Financing Building Decarbonization

The Roles of Government and Private Sector Investors

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In this August 11, 2022, file photo, installers from NY State Solar install solar electrical panels on the roof of a home in Massapequa, N.Y. (AP Photo/John Minchillo)
Executive Summary

In the United States, buildings account for approximately 40% of total primary energy consumption and about 30% of operational greenhouse gas (GHG) emissions. Further, approximately 80% of all buildings that will be standing in 2050 have already been built. Thus, while updating building codes to increase the efficiency of new buildings is essential to reducing GHG emissions, decarbonizing existing buildings is a key component of GHG emission reduction strategies.

We estimate that approximately $100 billion to $150 billion per year of financing will be needed over the next 30 years to retrofit existing buildings in the United States alone, if their operational emissions are to be reduced significantly to contribute toward reaching net zero emissions economy-wide by 2050. Currently, some jurisdictions offer public and ratepayer funding to help pay for the upfront capital necessary to retrofit both commercial and residential buildings, but this is not enough. It is essential to attract private funding into this area of investment to achieve any of the stated climate targets.

Private investors have been slow to finance existing residential decarbonization projects because of a range of barriers. Chief among them is a highly disaggregated and diverse market. Residential buildings include both single and multi-family buildings and retrofit solutions are highly heterogenous. Further, many building owners are unfamiliar with the upgrades necessary, unclear about their options for the near and longer term, and uncertain about their costs (both upfront capital and ongoing operational costs). On the supply side, each building’s retrofit needs are met with tailor-made solutions, while contractors with varied levels of training and knowledge are just beginning to expand their expertise to help building owners find the most efficient and effective solutions.
Overall, building retrofit projects range from investments that can yield positive returns because certain low-cost energy efficiency interventions are sufficient to capture large energy cost savings, to costly investments that are unlikely to pay for themselves through energy savings alone. Since the supply and demand for building decarbonization investments and services are quite diverse, there is little economy of scale to be captured to reduce the costs of retrofits, particularly for residential buildings. In addition, the financing need for each project is typically relatively small and the transaction costs are high for financiers to meet individual one-off needs. This is particularly challenging when the same financiers can finance large-scale renewable energy projects that have become much more standardized over the past decade. These challenges are particularly acute for residential properties compared to commercial buildings. In fact, commercial building owners typically work on a larger scale and have better access to capital, contractors, and planning techniques.

**Figure 1** summarizes the challenges:

![Framework of Disaggregated Marketplace for Residential Building Decarbonization Efforts](#)

To address the market segmentation issue, we developed a “Residential Building Financing Feasibility Framework” (see Figure 2) that groups residential building retrofit projects into three categories of projects based on their economics and ease of financing. The first category of projects can be served by established
business models and can obtain financing today since the anticipated energy cost savings substantiate the upfront capital investments. We designate this first category as “Easy-to-Finance” projects. The second category of projects have limited access to private financing; we designate them as “Potential-to-Finance.” The third category of projects are those that have very challenging economics; thus, we designate them as “Hard-to-Finance.”

![RESIDENTIAL FINANCING FEASIBILITY FRAMEWORK]

**Figure 2**: Residential Building Financing Feasibility Framework

Using such a framework in prioritizing building retrofit projects strongly suggests that resources (both public and private) should aim at delivering the most efficient solutions while growing the experiences of building owners, service providers, and financiers. Classifying building retrofit projects by their economics, with a particular focus on return on investments (ROIs), would focus near-term efforts on those that can maximize the benefits of investments and create a pathway for private investors to gain experience in financing building decarbonization efforts.

Our research, based on qualitative interviews of businesses, financiers, and project developers, highlights an opportunity to attract more private financing to the “Potential-to-Finance” segment. Projects in this segment are expected to
receive slightly below market-level ROIs but provide enough energy and emissions savings that can be justified with a relatively modest pseudo-carbon price.

We believe a green bank could help unlock public and private financing for these projects. In our analysis, we find that a green bank could go a long way towards addressing the two biggest challenges private investors have described as key barriers: low ROIs and small project size. A green bank can help aggregate capital, including mission-driven dollars that require lower returns in exchange for non-strictly financial value. Based on the European experience, green banks can also blend public and private funds to channel investments that typically have not been able to be financed by private investors alone. Additionally, either directly or indirectly, green banks can help build and grow the decarbonization market by investing in and by aggregating service providers, thereby accelerating the market’s development and creating project economies of scale.

Additionally, our choice to focus on a green bank and the “Potential to Finance” market segment derives from the following insights that we have gathered:

- Starting with residential buildings that are in a relatively good position to contribute toward emission reductions in a potentially cost-effective manner will help service providers learn by doing and improve their services over time.

- Many “Potential to Finance” projects face financing gaps that are relatively small such that they can be bridged by using green banks, even within existing regulatory and market environment.

- There is abundant capital that is ‘stuck’ and eager to be deployed to help advance decarbonizing residential buildings.

Although this paper focuses on the use of green banks as one of the solutions to advance financing for residential decarbonization projects, it recognizes the importance of more substantial government policies to guide the development of a market for decarbonization services. Carbon taxes, emission targets and green building codes, and regulatory incentives are approaches that governments are and should be using or exploring. If implemented well, they can increase the economic viability of new decarbonization business models and private financing will follow.
1. Introduction and Research Approach

Residential and commercial buildings account for approximately 30% of greenhouse (GHG) emissions in the United States. In almost all decarbonization scenarios analyzed across various reports, both at the national level and the state level, reducing GHG emissions from buildings is one of the key components of achieving climate mitigation goals.

However, building decarbonization is often complex and expensive. The upfront investments require significant initial capital outlays and the operational energy cost savings, if any, accrue over a long period of time. In some regions, because the retail electricity prices are very high, even the most energy efficient buildings would incur a very expensive electricity bill for heating and cooling, thereby reducing the economic rationale for investing a large sum upfront for heating system conversions.

Building decarbonization is more challenging for residential properties than commercial ones. Residential building retrofits are much more fragmented than those for commercial buildings because of the wide range of types of buildings, with a larger number of owners, each with varied levels of resources and/or knowledge to pursue energy efficiency upgrades. Commercial buildings are often owned by corporations or entities with established credit histories and easier access to financing at scale.

As a result, this paper focuses primarily on financing residential decarbonization efforts, though many of the challenges and opportunities described herein apply to all building types. The paper is organized as follows:

Section 2 provides background on the challenges and opportunities of building decarbonization, including funding and financing aspects.

Section 3 reports the observations made by stakeholders when discussing decarbonization projects. Based on stakeholder insights, this section presents a financing feasibility framework across sample decarbonization project types.
Section 4 analyzes case studies of entities obtaining private financing and scaling up residential building decarbonization solutions.

Section 5 describes the usefulness of green banks as a mechanism to address the key challenges identified through the research.

Section 6 recognizes the importance of additional and targeted government regulation to unlock further financing opportunities.

Section 7 concludes with key takeaways while pointing to important additional research needed for the residential decarbonization market.

Our research, conducted between October 2022 and April 2023, leveraged desk research, focus group discussions, and individual expert interviews.

First, our team conducted desk research and several informational interviews with finance experts and researchers to understand the scope of the existing market for investing in residential building decarbonization.

Second, our team organized a roundtable with experts to discuss in detail the practical barriers associated with financing building decarbonization. The roundtable produced key insights including the scarcity of business models capable of creating market-level returns on investments (ROIs) and the inadequacy of the regulatory environment. The roundtable also painted a high-level picture of the types of decarbonization business models in which commercial financiers are investing.

Third, our team conducted additional follow-on interviews to draw upon the experiences of existing decarbonization business owners/operators. The purpose of those interviews was to identify what existing organizations are doing to attract private financing towards building decarbonization.
<table>
<thead>
<tr>
<th>Research Phase</th>
<th>Key Stakeholder Types</th>
<th>Stakeholder #</th>
</tr>
</thead>
</table>
| Informational Interviews | • Building economics expert  
• Impact investing professor  
• Energy/infrastructure professor  
• Finance professor  
• Development bank manager | 7             |
| Roundtable Discussion       | • Impact investor  
• Investment banker  
• Green finance senior lead  
• Real estate economist  
• Climate scientist | 9             |
| Targeted Interviews       | • Impact fund founder  
• Renewable energy company CFO  
• Building green tech financial manager  
• Real estate property manager  
• Home retrofits program director | 10            |

Total Stakeholders: 26

**Table 1:** Research Stakeholders Interviewed

Both the concept of the “green bank” and the importance of long-term regulatory changes are derived from various interviews. The rest of this paper provides the background, the analytical framework, and our findings.
2. **Background**

Buildings are major consumers of energy and play a significant role in emitting greenhouse gases (GHGs). In the United States, they account for approximately 70% of electricity use, 40% of total primary energy consumption, and about 30% of operational GHG emissions. Figure 3 shows the relative proportion of energy use for commercial and residential buildings in the United States, across the types of use, with heating at 40% of all energy used in buildings. Various reports state that 80-85% of all buildings that will be standing in 2050 are already standing today. Thus, while ensuring that all new buildings are built to a high efficiency standard would help reduce GHG emissions, a significant amount of building retrofits will also be needed to reduce energy consumption and GHG emissions.

![Figure 3: Energy Use in U.S. Buildings, 2019 (Source: Data from U.S. Energy Policy Simulator. Graph adapted from “How To Reach U.S. Net Zero Emissions By 2050: Decarbonizing Buildings” in Forbes)](image)

It follows that in all decarbonization scenarios analyzed across various reports, either at the national or state level, reducing the GHG emissions from buildings is one of the key components of achieving climate mitigation goals, and retrofitting buildings is a key strategy therein.
Building retrofits that reduce emissions, for the most part, involve three types of mechanisms:

1. **Improving building envelopes** by sealing the building better and distinctly breaking the heat transfer between the outside and the inside of the built structure. This involves increasing the insulation of walls and attics, sealing leaks, and installing efficient windows.

2. **Increasing the energy efficiency** of all appliances used in the buildings through transitioning lighting, refrigeration, and other electronics toward low-energy consuming technologies.

3. **Decarbonizing heating and cooling systems** typically through electrifying space and water heating, cooking, and clothes drying. This is mostly accomplished by using electric heat pumps, assuming that the electricity system is powered by resources with decreasing amount of GHG emissions.

Table 2 is a slightly edited version of building decarbonization project “clusters” used in a U.S. Lawrence Berkeley National Laboratory study\(^3\) to help provide some description of the types of decarbonization interventions, from the lower cost “clusters” (i.e., basic) to the more expensive ones.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic (Low Cost)</strong></td>
<td>Low-cost, basic projects with mostly envelope improvements and limited HVAC work.</td>
</tr>
<tr>
<td><strong>HVAC and Advanced HVAC</strong></td>
<td>Building envelope improvements with medium cost HVAC upgrades with some electric heat pumps.</td>
</tr>
<tr>
<td><strong>Electrification with Local Solar PV</strong></td>
<td>Envelope improvements with rooftop solar PV.</td>
</tr>
<tr>
<td><strong>Superinsulation</strong></td>
<td>Comprehensive deep retrofits focused on aggressive envelope upgrades (e.g., double-stud walls, added exterior wall insulation with re-siding, R60 roofs, triple pane windows, etc.), extensive air sealing, little or no solar PV.</td>
</tr>
<tr>
<td><strong>Large Home with Geothermal Heat Pumps (High Cost)</strong></td>
<td>HVAC-focused projects in large homes with geothermal heat pumps and some building envelope and PV work.</td>
</tr>
</tbody>
</table>

Table 2: Building Decarbonization Interventions
2.1 **Costs of Building Retrofits**

As found in a report by Climate Action Tracker, “to reach the emissions and energy intensity goals, 2.5-3.5% of buildings need to be retrofitted every year.” These retrofits typically require significant upfront investment costs. Taking one major U.S. city as an example, a 2019 analysis conducted by the Urban Green Council estimates that retrofitting existing buildings in New York City would cost over $2.2 billion in the first five years with a total cost of between $16.6 billion to $24.3 billion from 2019 to 2030 (see Figure 4). While significant uncertainties exist around these cost estimates, if we assume, very roughly, that it costs about $2-$3 billion per year per state over the next 27 years, the overarching cost of retrofits across the United States through 2050 would be around ~$100-$150 billion per year, or ~$3-$4 trillion in total.

![Figure 4: Retrofitting Costs for Commercial and Residential Buildings (Source: Adapted from New York City Retrofit Market Analysis, Urban Green Council, 2019)](image)

To obtain significant GHG emissions reductions, the necessary building retrofits tend to be expensive and some of the investments could not pay for themselves through energy cost savings alone. The 2022 Lawrence Berkely National Lab study described above found that for residential homes, project cost “is the key barrier that homeowners are facing.” According to its data, to reach GHG emissions reductions of 50% or greater, project costs had to be at least $40,000-$50,000 per home. Many projects had long-term positive net present values (NPVs), which means that if measured over a long period of time, the present value of the cost savings would exceed the upfront capital investment. However, the study also found that some homeowners experienced increased energy costs even after the retrofits are made because of the switch from cheaper natural gas fuel to more expensive electricity to power the heating systems. In addition, the report found that the most successful building decarbonization projects received generous subsidies – between 24% to
60% of total project costs. Finally, the analysis pointed out that easier access to financing is a key tool in making projects more affordable and scalable.⁶

2.2 Building Decarbonization Funding Gap

Although investments in building decarbonization projects have been increasing, there remains a large funding gap, particularly if economies are to achieve net zero emissions objectives by 2050. According to data from the International Energy Agency (IEA), there is a roughly $300 billion annual gap in energy efficiency investments alone worldwide (see Figure 5). This figure only includes funding for energy efficiency, one of the most profitable and advanced segments of the decarbonization market.

![Figure 5: IEA: Annual Investment in Building Energy Efficiency in Net Zero Scenario, 2017-2030 (Source: Adapted from Annual Investment in Energy Efficiency in the Buildings Sector in the Net Zero Scenario, 2017-2030, IEA)](chart)

Today, in some U.S. jurisdictions, retrofitting homes to be more energy efficient can be partially paid for by ratepayer funds, which is a collection of charges from all electricity and/or natural gas ratepayers.⁷ However, ratepayer funds are expected to only pay for a portion of the necessary upfront costs.⁸ ⁹ The 2022 Inflation Reduction Act provides $89 billion for building decarbonization efforts, but even accounting for these public funds, studies still find a large financing gap. Since public resources and ratepayer funds are insufficient to retrofit buildings on the scale required to reach net zero emissions economy-wide by 2050, our research focuses on understanding how to mobilize private investments.
3. Findings from Research Interviews: Challenges in the Building Decarbonization Market

Based on our stakeholder interviews, we identified several market-related challenges to building decarbonization financing efforts. In this section, after describing the challenges, we propose a framework to organize the financial viability of residential building decarbonization projects. This framework considers how market-related hurdles affect economies of scale and potential for return on investments.

3.1 Disaggregated Marketplace for Building Decarbonization Efforts

Stakeholders interviewed agreed that a main barrier to investing in residential decarbonization efforts is the lack of a coherent building decarbonization market. The pool of bankable projects opportunities is not large enough for commercial financing entities to build a pipeline of projects that would provide market-level returns. As an interviewee said: “This is not a financing issue per se. There is abundant capital available but no good projects.”

The fundamental causes of lacking a marketplace include absent or inconsistent regulation and the heterogeneity of the real estate market. In addition, a substantial number of other issues remain in this market. Table 3 summarizes the key issues discussed by experts. While each of these issues taken individually is important, even more notable is their combined effect. Our discussions reveal that in practice, there is no coherent building decarbonization market with well-defined demand and supply chains. Markets, at their core, can help efficiently allocate capital and help aggregate and match demand and supply flows. Without an actual functioning market in place, there cannot be meaningful private sector financing. The rest of this section will describe the lack of a coherent marketplace for building decarbonization and its effects on financing.
Barriers to Residential Building Decarbonization

| Investment Constraints                  | • High upfront investment costs  
|                                         | • Lack of feasible financing options  
|                                         | • Misaligned landlord-tenant incentives  
| Heterogeneous Buildings & Building Owners/Operators | • Heterogeneous building stock  
|                                         | • Geographical differences in use cases and feasibility  
| Lack of Consistent Regulatory Policies  | • Lack of building decarbonization policies or regulations  
|                                         | • Lack of pricing on undesirable emissions externalities  
| Infrastructure Constraints              | • Electricity systems unprepared for electrification  
|                                         | • Lack of consistent planning for electricity system to support growing demand  
| Workforce Constraints                   | • Lack of skilled workforce for building system upgrades  
| Lack of Publicly Available Information  | • Lack of information on technology choices and cost tradeoffs  
|                                         | • Lack of information on financing options  

Table 3: Key Barriers to Residential Building Decarbonization

Residential building owners have a diverse set of needs for building decarbonization services and many are unaware of the retrofit options available or how retrofitting can improve the value of their properties. For example, major retrofits mostly occur when existing systems – such as roofs, windows, or heating equipment – reach the end of their operational lifespans. While these are economically and operationally rational decisions, at those critical times, consumers typically need a replacement roof, window, boiler, or heater to be installed quickly; they likely do not have the time or money to shop for the best long-term options. Many building owners/users do not have full access to capital resources and information that an effective decarbonization ecosystem could provide. This is particularly true for individual homeowners, who do not conduct long-term financial planning in the same way businesses or large commercial players might.

Demand for building retrofit services is inherently unique to each building’s distinct needs and characteristics. Residential buildings vary by typology, age,
design, materials, history, and use. Even for buildings of a similar vintage or style, the need for retrofit can be significantly different. For example, a residential home built before the 20th century may have been built with very little insulation, thick stone walls, high ceilings, and with airducts that move hot air through the home to heat it. A home built in the 1960s can be small, with low ceilings, oil heating, and no direct ventilation system. These examples illustrate that the range of suitable retrofit options can be quite extensive, and in the absence of standardized solutions, the associated costs can be dramatically higher than necessary. As a result, when building retrofit solutions are considered, it becomes essential to precisely align the financing options with the specific building retrofit design. This, in turn, poses a significant challenge to cultivating a market that can scale up and support decarbonization efforts in the most cost-efficient manner.

Parallel challenges exist on the supply side, with a fragmented market with small and highly specialized solutions. Contractors who specialize in implementing building retrofits are often small operators who may not be up to date with the latest technologies or options. For instance, some contractors may not be familiar with the latest technologies associated with building insulation, or air-source or ground-source heat pump systems, as they are quickly evolving. Additionally, different skills are needed to install more efficient lighting as opposed to replacing a water boiler. There are very few one-stop-shops for home efficiency retrofits. The lack of familiarity with multiple technologies and installation techniques, paired with the general shortage of a specialized climate workforce across the United States, severely impairs a well-functioning building decarbonization supply chain and labor pool.

It follows that securing financing in such an unstructured and fragmented market presents considerable challenges. In Figure 6, we summarize the dilemma that combines the challenges from both the supply and demand sides of this marketplace. Under such circumstances, traditional financiers, including commercial banks, often exhibit reluctance toward individual, small-scale, and diverse projects. This is particularly true for residential decarbonization investments, especially when accompanied by significant transaction costs. This situation can be further exacerbated by the limited availability of assets that can serve as viable collateral for lenders financing these initial investments. For instance, enhancements like weatherization, insulation, new windows, and installed heat pumps are highly unlikely to serve as collateral for financiers.
Consequently, in the event of loan defaults by borrowers, the lender is left with little to no practical recourse. As a result, private lenders are hesitant to finance transactions where the credit risks are uncertain or elevated.

![Figure 6: Building Decarbonization Market Challenges](image)

The outcome is a fragmented assortment of sub-markets with limited aggregation, hindering the financial viability of many projects. Indeed, without harnessing the advantages that market aggregation may offer to individual building owners, the costs of individual retrofit projects may stay relatively high in the foreseeable future and projects will be financially feasible only when the energy savings (in net present value terms) are overwhelmingly positive or when subsidies are exceptionally generous. While some decarbonization projects can secure private financing today thanks to energy efficiency interventions that create sufficiently large energy cost savings, many relatively cost-effective projects are not yet being financed. Market aggregation can play a crucial role by facilitating economies of scale, diversifying risks, and expediting technology learning. The subsequent section will delve into these opportunities and categorize them on a scale ranging from “Easy to Finance” to “Hard to Finance.”
3.2 A Building Decarbonization Financing Framework

Consistent with most investment opportunities, we have found, through the interviews conducted, that when evaluating a decarbonization investment, lenders and investors mainly evaluate the project’s expected rate of return and the size of the opportunity. Financiers mentioned that decarbonization projects must offer returns above prime rates, or at least, their market rates. If the level of returns is uncertain or below this threshold, the projects become harder to finance. Financiers also discussed that the scale of the investment opportunity is an important consideration. Although figures vary, they are generally hesitant to invest in small projects. They gave examples of small decarbonization projects as those providing upgrades in single family homes as opposed to larger buildings or a group of buildings (such as community buildings and social housing systems). Based on these insights, we created a framework to map the financing feasibility of decarbonization investments (see Figure 7). This framework helps illustrate and differentiate the projects that already have access to financing, those that could achieve financing when combined with the necessary incentives or financial support, and those that are unlikely to obtain private financing, absent some major regulatory, technological, or cost change.

This financing framework divides the residential building decarbonization market into three segments. The three segments are based on two key criteria for investing in decarbonization projects: (1) the scale of the investment (i.e., small to large) and (2) the return on investment (i.e., low ROI to high ROI). We find three designations:

- **“Easy-to-Finance”** for projects that are relatively large or naturally aggregated with expected market-level returns on investments.

- **“Potential-to-Finance”** for projects that are relatively risky, with varying size, and expected returns that are right below market levels.

- **“Hard-to-Finance”** for projects that are small, with negative expected returns on investments, and therefore unlikely to be financially attractive to investors or lenders.
Figure 7: Residential Financing Feasibility Framework

With this framework, we map out how financers roughly see residential decarbonization projects. Table 4 provides more details to describe the framework by using representative project examples. The table is not intended to be exhaustive but to provide indicative project/market benchmarks to facilitate this paper’s discussion and future research.

Table 4: Building Decarbonization Financing Framework
“Easy-to-Finance” projects include those projects that are already able to secure private financing because they are likely to provide large energy cost savings and bring a healthy return to the lenders and investors; typically, these are relatively large investments or can be naturally aggregated. We consider these projects the “low-hanging fruits” of residential decarbonization. Large real estate owners usually already have relationships with banks and lenders, who feel comfortable providing loans against predictable streams of energy cost savings. In turn, Energy Services Companies (ESCOs), along with their financing partners, have been operating in this market segment for the last decade, especially delivering energy-saving investments to public sector buildings. There is still room to grow and for more financing to flow, especially into large multi-family residential buildings, such as public/social housing buildings.

“Potential-to-Finance” projects refer to those with expected returns slightly below market rates or ones that are deemed too small, leading to hesitancy among private investors to participate. Most of the projects in this category are on the edge of economic viability for private investors. Considering the nature of the project profiles, this is an emerging space characterized by a relatively new and evolving risk profile. Public financing incentives can make a real difference in this category of projects. Based on our discussions, this is a significant addressable market for private financers and one for which there is great interest from consumers and policymakers.

“Hard-to-Finance” projects are not expected to bring a positive financial return to project investors either because of the expected negative cash flow or because the projects are too unique, small, or both. Given the current market forces, most of these projects are only pursued when building owners are willing to pay a large ‘green premium’ for a decarbonized built environment. Because public financing or ratepayer funds typically do not currently evaluate the individual project’s overall expected return, some of these projects are being funded today. However, more granular analyses are necessary to better estimate the size of this market segment and types of buildings or projects that belong in this category. It would make the most economic sense to decarbonize this category of projects last.

By mapping decarbonization projects from “Easy-to-Finance” to “Hard-to-Finance,” we have effectively drawn an abatement curve for project types and building types. Our framework illustrates that energy efficiency projects for large property owners often have sufficient access to private capital, while full
electrification projects in areas with very high electricity prices may encounter significant challenges in accessing capital markets effectively. It also highlights that there is a substantial addressable market with varying financial gaps which can be bridged with some favorable financing for the property owners. To address the “Potential-to-Finance” market segment, we asked private financers what would be helpful to bridge existing bankability gaps and push them to increase investments. The next section will discuss useful tools for propelling projects from the “Potential-to-Finance” into the “Easy-to-Finance” segment.
4. **Research Findings: Case Studies and Key Takeaways**

Stakeholder interviews highlighted market aggregation and the use of catalytic capital as key ingredients to facilitating financing of building decarbonization projects. The case studies below show how two organizations - EnergieSprong and BlocPower - utilize these elements to tackle the challenges of building decarbonization in their respective markets. While the long-term impact of their endeavors will have to be closely monitored, their approaches already provide valuable insights into how they are trying to address some of the most pressing challenges described in the previous sections.

**Case Study 1: EnergieSprong, Netherlands**

EnergieSprong is a nonprofit organization working to create a coherent demand and supply market for building energy efficiency and electrification services in the residential sector. EnergieSprong started in the Netherlands and currently has a presence in France, Germany, Italy, the United Kingdom, and the United States. The organization is promoting the development of performance-based contracts for retrofit aiming at Net Zero performance. To do so EnergieSprong works with ESCOs, private financers, homeowners and other stakeholders, with an initial focus on social or public housing projects to gain economies of scale. Through its interventions, EnergieSprong aims to reduce the energy needs of existing residential buildings by 80% and then electrify the remaining 20%.

**Key Value Proposition: Demand and supply aggregation by being the “market-maker.”**

On the demand side, EnergieSprong targets its services to large groups of buildings that share similarities and have great opportunities to increase their buildings’ efficiency. To avoid the difficulties associated with a heterogenous building stock and to create economies of scale, EnergieSprong has prioritized working with buildings that have similar features, such as multi-family social housing or public housing. Working with social housing can capture owners who own multiple
buildings, which also provides a natural platform for aggregating demand, as well as access to cheap public financing sources.

EnergieSprong offers its services to buildings according to their energy efficiency rating. In Europe, most countries require efficiency labels for buildings at the point of sale. This adds transparency to the market, and the value of lower energy consumption is reflected in buildings’ prices. EnergieSprong leverages this information by identifying buildings that are good candidates for Net Zero energy retrofits and the level of investment needed to increase their efficiencies using the rating scheme. For example, in France, EnergieSprong estimates that the majority of less efficient buildings, categorized as “D” through “G,” are potential candidates for retrofitting to become categories “A” and “B” (see Figure 8). Specifically, buildings in categories “D” and “E” may be earlier targets because of their number and the amount of work needed to make them more efficient, whereas the buildings in categories “F” and “G” are fewer in number and probably require costlier work.

![Figure 8](image-url)

**Figure 8:** EnergieSprong’s Estimate of Building Candidates for Deep Retrofits (Source: EnergieSprong)

On the supply side, EnergieSprong offers building decarbonization solutions that can be mass-produced, installed quickly, and be scaled up systematically. For EnergieSprong, scaling up supply services involves working with vendors to design and build retrofit solutions for many buildings simultaneously, with the specific goal of driving down the cost. EnergieSprong works with vendors, including builders, who can reconstruct the “envelopes” of buildings in factories by “prefabrication,” and then “install” those solutions at the building sites with minimal interruptions for the building occupants. These technical solutions
include prefabricated roofs, building façades, and integrated energy management systems that can help monitor and reduce energy consumption (see Figure 9).

**Figure 9:** EnergieSprong’s Approach to Prefabricated Building Envelopes to Reduce Cost and Installation Time (Source: EnergieSprong)

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**Case Study 2: BlocPower, New York, United States**

BlocPower is an energy technology company that aims to work across the ecosystem of building electrification retrofits. The company connects government agencies, utilities, building owners, and equipment manufacturers to identify buildings to retrofit. Founded in New York in 2014, the company is focused on projects in several U.S. cities, including New York City, Boston, Ithaca (NY), Denver, and Menlo Park and San Jose (CA), with expansion plans for others.

**Key Value Proposition:** Market demand identification and project management through a one-stop-shop solution.

BlocPower uses data analytics to identify clusters of small- and medium-sized buildings suitable for cost-efficient building retrofit solutions. BlocPower’s technology platform uses machine learning and building data to identify retrofit opportunities across buildings by examining various factors such as energy consumption, local climate, building characteristics, etc. Demand aggregation allows for scale efficiencies in engineering, purchasing, and project management, thus reducing associated costs.
On the supply side, BlocPower offers a one-stop-shop for building owners interested in reducing their carbon footprint and energy costs. BlocPower handles all tasks associated with the building decarbonization projects including conducting energy audits, designing retrofit plans, obtaining permits, managing construction, and overseeing quality control. It also collaborates with utility companies to identify energy efficiency incentives, rebates, and other financial programs to maximize the financial benefits for building owners. BlocPower’s offerings allow users to navigate the complexities of adopting building retrofits.

Figure 10: BlocPower’s Business Proposition (Source: BlocPower)

BlocPower plays a significant role in facilitating financing for building retrofits. BlocPower conducts a detailed financial analysis for every project to determine the cost of the proposed energy-efficient upgrades and the potential energy savings to illustrate the financial benefits of the project to potential investors. It also offers a variety of innovative financing solutions, including no money down leases, and energy services agreements (ESAs), whereby the costs of the retrofits are covered by third-party investors, and the building owners pay for the upgrades over time.

As part of its goal of being a market facilitator, BlocPower channels catalytic capital towards making investments in building decarbonization. BlocPower has raised grants and loans from foundations and impact investors (such as Microsoft and others) to provide financing for building owners in underserved communities who are financially constrained in offering the upfront capital. BlocPower’s market aggregator role, combined with its efforts in obtaining impact investor’s financing, has begun to shift the market in building decarbonization.
4.1 **Ingredients for Success**

Apart from major regulatory overhauls, the two key strategies we identified to facilitate financing in the “Potential-to-Finance” segment are market aggregation and the use of catalytic capital. By examining our research, including the case studies described previously, we have extracted essential elements - *ingredients for success* - which we incorporate into our recommendations to optimize and build upon existing practices.

**Ingredient 1: Market Making and Aggregation**

Aggregation of demand and supply is key to achieving economies of scale and de-risking potentially financeable projects. To address the challenges posed by a disorganized and incoherent market, we find that it would be crucial to facilitate “market making” efforts. Successful financing initiatives often involve organizations that can efficiently aggregate homogenous demand and align it with readily scalable decarbonization solutions. Additionally, it is highly beneficial when these organizations can directly pool and allocate capital to the “Potential-to-Finance” projects, especially when complemented by concessionary financing and incentive mechanisms.

Demand aggregation involves designing comprehensive decarbonization projects for large groups of buildings that share similarities and have great opportunities to increase their buildings’ efficiency. Demand aggregation mitigates the difficulties related to a heterogenous building stock by prioritizing working with buildings that may have similar features, such as multi-family social housing or public housing. Working with social housing can capture owners who own multiple buildings, which also provides a natural platform for aggregating demand, as well as access to cheap public financing sources.

Supply chain development and aggregation efforts include promoting building decarbonization solutions that can be mass-produced, installed quickly, and scaled up systematically. Supply aggregation entails working with vendors, including builders, who can reconstruct the “envelopes” of buildings at scale, possibly in the factories by “prefabrication,” and install the upgraded components with minimal interruptions for and costs to the building occupants. It seems that it would be worth pursuing technical solutions that include prefabricated roofs, building façades, and integrated energy management systems that can help the building
monitor and reduce energy consumption. One-stop-shop companies can provide valuable aggregated supply of services. Increasingly, successful decarbonization companies offer services that range from building audits to equipment installation and financing across renewable energy, energy efficiency, and energy management.

**Ingredient 1 Key Takeaways**

- **Prioritize** homogenous demand in neighborhoods, blocks, or property complexes with similar buildings that can be retrofitted with similar solutions.
- **Promote** decarbonization solutions that can be mass-produced and scaled.
- **Provide** building owners with financial support tools to clearly demonstrate the economic value of energy savings and emission reductions.

**Ingredient 2: Innovative Financing Mechanisms**

Catalytic capital and combining public and private funds represent another vital ingredient that can facilitate projects in crossing the bankability threshold. When decarbonization project economics do not provide market-level returns, the use of concessionary financing, public incentives, and other instruments becomes pivotal in accessing larger pools of private capital. Decarbonization start-ups that secure grants and low-interest loans from impact investors can subsequently tap into commercial credit lines to finance projects on behalf of their clients.

Additionally, the use of incentives and concessionary financing can make a big difference for projects that are close to being bankable. The use of energy savings performance contracts that guarantee a certain amount of energy savings (not necessarily cost savings) is becoming a template for many building decarbonization projects. For example, cost savings obtained from lower energy bills due to heat pump installations can be securitized over time and used to pay for upfront investments. Through our research, we have come across several tools that are being tested across various jurisdictions in facilitating financing building decarbonization projects. Table 5 summarizes some of the financing tools that interviewees have highlighted as useful.
Public/development banks traditionally have used these financial instruments to reduce risk exposure for commercial lenders, facilitating their participation in projects – in this case decarbonization projects. A loan loss reserve fund is a pool of money set aside to cover potential losses when borrowers default or are unable to repay their loans. A loan guarantee is a commitment to assume part of the risk of a loan made by a lender to a building owner. Both structures help reduce the lenders’ risk and make them more likely to offer financing for building decarbonization projects that would otherwise go unfunded. As an example, the Connecticut Green Bank offers a product called “Smart-E Loans” that helps residents perform building upgrades. The bank provides a standard-offer loan loss reserve fund to help cover a portion of the loss in the event of a default on a clean energy loan. In return, the participating commercial banks agree to offer the loan at an extended term at a favorable rate to the borrower.

<table>
<thead>
<tr>
<th>Tool</th>
<th>Description</th>
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<tr>
<td>Loan Loss Reserve Funds and Loan Guarantees</td>
<td>Public/development banks traditionally have used these financial instruments to reduce risk exposure for commercial lenders, facilitating their participation in projects – in this case decarbonization projects. A loan loss reserve fund is a pool of money set aside to cover potential losses when borrowers default or are unable to repay their loans. A loan guarantee is a commitment to assume part of the risk of a loan made by a lender to a building owner. Both structures help reduce the lenders’ risk and make them more likely to offer financing for building decarbonization projects that would otherwise go unfunded. As an example, the Connecticut Green Bank offers a product called “Smart-E Loans” that helps residents perform building upgrades. The bank provides a standard-offer loan loss reserve fund to help cover a portion of the loss in the event of a default on a clean energy loan. In return, the participating commercial banks agree to offer the loan at an extended term at a favorable rate to the borrower.</td>
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<tr>
<td>Green Bonds</td>
<td>Green bonds are fixed-income securities that are issued to finance projects with environmental benefits. They are the same as traditional bonds, where the issuer (usually a corporation or government) raises capital by issuing a bond with a fixed interest rate and a maturity date, except funds raised via green bonds are earmarked for specific projects that yield environmental benefits, such as building decarbonization projects. Green bonds are used to tap into the capital market and can reduce the financing costs by pooling investments and matching green projects to funds interested in environmentally sustainable investments. Green bonds are becoming an increasingly attractive source of funds for building decarbonization projects. Using green bonds can enhance the market visibility of building decarbonization projects, as they are often listed on dedicated green bond markets and are subject to additional reporting requirements. In 2017, the Connecticut Green Bank issued a $38.4 million green bond to finance energy efficiency retrofits for multifamily buildings in the state. The retrofits included upgrades to heating and cooling systems, insulation, and lighting, and were expected to reduce energy consumption by up to 40% in the retrofitted buildings. The green bond was oversubscribed, with demand exceeding the available funds. Also in 2017, the New York Green Bank issued a $134 million green bond to finance a range of clean energy projects, including energy efficiency retrofits for public housing buildings.</td>
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<td>PACE Loans</td>
<td>PACE financing is a structure through which a building owner repays an energy upgrade loan through property taxes via a new lien on the building. PACE liens typically sit senior to all other non-tax liens on a building, including the mortgage, significantly reducing repayment risk. If approved at a state level, any municipality can allow PACE; technically a PACE loan can be made by any lender. That repayment is collected by the taxing agency and remitted to the lender. PACE financing is attractive for building owners that estimate that efficiency or clean energy projects cost less than the energy savings they bring. This means that PACE financing makes sense when the project has a positive net present value. Accordingly, PACE programs have grown in adoption, with some of the largest cities adopting them including Atlanta, Cincinnati, Columbus, Dallas, Kansas City, and Orlando. Some first mortgage holders find such a tool to be placing more risks onto them and therefore oppose the use of PACE loans to help finance building retrofit projects.</td>
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Table 5: Financing Mechanisms for Building Decarbonization Projects
Ingredient 2 Key Takeaways

- **Prioritize** financial mechanisms to securitize energy cost savings to pay back upfront costs.

- **Deploy** catalytic capital towards decarbonization efforts in segments of the market that could benefit from using that capital to scale up and attain financial feasibility.

- **Leverage** financial tools that de-risk private sector investments through pooling, tax-incentives, credit guarantees, etc.

5. **The Opportunity for Green Banks**

After analyzing the barriers and various potential ingredients for success, we recognize that absent regulatory reforms (more on this in Section 6), a national green bank and/or multiple regional green banks are well-suited to help develop a market for public and private financing of building decarbonization. Green banks are publicly funded financial institutions that are dedicated to mobilizing private capital towards clean energy and sustainability projects. In most circumstances, their common principles include: (a) offering financing, (b) attracting and leveraging private capital into the same investments, and (c) recycling public funding to increase the efficiency of public funding. Their value-add lies in providing low-cost financing, technical assistance, and risk mitigation solutions to support the development of innovative and high-impact green projects. National green banks have been successful in Europe (for example, KfW of Germany) in jumpstarting efforts to direct private capital towards real estate decarbonization. By partnering with private sector actors, green banks have helped to bridge the gap between innovative clean energy technologies and the mainstream financial markets.
5.1 Green Banks as Market Makers

Green banks can both support, and in some cases, play the important market-maker role to help aggregate demand, supply, and financing, mitigate investment size challenges, and reach scale. A green bank could invest in organizations that play an intermediary role to aggregate demand and supply or attempt to interpret that role themselves. As EnergieSprong’s approach illustrates, there is a great need for entities that develop tools and approaches that help to mobilize demand by creating portfolios of buildings to be retrofitted simultaneously and to mobilize supply by developing enhanced manufacturing capabilities.

Organizations offering this level of coordination and visibility through the supply chain – from buildings to contractors – could use the funds from a green bank to reduce the market frictions in building decarbonization efforts and reduce costs. By understanding the building types and interventions required and their diverse level of risks, green banks can work with intermediaries to aggregate portfolios of buildings that could help diversify risks that private financing entities may face. At the same time, green banks could be an intermediary themselves within the financing community, combining multiple financing commitments from diverse investors.

The Cities Climate Finance Leadership Alliance and Climate Policy Initiative said it best in the key findings of their report Financial Aggregation for Cities:\(^\text{13}\)

“Supply- and demand-side aggregation are potential strategies to alleviate many of the barriers that cities face in financing urban climate projects. This includes overcoming external barriers related to project size, high upfront costs, and interest rate risk by combining projects into a single, larger financial vehicle, utilizing financial mechanisms that attract a broad range of investors, and mobilizing private and early-stage finance. It can also help address internal barriers, such as municipal creditworthiness and organizational barriers like capacity building through risk pooling, project preparation facilities, and other blended finance instruments.”
From a market maker perspective, a green bank can support businesses and organizations that systematize, standardize, aggregate, and connect supply chain and demand. From a financing perspective, a green bank can help match projects or portfolios of projects with pooled financing entities, with a focus on attracting private financiers to such a new market with which commercial entities might have limited experience.

**Figure 11:** Green Bank to Support Building Decarbonization
5.2 Green Banks as Providers of Catalytic “Development” Capital

Green banks can provide grants, concessional funding, and credit enhancements to reduce the credit risks that private investors face. Although public funding alone is not enough to finance the required building decarbonization, it can be a powerful tool in a capital stack that includes public and private funds. The traditional capital stack is shown in Figure 12. This capital stack primarily includes debt and equity, with the senior debt bearing the least risk and the equity bearing the greatest risks but also the highest upside gains.

![Figure 12: Traditional Capital Stack for Real Estate Investments](https://www.arborcrowd.com/real-estate-investing-learning-center/capital-stack-and-equity-debt/)

However, given the uncertainties around the likely financial returns from some decarbonization projects and the shared social value they generate, it seems reasonable that the capital stack may include public and private funds. This model would be like that of an economic development bank where multiple public and private funding sources are stacked to finance the projects. Figure 13 shows that a capital stack that can help develop the decarbonization effort includes government funding and ratepayer funding, shown on the right-hand side of the
diagram. On the left-hand side are private funding sources, including private equity, commercial banks, philanthropic “investors,” and impact investors. The blue dotted line on the outside of the diagram shows that governments and quasi-governments can provide guarantees and other risk mitigation measures to attract and enable private investors to participate in the projects.

**Figure 13:** Various Sources of Financing for Building Decarbonization Efforts (Source: Figure adapted from Financing Low-Carbon, Climate-Resilient Cities)

Access to more affordable capital flows can empower project sponsors to design sustainable business models that yield strong returns for specific categories of investors. For instance, the availability of concessional financing can unlock numerous project opportunities and, consequently, attract traditional investors to this burgeoning sector focused on building decarbonization. Throughout our research and interviews, we observed that private investors are receptive to collaborating with green banks as it enables them to mitigate risk exposures and assume risks they can best assess and price.
5.3 **Momentum for Green Banks in the United States**

Recently, the Coalition for Green Capital has formed a “National Green Bank.” This National Green Bank is set up to receive funding provided via the U.S. Inflation Reduction Act. The concept is to use a national platform to support local entities across the United States and use the federal funding to mobilize private sector financing. The National Green Bank’s intentions include using a portion of the federal funding to directly invest, alongside private investors (both debt and equity providers), in large-scale infrastructure projects and local community-based projects that would reduce GHG emissions.
The National Green Bank intends to invest in emission reduction projects and recycle those returns on capital in additional projects. Effectively, the National Green Bank would use a portion of the federal funding received to mobilize private funding in areas that are traditionally not able to attract private capital. The federal funding channeled through the National Green Bank would take a low, but positive return, and simultaneously reduce the risks of the private investors by reducing their credit risk exposures by providing loan guarantees or other approaches that help increase the appetite of the private investors in engaging in the clean energy projects.

Lessons can be gained from various types of public-private joint financing structures that have helped grow the deployment of residential solar PV projects. Some state entities, including state green banks, have helped finance residential solar PV projects, yielding its significant growth over the past decade, by providing either direct loans to residents or loans to contractors selling and installing the solar PV projects. For examples, Massachusetts’ Clean Energy Center has worked with commercial banks to provide financing for solar PV projects. In the case of New York, the NY Green Bank has provided loans and credit enhancing financing options to developers of relatively large-scale solar PV projects.¹⁶

Using a National Green Bank has political momentum in the United States. Such a National Green Bank is a part of the federal government’s plan of attracting private capital to “difficult-to-finance” greenhouse gas reduction projects. Building decarbonization will likely be in the portfolio of the projects to be financed by such a National Green Bank. However, to make a big push for using the National Green Bank to successfully finance individual residential home retrofits will require significant additional efforts to remove the barriers discussed in the previous sections of this paper.¹⁷
6. **The Role of Government**

Although green banks can help motivate private sector participation by developing the market and closing some of the financing gaps (as discussed previously), they are not a substitute for government regulation to drive adoption and mobilize a well-functioning market. The central problem is that the value of decarbonization is a positive externality that is hard for individual actors or businesses to capture and monetize. Clear policies, regulatory rules, and standards could help set up standard measurement approaches and help private actors to capture and monetize the value of carbon emissions reduction. If implemented well, governments can use regulation to create opportunities to improve the economics of decarbonization allowing new business models to emerge. Underlying such an assumption is that GHG emissions carry with them a cost to society that can be quantified and used to evaluate the benefits of projects compared to the costs that they abate, including the cost of GHG emissions.

6.1 **Carbon Pricing**

Government regulation could unleash private sector participation by placing a “value” or “price” on GHG emissions. One example is placing a regulated cost on GHG emissions. Building owners and developers would then have a financial incentive to adopt low-carbon solutions to avoid paying such costs. The revenue generated from the collection of costs could be used to fund building decarbonization initiatives and provide incentives for private investment in energy-efficient solutions. For example, in 2019, the City of Toronto introduced a Carbon Neutral Buildings Framework, which set targets for new and existing buildings to achieve carbon neutrality by 2030. As part of the framework, the city introduced a carbon tax on natural gas and other fossil fuels used for heating and cooling buildings, which is set to increase annually until 2025. The most economically efficient approach for instituting a carbon price is to have a uniform price (or market for cap and trade) across the whole economy, not just for buildings. If an economy-wide price on carbon is impossible to implement, some version of carbon price on GHG emissions from buildings will have a direct impact on investments in buildings and potentially a strong effect on the markets for various fuels used in buildings.
Designing any carbon pricing regime will require careful analyses of the costs and benefits associated with the parameters of implementation. Particularly important in the cost and benefit analyses are the potential short-term and long-term impacts on fuel markets. Further, designs of any such regulation will require thoughtful evaluation of potential emissions leakage to ensure that the activities regulated in one jurisdiction do not simply transfer emissions to either another jurisdiction or another sector.

Some have considered the use of a market for carbon offsets, which would allow building owners and developers to generate credits (and therefore monetary value for those credits) for other sectors to purchase, or purchase offset credits from projects that reduce or remove carbon from the atmosphere in other sectors. A global market for carbon emissions with clear standards, measurement, and verification would be needed to ensure compliance and reduce the risks of leakage, fraud, and double counting. While this paper does not delve into various methods of carbon pricing, we would be remiss to exclude the discussion of the possibility of various ways to put a price on GHG emissions, even if imperfect, incomplete, and sector-specific.

6.2 Building Codes

Reducing GHG emissions from new buildings is the first step to take in transforming the built environment and its market. Building codes set the performance standards for all new buildings and major renovations. Thus, using building codes to ensure that every new building built from this day forward is as efficient as possible would be the first objective to achieve. While it is important to encourage technological improvement over time, in most instances, it would likely be more costly to build an inefficient building today that must be retrofitted in the future, than to simply build it to be maximally emission-free today. Thus, setting building codes today to motivate building architects and developers to the forefront of efficiency development should help minimize the long-term costs for society at large.

However, as mentioned, given that 80-85% of the buildings that will exist in 2050 are already standing today, additional policies are needed to reduce emissions from the existing building stock.
6.3 Building Labeling and Building Standards

Governments can also help facilitate building decarbonization markets by setting standards to evaluate buildings’ GHG emissions performance. For example, governments can require building owners to disclose the efficiency of the buildings, including the equipment used by the buildings for heating and cooling. Such labeling will bring transparency to the real estate market. Real estate buyers and renters are increasingly willing to pay more for more efficient and healthier buildings, particularly if the operating costs of those buildings decrease. Many European countries already require building owners to disclose information about the building’s energy usage via a “score card” at points of sale and lease (see Figure 15 for an example of a scorecard used in Belgium). This has allowed the market to better recognize and price the value of energy efficiency. The United States currently has no such requirements.
Figure 15: Sample Building Energy Performance Certificate in Belgium (Source: Certinergie Belgique)
This approach can be tested at a small scale first in certain municipalities. For example, a state can require building labeling in a certain segment of its building stock and evaluate the potential impact on the real estate market in that segment. Such an evaluation could help regulators to determine the potential impact, if any, on building owners, building users, on the real estate market broadly, and other stakeholders.

Even in the absence of government labeling requirements, the private sector could initiate a labeling mechanism that attracts building owners to participate. One such initiative is being tested out by the company Pearl Certification. Follow-on research should include an analysis of whether it would be necessary and/or important for building labeling initiatives to be required by government to ensure uniform participation or whether private voluntary approaches would be sufficient for achieving the goals of building decarbonization overall. This is an area that will require significantly more regulatory analysis.

6.4 Building Emission Targets

National and local governments can directly require decarbonization efforts when they set specific decarbonization mandates or GHG emission caps. This is particularly effective if those measures are accompanied by non-compliance penalties. Avoiding those penalties becomes the opportunity cost against which building owners assess their decarbonization investments. Some major cities such as Boston and New York City have set building ordinances that include a structure for each building to comply; failure to comply comes with a penalty payment. For example, New York City’s Local Law 97 is a part of the city’s approach to reduce GHG emissions from buildings and help it reach carbon neutrality by 2050. Under Local Law 97, buildings covered by the law will face annual emissions limits and buildings that exceed the set emissions limits will face an annual financial penalty of $268 per ton of CO₂ equivalent over the established limit.

In another example, Boston’s Building Energy Reporting and Disclosure Ordinance (BERDO) requires non-residential buildings that are greater than 20,000 square feet and residential buildings with 15 or more units to report their energy and water use annually and to conduct an energy assessment every five years. BERDO also requires buildings to meet specific energy performance
standards based on each building’s size and type. Building owners that do not meet their emission targets and do not have an approved “Hardship Compliance Plan” can pay an Alternative Compliance Payment roughly equivalent to $234 per metric ton of CO$_2$ equivalent in excess of each building’s target. Boston will use the collected payments to help upgrade buildings and improve energy performance for low-income and underrepresented populations.\textsuperscript{18}

These non-compliance payments effectively place a price on GHG emissions from those cities’ buildings. These approaches are expected to increase building owners’ willingness to invest in decarbonization efforts to limit such penalties and costs. While sector-specific carbon pricing is not an optimal way to find the most cost-effective carbon reduction measures, it may be a good temporary approach to encourage the adoption of an efficiency standard that significantly reduces GHG emissions from the building sector.

6.5 **Clean Heat Standard**

One of the regulatory approaches that has helped to increase the deployment of clean energy in the electric power sector is the Renewable Energy Standard (RES) or Renewable Portfolio Standard (RPS). Parallel to the RES or RPS, a Clean Heat Standard would allow investments made to reduce the GHG emissions from buildings to obtain “credits” and all energy suppliers would be required to obtain and retire a certain amount of “clean heat credits” for each compliance period. Such an approach would create a secondary market for the clean heat credits and place a value (price) on the credits generated. The value of the credits will depend on the regulatory requirements. More stringent requirements (higher emissions reduction targets) would place greater pressure on the fuel suppliers to obtain the necessary credits, which in turn would drive up the prices for those credits, providing more incentives for the market to provide GHG reduction approaches. Those that can reduce energy consumption and associated GHG emissions from buildings would receive tradable credits, which would generate credit revenues for the investors of those emission reduction measures.
Such a standard has not yet been implemented. Vermont and Massachusetts have begun to consider the possibility of using such a regulatory approach. The likely impacts of such a regulatory approach will need to be carefully analyzed. It is effectively an alternative to placing a price on GHG emissions from buildings. Like any market design, the details can greatly affect the potential impact and outcomes. Thus, such a market design requires detailed analyses and simulations of the potential impact on consumer costs (both in terms of net upfront retrofit costs and the ongoing operating costs of residences) and GHG emissions. Like other carbon pricing approaches, important considerations such as GHG emissions leakage and impact on fuel markets will need to be carefully analyzed. If implemented, ongoing tracking and measurements, as well as regulatory design improvements, will be essential for long-term success.

### 6.6 Fossil Fuel Use Mandates and Bans

Finally, a government intervention that is currently being considered in some jurisdictions includes requiring the phase-out of fossil fuel-based energy use in buildings. In 2019, Berkeley, California, became the first major U.S. city to ban the installation of natural gas infrastructure in new buildings, including for heating and cooking. Several other cities and states have followed suit, with San Francisco passing a similar ban in 2020 and New York City passing one in 2021. However, any such measure must be carefully evaluated to ensure that the emission reductions can be achieved without negative consequences for the communities.

When Massachusetts instituted its “Ten-Town-Pilot” program that would disallow new natural gas hookups in participating municipalities, a significant concern was raised by stakeholders that such limits would reduce new housing units to be built in those participating cities and towns, which in turn, could exacerbate the housing shortage crisis in the state. Further, such fossil-fuel limitations are likely to create emissions leakage to other cities and towns because the new buildings would move to municipalities that do not participate in the program. Thus, any specific regulatory limitations to new fossil fuel installations in buildings need to be carefully evaluated to gain better understanding of the impact on actual emissions reductions.
Advocates for using government policies or regulations to phase out the use of fossil fuels in buildings argue that having a specific phase-out schedule helps provide certainty to investors. In turn, investors in clean heating technologies would be better assured that the market demand for them would grow over time and would be more willing to invest in technological development, manufacturing capacity, and workforce training. While these measures would undoubtedly force the market to provide greater building retrofit services, there is a possibility that the potential negative impact on available affordable housing and the lack of real net emissions reductions could outweigh the potential benefits of mobilizing the market for more cost-efficient building retrofit options. Undoubtedly, this is a policy area that will continue to be debated. A well-designed analysis of the potential benefits and costs of various ways of using regulatory authority to phase out fossil fuel usage in buildings would contribute greatly to such policy discussion and decisions.

7. Conclusion and Additional Research

Given the significant contribution of buildings to GHG emissions, coupled with the realization that most of the buildings standing in 2050 have been already built, real estate decarbonization efforts are a key component for a climate transition strategy. However, these efforts require a mammoth upfront investment, which can only be met through significant public finance, ratepayer funds and private investments, especially for retrofitting residential buildings. Upon analysis of financing constraints, through stakeholder engagements and secondary research, we have identified key market-level challenges hindering investment, as well as approaches that could help gain traction on some of the existing challenges.

We developed a simple framework using the criteria of scale and expected return on investments to segment residential building decarbonization projects into Easy-, Potential-, and Hard-to-finance opportunities. This paper centers on addressing the “Potential-to-Finance” segment of the market because these opportunities, with appropriate interventions, are on the verge of yielding a positive present value, making them sound investment choices. By distilling essential components from already-operating business models and approaches, we
have explored the appealing aspects of establishing and utilizing a green bank to channel capital into building decarbonization endeavors.

The proposed green bank could help support market aggregators to address the lack of scale in an evolving marketplace and provide financing mechanisms to address investment-viability concerns. Such a solution certainly would not operate in a vacuum and would require complementary regulatory support from the government. In essence, with the right tools, motivation, and regulatory support discussed in this paper, a green bank would provide a viable piece of the puzzle for creating an enabling ecosystem that spurs additional private sector investment.

In the process of formulating a practical solution to observed challenges, we have identified a few key topics that would benefit from additional research:

- **While this paper presents a framework for assessing financing feasibility of building decarbonization projects based on investment returns and project scale, it could benefit from further efforts on quantifying these factors.** For example, investment returns could be further fleshed out with considerations of carbon pricing needed to reach breakeven for investors or building owners, while scale factors could be further contextualized based on specific technologies, project type, geographies, etc. The framework in this paper shows that there are projects that should be pursued immediately because they are already economic under current conditions, and then it separates projects that need some financial support, such as through a green bank, from those that are not likely to be economic, even with financial support. However, exactly how specific projects can and should be evaluated is a deep and broad question and requires building technology and cost analyses. This presents a significant opportunity for future analytical work.

- **On the technology front, there are gaps in understanding the technology-readiness and economic feasibility for various solutions addressing energy efficiency, building materials, automation, etc.** New methods and technologies to help consumers monitor and use less energy are emerging every day. This is a rich area for further venture investing to ensure that the best and most efficient technologies and methods can be made available as soon as possible. Some level of prioritization would be
helpful. For example, would it be more useful to develop efficient windows or ensuring every new roof has solar PV capabilities? Should the research and development dollars focus on creating lighter and more insulating materials or should they go to more efficient heating systems? Or perhaps an “all-of-the-above” approach is necessary?

- **As building ownership is disparate, further research is required to analyze consumer choice and behavior, and to design approaches for articulating and presenting the costs and benefits of building decarbonization to disparate consumers.** Questions about how to reach consumers and present them with the best choices at the most relevant time will need substantial understanding of how purchasing and investment decisions are made by different types of building owners. A significant amount of investigation is needed in this area.

- **On the policy front, various types of policies and regulations used to limit the emissions from buildings are being tested across the United States and across the globe. Significant research and analysis will be needed to test and measure the potential impact of these policy trials.** Many questions remain about how each type of policy or regulation might affect markets, emissions, and consumers, with a particular focus on the costs and benefits to various stakeholders, including those involved in the fuel industries and real estate markets. Assuming that GHG emission reductions from buildings are essential and urgent to mitigate global climate change, a holistic regulatory analysis that compares various approaches and fully articulates each approach’s tradeoffs and potential impact on other sectors is critical.

While energy efficiency measures have been deployed over the last 20 years, the scale and scope of additional efficiency work, retrofitting, electrification, and the resulting reduction of GHG emissions from buildings is enormous. Thus, research on how to best attract private investments into this space must continue. Hopefully, green banks will be set up to push this effort forward. As this occurs, it would be essential to track the progress of the various approaches that green banks may use to mobilize private sectors investments. Follow-on studies in this topic could include quantitative impact evaluations on capital investment and emission reductions from the building sector.
8. **Glossary of Key Terms**

The terms below are key concepts used in the research paper. The definitions provided are meant to help contextualize the paper’s ideas and improve its readability. Definitions are specific to how the concepts below are used in the paper and are not meant to be exhaustive.

**Access to Finance**: Capability of homeowners and/or businesses to obtain financial services, mainly loans and loan guarantees, to fund home decarbonization initiatives. Limited access to finance can refer to the inability to obtain a loan altogether or to loans that are so expensive that they render a project non-viable.

**Carbon Pricing**: Carbon pricing is an economic term used in this paper to capture any form of value placed on the costs of greenhouse gas (GHG) emissions. The prices can be a result of tax set by a government or can be the clearing prices of auctions for emission allowances.

**Catalytic Capital**: Financial resources that help to unlock additional financial resources that otherwise would not be available. The MacArthur Foundation defines it as “investment capital that is patient, risk-tolerant, concessionary, and flexible.”

**Decarbonization**: Process through which an entity reduces its carbon footprint, primarily GHG emissions such as carbon dioxide and methane, to fight climate change. Decarbonization of residential buildings mainly refers to ensuring homes consume less and cleaner energy to reduce operational GHG emissions. This paper uses the term ‘building retrofits’ to refer to decarbonization projects of existing buildings.

**Green Bank**: The Organization for Economic Co-operation and Development (OECD) defines a green bank as a public, quasi-public, or non-profit entity established to facilitate investment into domestic low-carbon, climate-resilient infrastructure. Green banks can be publicly funded, and their primary function is to leverage private capital. Green banks seek financial returns and reduce GHG emissions; therefore, they typically aim to earn sufficient financial returns to
sustain their operations, and thus can sometimes afford to finance at lower-than-market rates.

**Innovative Financing:** Includes a range of non-traditional financial tools to raise additional private funds. In this paper, this term is mostly used in the context of creating opportunities to attract private investments.

**Market Aggregation:** Markets in which a relatively large number of producers and consumers have similar targets, requirements, and resources, but to reach an economy of scale may require additional organization. Market aggregation can apply to both demand- or supply-side activities. To reach greater market aggregation, it is assumed a certain homogeneity of the products and players in the market.

**Market Fragmentation:** Opposite of market aggregation. Occurs when consumers and producers have such diverse needs and solutions that it becomes difficult and costly to define a single market. When a market is fragmented, consumers in that market require customized offerings, which in turn makes it difficult to reach economy of scale.

**Public Housing:** Form of housing whereby the property is owned by a government (either federal or local) and provided to low-income qualified citizens to offer affordable living options. In some instances, a private development can act as public housing if it receives government subsidies to provide affordable living spaces. The term 'social housing' is also used in place of public housing.

**Return on Investment (ROI):** A measure of a project's financial viability. In this paper, it refers to the overall return on the investments made in a decarbonization project. In this paper, when referring to a loan, from a lender's perspective, the interest payment is also the return on loan. This paper also uses the term net present value (NPV) to indicate the overall economics of projects in present value terms. A project is “NPV positive” if the investors can earn a positive return on their investment, whether it is debt or equity. When this paper refers to a project “not penciling out,” the project is “NPV negative,” or the returns are not high enough to pay back the investments. “NPV negative” can occur even when a debt is fully paid back or equity earns a positive return, but the interest payments or the equity returns are below market levels.
NY Green Bank focuses on transactions with solar developers and financiers, alongside private sector lenders. To be considered for funding, projects must have the potential to drive market transformation in addition to reducing the New York state’s greenhouse gas emissions and providing a positive financial return for the NY Green Bank. The investment criteria include: (a) Transactions will have expected financial returns such that revenues of NY Green Bank on a portfolio basis will exceed operating costs and expected portfolio losses; (b) Transactions will contribute to financial market transformation (e.g., multiples of capital mobilized to fund total project costs and potential to drive the type of volume, including scalability and replicability, that can materially and sustainably expand markets); and (c) Transactions will have the potential for energy savings and/or clean energy generation that will contribute to greenhouse gas emissions reductions in support of New York’s clean energy policies. Source: https://aurorasolar.com/blog/green-bank-programs-making-solar-financing-more-accessible-part1/


19 Nilsen, E. (2022). Cities tried to cut natural gas from new homes. The GOP and gas lobby preemptively quashed their effort. CNN.