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Evaluating Business Models for Renewable Energy Community in Quebec Multi-Unit Residential Buildings

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ABSTRACT: Renewable Energy Community (REC) is an emerging concept that empowers local customers to generate decentralized renewable energy. Integrating RECs into the building industry presents a promising opportunity to support the transition toward net-zero cities. However, the viability of RECs depends on regional regulatory frameworks, permitted governance structures, and very importantly, business models. Compared to pioneering European countries, Canada lacks the regulatory support needed to fully enable REC. This paper proposes and evaluates various business models for potential REC implementations under Canada's existing regulatory constraints. The analyzed models focus on "behind-the-meter" electricity distribution, a multi-stakeholder type of REC, where generation occurs independently of the Distribution System Operator. The study also explores different ownership structures, including resident-led (community-based) ownership and non-occupant (investor-led) ownership, as well as financing strategies. Additionally, it examines various legal structures and income distribution models, which collectively shape business models. A case study was conducted based on a multi-unit residential building in Montreal. The results indicate that Canada's current regulatory framework, particularly Quebec, does not support diverse scales and models of REC. Regulatory changes, including rebates for generator purchase, low-interest loans, and tax incentives, are necessary to facilitate local renewable energy developments.

1. INTRODUCTION

Canada commits to achieve net-zero emissions by 2030 under the Paris Agreement (Environment and Climate Change Canada, 2016). The building industry plays a substantial role in this effort. The building industry contributes 10.3% of Québec's total emissions in 2017, making it the third-largest emitting sector. Of these emissions, 59.5% come from commercial and institutional buildings, where fossil fuels are the primary energy source. The remaining 40.5% originate from the residential sector. Although most electricity in Quebec comes from hydropower, fossil fuels are still prevalent in Quebec homes, particularly for heating purposes (Gouvernement du Québec, 2020). Self-generation from renewable energy sources is a fundamental solution, according to the concept of Renewable Energy Communities (RECs), as introduced in the Renewable Energy Directive II (RED II) (European Parliament and Council, 2018). In Spain and Italy, the Distribution System Operator (DSO) authorizes RECs as entities composed of multiple members who own a shared renewable energy generation system. In a multi-unit residential building with collective self-consumption, the DSO calculates and distributes the income among members, allowing multiple account holders to share the benefits. In Spain, the DSO records the total generated energy and allocates credits among members according to internally defined coefficients. The energy allocation occurs behind the meter, meaning that the generated energy is directly used by members without being metered externally or tracked by a DSO (Mustika et al. 2022). In contrast, Italy employs a virtual distribution approach, or in-front-of-the-meter energy distribution, where energy flows through the grid and a DSO tracks and allocates credits based on each member's actual consumption from community-generated electricity (D'Adamo et al., 2024), as shown in Figure 1.

The regulatory environment in Canada generally supports small- and medium-scale local and decentralized energy generation, provided it is connected to a single utility account and does not authorize multiple account holders for a shared system. Therefore, local electricity generation occurs behind the meter, allowing surplus electricity to be exported to the grid for net metering benefits, which are credited to a single account holder. This condition creates a barrier to distributing energy and benefits among members of a shared generation system (Fioriti et al., 2021). In the form of physical self-consumption (Figure 1), a REC in a multi-unit residential building enables customers to generate and consume electricity within their restricted premises. This model relies less on collaboration with the DSO, bypassing regulatory barriers by enabling internal energy distribution (Hall and Roelich, 2015; Reis et al., 2021; Koirala et al., 2016). Therefore, identifying a feasible business model within the current regulatory constraints is crucial for enabling collective self-consumption of locally generated electricity, which is a key first step toward establishing RECs in Canada.

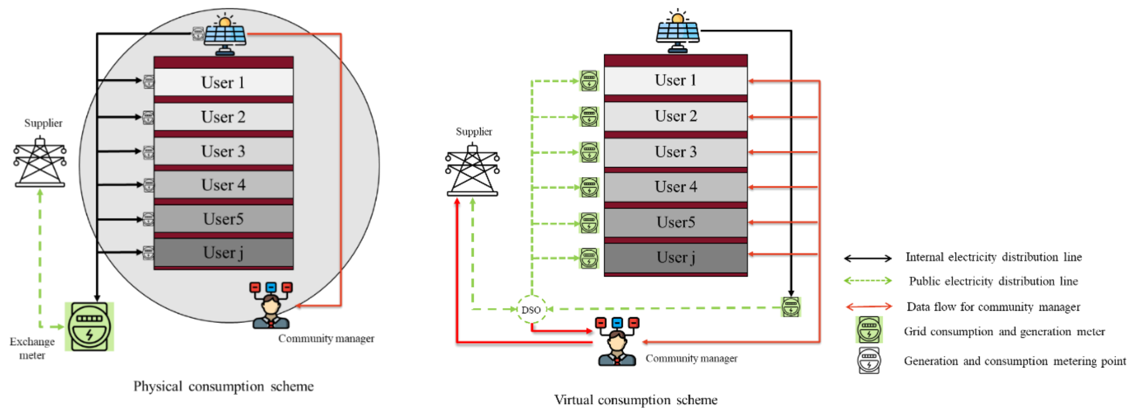

Figure 1: Physical (Behind-the-Meter) and Virtual (In-Front-of-the-Meter) Energy Self-Consumption

As shown in Figure 1, in the physical model, electricity is distributed internally behind the main utility meter, which may include an embedded network. In the virtual model, each user has an individual utility meter, and the generation system is connected to the public grid downstream, with separate metering allowing energy allocation by DSO.

Table 1: Comparative Overview of Regulatory Environments for RECs in Canada, Spain, and Italy

Aspect	Canada (Quebec)	Spain	Italy
Metering Model	Behind-the-meter	Behind-the-meter + credit	Virtual net metering
Legal Structure	1 account per system	Shared REC entity allowed	Shared REC entity allowed
Income Distribution	Manual, internal	DSO-automated	DSO-automated

This paper evaluates the feasibility of behind-the-meter shared rooftop photovoltaic (PV) systems in multi-unit residential buildings in Canada. The key contributions of this study include:

- Proposing feasible REC business models for collective self-consumption for multi-unit residential buildings that align with Canada's general regulatory environment.
- Conducting an economic assessment of the proposed business models, with considerations of the regulatory framework, REC organizational structures, ownership, and financing methods.

2. RENEWABLE ENERGY COMMUNITY BUSINESS MODELS

A REC project requires a governance model that aligns with regulations, defining rules for stakeholder participation, interaction, and decision-making. Shaped by legal factors, governance models serve as the foundation for business model operations (Moreno et al. 2022), as shown in Figure 2. Therefore, regulatory environments impact business models and governance structures. In terms of governance structure, RED II defines RECs as legal entities (European Parliament and Council, 2018). As Canadian regulatory environment only accepts one account holder for each generation system, to engage in net metering programs, a legal entity must hold a utility account and sign a net metering agreement. In cases where the building has a single owner, such as a real estate developer or a private landlord, this entity acts as the primary contact and beneficiary of financial incentives. Since the owner is not the occupant, they may either retain all financial benefits or share them with tenants (Kühn et al., 2024). However, in buildings with individually owned units, a legal entity must be formed to act as the contact point. An association of owners can serve this role, oversee asset purchases, manage operations, and apply for incentive programs. Therefore, a private person, a for-profit corporation (e.g., a real estate developer, a corporation by the community members), or a non-profit organization (e.g., the association of owners, known as syndicate of ownership in Quebec) are the three potential legal entities for REC in this paper.

In the case of benefit distribution in the behind-the-meter model, where there is no DSO cooperation in metering or distribution, the REC entity's governance structure must include an internal agreement on how benefits are allocated. These benefit can be distributed equally, based on each unit's investment share, or proportional to the "relative value of their fraction" which reflects the unit's overall contribution to the total value of the property (Syndicate of Co-Owners Legal Hypothec, 2021). The last method is commonly used to calculate each unit's share of building common expenses in co-owned buildings (Section 1064|Annotated Civil Code of Québec, n.d.). Alternatively, distribution could be based solely on the units' areas. Distribution based on actual consumption requires internal metering. In Canada, behind-the-meter connections with the DSO allow community members to reduce their electricity bills, forming a key value proposition. This generates two main revenue streams for business models: savings on electricity bills through local self-consumption and revenue from selling surplus collective electricity to the grid via a net metering program (Valta et al., 2023).

Since revenue in this model is consolidated under a single electricity account, this account can either represent the entire building or just common areas (Electrical Service Connections, n.d.). In one case, PV generation credits are allocated exclusively to the common areas, leaving household electricity bills unaffected (Roberts et al., 2019). Alternatively, PV generation offsets the overall building's electricity consumption, serving as a direct revenue source for all participating units (D'Adamo et al., 2022). The financial feasibility of energy community business models greatly influences their attractiveness and stakeholder participation, depending on the proposed revenue stream, financing method, and ownership structure (Schwidtal et al., 2023; González et al., 2023). Additionally, the distribution of income and costs among members, such as their share of debt, impacts project profitability at the user level. These aspects are managed and shaped by a project's governance structure. Figure 2 shows the relationship between regulatory environments and governance structures in defining the REC business models in this paper.

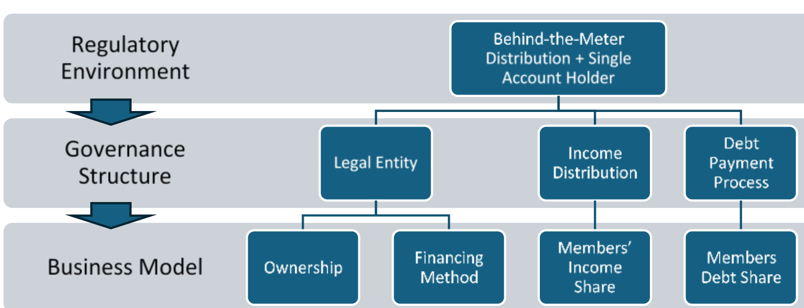

Figure 2: The Aspects Influencing REC Business Models

As shown in Figure 2, this paper focuses on a regulatory context only permitting behind-the-meter distribution and a single account holder. Regulatory environments also impact potential legal entities, income distribution schemes, and debt repayment processes, all of which are governance structure components. Ultimately, both regulatory environments and governance structures influence business models. The ownership and financing mechanisms, which relate to the organizational structure of legal entities, affect business models as well. Additionally, members' shares in income and debt repayment determine the benefits they receive from the operation performance of business models.

2.1 Business Models Financial Assessment

This study employs the Discounted Cash Flow (DCF) method to evaluate and compare the financial performance of various potential business models. The assessment includes the net present value (NPV) and payback period (PBP), which are analyzed at both the community level and the individual household level. The financial benefits derived from self-consumption and net metering are significantly influenced by the tariff structure, which varies across provinces in Canada. The process of debt repayment depends on the legal entity's governance structure. If the legal entity provides limited liability for community members, such as in the case of a cooperative or a corporation, debt payments are made from the entity's income and are settled before distributing any income to members. On contrary, if the governance structure of REC's legal entity is based on proportional liability, the income is distributed directly to the members, and debt repayment is factored into their regular payments as charges. In the first case, members' investment share does not impact the debt repayment, while in the second case, members pay the debt according to predefined agreements based on their share of costs and incomes. Eligibility for tax deduction incentives also depends on the REC's legal entity type. In Canada, the "Accelerated Capital Cost Allowance" incentive allows for a deduction of 100% of the capital cost of eligible assets, such as PV panels, in the first year. The general combined federal and provincial corporate tax rate in Quebec is 26.5% (Investissement Québec International, 2022), meaning that businesses benefiting from this incentive effectively save 26.5% of the capital cost of eligible assets by reducing their taxable income. Therefore, this incentive serves as a revenue stream, allowing taxable entities, such as for-profit corporations, to reduce their taxable income.

2.2 Proposed Business Models

This paper proposes REC business models for multi-unit residential buildings, considering key components such as ownership, legal entity, governance, value proposition, financing, revenue, and income distribution. Each factor has multiple options. As shown in Figure 3, ownership may lie with residents forming a corporation or syndicate, or with an external party like a developer. The typical governance structures for each case are illustrated in the figure. The value proposition across models is reduced electricity bills for community members. Figure 3 also presents variations in financing, revenue streams, and income distribution. Other business model components remain constant and are not detailed further.

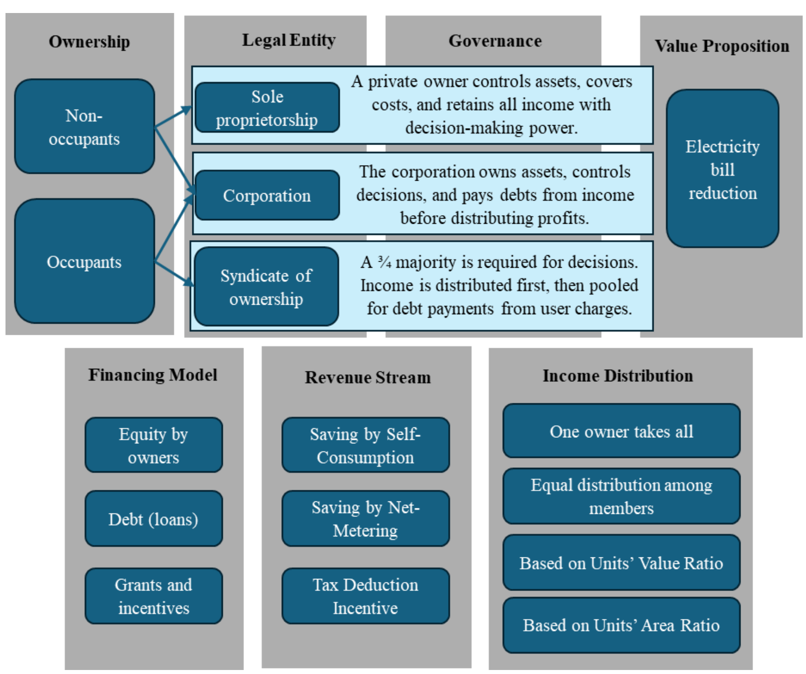

Figure 3: Factors in the Design of REC Business Models

According to the options listed in Figure 3, here we propose the following potential REC business models (BM) for behind-the-meter, self-consumption multi-unit buildings in Quebec (Table 2). BM1 to BM4 focus on a single non-occupant owner. BM5 to BM7 involve basic co-ownership scenarios with varying earning distribution models for building occupants. BM8 considers the option of tax credit eligibility for the REC legal entity. BM9 and BM10 evaluate scenarios involving debt financing for occupant co-ownership.

Table 2: Comparison of Renewable Energy Community Business Model Configurations

BM #	Ownership	Occupancy Status	Legal Entity	Financing Method	Income Distribution	Tax Incentive?	Debt Payment Responsibility
BM 1	Single private	Non-occupant	Private owner	Equity + Grants	Owner retains all	No	Not applicable
BM 2	Developer	Non-occupant	Corporation	Equity + Grants	Owner retains all	Yes	Not applicable
BM 3	Developer	Non-occupant	Corporation	Equity + Zero-interest Loan + Grants	Owner retains all	Yes	Developer: full liability Tenant: no liability
BM 4	Developer	Non-occupant	Corporation	Equity + Inflation-indexed Loan + Grants	Owner retains all	Yes	Developer: full liability Tenant: no liability
BM 5	Co-owners	Occupant	Syndicate	Equity + Grants	Equal split	No	Not applicable
BM 6	Co-owners	Occupant	Syndicate	Equity + Grants	Proportional by unit value	No	Not applicable
BM 7	Co-owners	Occupant	Syndicate	Equity + Grants	Proportional by unit area	No	Not applicable
BM 8	Co-owners	Occupant	Corporation	Equity + Grants	Proportional by unit value	Yes	Not applicable
BM 9	Co-owners	Occupant	Syndicate	Equity + Zero-interest Loan + Grants	Proportional by unit value	No	Co-owners: limited liability
BM 10	Co-owners	Occupant	Syndicate	Equity + Zero-interest Loan + Grants	Proportional by unit value	No	Co-owners: proportional liability
BM 11	Co-owners	Occupant	Syndicate	Equity + Inflation-indexed Loan + Grants	Proportional by unit value	No	Co-owners: limited liability

3. CASE STUDY

A multi-unit residential building in Montreal, Quebec, serves as a case study (Figure 4). The real hourly electricity consumption of the entire building is analyzed using a single meter provided by Hydro-Québec. The building, constructed in 2004, consists of 111 individually owned residential units across six floors. Unit values and building areas are extracted from property tax records (Rôle d'évaluation Foncière, n.d.). The building's rooftop covers approximately 1,300 square meters, with 590 square meters occupied by technical utilities. There are no shading effects from nearby buildings or trees. Although additional solar panels could be installed, the analysis considers a 50 kW PV system to align with Hydro-Québec's net metering incentives. PV hourly generation is modeled by SAM NREL software to simulate the hourly electricity generation of PV panels. The financial assessment incorporates:

- **PV panel assumptions:** 50 kW peak capacity, 1% annual degradation rate
- **Economic factors:** 3% inflation and 5% discount rate, reflecting average values from Canadian and Quebec economic data (Electricity Rate Increase on April 1, 2024 | Hydro-Québec, n.d.; Canada 2025)
- **Electricity tariff:** $0.06/kWh, based on Hydro-Québec's residential Rate D (Hydro Quebec 2024)
- **PV capital cost**: $1,800/kW for systems exceeding 20 kW in capacity and less than utility scale (Solar Panel Installation - Solar Energy Montreal | Quebec Solar, n.d.; Government of Canada 2023)
- **Optimal PV tilt angle:** 39° facing south (Montreal conditions)
- **Project lifetime**: 25 years for the overall system, with 10% of the initial PV components renewed in Year 12 to account for equipment replacement (e.g., inverters). Salvage value at the end of the system's life is not considered in the analysis and is acknowledged as a limitation of the study.

Since the building uses a single meter for all units, distinguishing common area consumption is not feasible, which excludes the evaluation of the last proposed business model.

Figure 4: The Building and the Rooftop Area with PV Installation (highlighted areas)

4. RESULT

Analysis shows that, in all business models with current electricity prices and without incentives (as the situations in Quebec), the NPV is negative, and the discounted PBP exceeds 25 years, making the PV system unfeasible. Considering a different range of grants for the basic scenario (BM1), at least $850 per kW incentives are required for the project to become feasible, with a positive NPV and a PBP of less than 25 years, as shown in Figure 5. Incentives in the form of rebates per kW of purchased PV panels would help reduce the system's initial cost.

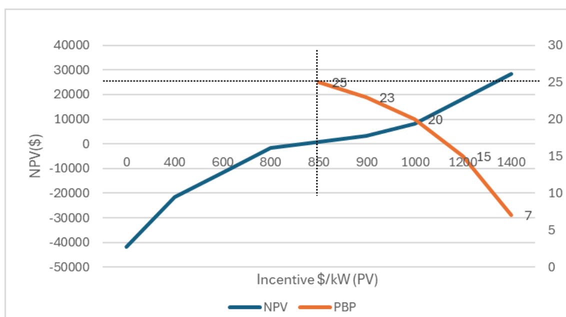

Figure 5: Sensitivity Analysis of BM1 Based on Incentive Amounts for Generation Asset Rebates

The ratio of annual PV generation to annual building demand, referred to as self-sufficiency in this case study, is calculated at 6.2%, while the rate of self-consumption by households is 99.7%. These values are derived by analyzing the building's annual electricity demand and the expected PV generation based on the simulated system capacity. The main reason for the low self-sufficiency rate is the relatively small-scale PV system installed for net metering. This capacity, constrained by utility-defined limits on peak PV panel capacity, is insufficient to meet the demand of larger residential buildings. Increasing the allowed installed capacity under net metering programs would enable a more adequate PV system. In this case, assigning PV generation to specific areas, such as the common areas, would increase the self-sufficiency rate. In the first two business models (BM1, BM2), having a single private owner and a single corporate owner, the NPV is $830 and $11,702.67, and the payback period is 25 and 18 years, respectively. This underscores the impact of incentives, such as tax deductions, on enhancing business profitability. Profitability further improves with other types of incentives, such as zero-interest loans (BM3) or low-interest loans (BM4), raising the NPV to $ 24,213.35 and $19,157.47, respectively. In Quebec, although no government loan incentives exist for PV panel installations, the Canada Greener Homes Loan, with a cap of $40,000 and a 10-year, interest-free loan term, can cover nearly 80% of the initial net costs. Meanwhile, if interest rates exceed 3% (the assumed inflation rate), a longer loan term would be necessary. This is an important consideration for funding providers who aim to support renewable energy development.

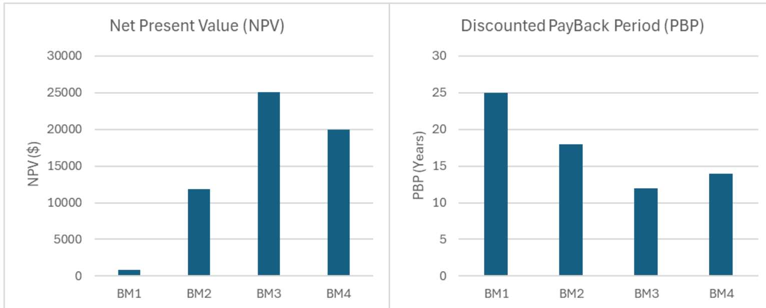

Figure 6: Financial Assessment Results – NPV and PBP Comparison Across BM1 to BM4

Figure 7 illustrates the area and value ratios of each unit in relation to others. These ratios determine each user's share in equity, debt payment, and income distribution. These factors are important for BM5 to BM14.

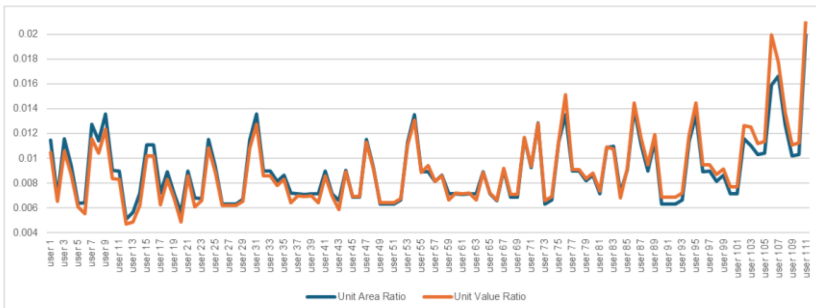

Figure 7: Unit Area and Value Ratios of Each Unit

BM5 to BM7, as shown in Figure 8, introduce different approaches to cost and income distribution. BM5 generates equal NPVs for all users, regardless of their unit area and value ratio, with a 25-year PBP. When comparing BM5 to BM6 and BM7, which also have 25-year PBPs, it becomes apparent that BM6 and BM7 generate lower net profits for smaller and less expensive units, favoring higher-value units. Among these three models, BM5 is more favorable for units with lower area and value ratio. However, due to the large scale of the building and the limitations of smaller systems, the differences remain relatively small. Compared to BM7, BM6, which uses the unit value ratio, results in a greater disparity in NPV between high- and low-value units.

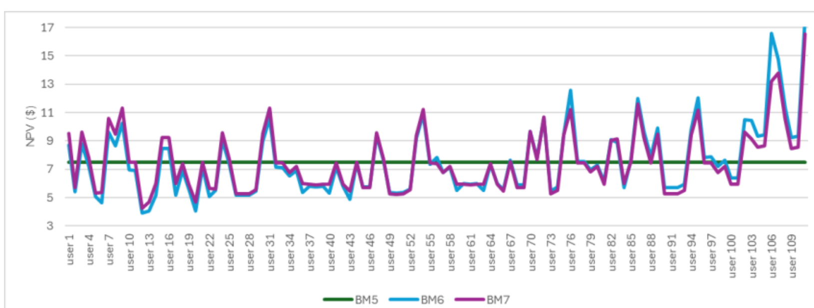

Figure 8: Financial Assessment Results – NPV Comparison Across BM5 to BM7

In BM8, treating the REC as a taxable entity (e.g., a cooperative or corporation) makes it eligible for tax deduction incentives. BM8 enhances BM6 by incorporating tax deductions, significantly increasing users' NPVs and reducing the PBP to 18 years. Figure 9 presents a comparison of NPVs between the models.

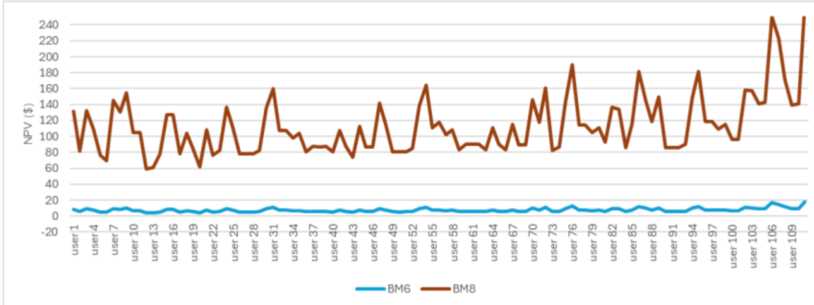

Figure 9: Financial Assessment Results – NPV Comparison between BM6 and BM8

BM9 to BM11 assess debt financing's impact on REC business models, using the same loan features as BM3 (i.e., interest-free). This approach increases BM6's total community NPV by $24,213 and reduces the PBP to 12 years. BM10 explores different governance models for debt repayment (before vs. after income distribution) but finds no significant impact on individual NPVs. BM11, similar to BM4, assesses the effect of higher loan interest rates, which, as expected, results in an NPV reduction of $5,055 and an increased PBP of 14 years.

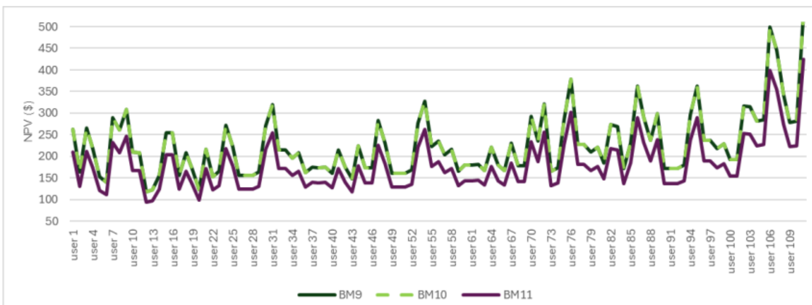

Figure 10: Financial Assessment Results – NPV Comparison across BM9 to BM11.

5. CONCLUSIONS

This paper explores potential business models for collective self-consumption in multi-unit residential buildings as RECs within the Quebec regulatory environment. Since the grid allows only one connection per generation system, shared generation must be managed behind the meter via a legal entity representing REC members. Two types of ownership were analyzed: single-entity ownership (held by private individuals or corporations) and co-ownership by unit owners (a community-based model). While single-entity ownership is not classified as a REC, it still represents a form of renewable energy utilization. Co-ownership models, on the other hand, require the establishment of a syndicate of ownership or a corporation, with the latter benefiting from tax deductions while the former operates as a non-profit that directly distributes income. The study modeled 11 potential business models based on varying governance structures, ownerships, financing strategies, and income distribution.

Under current Quebec regulations, without PV incentives, all models result in negative NPVs. However, with $850/kW in rebates, they become viable with a 25-year payback period. In single-owner models, corporate entities benefit from tax deductions, reducing the payback period to 18 years, compared to 25 years for private ownership. Zero-interest or low-interest loans further increase the NPV and shorten the payback to 11 years. However, loan conditions must ensure that annual income covers repayments.

The study also examined different income distribution strategies. Equally distributing revenues among all members, regardless of unit size or value, favors smaller and cheaper units. On contrary, proportional distribution based on unit size or value benefits larger and more expensive dwellings. When costs are assigned based on unit value while income is distributed equally, smaller dwellings benefit the most. However, large unit members may find the model financially unattractive. To address this, tax incentives for RECs can enhance feasibility and encourage broader participation. A combination of rebates and low-interest or zero-interest loans can offset initial and operational costs, making RECs more attractive for all members. However, loan terms and interest rates should be evaluated case by case.

Moreover, Quebec's current policy capping PV system capacity at 50 kW for net metering eligibility limits the potential benefits of solar systems for buildings of varying scales. Lifting the cap and introducing additional incentives would significantly enhance feasibility, especially for larger-scale RECs in multi-unit buildings. This paper focuses on proposing implementable business models for RECs in Quebec, with a specific emphasis on evaluating the economic feasibility of potential combinations of ownership, governance, financing, and income distribution options. Overall, this analysis suggests that enhancing REC performance requires an enabling regulatory environment, such as raising the 50-kW cap on net metering and expanding government incentives, to improve REC's feasibility.

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