voluntary code 1: 71.3 kWh/m² per year + 1,650 kWh per / heated area of the building.*
- *Voluntary code 2: 135 kWh/m² per year + 3,200 kWh per / heated area of the building.*

If a component is renovated (not entirely replaced), profitable energy improvements shall be made. Profitability is defined as: If the annual energy savings multiplied by the expected life of the component (after installation) divide by the cost of total investment is larger than 1.33, the investment is profitable.

$$\frac{Annual\ energy\ savings * Lifetime\ of\ renovated\ component}{Total\ investment} > 1.33$$

Air tightness

The fresh air-volume-flow through leaks in the climate screen in new buildings heated to 15°C or more must not exceed 1.0 l/s per m² heated floor area at a pressure difference of 50 Pa. It is possible to perform a blower door test and, if the result is lower than the requirement, then the actual reported values can be used.

Energy supply

The heating of a new home or building must be based on 100% renewable energy. This is understood as either district heating (assuming net zero energy production by 2030) or the use of electrical heat pumps (assuming 100 % renewables in the electricity grid by 2030).

Voluntary Low-energy class

In the Danish building code, there is a possibility to go beyond the requirements by using the voluntary low-energy class. This is similar to the BC Energy Step Code, but for individual building owners rather than local governments.

Previously, the low energy step code/voluntary energy class would become the next mandatory requirement in the building code. In the building code from 2010, for example, it was possible to adhere to the "Low-energy Building 2015 class". The overall requirements for the energy frame in the BR15 were 25% lower than the requirements for BR10. In 2015, when the new building code came into force (BR15), and the BR10 was no longer valid, there was the possibility for a voluntary "Low-energy building 2020 class", again with an energy demand 25% lower of the building code in force.

The plan was to continue this for the expected revision in 2020 (BR20), again with a reduction of 25%. However, there was an extra revision in 2018 (BR18) and therefore the newest building code came into effect in January 2023.

It is unlikely that the requirements for the U-values will be reduced further in the near future. For the time being, it is not economically viable to introduce more insulation or reduce the requirements for air change further.

However, there is still an option for going beyond the building code by using a voluntary energy class. The developer or the builder can decide to go beyond the code, but the regulatory authority at the municipality maintains responsibility for checking for compliance. Residential buildings (homes, multi-family buildings, hotels etc.) can be classified as low energy buildings, if the total calculated energy demand for heating, ventilation, cooling and production of hot water is not exceeding **27.0 kWh/m2 per year**.

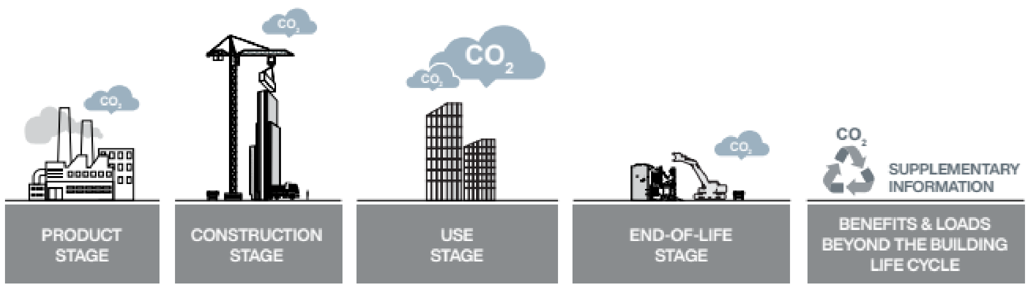
Non-residential buildings can be classified as low energy buildings if the total calculated energy demand for heating, ventilation, cooling, hot water and lighting is under **33.0 kWh/m2 per year**.

For both residential and non-residential buildings, heat recovery for ventilation must be at least 85% for the low energy class (80% in the normal building code).

The general focus in the work on the future building code is on decarbonization, reduced energy demand, improving the energy efficiency for the installations (heating, hot water, ventilation, cooling, lighting etc.) and embedded carbon in the building materials and on the documentation of compliance with the requirements after completion of the building by using performance tests.

LCA - New Danish building code from January 2023

By January 1, 2023, a new requirement has been introduced into the Danish Building Code, where a LCA calculation shall be included in the documentation. For buildings under 1,000 m^2 the requirement is only to make the calculation and for buildings over 1,000 m^2, the LCA calculation shall document that the total emission of CO_2 over 50 year including the production of the building materials, the construction of the building and the operation of the building will be kept under 12 kg CO2/m2 per year. This requirement will be reduced in 2025, 2027 and in 2029[7].



The LCA calculation shall be made according to the European standard EN 15978:2012. A calculation system (LCABYG[8]) has been developed by the Danish Building Research Institute and can be used for the calculation.

Compliance on energy demand

For new buildings, compliance is demonstrated by making an energy calculation using a simulation program developed by the Danish Building Research Institute[9]. All the assumptions shall be presented, as well as the drawings used for measuring the areas of the different building elements like walls, roofs and windows etc.

Additionally, documentation for the U-values, the thickness of insulation, the parameters for the windows, and the efficiencies for technical installations must be documented and put together

[7] See more in Danish: https://baeredygtighedsklasse.dk/

[8] https://www.lcabyg.dk/da/download-legacy/

[9] https://sbi.dk/beregningsprogrammet/Pages/Start.aspx

with the application for the building permit. If something is changed during the construction, the energy calculation must be adjusted accordingly. The compliance check is done by the municipalities, who have the permitting authority. They do not necessarily check the calculations directly but instead the pre-conditions and the results.

Municipalities also have the possibility to make thorough sample checks. At this point, the energy performance certificate is also developed (from the same simulation program used for showing compliance). When the building is finished, a new calculation must be made (using again the same digital tool) to show final compliance and the final energy performance certificate is also made at this time. If at this point, it is not possible to achieve compliance, changes must be made to the building and paid by the building owner. In order to get the occupancy permit, a performance test must be made of the technical installations (for residential buildings, this is a small test of the heating system, for non-residential buildings it is a test of all technical installations for heating, ventilation and lighting). If the performance test is in compliance the building can get the occupancy permit.

3.7 Energy performance certification for buildings (EPC)

The system for EPC or energy performance certificates of buildings for both residential and non-residential buildings was introduced in Denmark in 2006. It is mandatory to produce the energy performance certificate for all new buildings and when a building owner sells or rent out the building. All the energy certificates are registered in a central database administered by the DEA and displayed on a website. The EPC documents rate buildings on an energy efficiency scale ranging from label **A** (high energy efficiency) to **G** (poor energy efficiency). In the EPC, there is also a plan and suggestions for cost-effective measures for improving the energy performance of the building.

Figure 8 The EPC scale, the scale goes from A to G, where A is the best label, A2020 is reserved for new buildings.

In an analysis from 2015, made by the consultancy Copenhagen Economics[10], the relationship between house prices and energy standards was examined. One of the key results that emerged was that the energy standard has a clear and significant influence on the price of private homes and the purchaser's willingness to pay a higher price for a higher energy rating. For example, in the case of a 100 m^2 house with a C-label rating compared to a D-label rating house it was found, that it capitalized into a willingness for the house-owner to pay an extra price of approx. US$ 6,500 for the higher rated house.

A geo-mapping of the EPC for buildings is also available. It is possible for everybody to find and see an EPC on the digital platform (SparEnergi.dk) hosted by the Danish Energy Agency.

[10] https://ens.dk/sites/ens.dk/files/Energibesparelser/giver_en_god_energistandard_en_hoejere_boligpris_-_sammenfattende_rapport.pdf

Figure 9 Example of EPC and geographical mapping of the EPC's

The labels refer to the energy requirements in the building codes. This means that a house marked with **A**$_{2015}$ meets the requirements that were applicable in building code from 2015. **A**$_{2020}$ similarly covers the former voluntary Building Class 2020, which has been changed to a voluntary Low Energy Class since 1 July 2018**.** **A**$_{2020}$ is reserved for new buildings only.

The energy label of buildings for sale or rent must be announced with the scale value stated in the energy labeling report.

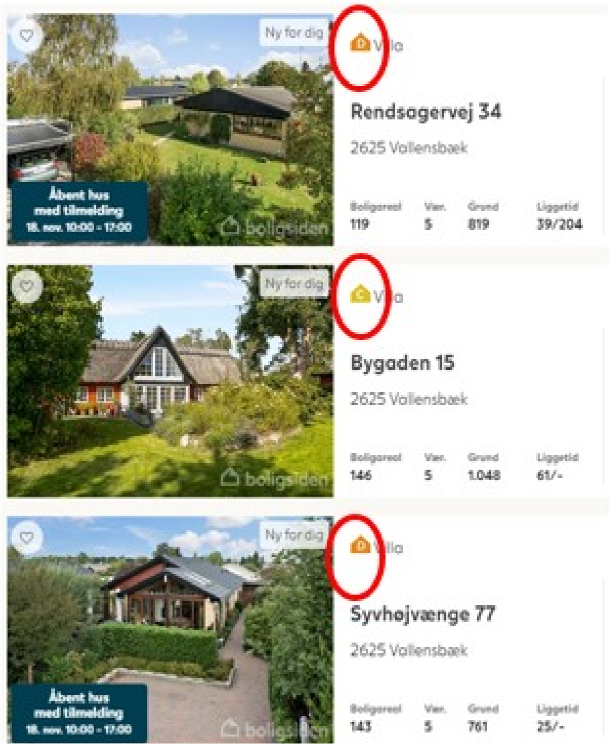


Figure 10 Example of page from a real estate page

All year-round housing and commercial properties of more than 60 m^2 shall have an energy performance certificate (EPC) for sale and rental. In the EPC, there is an overview of the theoretical energy demand both in energy units and in economic units as well as potential energy saving measures and the economic saving potential from implementing the suggested measures and the payback period.

The EPC ensures an overview of building segments, including the least energy efficient. There are currently over 600,000 buildings in Denmark with an EPC, this is about 45% of all buildings. The EPC must be carried out by a trained and certified energy consultant.

3.8 Public buildings

Article 5 of the European Directive on Energy Efficiency states that EU member states are obliged to renovate 3% of the central government building stock every year, or to achieve the same effect with an alternative approach. Denmark previously had a requirement for all state buildings to achieve a total saving of 14% from 2006 to 2020 (1% per year). A platform has been established for the registration of energy consumption in public buildings in order to follow, display and document these savings. All public buildings must report the annual energy consumption on this platform and also introduce energy management and appoint and energy responsible person.

3.9 Energy poverty

In Denmark, there are a number of initiatives to address energy poverty. Energy poverty is generally addressed through social policy though. In Denmark, pensioners and early retirement pensioners can, upon application, receive a heat supplement. The allowance goes directly to the payment of the heating and hot water.

3.10 Informative initiatives - Digital tools and platforms

The Danish Energy Agency is hosting two information platforms: the one is directed towards house owners and the other is directed towards installers and professional people.

Information to house owners – SparEnergi.dk (“SaveEnergy”)[11].

SparEnergi.dk is the central platform for information activities regarding energy efficient solutions. The target group is both private and public building owners. The site contains multiple digital tools that can support and qualify the building owners' decisions in relation to energy

[11] https://sparenergi.dk/

renovation. In addition, there are numerous cases on renovation and the opportunity to get an overview of grant opportunities.

Information to installers - Knowledge Center for Energy Savings in Buildings[12].

The center collects and organizes knowledge and information of energy savings in buildings and clearly communicates the knowledge out to the construction sector. The purpose of this platform is to provide the best possible conditions for profitable energy renovations. The center develops tools and teaching materials targeted at professionals and vocational education. The Knowledge Center is part of the Danish Energy Agency's targeted information efforts.

3.11 Renewable Energy Authorization System for installers

The Renewable Energy Authorization System provides information for companies installing small renewable energy systems in private homes, i.e., heat pumps, photovoltaic cells, solar heat and small biomass boilers. The Danish Energy Agency authorizes which companies are permitted to install small renewable energy systems. To be approved, the company must already be a licensed electrical or plumbing company, and have employees who have completed special training. The training is provided by companies that are selected by the Danish Energy Agency, but the financing and the training itself are independent from the Danish Energy Agency.

3.12 Data and digitalization

Denmark focuses on how the use of data and the increasing digitalization can be better utilized, so that energy efficiency improvements are implemented where they provide the most value, leading to reduced transaction costs in energy renovations. Among other things, a series of analyses and demonstration projects are planned with a focus on promoting the use of data and digitization as a driving force for energy efficiency and flexible energy consumption in buildings, including supporting a data-based energy management approach.

In 2021, the Danish Energy Agency initiated four new projects, including a collaboration with the Danish Agency for Data Supply and Efficiency. The four projects will together form a better basis for the development of database solutions to promote energy efficiency, flexible consumption and a better and healthier building stock. The following are projects that have been initiated since 2021:

- Testing Facility - The Danish Energy Agency, in collaboration with the Danish Agency for Data Supply and Efficiency, is developing a test facility for a Building Hub, which will collect and exhibit data on buildings and their energy consumption. The Building Hub will help to uncover the possibilities for streamlining energy consumption through better utilization of data and digital tools.
- Digitalization of the energy performance certification scheme – All energy performance certificates are stored digitally as an XML-file and can be used by the next consultant. The database is hosted by the Danish Energy Agency
- Homeowner Retrofit Planning Support - The Better Housing scheme gives homeowners the opportunity to receive a comprehensive proposal for energy renovation of their home from a trained consultant.
- Adaptive Building Planning - A project is being initiated to test the potential of the EU scheme for Smart Readiness Indicators (SRI). The SRI must be able to describe the ability of buildings to adapt operations to the needs of users, e.g. in relation to indoor climate and heat management, the energy efficiency of buildings, as well as the ability to provide flexibility to the surrounding energy systems - in short, the intelligence readiness of buildings.

[12] https://www.byggeriogenergi.dk/

3.13 Loan and finance

Private households can borrow money for energy efficiency measures through special bank loans intended for energy-saving measures such as renovation or alternative energy sources.

Private households can also use mortgage loan to borrow money as a home equity loan up to 80% of the value of the property.

The municipalities have automatic loan access to energy saving measures if there is an energy saving potential in the EPC. The loans can be used for energy efficiency measures described in the EPC of the buildings. Furthermore, the loan can be used for upgrading the building envelope, replacement of heating and ventilation systems in buildings, connecting to district energy systems and replacement of lighting installations.

3.14 Social housing associations

All tenants pay a small amount of the rent to a national fund for large renovations of social housing. The renovation can be replacement of old roofs, installation of new kitchens or addition of new balconies. However, in 2023, as a response to the COVID 19 crisis, money has been set aside specifically for energy renovation of social housing schemes. In order to receive funding, an energy audit has to be made and the potential for savings must be calculated.

4. ENERGY EFFICIENCY IN BUILDINGS IN BC

4.1 Background on energy efficiency in BC

British Columbia (BC) is one of the most ambitious provinces in Canada in regards to reducing the GHG. The climate target set by the government is to lower climate-changing emissions by 40% by 2030[13].

The B.C. government develops and implements energy efficiency policies and regulations to support the Province's energy, economic and greenhouse gas reduction priorities.

4.2 The Clean Energy Act:

The Clean Energy Act is a legislation passed by the government of British Columbia in 2010, with the goal of promoting and developing the province's clean energy sector. The act focuses on increasing the production of clean and renewable energy, such as hydroelectric, wind, solar, and geothermal power. It also encourages energy conservation and promotes energy efficiency measures across all sectors, including residential, commercial, and industrial. The Clean Energy Act provides a framework for the development and regulation of clean energy projects, including the establishment of a feed-in tariff program to encourage the development of small-scale renewable energy projects. The Clean Energy Act of British Columbia is an important step towards a more sustainable energy future for the province, contributing to the reduction of greenhouse gas emissions and helping to mitigate climate change.

The ***Clean Energy Act*** specific energy objectives are:

One of the means to achieve the climate targets is the Clean Energy Act where some of the aims are:

1. to achieve electricity self-sufficiency;
2. to take demand-side measures and to conserve energy, including the objective of the authority reducing its expected increase in demand for electricity by the year 2020 by at least 66%;
3. to generate at least 93% of the electricity in British Columbia from clean or renewable resources and to build the infrastructure necessary to transmit that electricity;
4. to use and foster the development in British Columbia of innovative technologies that support energy conservation and efficiency and the use of clean or renewable resources;
5. to ensure the authority's ratepayers receive the benefits of the heritage assets and to ensure the benefits of the heritage contract under the BC Hydro Public Power Legacy and Heritage Contract Act continue to accrue to the authority's ratepayers;
6. to ensure the authority's rates remain among the most competitive of rates charged by public utilities in North America;
7. to reduce BC greenhouse gas emissions
8. by 2050 and for each subsequent calendar year to at least 80% less than the level of those emissions in 2007, and
9. to encourage the switching from one kind of energy source or use to another that decreases greenhouse gas emissions in British Columbia;
10. to encourage communities to reduce greenhouse gas emissions and use energy efficiently;
11. to reduce waste by encouraging the use of waste heat, biogas and biomass;

[13] https://cleanbc.gov.bc.ca/

12. to encourage economic development and the creation and retention of jobs;
13. to foster the development of first nation and rural communities through the use and development of clean or renewable resources;
14. to maximize the value, including the incremental value of the resources being clean or renewable resources, of British Columbia's generation and transmission assets for the benefit of British Columbia;
15. to be a net exporter of electricity from clean or renewable resources with the intention of benefiting all British Columbians and reducing greenhouse gas emissions in regions in which British Columbia trades electricity while protecting the interests of persons who receive or may receive service in British Columbia;
16. to achieve British Columbia's energy objectives without the use of nuclear power.

4.3 The CleanBC Plan and Roadmap to 2030

The CleanBC Plan and Roadmap to 2030 is a comprehensive strategy developed by the government of British Columbia to reduce greenhouse gas emissions and promote clean energy and sustainability across the province. It is the policy mechanism through which BC's legislated GHG targets of 40% reduction by 2030 and 80% by 2050, below 2007 levels, will be realized.

The plan focuses on four key areas:

1) Industry, Buildings, and Communities;

2) Transportation;

3) Clean and Renewable Energy; and

4) Clean Growth Modelling.

The CleanBC Plan includes measures such as incentives for the adoption of clean technology and energy-efficient buildings, increasing the use of public transit and active transportation, and expanding the production of renewable energy sources. The Roadmap to 2030 outlines specific targets and actions to achieve the goals of the CleanBC Plan, including a 40% reduction in greenhouse gas emissions by 2030, increasing the use of electric vehicles, and increasing the number of energy-efficient buildings. The CleanBC Plan and Roadmap to 2030 represent a significant step forward in the province's efforts to combat climate change and promote a more sustainable future. By focusing on a broad range of sectors and implementing targeted measures, the plan aims to create a cleaner, healthier, and more resilient province for all British Columbians.

4.4 Energy efficiency in the building sector in BC

In BC, the GHG emissions from buildings account for about 10% of the province's GHG emissions, and comes mainly from the energy used to heat buildings and provide hot water.

In the CleanBC roadmap[14] the following actions for the building sector is highlighted:

- Zero-carbon new construction by 2030
- Highest efficiency standards for new space and water heating equipment
- Enhancing energy efficiency programs
- Introducing home energy labelling
- More low carbon building materials

[14]https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_roadmap_2030.pdf

4.5 The building stock and energy consumption in the building sector

As of 2021, the estimated population of British Columbia is approximately 5.1 million people. This makes British Columbia the third most populous province in Canada, after Ontario and Quebec. The majority of the population is concentrated in the Lower Mainland region, which includes the cities of Vancouver, Surrey, Burnaby, and Richmond. However, British Columbia also has many rural areas and small towns, particularly in the northern and interior regions of the province. The population of British Columbia has been steadily increasing over the years, driven in part by immigration and natural population growth.

The energy consumption for both commercial and residential buildings in Canada and British Columbia is expected to increase in the future due to an increase in the building stock. The years with Corona reduced the growth somewhat but the growth rate it is expected to increase in the future.

In most commercial buildings and homes, the majority of energy is used for heating, cooling, fans for ventilation and water heating as well as lighting.

Housing:

The total population of Canada is about 38 million people and the total number of households is about 15.5 million giving about 2.4 person per household. In BC the population is about 5.1 million and the total number of households is about 2.04 million giving 2.5 person per household; 66.8% of which are owner-occupied and 32.8% of which have renters living in them.

There are about 866,000 single-detached homes in B.C., representing 42.4 per cent of the housing distribution and about 222,000 apartments in buildings with five or more floors, which make up about 11 per cent of all dwellings in the province.

The distribution of residential buildings in BC according to the year of construction can be seen in fig. 11:

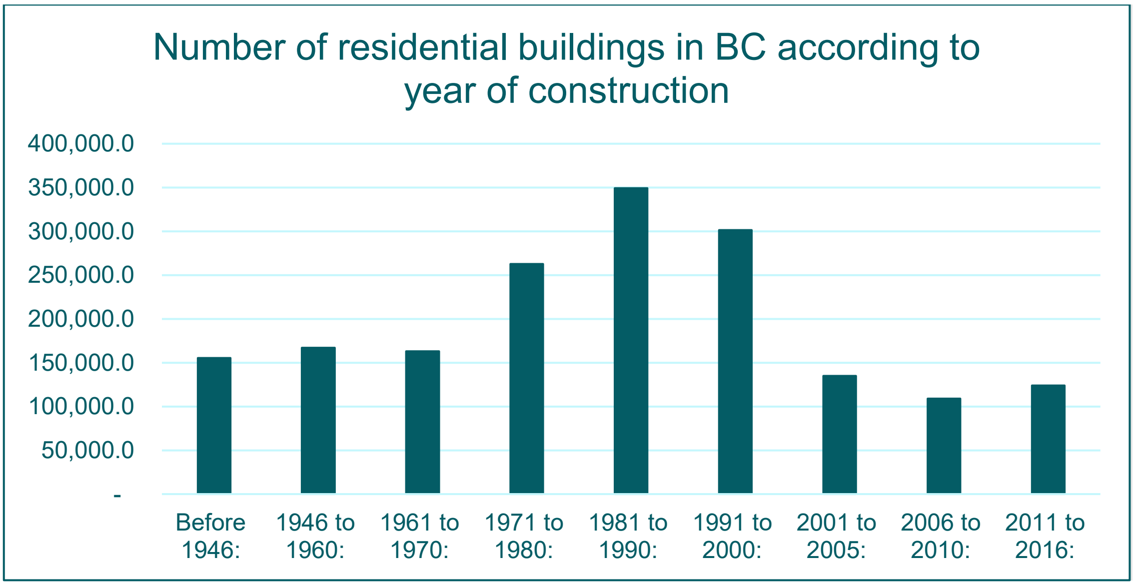


Figure 11: Number of residential buildings in British Columbia, Source: 2016 Canadian Census

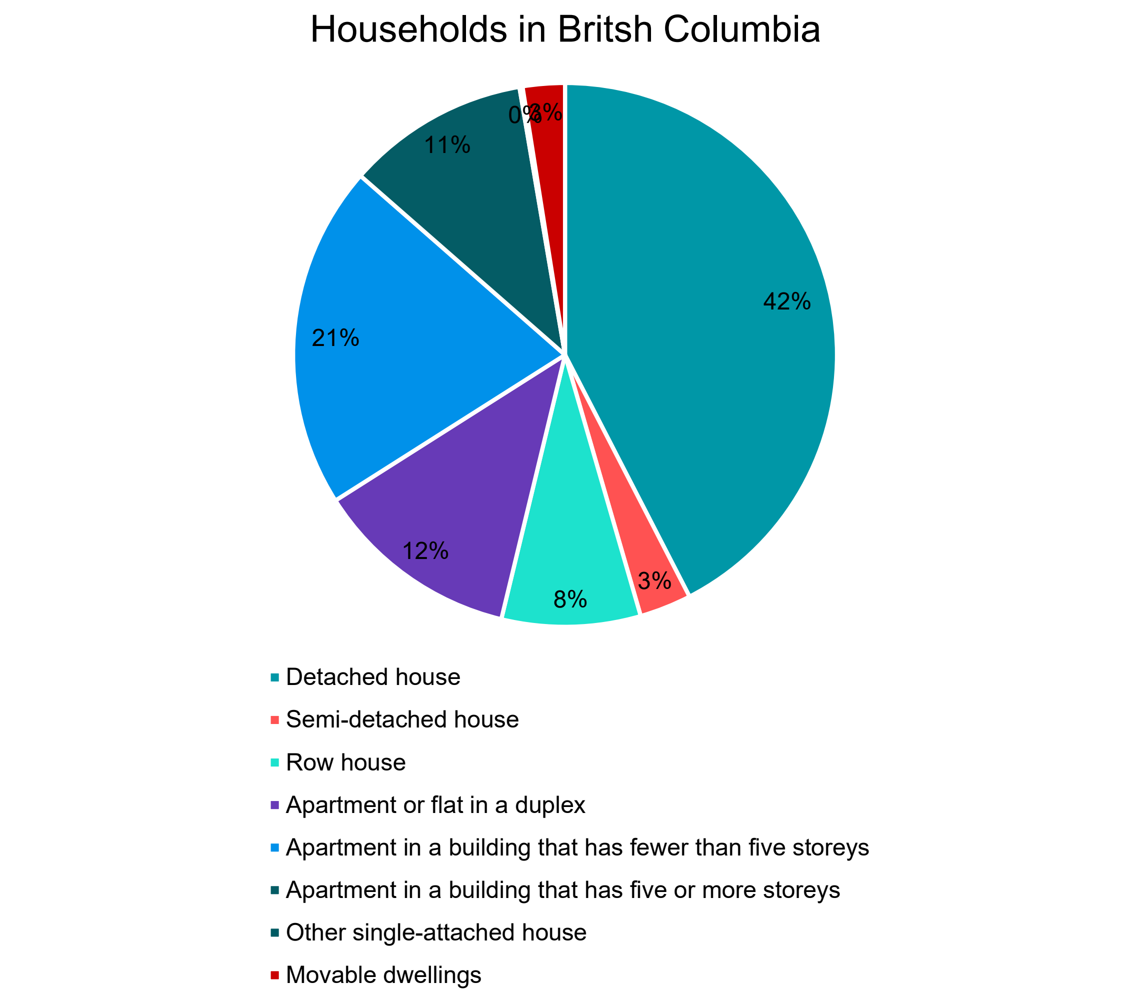


Figure 12 Split of households in British Columbia, Source: StatCan[15].

4.6 Challenges in the building sector in British Columbia

A large amount of the dwellings in British Columbia are built in the period 1984 to 1995, many of these buildings are multi-family buildings, which have been built very quickly and with low levels of insulation, resulting in a relatively high energy consumption. Older buildings often have a high energy consumption and may also be more difficult to renovate. A very big challenge is the problems with moisture and mold in buildings from the 80'ties and 90'ties with low level of insulation in the building envelope.

The level of awareness about the benefits of electrification and other low and zero emissions building options is generally low. For example, many people are not aware that natural gas is responsible for almost all of the greenhouse gas emissions that come from buildings. Nor are they aware of the climate, health and resiliency benefits associated with high-efficiency electric heat pumps. Often the zero emissions and resiliency solutions for any new or existing building are hidden inside and behind the walls. A huge opportunity exists to amplify the benefits and success stories of zero emissions buildings.

Other challenges are:

[15] https://www12.statcan.gc.ca/census-recensement/2021/dp-pd/prof/details/page.cfm?Lang=E&SearchText=British%20Columbia&DGUIDlist=2021A000259&GENDERlist=1,2,3&STATISTIClist=1&HEADERlist=0#Note4

- Old and inefficient heating installations with no controls or thermostats
- Lack of insulation in walls and roofs, or low performance insulation
- Single pane windows
- Old lighting installations
- Bad indoor air quality
- Low occupant comfort (indoor air climate focus)

In a report from the Vancouver Economic Commission in 2019 the market for high-performance building materials and equipment in new construction from 2021 to 2032 is estimated to be in the order of $ 3.3 Billion (CAD) split into:

- Fenestration products
- Insulation product
- Heat recovery ventilators (HRV)
- HVAC and Heat pumps
- Domestic hot water

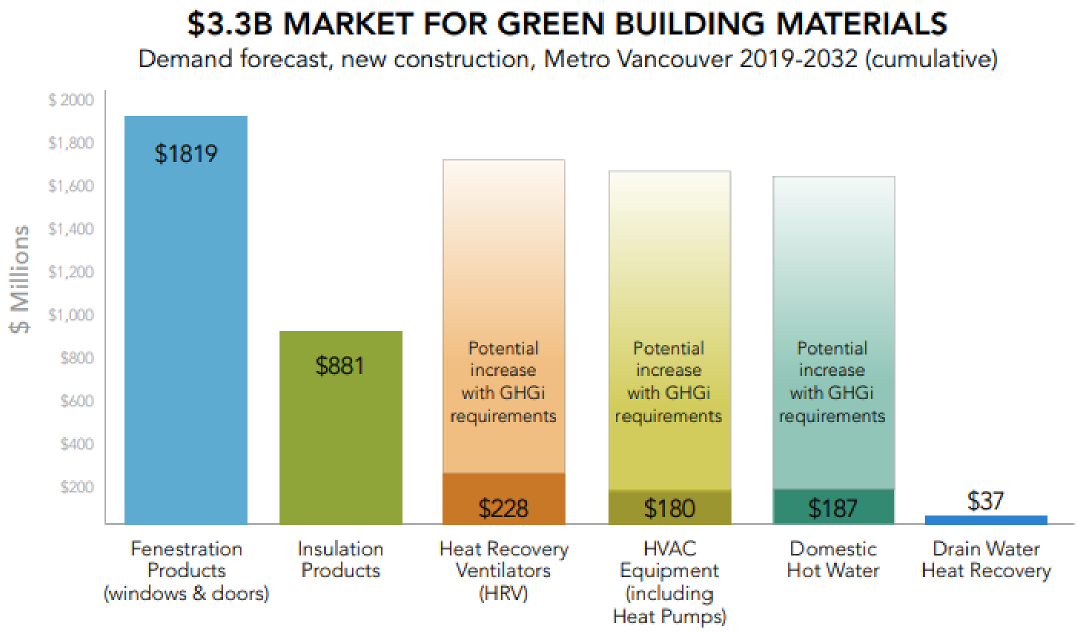


Figure 13 Market potential for renovation in Metro Vancouver

4.7 The building code in BC:

British Columbia must follow the National Energy Code for Buildings (NECB). A consortium of provinces, utilities, industry stakeholders, the National Research Council of Canada (NRC) and Natural Resources Canada developed the first Model National Energy Code for Buildings (MNECB) in 1997. It was Canada's first national standard for building energy performance. In 2011, the MNECB was updated and renamed the National Energy Code for Buildings (NECB) for consistency with other model national construction codes including an average 25% performance improvement over its predecessor. This edition established minimum energy efficiency requirements for buildings and aimed to reduce energy consumption and greenhouse gas emissions from buildings. The 2011 NECB was the first NECB code to include mandatory energy requirements. The NECB was updated in 2015 and again in 2017. The NECB outlines the minimum energy efficiency levels for all new buildings and offers more flexibility for achieving code compliance. The 2017 edition did not include mandatory energy requirements, but it provided recommended energy performance targets for buildings.

The National Energy Code of Canada for Buildings (NECB) sets out prescriptive and performance-based requirements for building envelope, lighting, heating, ventilation, and air conditioning systems, as well as renewable energy and energy recovery systems. The NECB is updated every five years to reflect changes in technology, energy prices, and other factors that affect building energy use and performance.

The NECB focuses on five key building elements typically considered during design:

1. **Building envelope** - Includes walls, windows, doors and roofing, and addresses air infiltration rates. Also includes thermal transmission through building materials (ie thermal bridging).
2. **Lighting** - Measures such as reducing lighting power densities, using lighting controls and making effective use of available daylight are included.
3. **Heating, ventilating and air conditioning systems** - Includes heat recovery ventilation, pipe and duct insulation to reduce energy waste. Also includes building automation and control systems to monitor and optimize equipment operation.
4. **Service water heating** – is the heated water used in a building. It includes requirements to limit water flow rates, maximize waste-water heat recovery and sets minimum performance standards for service water heating equipment.
5. **Electrical power systems and motors** - Establishes requirements for monitoring energy use of electrical distribution systems, sets limits on the size of conductors so as to minimize voltage drop, and establishes standards to govern the selection of transformers and electrical motors.

The national building code was revised again in 2021. Currently only a handful of the provinces have adopted the 2021 version of the national building code, and instead use earlier versions of the code. The provinces are not obliged to follow the national code, as they can create their own provincial codes.

Local governments are allowed to implement stricter rules and regulations regarding their building standards and the province of British Columbia has introduced a system with five voluntary levels. In addition, the City of Vancouver has implement its own building code through legislation developed with the province. In addition, in BC's largest urban area, Metro Vancouver, there are also additional delegated powers. For example in Metro Vancouver specific restrictions exist related to air quality, that are likely to be used in the future to regulate emissions from buildings, in addition to existing city and provincial policy.

Net Zero Energy Ready (NZER):

Canada has decided that all new residential buildings shall be NZER (Net Zero Energy Ready) by 2030. Net Zero Energy Ready (NZER) is a method of design and construction that aims to achieve an energy efficient, grid-connected building, enabled to generate energy from renewable sources to compensate for its own energy demand. As a result, these types of buildings boast a net zero energy consumption. A net zero energy consumption means the total energy used by the building on an annualized basis is equal to the amount of renewable energy created on the site or at a nearby location.

NZER buildings are optimized to use passive solar heat gain and shading, combined with thermal mass, to stabilize temperature variations throughout the day. They include a wide variety of energy efficiency measures - some highly complex and others quite simple - such as high efficiency heating and cooling equipment, appliances, windows and doors, as well as high levels of insulation in the walls, roofs and floors, use of natural ventilation, air sealing and more advanced renewable energy solutions such as solar photovoltaics and geothermal energy systems.

Ensuring buildings are not only designed to NZER, but also perform to NZER standards will require post-construction reporting and analysis and a framework for oversight and enforcement. It will require measurement of actual energy use. However, today's codes and standards are based on calculated figures for energy consumption with no requirement to actually quantify or prove the result. To reach the goal of net-zero energy buildings, it is necessary that modeling capabilities improve, and that the actual outcomes are measured.

The most cost-effective time to incorporate energy efficiency measures into a building is during the initial design and planning phase. It is significantly more expensive to retrofit or include energy efficiency measures later, especially during detailed design or construction. This is particularly true for upgrades to the building envelope. The use and application of the strict building codes from the onset of a design is an effective way to achieve long lasting energy savings, without retroactively needing to make changes to the design.

The BC Building Code is a provincial regulation on how new construction, building alterations, repairs and demolitions are done. This code sets minimum requirements for safety, health, accessibility, fire and structural protection of buildings and energy and water efficiency.

Buildings shall be designed and constructed to conform to either:

a) ANSI/ASHRAE/IES 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings" (except Subsection 8.4.2.),

b) The NECB (National Energy Code of Canada for Buildings), or

c) The Building Code of British Columbia Subsection 10.2.

The **ANSI/ASHRAE/IES 90.1** is a widely recognized energy standard for buildings in the United States that provides minimum requirements for the design and construction of energy-efficient buildings. It covers a broad range of building types, including commercial, institutional, and high-rise residential buildings. The standard sets out requirements for building envelope, lighting, heating, ventilation, and air conditioning systems, as well as renewable energy and energy recovery systems. The Canadian version of the standard is known as ASHRAE 90.1-2010 (I-P edition).

The **NECB** (National Energy Code of Canada for Buildings) is described in the previous chapter.

Subsection 10.2 of the Building Code of BC is a specific section of the British Columbia Building Code that addresses energy efficiency requirements in buildings.

The energy requirements in the building code in British Columbia, Canada have evolved over time to address the need for more energy-efficient buildings. Here is a brief historic overview of the energy requirements in the building code in British Columbia:

- *1989 Building Code:* The first energy code was introduced in 1989. It required buildings to have a minimum thermal resistance (R-value) for the building envelope, which varied depending on the climate zone.
- *1998 Building Code:* The 1998 Building Code introduced prescriptive energy requirements that were based on the building envelope and the mechanical system. It also included a voluntary energy efficiency compliance option, which allowed builders to exceed the prescriptive requirements by using energy modelling.

- *2006 Building Code:* The 2006 Building Code introduced mandatory energy efficiency requirements for buildings, which were based on energy modelling. The code included the option for builders to use the prescriptive requirements instead of energy modelling, but the prescriptive requirements were more stringent than in previous versions.
- *2012 Building Code:* The 2012 Building Code increased the stringency of the energy efficiency requirements for buildings. It also introduced new requirements for lighting, heating, ventilation, and air conditioning systems.
- *2018 Building Code:* The most recent update to the Building Code in British Columbia came in 2018. The code requires all new buildings to be designed to be net-zero energy ready by 2032. This means that new buildings will need to have a high level of energy efficiency and be designed to be easily upgraded to net-zero energy use in the future. The 2018 Building Code marks a significant step forward in the province's efforts to promote sustainable and energy-efficient building practices.
- *2023 Building code changes to support B.C.'s zero-carbon targets* New changes to the Province's building code will ensure cleaner, more efficient buildings are built in line with B.C.'s commitment to zero-carbon new construction by 2030 to meet the CleanBC 2030 goals. Effective from May 1, 2023, the BC Building Code will require 20% better energy efficiency for most new buildings throughout the province. The Zero Carbon Step Code provides tools for local governments to encourage or require lower emissions in new buildings. Together, the changes meet commitments in the CleanBC Roadmap to 2030 to gradually lower emissions from buildings until all new buildings are zero carbon by 2030 and are net-zero energy ready by 2032. The higher energy-efficiency requirements are a progression of the BC Energy Step Code, introduced in 2018, which local governments can use to encourage or require energy efficiency that goes beyond the requirements of the BC Building Code. The BC Energy Step Code enhances energy efficiency in new construction, while the Zero Carbon Step Code focuses on emissions reductions from new construction.
  Quick Facts:
  - *The Zero Carbon Step Code is a voluntary, provincial standard for reducing emissions in new buildings.*
  - *Local governments reference the Zero Carbon Step Code in bylaws and programs to require or encourage lower carbon new construction in their communities.*
  - *The BC Energy Step Code is a mandatory energy-efficiency requirement in the BC Building Code for most new buildings.*
  - *Local governments can still encourage or require a level of energy-efficiency in new construction that goes above and beyond the minimum energy-efficiency step required in the BC Building Code.*
  - *Zero carbon refers to carbon dioxide (CO2) emissions, while a "net-zero energy-ready" building is a site that uses 80% less energy than typical new construction.*
  - *Using less energy reduces the cost of energy bills and reduces a building's effect on climate change.*
  - *It also reduces energy demand, which reduces the need for utility providers to expand their generation capacity.*

Designers and builders have had the option to use either a prescriptive or a performance-based approaches to comply with the code's efficiency requirements.

The prescriptive energy requirements in the building code for British Columbia depend on the type of building and the climate zone in which it is located and contains requirement within these topics:

Building Envelope: The building envelope must meet minimum thermal resistance (R-value) requirements for walls, roofs, and foundations based on the climate zone.

Windows: The maximum allowable window area is limited based on the orientation of the building and the climate zone. Windows must also have a minimum thermal resistance (R-value) and be double paned.

Mechanical Systems: Mechanical systems, including heating, cooling, and ventilation, must meet minimum efficiency requirements. For example, air conditioning systems must have a minimum Seasonal Energy Efficiency Ratio (SEER) and heating systems must have a minimum Annual Fuel Utilization Efficiency (AFUE).

Lighting: Lighting systems must meet minimum efficacy requirements, which measure the amount of light output per watt of energy input.

Renewable Energy Systems: The building code encourages the use of renewable energy systems, such as solar panels, through incentives and requirements.

Commissioning: The building must undergo a commissioning process to ensure that all systems are installed and functioning as designed.

Climate Zones: British Columbia has five climate zones. For comparison with Denmark where there is only one climate zone (3000 heating degree days), this analysis will therefore look at the British Columbia Climate Zone 4 (Heating degree-days between 3,000-4,999) which includes regions such as Prince George, Williams Lake, and parts of the Cariboo and Northern Rockies.

The specific values for the minimum thermal resistance (R-value) requirements in Climate Zone 4 in British Columbia for the building envelope are as follows:

Building element	**R-value, ft^2 x F x hr/Btu**	**U-value W/m^2K**
Walls:	R-22.2 to R-32.9, depending on the type of wall construction (e.g. wood frame, masonry)	0.15-0.17
Roof:	R-32.1 to R-49.0, depending on the type of roof construction (e.g. flat, sloped)	0,12-0.18
Foundation:	R-12.9 to R-17.5, depending on the type of foundation construction (e.g. basement walls, slab-on-grade)	0,32-0.44

Table 1: Thermal resistance and U-values in the Buildings Code of British Columbia, climate zone 4. Source: https://free.bcpublications.ca/

These are minimum requirements, and builders can choose to exceed them if they wish to achieve a higher level of energy efficiency. Additionally, the specific values may vary depending on the size, location, and use of the building.

Overall, the energy requirements in the building code in British Columbia have become more stringent over time to promote energy efficiency and reduce greenhouse gas emissions.

To date, the vast majority of builders in British Columbia have pursued the prescriptive approach. It focuses on individual elements, rather than ensuring the overall energy efficiency of the building.

Builders have a second option to comply with the energy-efficiency requirements of the BC Building Code: the performance approach. The BC Energy Step Code offers a specific form of this approach. The performance approach establishes a desired outcome, and leaves it to the design and building team to decide how to achieve it.

4.8 The BC Step Code

In April 2017, the Province of British Columbia adopted the BC Energy Step Code as a series of amendments to the Building Act and the Local Government Act. Local governments may now use the standard, if they wish, to incentivize or require a level of energy efficiency in new construction that goes above and beyond the requirements of the BC Building Code. Builders may also adopt the standard voluntarily.

The standard consists of a series of steps, representing increasing levels of energy-efficiency performance as compared to a reference building. By adopting one or more steps of the standard, local governments and builders can increase building performance requirements in their communities. Local governments and builders may apply the BC Energy Step Code to new residential construction across the province. They may also apply the standard to multi-unit and commercial buildings in the Lower Mainland and on southern Vancouver Island. The Province of British Columbia has set a goal that all new buildings must reach a "net-zero energy ready" level of efficiency by 2032. The BC Energy Step Code serves as a policy pathway and technical roadmap to reach that target.

The Step Code is designed to help builders and designers construct buildings that are more energy-efficient than the minimum requirements set out in the British Columbia Building Code.

The Step Code consists of five steps, with each step representing a higher level of energy efficiency. Each step corresponds to a target energy performance level that must be achieved for a building to be considered compliant with that step. The targets for each step are based on metrics such as the building's energy use intensity (EUI) and greenhouse gas emissions. The Step Code encourages builders and designers to use a range of strategies to improve energy efficiency, such as better insulation, high-performance windows, and more efficient heating and cooling systems. While compliance with the Step Code is voluntary, many municipalities in British Columbia have adopted it as part of their building bylaws.

To comply with the BC Energy Step Code, builders must use energy software modelling and on-site testing to demonstrate that both their design and the constructed building meet the requirements of the standard. They may use any materials or construction methods to do so.

The regulation sets performance targets for new construction and groups them into "steps" that apply across various building types and regions of the province. The Lower Steps are relatively straightforward to meet; the Upper Steps are more ambitious.

All authorities having jurisdiction over the BC Building Code—including local governments—can choose to require or incentivize builders to meet one or more steps of the BC Energy Step Code as an alternative to the code's prescriptive requirements.

For governments, the BC Energy Step Code offers assurance that new buildings are performing as planned. Meanwhile, for industry, builders and designers have a more flexible option to comply with the energy-efficiency provisions of the provincial legislation. The new standard empowers builders and designers to pursue innovative, creative, cost-effective solutions—and allows them to incorporate leading-edge technologies as they come available.

Local governments can choose to require or incentivize a given step of the BC Energy Step Code in new construction. In addition, beyond the regulatory context; builders, designers and developers can adopt a given step to use across all of their projects, if they wish.

Danish Energy Agency

VANCOUVER ECONOMIC COMMISSION

For Small Residential Buildings ("Part 9") the Steps of the Code Work as Follows

- **Step 1**: Step 1 is often referred to as "enhanced compliance", because it simply requires builders to demonstrate that they have achieved the energy-efficiency requirements of the existing BC Building Code. In a Step 1 project, builders must supply officials with an energy model to demonstrate that their design will meet the code requirements. Upon substantial completion, a builder must also submit the results of an airtightness test. The builder would ideally do so before installing drywall or other interior surfaces, to allow opportunities to address leaks.

- **Step 2:** Builders can achieve Step 2 using conventional practices and widely available materials. However, they will need to improve the building's overall airtightness and use additional measures. For example, they should:
    - Design for a lower overall window-to-wall ratio (e.g. 40% WWR)
    - Require higher building R-values (e.g. minimum effective R-10 for walls and effective R-20 for roofs)
    - Improve window performance (e.g. double- and triple-glazed windows with higher U-values)
    - Improve heat-recovery efficiency (e.g. 60%)

- **Step 3:** To comply with the requirements of Step 3, designers will use many of the Step 2 strategies noted here. However, they will also begin to take a more integrated approach. To reach Step 3, they might also: consider sealing off individual building units and uses from one another to improve airtightness, a practice known as compartmentalization
    - Consider sealing off individual building units and uses from one another to improve airtightness, a practice known as compartmentalization
    - Reduce thermal bridging

- **Step 4:** Designers wishing to achieve Step 4's more rigorous energy efficiency and airtightness requirements will need to reconsider multiple practices and systems. Although they can achieve this level of performance using wall systems applicable to the Lower Steps, they will want to consider the building envelope first. Designers should look to the strategies we suggest for Step 3 and also:
    - Specify very high levels of heat recovery efficiency (e.g. at least 80%)
    - Source triple-glazed windows with high performance frames and reduce frame elements Eliminate all significant thermal bridges

The diagrams below show what the performance improvements look like for simple buildings (those covered under Part 9 of the BC Building Code) and more complex buildings (covered by Part 3 of the code). The first diagram outlines five steps from the current BC Building Code requirements to net-zero energy ready requirements for Part 9 residential buildings. As shown in the second diagram, the same progression for Part 3, wood-frame residential buildings is four steps.

Figure 14: Overview of the step codes for homes and wood-frame residential, Source: https://energystepcode.ca/how-it-works/

The BC Energy Step Code is currently a voluntary provincial code. It does so by establishing a series of measurable, performance-based energy-efficiency requirements for construction that builders can choose to build to, and communities may voluntarily choose to adopt in bylaws and policies.

Over time, as high-performance designs, materials, and systems become increasingly available and cost-effective, the building industry will integrate new techniques into all new buildings. By 2032, the BC Building Code will move toward the highest steps of the BC Energy Step Code as a minimum requirement. The National Building Code of Canada is similarly moving towards this outcome by 2030.

In the future, new homes will need to be built better than the current BC Building Code:

- 20 per cent more energy efficient by 2022
- 40 per cent more energy efficient by 2027
- 80 per cent more energy efficient by 2032 which is the net-zero energy ready standard

In the step code, the following terms are used:
1) **"total energy use intensity"** meaning total energy used over a year by the building, estimated by using an energy model, per square meter of floor area of conditioned space and expressed in kWh/m^2 per year, for all of the following areas:

1. Space-heating equipment,
2. Space-cooling equipment,
3. Fans,
4. Interior and exterior lighting devices,
5. Service water-heating equipment,
6. Pumps,
7. Auxiliary HVAC equipment (see A-9.36.6.2.(1)(f) in Appendix A),
8. Receptacle loads and miscellaneous equipment,
9. Appliances, and
10. Elevators and escalators.

2) "**Thermal energy demand intensity"**, which is the annual heating required by the building for space conditioning and for conditioning of ventilation air, estimated by using an energy model normalized per square meter of floor area of conditioned space and expressed in kWh/m^2 per year, taking into account all of the following:

1. Thermal transmittance of above-ground walls and roof-ceiling assemblies,
2. Thermal transmittance of floors and walls in contact with the ground, or space that is not conditioned space,
3. Thermal transmittance and solar heat gain of windows, doors and skylights,
4. Air leakage through the air barrier system,
5. Internal heat gains from occupants and equipment, and
6. Heat recovery from exhaust ventilation

The code is also valid for existing buildings, when a home or building is altered, rehabilitated or renovated or if there is a change in the occupancy, the energy performance of the alteration shall comply with the energy requirements in the building code.

4.9 Barriers for implementing the step code:

Construction costs: Increased construction costs.

Training of local staff: Local government staff and builders will need to be trained on new practices.

Design of buildings: While it is possible to build homes and high-rise buildings to meet the Upper Steps, designers must pay special attention to the amount and location of window glazing and the design of balconies, to mitigate heat loss as much as possible. The added costs associated with implementing these changes may, in practice, result in less glazing in some buildings.

Compliance: Energy efficiency may have low priority at municipal level compared to other initiatives. There is generally not so much focus on the benefits of building codes, as there is more focus on the other areas of compliance (safety, fire, health, accessibility and environment).

Knowledge: It is difficult and time consuming to show compliance with the energy requirements in the building code. There is a potential for making it easier to show compliance with the code. The building owners and the developers generally have low knowledge about the energy requirements and the requirements for documentation.

Economic barriers: Many developers believe that it is expensive to use energy simulation tools and energy consultants during the building process, but if energy requirements are implemented early in the process, this is often not the case. There is generally a lot of mistrust about the benefit of energy codes.

Capacity buildings: There is a need for capacity building on building codes, some of the subjects that are required are:

- Energy and non-energy benefits from using building codes
- Need for energy compliance guide
- Stakeholder training for planners and builders
- Certification scheme for people making building performance models

1.1 Energy labelling, energy benchmarking, EPCs

British Columbia is using the Energy Star rating system that rates the energy efficiency of buildings. The program requires commercial and multi-unit residential buildings to disclose their energy performance at the time of sale or lease. This is intended to encourage energy-efficient building design and to help building owners identify opportunities for energy savings.

The energy label provides information on the building's energy use intensity (EUI) and greenhouse gas emissions. This information can be used to compare buildings and to identify areas for improvement. The label also provides a benchmark for energy performance that can be used to track improvements over time.

The program is voluntary for residential buildings and mandatory for commercial and multi-unit residential buildings that are over 10,000 square feet. The program is administered by the BC Ministry of Energy, Mines and Low Carbon Innovation.

Overall, the building energy labeling program in British Columbia is an important tool for promoting energy efficiency and reducing greenhouse gas emissions in the built environment.

4.10 The City of Vancouver

The City of Vancouver, which, as a charter municipality, controls its own building code, plans to transition to zero emissions buildings in all new construction by 2030. To achieve this, the city is setting limits on emissions and energy use in new buildings, and will reduce these limits over time.

The targets are:

- Carbon pollution from buildings will be half what it was in 2007 by 2030
- There will be 40% less embodied emissions from new buildings and construction projects compared to 2018 by 2030

In 2016, the city produced a Zero Emission Building Plan (ZEBP)[16]. The plan establishes specific targets and actions to achieve zero emissions in all new buildings by 2030. The plan does not focus on retrofitting buildings. The plan lays out four action strategies to require the majority of

[16] https://vancouver.ca/files/cov/zero-emissions-building-plan.pdf

new buildings in Vancouver to have no operational greenhouse gas emissions by 2025 and that all new buildings have no greenhouse gas emissions by 2030.

More recently, the Climate Emergency Action Plan (CEAP), lays out four strategies to enhance and advance the ZEBP, including existing buildings. These four strategies include:

1. ***Limits:*** establish GHG and thermal energy limits by building type and step these down over time to zero.
2. ***Leadership:*** require City-led building projects to demonstrate zero emission building approaches where viable
3. ***Catalyze:*** develop tools to catalyze leading private builders and developers to demonstrate effective approaches to zero emission new buildings; and
4. ***Capacity Building:*** build industry capacity through information sharing tools and the development of a Centre of Excellence for Zero Emissions Building to facilitate the removal of barriers, the sharing of knowledge, and the development of the skills required to successfully achieve this goal.

If all buildings are to use only renewable energy by 2050, the sooner new buildings achieve near zero emissions, the fewer buildings there will be that require costly and challenging deep energy retrofits to achieve the target.

New Construction

The City of Vancouver has authority over its own building code, and has instituted its own step code-like provisions described in the Zero Emissions Building Plan (ZEBP). In addition to setting targets for TEUI and TEDI, the ZEBP sets thresholds for performance in greenhouse gas intensity (GHGI). GHGI is a measure of the emissions intensity of a building's emissions, measured and expressed in tons or kilograms of carbon dioxide equivalent per unit area over the course of a year (kg CO_2/m^2/year).

The addition of a GHGI threshold requires building designers to consider not only the quantity of energy that a building will demand, but the source of that energy. As such, the selection of mechanical strategies is of central importance to the achievement of GHGI performance targets in the City of Vancouver's ZEBP. One of the easiest ways to achieve the GHGI targets in the ZEBP is to select a mechanical system that runs on the low-carbon electricity available in British Columbia. Heat pumps and electric resistance (e.g. baseboards) heating systems are readily available systems that can provide heat cost effectively, while reducing emissions. In some cases, buildings can also connect to a low-carbon district energy system. Conversely, the selection of mechanical strategies that rely on energy sources with higher carbon intensities will render the achievement of GHGI targets more difficult. Due to their higher emissions intensity, designs that incorporate natural gas-based systems may not be able to meet the City of Vancouver's GHGI targets. While natural gas can still be used when necessary (e.g. for hot water heating), designers looking to lower GHGI should try to minimize the combustion of natural gas in the building wherever possible.

The design strategies necessary to meet the Step Code (p. 25) are also applicable to designers seeking compliance with the City of Vancouver's Zero Emission Building Plan (ZEBP)

New development in Vancouver is predominantly residential with 82% of new building area being for houses, condominiums and apartments. Mid and high-rise multi-unit residential buildings (over 6 stories in height) are the second most significant form representing 29% of new building area.

Existing Buildings

Because almost 100% of Vancouver's electricity is already decarbonized, there is a significant focus on shifting the heating systems in existing buildings, which are almost entirely powered by gas (which represents 57% of all emissions in Vancouver).[17] Furthermore, because many of the buildings in Vancouver are smaller (see Figure 15), there are many challenges in decarbonizing these homes in a cost-effective way.

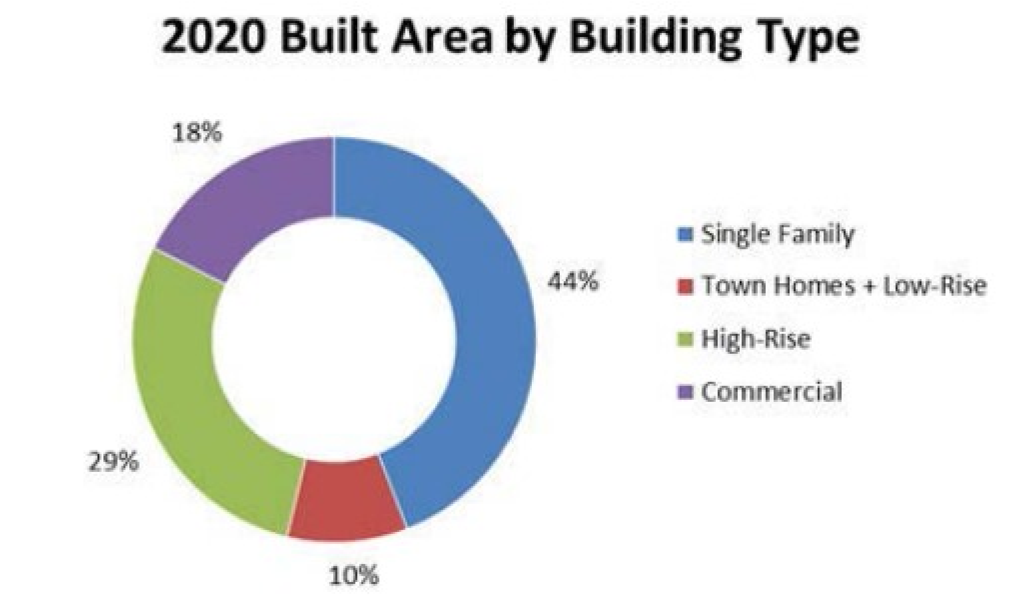


Figure 15: Buildings in Vancouver, Source: Zero Emissions Building Plan, 2016

CEAP enhances prior building work by creating the Zero Emissions Building Plan for Retrofits (ZEB-R), and focuses on four areas of work in retrofitting buildings:

1. Set carbon pollution limits for existing buildings and streamline energy efficiency regulations
2. Support early owner action
3. Build industry capacity
4. Facilitate access to renewable energy

As they note in the 2022 Council Report: "The City is already demonstrating leadership and reducing emissions from its own existing buildings in advance of regulations on private buildings in Vancouver. Where feasible, heating and hot water equipment is being replaced with heat pumps in existing City facilities. City owned buildings have reduced their emissions 37% since 2007 and are on-track to achieve a 60% reduction by 2030."[18]

The strongest area of focus out of the ZEB-R has been on large buildings, where, based on a Council-approved report in 2022, the City is proceeding with:

- Setting greenhouse gas intensity (GHGi) limits for large existing buildings larger than 9,290 m^2
- Setting heating energy lmits (by 2040) of 0.09 gigajoules of energy equivalent oer square meter of gross floor area per year ($GJ/m^2/year$)
- Decarbonizing existing district energy systems

[17] City of Vancouver. Council Report: "Annual Carbon Pollution Limits for Existing Large Commercial and Multifamily Buildings." (May 17, 2022) Accessed from: https://council.vancouver.ca/20220517/documents/R1c.pdf
[18] Ibid

- Energy and carbon reporting
- Creating commercial building owner supports

From 2023 onwards, Council has approved the broad consideration of a regulatory roadmap on existing buildings, which, while still under development, has been conceptualized as outlined in the following table.

Phase	Details
2022-2024	• Analysis and stakeholder consultation on performance and prescriptive regulations • Launching of initial Multifamily owner supports and Multifamily/Commercial demonstration programs • Recommendations for 2026 – 2040 brought to Council
2026	• Time-of-Replacement Requirements come into effect for select, secondary and amenity heating equipment, e.g.: o Pools o Fireplaces and decorative gas appliances o Rooftop heating units o Make-up-air units • Sub-metering requirements for major heating and hot water equipment
2030	• Updated GHGi for Office and Retail > 9,290 m^2
2030	• GHGi Limit effective for: o Office & Retail > 4,645 m2 o Hotels > 4,645 m2 o Assembly > 32,500 m2 o Other Commercial building types > 4,645 m2 (to-bedetermined) o Multifamily buildings > 9,290 m2
2030 - 2032	• Phased Deadlines for Equipment Replacement of select secondary heating equipment, potentially including: o Rooftop heating units o Make-up-air units o Pools o Fireplaces and decorative gas appliances
2040 - 2050	• GHGi limits for Commercial and Multifamily Buildings > 4,645 m2 (all uses): 0 kg CO2e/m2 /year • Heat Energy Limit for additional commercial building types

5. CONCLUSIONS

Both Denmark and British Columbia have set ambitious targets for decarbonization of the building sector and as described here there is a possibility for both jurisdictions to be inspired by and support one another.

From this analysis, it appears BC and Denmark may have many opportunities to learn from each other on reducing both operational and embodied carbon in the built environments.

In spite of the differences between the two jurisdictions, the analysis has also found these areas where there are potential for further development and inspiration:

- There is an ongoing need for strengthening building codes for new and existing buildings
- The largest potential for energy savings is for existing buildings constructed before energy requirements were included in the building codes.
- Energy Performance Certificates can assists the green transition if they are easy to use.
- Funding is needed to motivate building owners to make energy upgrades on their buildings and homes
- Building owners need targeted support and information to renovate their buildings.
- There is a lack of knowledge and skills among installers, building owners, developers, architects and engineers on of energy efficient technologies and there is a general lack of qualified installers.
- There is a need for training and information about the non-energy benefits of improved buildings codes for all stakeholders in the building sector.
- Access to data and digital solutions will play an important role in the future.

6. ANNEXES

Annex 1: Overview of energy saving measures BC and Denmark

Measures	British Columbia	Denmark
Building code next step	BC Step code with five voluntary steps	Building code mandatory for new buildings and major renovations in existing buildings
Energy related research	The CleanBC Building Innovation Fund supports research, demonstration and development of low carbon building materials, construction methods and building components[19]	Research program EUPD, support the research and development of new energy technologies[20]
Funding for renovation	CleanBC Better Homes and Home Renovation Rebate Program	*Bygningspuljen* – Fund for thermal upgrade of buildings and replacement of heating installations
Energy related loans	CleanBC Better Homes Low-Interest Financing Program, no interest loans on replacement of heating installations to heat pumps	Energy loans from banks with low interest rate
Home rating system	As part of the Roadmap to 2030, B.C. will put tools in place to require home sales to include an energy efficiency rating or label	Energy Performance Certificates (EPC) have been mandatory when selling or renting out houses and buildings since 2006. The EPC is also the base for applying for funding
Information to homeowners	Better homes BC, https://www.betterhomesbc.ca/	*SparEnergi* https://sparenergi.dk/
Information to installers	ZEBx, the Home Performance Stakeholders Council [21]	Knowledge-center on energy efficient buildings https://byggeriogenergi.dk/om/kort-og-godt-om-videncentret/

[19] https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/energy-efficiency-conservation/programs/cleanbc-building-innovation-fund
[20] https://www.eudp.dk/en
[21] https://homeperformance.ca/

6.1 Annex 2: Energy requirements in the Danish Building code (2023)

Measure	Denmark
Building code with energy requirements	1979, first a prescription code, now a performance based code with voluntary steps. The performance code was introduced in 2006.
Requirements for R-value/U-Values:	
Walls	0.30 W/m2K
Roofs	0.20
Windows	1.2 W/m2K, A heat balance of 0.
Airtightness	1.5 l/s unless a blower door test is carried out, then the figure from the test can be used.
Thermal bridges	Documentation that they are reduced/avoided
Overall thermal Requirement	30 kWh/m2 for residential buildings, 41 kWh/m2 for non-residential buildings
Heating	Must be renewable (district heating or heat pumps)
Cooling	Must demonstrate that the demand for cooling is reduced by the use of sunscreens and blinds before cooling can be included.
Ventilation	Efficiency requirements for fans and motors, overall efficiency requirement for energy use per air volume, min. 80% energy recovery.
LCA calculation	LCA calculation introduced in building code from January 1 2023
Existing buildings	The building code is also valid for major renovations of existing buildings

7. REFERENCES

The Danish Building regulation: https://bygningsreglementet.dk/

Guide to the Danish Building regulation:

https://www.byggeriogenergi.dk/media/2202/danishbuildingregulations_2018_energy-requirements.pdf

Danish Energy Agency: Will a better energy label increase the sales price of a house?

https://ens.dk/sites/ens.dk/files/Energibesparelser/giver_en_god_energistandard_en_hoejere_boligpris_-_sammenfattende_rapport.pdf

Danish Building Institute SBI: calculation of energy demand for buildings:

https://sbi.dk/anvisninger/Pages/213-Bygningers-energibehov-6.aspx

One-stop-shop for house owners: https://sparenergi.dk/

Information platform for installers: https://www.byggeriogenergi.dk/

Information on the Canadian National building code: https://nrc.canada.ca/en/certifications-evaluations-standards/codes-canada/codes-canada-publications/national-building-code-canada-2015

https://www.efficiencycanada.org/what-you-need-to-know-about-the-new-building-codes/

https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/energy-efficiency-conservation

British Columbia Clean Energy Act:

https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/10022_01#part1

National building code of Canada (NEBC): https://nrc-publications.canada.ca/eng/view/ft/?id=515340b5-f4e0-4798-be69-692e4ec423e8

The BC step code:

http://www.energystepcode.ca/

https://free.bcpublications.ca/civix/content/public/bcbc2018/?xsl=/templates/browse.xsl&xsl=/templates/browse.xsl

https://www.bchousing.org/publications/BC-Energy-Step-Code-Design-Guide-Supplement.pdf

U-values requirements according to the building code of British Columbia:

https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and-standards/guides/climatezone4.pdf