

WHAT ARE THE TECHNICAL AND REGULATORY TOOLS TO ACHIEVE DECARBONIZATION OF THE CONSTRUCTION INDUSTRY IN CANADA?

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ABSTRACT: This article presents a systemic exploration and subsequent discussion of the diverse technical and regulatory measures implemented by the Canadian government to achieve its climate objectives. It also provides a framework detailing how cities are currently being constructed in Canada. The article seeks to elucidate the meaning of sustainable development for Canadian cities and territories, with a view to reducing their carbon footprint effectively. Furthermore, it evaluates the efficiency of current decarbonisation targets and examines existing solutions. Canada's regulatory framework is analyzed, highlighting the limitations and challenges the government encounters, while proposing viable solutions to attain the net-zero target by 2050. The article then delves into the two primary decarbonization frameworks applicable to the building sector: embodied and operational carbon. The study provides key performance indicators that have been achieved, alongside an analysis of the technical and economic challenges the sector faces, particularly concerning the embodied carbon. Finally, the study explores the potential of various existing certifications. The study assesses the scope of these certifications, the qualitative aspects of their implementation, and the experiential outcomes. This provides a comprehensive review of their effectiveness in advancing sustainability goals.

1. INTRODUCTION

According to the International Energy Agency (IEA), the global emissions of the construction sector account for 38% of the total worldwide emissions. Within the Canadian context, this figure is approximately 14%. Canada ratified the Paris Agreement in 2015 and committed to achieving carbon neutrality by 2050. However, the nation is confronted with considerable challenges in achieving its net-zero target and is grappling with a critical lodgement crisis. Indeed, as reported by the Canada Mortgage and Housing Corporation (CMHC), the need for 3.5 million new lodgements has been identified. In order to meet this target, it is essential that the country studies and understands which measures must be taken to ensure the provision of lodgements and the achievement of net-zero emissions. The present article is structured as follows: firstly, it provides a detailed overview of the challenges currently being faced by the country, including, but not limited to, the increasing square footage per capita and the intensification of condominium tower construction, both of which are known to increase the carbon footprint of the construction sector. We also explore the political challenges posed by the federal government and the various provinces, which have different realities and interests. We argue that articulating technological progress with a sense of construction is imperative for Canada to achieve its net zero targets. They contend that this approach, involving the integration of technological advancement and construction expertise, is more effective than relying solely on technical tools. The present study also seeks to provide a qualitative assessment of the certifications, examining their scope and the potential benefits they offer. While numerous certifications already exist, it is crucial to ascertain their alignment with the Paris Agreement. We conducted a qualitative exploration of these certifications, eschewing quantitative analysis due to the absence of a quantitative benchmark. The final objective was to assess the operational and embodied carbon, and to determine Canada's current achievements in this area. The exploration of potential economic and technical limitations, if applicable, is also undertaken.

2. NET ZERO MEANS FOR CANADIAN

For the United Nations (Nations, n.d.), the concept of net zero signifies that emissions are reduced to the greatest extent possible, with any residual emissions being offset by carbon sinks such as forests and oceans. Achieving this objective necessitates the integration of sustainable development into urban planning, ensuring that development, maintenance, and construction activities are as close to zero emissions as feasible. This objective necessitates the development of green areas or the utilization of biogenic materials to offset any residual emissions.

3. DIMENSION OF THE SPACE OCCUPATION AND SHARING

In the period between 2001 and 2021, the square metres occupied by inhabitants increased to 19 m² per person, reaching approximately 70 m² per person in Canada (Bélanger et al., 2005). In comparison, the United States is approximately 214 m² per person, France is around 45 m², and Japan 27 m².

This disparity can be attributed to the varying sizes of the countries in question, with the Canadian population likely occupying a greater proportion of the available space. However, from a physical perspective, this increase in space per person necessitates greater consumption of resources and energy. One potential solution to this problem could be the mutualization of spaces and facilities in buildings, such as kitchens, laundry facilities, and water management, thereby facilitating the development of co-housing.

As demonstrated in Figure 1 (Steenberg et al., 2023), the figure provides insight into the range of facilities and spaces that can be integrated. The figure delineates two distinct dimensions:

- Facilities such as local energy production and car sharing, which have the potential to curtail the carbon footprint of the transport sector while concomitantly mitigating urban traffic congestion.
- Shared spaces such as gardens and parking areas.

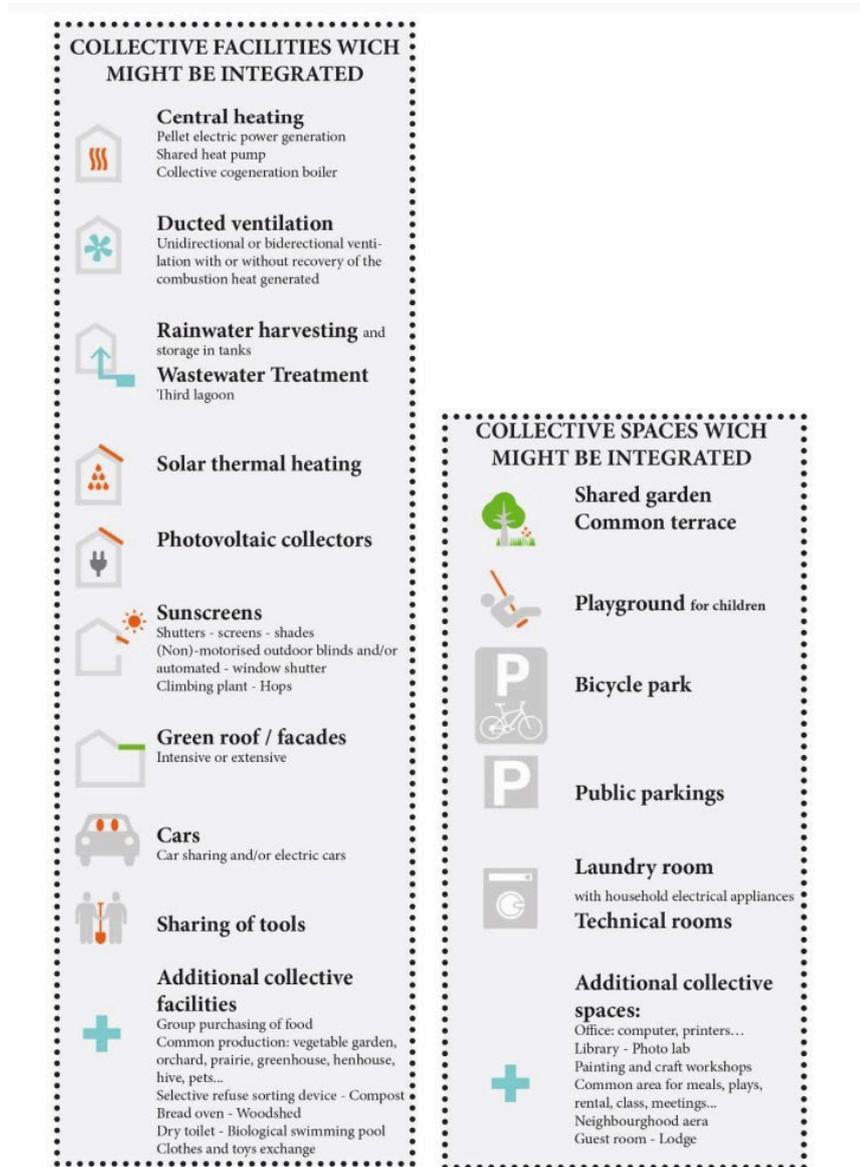


Figure 1 : Examples of collective facilities and spaces

Such measures have the potential to curtail the construction of additional square metres whilst concomitantly promoting the collaborative utilization of domestic appliances. This effect has been demonstrated to reduce operational carbon emissions for buildings. Furthermore, such measures have been demonstrated to play a pivotal role in mitigating social isolation, whilst concurrently addressing contemporary housing demands (Mengel & Reid Fairhurst, 2024). The study by (Stiernon & Massart, n.d.), examined the integration of mutualization in cohousing, but it was found that the initial cost was more expensive. Concomitantly, about the management of common areas, people must adhere to a set of rules and regulations that define the hierarchy amongst inhabitants.

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An inhabitant of the cohousing study declared that the common spaces have a financial price, but the benefit of usage is worthwhile (A resident of cohousing "L'Echappée", 2016)

A significant number of studies have recently examined the concept of sufficiency in the context of the building sector. In France, the ADEME concluded through an article (Gaspard et al., 2023) that in order to reach the net zero emissions, energetic efficacy will not be sufficient and should be complemented with sufficient measures such as reduced space and shared spaces. It is evident that a similar approach will need to be adopted in Canada. The authors of the study identified that 13 co-housing developments have been completed, with a further 20 currently in various stages of development in Canada.

4.ARCHITECTURE OF BUILDINGS AND PUBLIC CONSTRUCTIONS

An additional intriguing observation pertains to the architectural design and the utilization of space. Since the turn of the millennium, there has been a discernible trend towards the construction of tall buildings, particularly condominiums. These structures offer distinct advantages, including their capacity to provide accommodation for migrants in urban areas and their affordability.

As demonstrated in Figure 2, there has been a marked increase in condominiums since the year 2000. The purple line in Figure 2 represents the condominiums. These are typically constituted by tower apartments, which are distinguished by shared facilities such as swimming pools or gyms. The condominiums located in the rowhouses (illustrated in green) exhibited a growth trajectory, however, this trajectory underwent a decline around the year 2005, a development that may be attributed to heightened competition from the condominiums in the apartment sector. Finally, the duplexes (yellow) have remained relatively static since 1992.

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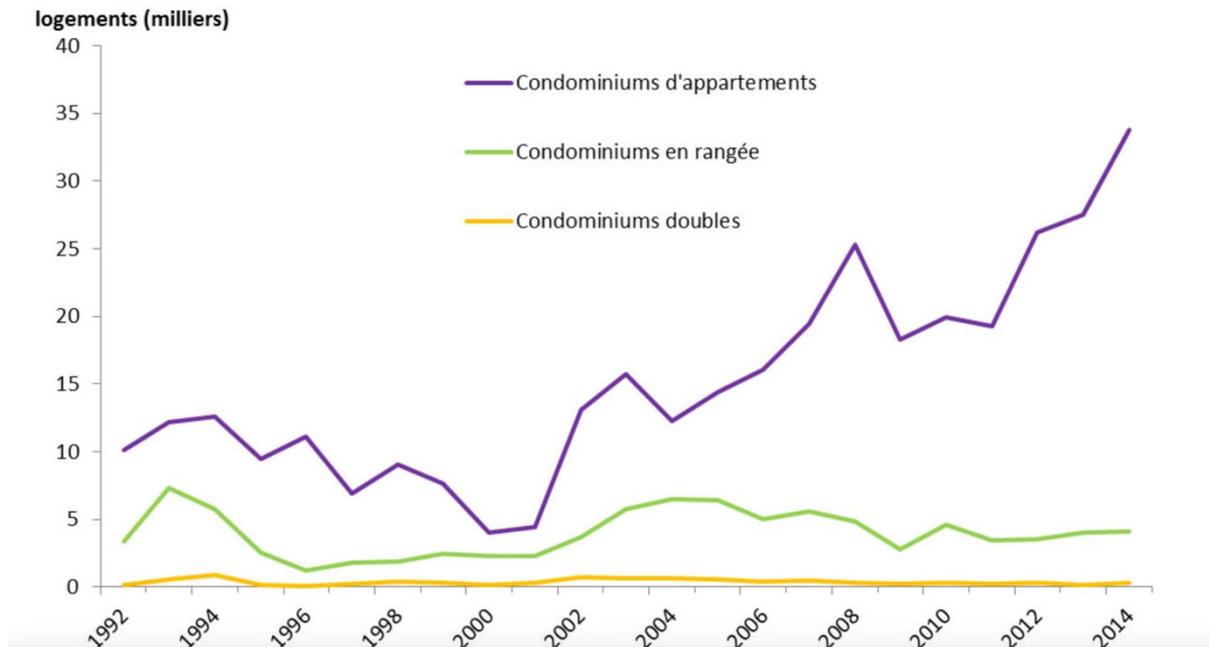


Figure 2: Constructions trend evolution in Canada established by the government

The construction of condominiums utilizes substantial resources, with a notable emphasis on concrete and steel for the foundation and structural framework of the building. The law of diminishing, as demonstrated in Figure 3, can be applied by returning the intensity of carbon per the CO₂eq.kg/inhabitants. To illustrate this point, consider a single family residing in a 150-square-metre residence; this would result in a higher carbon footprint per square metre and capita than a family inhabiting a four-level structure with 100 square metres per family. However, it is important to note that this family's carbon footprint would be amplified due to the embodied and operational carbon associated with a high-rise building. Concurrently, the reduction of embodied carbon in construction towers can present technical challenges. In the event of the utilization of timber or certain co-products in concrete construction, the employment of alternative materials, such as different types of mud, becomes unfeasible due to the presence of mechanical charges. Finally, the option that could be the best one of the carbon balances and usages of the space could be an architecture of 2-3 floors with using the less concrete and steel by shifting for bio and geo sourcing materials. It is imperative that Canada's first conducts a thorough examination of the potential offered by natural resources, with a view to utilizing these materials within the context of climate change, which has the capacity to impact resource stocks. The acceptance of the society should also be studying and accepted. The maintenance of public infrastructure has the potential to be energy-consuming. (Mollaei et al., 2021) conducted a case study that could be readily applied to all Canadian cities, demonstrating that an increasing demand for resources, particularly concrete and aggregates, is inevitable. The study revealed that roads and pavements accounted for 44% of demand, and only 5% of recycled materials were utilized between 2013 and 2018, despite the fact that 75% of demand could have been met by recycled materials. This disparity can be attributed to the regulatory framework governing urban infrastructure development. The various scientific evidence indicates that the use of recycled aggregates in pavement and sidewalk construction is both feasible and beneficial.

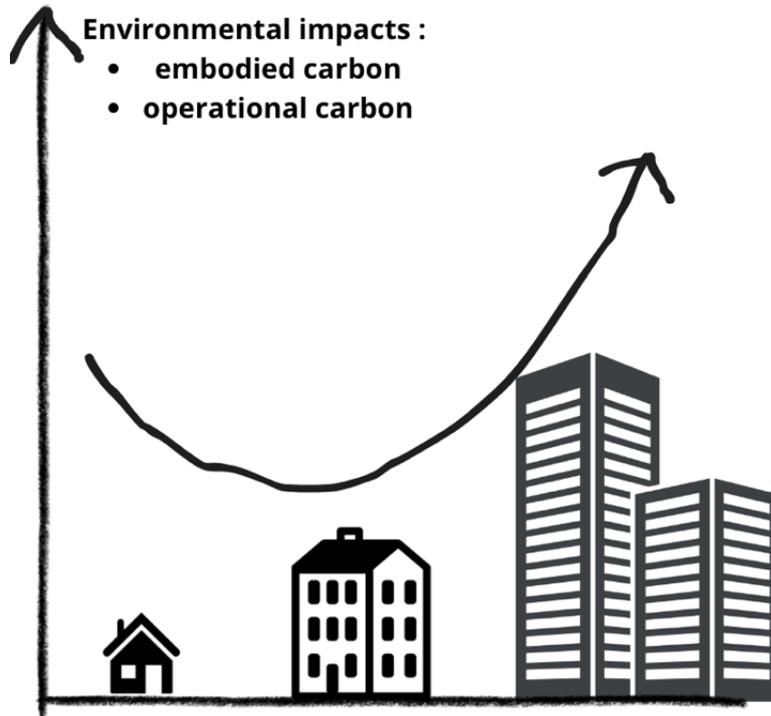


Figure 3 : Law of diminishing returns on carbon construction and usage

5 GENERAL FRAMEWORK OF DECARBONIZATION CONSTRUCTION IN CANADA, POINT VIEWS AND RUPTURE IF THE DIFFERENT PROVINCES.

It is imperative to comprehend the regulatory framework that governs Canada. This framework is characterized by a multi-level structure, involving various dimensions such as structures, resources, and capacities, which in turn give rise to different trajectories (Hasan, 2024). The constitutional resources are allocated between the federal government and the provinces through the Canadian Constitutional Act (Hasan, 2024).

The Pan-Canadian Framework on Clean Growth and Climate Change (PCF), endorsed by all provinces except Saskatchewan, was published during the Paris Agreement, and has approached decarbonization by three main regulatory instruments: equipment efficiency standards, building codes, and building performance standards (Hasan, 2024).

A review of the framework has been undertaken for the year 2022, and the following three key aspects have been identified:

1. Acting on the new construction by adding the Net zero energy codes (NZER) for the new building. In 2020 the government published new model codes. Those codes are focusing on the energy efficiency of buildings.
2. Retrofitting on the existing buildings by the buildings recommissioning framework launch, develop a platform of labelling and sharing energy use data and keep going to develop certification such as ISO-50001 and Energy Star Manager.
3. The Canadian amendments 14, 15 and 16 are instrumental in enhancing energy efficiency for appliances and equipment.

It is imperative to comprehend the regulatory framework that governs Canada in order to understand how the regulatory decarbonization framework should be deployed. This is because such actions should be taken by public power. The regulatory decarbonization framework under discussion is distinguished by a multi-level structure, involving various dimensions such as structures, resources, and capacities, which in turn give rise to different trajectories (Hasan, 2024). The constitutional resources are allocated between the federal government and the provinces through the Canadian Constitutional Act.

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6. SITUATION ON THE REAL ESTATE IN CANADA

To achieve the net zero for 2050 two key are important to understand, the situation on the real estate now and the urban and construction planification do decarbonize the future.

6.1 OPERATIONAL CARBON

On the current real estate, 17% of the emissions from Canada are coming from the usage of buildings. Most of the emissions are from the heating followed by the cooling. In Québec, this represents 9% of the provincial emissions.

In response to this challenge, various certifications, standards, codes and assistance programmes have been implemented, including the Logisvert programme in Québec, the oil-to-heat-pump affordability programmes and the Canadian green building strategy.

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As the figure 4 shows the combined effect of these initiatives, coupled with heightened public awareness, has been a notable shift in market trends. The heat pump market in Canada has grown from approximately 1.7 billion dollars in 2023 to an estimated 7.5 billion dollars by 2030, indicating a substantial increase in market size and a growing commitment to environmentally sustainable energy solutions.

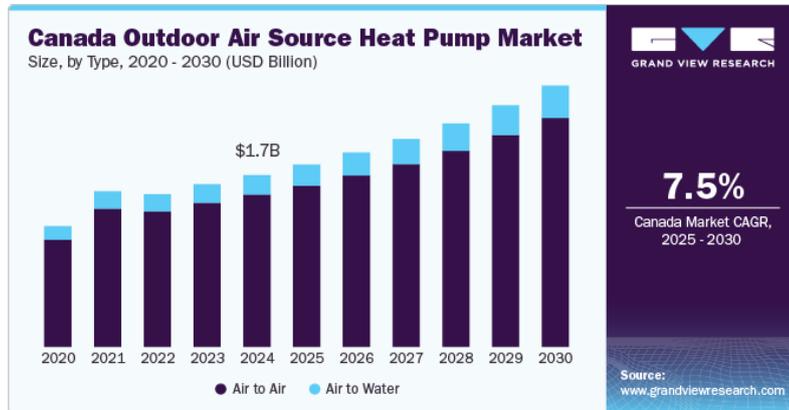


Figure 4: Heat pump Canadian market projection

In the period between 1990 and 2015, Canada witnessed a 26.5% increase in energy efficiency. This development can be attributed to the initiatives undertaken in research and development, as well as the introduction of various codes for energy management in buildings. The subsequent challenges are to enhance the efficiency of the building envelop within the present real estate context.

7. DIFFERENT CERTIFICATIONS WITH DIFFERENT RESULTS

A variety of tools are currently available, with some having been presented in a 2017 report to the Canadian Parliament by the Ministry of Resources. As demonstrated in the table 1, a variety of certifications and associated advantages have been identified. However, it should be noted that despite their potential benefits, these certifications are not mandatory and are instead voluntary, neither federal nor provincial governments having imposed them.

Table 1: Building certifications

Certification	Type of certification	Carbon Scopes	Experience return?
Energy Star building	Certification on energy with points system by a third party. Calculated by the consumption of the energy and the efficiency of the house.	Operational	Any studies find but resources Canada said an economy of 20% on the energy in comparison of classic construction.
R-2000	Certified by independent consultants, the R-2000 houses can be built only by stakeholders who passed a certification. The certification is focused on energy efficiency, raw materials used and air quality.	Operational	The efficiency of 50% on the energy is declared, but any recent studies prove the percentage.
Novoclimat	Certification developed in Quebec. Focused on energy	Operational	The efficiency of 20% instead of a classic construction is announced, but any scientific studies had been found.
LEED	One of the most popular certifications. Was historically focus on energy but the version 4 is now including embodied carbon.	Operational and embodied	The efficiency of 20% to 50% on the efficiency is announced proven by scientific articles like

8. DECARBONATION OF RAW MATERIALS

In recent years, there has been considerable discourse within the sector on the use of new low-carbon concrete and steel, as well as the utilization of raw materials such as wood or mud. In Canada, the government and the Canadian cement association have collaboratively developed a roadmap for net-zero concrete, which details various technological solutions, including the reduction of clinker and the implementation of carbon capture and sequestration (CCUS). However, it should be noted that the implementation of these solutions may encounter technical and economic challenges. The International Agency of Energy has calculated a cost of between 60 and 120 USD per tonne of CO₂ sequestered for cement industries. There is considerable interest among various industries in achieving carbon neutrality through this technology, and there is potential for collaboration on government funding allocation. Concurrently, technical challenges may emerge in terms of storage. In order to mitigate the issue of carbon leakage, it may be necessary for industries to store carbon in geologic rocks that are impermeable to such leaks.

The utilization of co-products, such as blast furnace slag, fly ash, and the reintroduction of used concrete in the process, has been a subject of ongoing research. A substantial body of research has reached a consensus that, while these products hold potential, their practical applications are constrained by physical limitations, rendering them unsuitable for widespread incorporation into concrete production on a yearly basis. Furthermore, there is a need for these products to be readily

available to mitigate the increasing carbon footprint associated with transportation. In the case of co-products, the potential benefits of blast furnace slag, fly ash, and the reintroduction of used concrete in the process have been a subject of extensive research for a considerable period. Numerous studies have reached a consensus that while these products hold relevance, their practical applications are constrained due to their limited availability and the fact that they cannot be utilized in all quantities of concrete produced annually. This limitation necessitates their physical availability, which in turn results in a limited reduction in the carbon footprint associated with transportation. For instance, the province of Québec does not produce furnace slag or fly ash. The sole notable co-product utilization is glass, given Québec's commitment to enhancing the recycling of glass through the "consignation" programme. It is therefore incumbent upon the industry to consider the reduction of glass volume.

Over recent years, a significant number of studies have been undertaken on the sourcing of raw materials from geo and bio sources. The availability of certain materials, such as mud, has been demonstrated as a substitute for wood. The question therefore arises as to why these alternative materials have not yet been adopted by the Canadian industry. The primary reason for this is the inflexibility of current construction codes, which do not permit the utilization of these materials. Concurrently, a psychological approach is required to inform and modify public perceptions of these materials.

10. DISCUSSION AND FUTUR WORK

The future work can include :

- Quantitative studies and simulations about the different certifications. The importance is now to demonstrate if those certifications are connected with the objectives of net-zero that Canada should reach.
- The quantitative methods can explore different spatial areas. While the certifications are currently focused on building scopes, there is now an opportunity to expand analysis to the neighbourhood and even city-wide scales.
- The role of the city in a net-zero model and the optimal architectural design. This article has explored the notion that a tower model would require significantly more effort to reduce carbon emissions than a smaller building. However, it has also been observed that condominiums are the reference in cities. The underlying reasons for this phenomenon are yet to be elucidated. Future research could explore the social acceptance of smaller construction by the population.
- It is imperative to explore the bio and geo-sourcing materials in the context of a massive potential usage impact. This exploration should encompass the availability of these resources, the economic impact, and the social acceptance. Furthermore, it is imperative to initiate a comprehensive study on the regulatory framework that should be implemented to facilitate the deployment of these materials.
- The present study does not delve into the intricacies of adaptation to climate change; however, this is a subject that could be explored in future research. The question of whether the certifications take this aspect into consideration is posed.

11. CONCLUSION

This conference paper is a systemic exploration to understand the framework and challenges of decarbonizing the building sector. It tries to show that the actual dynamics and flows of cities are not in the right way to decarbonize the sector. It also tries to explore the impact of the certifications and the experience returns. Through the research, the authors didn't find public data comparison by projects of those certifications but also those certifications don't have benchmarks. The most important challenge identified by the authors of this paper is the need to adapt a clear federal roadmap and to find efficient ways to implement it quickly by the provinces, taking into account the reality of each province.

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