OVERCOMING FINANCIAL BARRIERS TO ELECTRIFY HVAC SYSTEMS IN COMMERCIAL BUILDINGS

APPLIED PUBLIC POLICY PROJECT

Prepared for the General Service Administration

ZIWEI VICTOR XUE

Master of Public Policy

Frank Batten School of Leadership and Public Policy

University of Virginia

UNIVERSITY of VIRGINIA | FRANK BATTEN SCHOOL of LEADERSHIP and PUBLIC POLICY

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CLIENT PROFILE

The General Services Administration (GSA) plays a pivotal role in the heart of American government operations, serving as the primary agency that procures and manages the federal government's office space and logistics. It specializes in the construction, management, and preservation of government buildings, alongside leasing and managing commercial real estate to meet federal needs. Beyond its logistical and operational roles, the GSA is a leader in promoting efficient government operations and management best practices by developing and implementing policies that set the standard for excellence in governmentwide operations. Its mission is to provide, through its actions and initiatives, a more sustainable, accessible, and efficient government for the American people.

DISCLAIMER

The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, or by any other agency.

TABLE OF CONTENTS

ACRONYMS AND DEFINITIONS

ABS – Asset-Backed Securities

BTU – British Thermal Units

CBA – Benefit Cost Analysis

CBECS – Commercial Buildings Energy Consumption Survey

C - PACE – Commercial Property Assessed Clean Energy

DOE – United States Department of Energy

DWL – Deadweight Loss

ESCO – Energy Service Company

ESPC – Energy Savings Performance Contracts

EERE – Office of Energy Efficiency and Renewable Energy

EIA – Energy Information Agency

EPA – United States Environmental Protection Agency

GSA – General Service Administration

HVAC – Heating, Ventilation, and Air Conditioning

IEA – International Energy Agency

IPCC – Intergovernmental Panel on Climate Change

NPV – Net Present Value

OBF – On-Bill Financing

OECD – Organization for Economic Co-operation and Development

PACE – Property Assessed Clean Energy

PPA – Power Purchase Agreements

SPV – Special Purpose Vehicle

EXECUTIVE SUMMARY

The Commercial Buildings Integration (CBI) program, launched by the U.S. Department of Energy in 2008, aims to significantly reduce energy consumption and carbon emissions in the commercial sector, targeting a 30% reduction in energy use intensity by 2030 and net-zero greenhouse gas emissions by 2050 (EERE, 2020). Despite these ambitions, the sector's energy consumption escalated from 6.8 quadrillion Btu in 2018 to 9.6 quadrillion Btu by 2022, underscoring the critical need for substantial improvements in energy efficiency (EIA, 2022).

Central to achieving these goals is the advancement and implementation of high-efficiency HVAC systems, capable of markedly reducing both energy use and emissions. Nevertheless, the presence of a significant energy efficiency gap, driven by the upfront cost, presents a formidable barrier to the adoption of such technologies. By detailing and proposing innovative financing alternatives, the report seeks to unlock the potential for widespread adoption of energy-efficient HVAC systems in commercial sectors, aligning economic incentives with environmental goals.

This report is prepared for the **General Services Administration (GSA)**, focusing on the agency's goals to boost sustainability and efficiency in federal buildings. It specifically looks at how electrifying HVAC systems in commercial spaces aligns with the GSA's sustainability efforts and broader federal targets to promote clean energy and environmental sustainability.

Upon examining existing financing mechanisms, this report underscores two established approaches. The Commercial Property Assessed Clean Energy (C-PACE) program is a cornerstone in this domain, providing essential upfront funding for energy upgrades, which are repayable through an addition to the property's tax bill. Equally critical are Energy Savings Performance Contracts (ESPCs), which enable the installation of energy-efficient equipment at no initial cost, with repayment structured through the savings generated from reduced energy consumption.

Building on the examination of established mechanisms, the subsequent sections of this report will introduce and evaluate alternative financing solutions. These alternatives are not yet widely implemented in the commercial sector but hold significant potential for further advancing energy efficiency initiatives.

> Alternative 1: **On-Bill Financing (OBF)** is a financing mechanism, established in the residential building sector, that aims to empower commercial entities to invest in energy upgrades without the deterrent of upfront costs. By facilitating repayment through utility bills and directly tying financial obligations to the utility savings generated, OBF uniquely addresses the split incentive problem and reduces loan default risks (Bell, Nadel & Hayes, 2011). This model benefits from tying repayments to the actual utility savings generated by energy efficiency improvements, making energy upgrades attractive and financially viable for property owners and tenants alike.
>
> Alternative 2: **Asset-Backed Securities (ABS)** is proposed to introduce HVAC financing to the capital market and attract a broader investor base. By converting illiquid assets, such as loans and leases, into marketable securities, ABS enables significant capital mobilization for large-scale energy efficiency and HVAC projects within the commercial sector. This approach not only grants immediate liquidity and opens new avenues for funding but also plays a crucial role in presenting HVAC upgrades as attractive investment

opportunities. The capital raised from these securities is directly utilized to fund the associated projects. Subsequently, the repayment of these initially illiquid assets, including the principal and interest of loans and leases, is channeled back to the investors.

Alternative 3: **Guarantee Facility Model** is a risk mitigation strategy in this analysis, featuring two core strategies: diversification across energy technologies and the implementation of government-backed first-loss protection. By spreading investments across various energy projects, this model effectively reduces financial risks of the overall portfolio (Evans, 2006). Simultaneously, it leverages guarantee instruments, particularly government-backed first-loss protection, to safeguard investors against initial losses. The dual strategy aims to elevate investor confidence and secure a consistent influx of investment into energy efficiency projects, particularly those with higher perceived risks.

However, the study acknowledges certain challenges, notably the voluntary nature of program participation and the scarcity of comprehensive data on energy savings and market behaviors. These factors complicate the assessment of the causal effectiveness of financing mechanisms in driving the adoption of energy-efficient solutions.

The evaluative criteria for policy alternatives focus on reducing financial barriers and enhancing the energy savings potential of energy efficiency upgrades. The criteria include Benefit Cost Analysis, Equity, Administrative Feasibility, and Financial Risk considerations.

The analysis recommends the implementation of On-Bill Financing (OBF) as the optimal strategy to enhance the adoption rate of electrified HVAC systems, addressing upfront cost barriers and the split incentive problem that undermines energy efficiency efforts. While the Guarantee Facility Model shows the highest net present value (NPV), indicating a strong financial return and effective risk mitigation, the OBF approach is favored for its direct impact on reducing the energy efficiency gap and promoting equity within the commercial building landscape. Although ABS helps reach a wider market, OBF directly tackles the issues of equity and initial costs. Also, these mechanisms can coexist and complement each other in the financial ecosystem. The recommendation is also supported by the success of OBF in residential sectors across several states, providing a foundational understanding that can be scaled for commercial sectors.

To implement this strategy, the General Services Administration (GSA) should develop a detailed OBF program proposal, recommend structures, and establish partnerships with federal utility service providers. This includes leveraging existing frameworks and insights from the residential OBF programs and supplementing funding through partnerships with financial institutions committed to sustainability. Moreover, to stimulate demand for energy efficiency upgrades and maximize the program's impact, the GSA should launch informational campaigns, leveraging social proof principles to increase consumer awareness and demonstrate the tangible benefits of energy-efficient improvements within GSA's facility.

In conclusion, electrifying HVAC systems in commercial buildings is vital for reducing energy use and greenhouse gas emissions, aligning with national goals, but financial barriers hinder progress. On-Bill Financing (OBF) emerges as the optimal solution, directly addressing equity and upfront cost issues. The limitations of this study include challenges in acquiring accurate cost-effectiveness data and overlooking regional building code variability. Future research should address these limitations to ensure better adaptation to market dynamics and policy alignment for environmental sustainability in commercial sectors.

INTRODUCTION

The electrification of Heating, Ventilation, and Air Conditioning (HVAC) systems in commercial buildings stands as a pivotal strategy for significantly reducing energy consumption and greenhouse gas emissions, with research indicating potential decreases of approximately 37% and 44%, respectively (Nadel & Perry, 2020). This transformation not only presents an opportunity for environmental and economic benefits but also aligns with the goals of reducing commercial building energy use by 30% from 2010 levels by 2030 (EERE, 2020). Despite these clear advantages, substantial financial barriers significantly hamper the adoption of these energy-efficient technologies. These barriers not only hinder the uptake of innovative green technologies but also contribute to ongoing environmental degradation through increased carbon emissions, thereby obstructing efforts to meet established energy reduction targets.

This report addresses the critical financial challenges obstructing the widespread adoption of energy-efficient HVAC systems in the commercial sector. Through an exhaustive examination of existing financing mechanisms, it seeks to propose effective alternatives capable of mitigating these financial obstacles and facilitating substantial investments in energy efficiency. From public initiatives like On-Bill Financing to private sector innovations such as Asset-Backed Securities, and risk mitigation mechanisms like the Guarantee Facility Model, the assessment aims to highlight solutions that can facilitate substantial investments in energy efficiency and effectively bridge the financial gap. Acknowledging the diverse financial risks—from potential defaults to the volatility of investment returns—associated with these financing models, the analysis is committed to finding mechanisms that not only alleviate financial barriers but also ensure the protection of investors and stakeholders through effective risk management. Each model is rigorously evaluated for its capacity to mitigate financial risks, its implications for equity, its administrative feasibility, and its net present value (NPV) resulting from the benefit-cost analysis.

Furthermore, this report recommends On-Bill Financing (OBF) as a particularly effective strategy within the framework of the General Services Administration's (GSA) authority and the U.S. commercial building sector. It also outlines a proposed implementation plan that underscores the importance of strategic partnerships, comprehensive planning, and targeted informational campaigns to ensure the successful rollout of the recommended financing mechanism.

In conclusion, this report provides a comprehensive overview of strategies to overcome financial obstacles and accelerate the adoption of energy-efficient technologies, aiming for a commercial sector that is not only more sustainable but also economically stronger.

CLIENT OVERVIEW

This report is prepared for my client, the General Services Administration (GSA), a pivotal federal agency tasked with overseeing the procurement, real estate, and development of federal properties. The GSA's commitment to sustainability and efficient resource management positions it to tackle the challenge of electrifying HVAC systems in commercial buildings. This section provides an overview of how addressing this challenge fits into the GSA's overall goals, the significance of tackling this issue promptly, and the GSA’s role in spearheading this transformation.

In 2021, the GSA committed to environmental action by aligning its practices with the goals of Executive Order 14057, "Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability," introduced by the Biden-Harris administration (Federal Center, 2021). This order sets forth a government-wide approach to achieve significant sustainability milestones, including a transition to 100% carbon pollution-free electricity by 2035 (U.S. GSA, 2023). By reducing reliance on fossil fuels and boosting buildings' efficiency, electrified HVAC systems significantly contribute toward environmental goals. This move is part of the GSA's commitment to not just fulfill but to exceed energy efficiency standards set by the federal government.

Addressing the electrification of HVAC systems now is crucial due to the pressing deadlines for meeting environmental goals and the immediate benefits of reduced energy consumption and cost savings. As a federal leader in real estate management, the GSA's prompt action on HVAC electrification sets a strong example for other federal agencies, state and local governments, and the private sector. In 2008, the Commercial Buildings Integration (CBI) program sets the goal to decrease the energy consumption of commercial buildings by 30% from 2010 levels by 2030 (EERE,2020). In pursuit of federal requirement, the GSA must adopt and implement best practices ahead of time, thereby setting a precedent and leading by example in sustainability efforts.

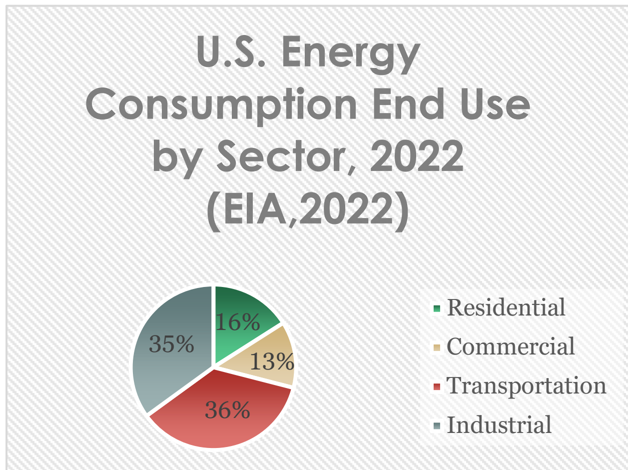
In terms of capability, GSA has the authority to set procurement policies that mandate the use of electrified HVAC systems across all federally owned and leased buildings (Fiorentino & Hatch, 2023). Through leading by example, the GSA can influence the market both as a policy maker and as a player with vast amounts of buying power. This position allows the GSA to negotiate favorable terms with commercial building owners to benefit the broader energy sector.

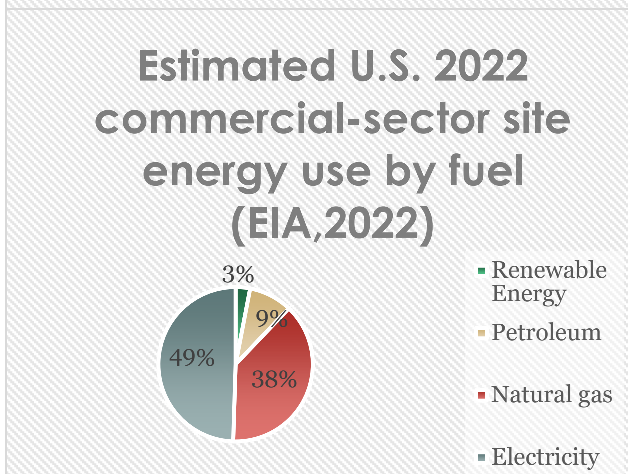
BACKGROUND

COMMERCIAL BUILDING CARBON EMISSION

In August 2008, the U.S. Department of Energy (DOE) launched the Commercial Buildings Integration (CBI) program, marking a significant step towards reducing energy consumption and carbon emissions in the commercial building sector. The program sets forth ambitious goals: to reduce commercial building energy use intensity by 30% from 2010 levels by 2030 and to achieve zero greenhouse gas emissions related to commercial buildings by 2050 (EERE, 2020).

Commercial buildings in the U.S. are significant consumers of energy. Data from the 2018 Commercial Buildings Energy Consumption Survey (CBECS) by the Energy Information Administration (EIA) reveals that approximately 6 million commercial buildings consumed 6.8 quadrillion British thermal units (Btu)[1] of energy. The primary energy sources for these buildings are electricity and natural gas, with space heating being one of the largest end-use energy categories. In 2022, commercial buildings increased their energy usage to a total of 9.6 quadrillion Btu of primary energy (EIA, 2022). This rise in consumption not only escalates direct emissions from the combustion of fossil fuels on-site but also amplifies indirect emissions tied to the electricity these buildings consume, which is mostly generated from fossil fuels as well.





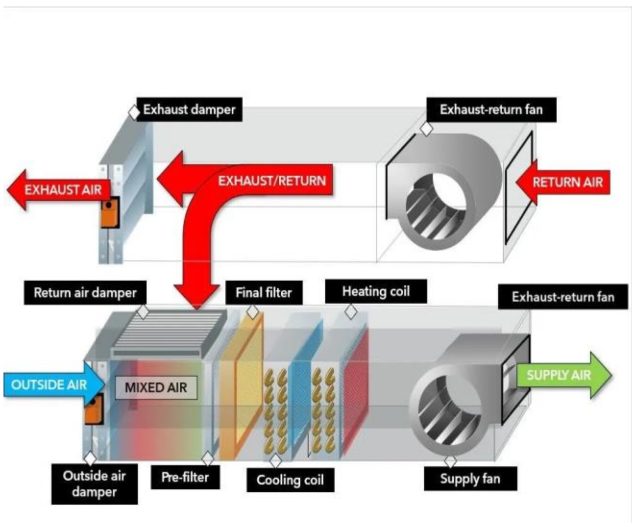
The combustion process releases greenhouse gases such as carbon dioxide, methane, and nitrous oxide into the atmosphere, playing a crucial role in global warming by trapping heat and causing Earth's temperature to rise (EPA, 2024). These greenhouse gases absorb solar radiation and prevent heat from escaping the atmosphere, causing Earth's temperature to rise gradually. The UN Environment Programme's Emissions Gap Report 2023 indicates a pressing need for enhanced global efforts to mitigate climate change. It warns that without more ambitious action from countries, global temperatures are projected to exceed the Paris

[1] A quadrillion is a one followed by 15 zeros. For scale comparison, the annual energy consumption of the entire United States is approximately 100 quads.

Agreement's targets significantly(UNEP, 2023). Specifically, to align with the 2°C goal, emissions in 2030 need to be 28% lower than current projections, and for the 1.5°C pathway, a reduction of 42% is required. The Intergovernmental Panel on Climate Change (IPCC) underscores the critical importance of rapid and extensive emissions cuts across all sectors to keep warming to 1.5°C. An immediate global response is imperative, with a target to peak greenhouse gas emissions by 2025 and achieve a 43% reduction by 2030 (IPCC, 2022). Thus, addressing carbon emissions is a central public policy issue.

By 2022, commercial buildings accounted for 13% of total energy use, with nearly half (49%) of this energy deriving from fossil fuels (EIA, 2022). The necessity for the sector to significantly reduce its emissions cannot be overstated. Enhancing energy efficiency in commercial buildings is imperative to align with global objectives aimed at mitigating climate change.

HVAC UPGRADE



Source : (Kosik, 2023)

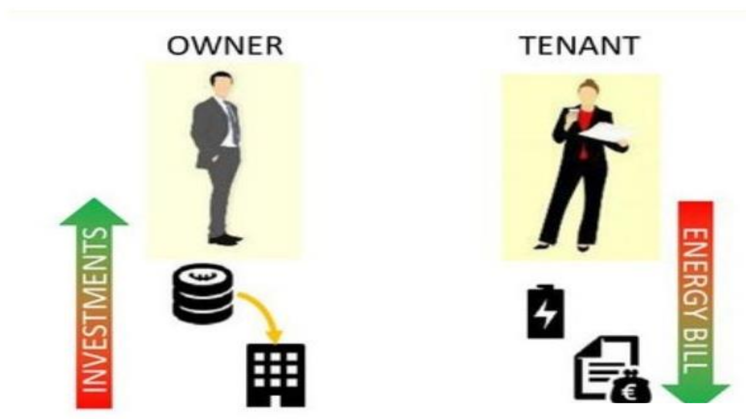
By using advanced filtration and air handling processes, HVAC systems can precisely regulate temperature, humidity, and air purity. Adjustable dampers regulate the mix of outdoor and return air, which serves as the cornerstone of optimizing system efficiency (U.S. EPA, 2023b). A dual-stage filtration process—consisting of pre-filters and final filters—crucially maintains high indoor air quality by filtering out particles and contaminants. Meanwhile, heating and cooling coils ensure precise thermal control to meet desired temperature standard.

The most crucial initial step towards building energy efficiency involves optimizing the electrification of heating, ventilation, and air conditioning (HVAC) systems. This can be achieved by implementing advanced HVAC technologies, such as high-efficiency heat pumps, and ensuring proper maintenance and system upgrades. Enhancing HVAC systems not only improves thermal comfort within buildings but also significantly reduces energy consumption and greenhouse gas emissions. Specifically, transitioning to efficient electrified heat pumps could slash emissions by 44%, and this strategy could lead to an overall reduction in energy use by approximately 37% (Nadel & Perry, 2020). Integrating these efficiency improvements with electrification allows for more effective operation of space and water heating systems, minimizing the operational costs. For instance, air-source heat pumps consume around 50% less electricity than electric resistance heating and can outperform standard air conditioners in efficiency. Additionally, heat pump water heaters are two to three times more efficient than their electric resistance counterparts, with certain models nearly four times as efficient (DOE, 2022b). Despite their limited popularity in the United States, heat pump clothes dryers have demonstrated superior energy performance in European contexts, consuming up to 28% less energy compared to conventional American electric dryers (SEDI, 2012). Similarly, induction cooktops outperform electric resistance cooktops by 5–10% in terms of efficiency (EPA, 2022).

ENERGY EFFICIENCY GAP

The energy efficiency gap in the commercial building sector in the U.S. encapsulates the difference between the optimal level of energy efficiency that could be achieved with current technology and practices, and the level that is actually attained. This gap is not merely a reflection of technological shortcomings but arises from a combination of financial and informational barriers.

First, the initial investment required for these technologies often far exceeds that of standard options. In construction projects, budgeting for the HVAC system typically ranges from 3 to 5% of the total cost for basic compliance with codes. Upgrading for higher efficiency or additional features can increase this to 10% or more (Hill, Dirr, and Harrison, 2020). Larger corporations or wealthier individuals might have the capital necessary to invest in energy efficiency improvements. Motivated by the long-term savings on energy bills and increased property value, these entities have a high chance of accepting the upfront costs. For smaller business owners or those in less affluent areas, the cost of construction alone can significantly strain their finances, leaving little room for energy efficiency investments despite the long-term savings potential (Bell, Nadel & Hayes, 2011). Furthermore, the commercial real estate market consists of various stakeholders with differing priorities, from facility engineers to tenants. This often leads to a misalignment of costs and benefits due to the structure of leases, where the party investing in energy efficiency improvements is not the one that benefits from the energy savings. This split incentive issue can exacerbate the financial challenges faced by those with limited budget (Pearce et al., 2016).



Source: (Chandler, 2019)

The financial challenge of investing in energy efficiency is further intensified by the unpredictable nature of return on investment (ROI) timelines. These timelines can significantly differ based on several factors: the selection of HVAC technologies, the current efficiency levels of the building, and the fluctuation in energy market prices (OECD, 2021). This variability introduces an additional layer of complexity when planning for energy upgrades.

An additional factor contributing to the persistence of the energy efficiency gap is commercial building owners' uncertainty and knowledge gaps regarding the potential energy savings from efficiency upgrades (Gerarden et al., 2015;Palmer et al., 2012). Additionally, distrust towards information provided by vendors or companies offering energy efficiency solutions can also hinder decision-making. Owners might be skeptical about the advice's impartiality and the consistency of energy savings over time, fearing that sales motives might overshadow honest guidance (Gillingham & Palmer, 2014). This skepticism can lead to reluctance in pursuing energy efficiency improvements, even when such upgrades could significantly reduce operational costs.

The identified barriers highlight the need for government intervention to create an energy efficiency financing program specifically tailored to enhance affordability and accessibility of energy efficiency upgrades within the U.S. commercial sector. Such a program would not only support businesses in overcoming financial and informational hurdles but also contribute to reducing greenhouse gas emissions on a broader scale.

LITRATURE REVIEWS

Energy efficiency programs often face challenges in achieving significant market penetration, engaging only between 1 percent to 5 percent of eligible property owners (Palmer et al., 2012). Current debates among researchers and policy analysts reveal differing views on what constitutes the main barrier to enhancing energy efficiency in the commercial sector. While considerable research suggests that the lack of accessible capital significantly hinders the implementation of energy upgrades, there's an emerging perspective that the core issue may instead be the low demand for upgrades, compounded by perceived risks associated with making such investments (Borgeson et al., 2014; Mundaca & Kloke, 2018).

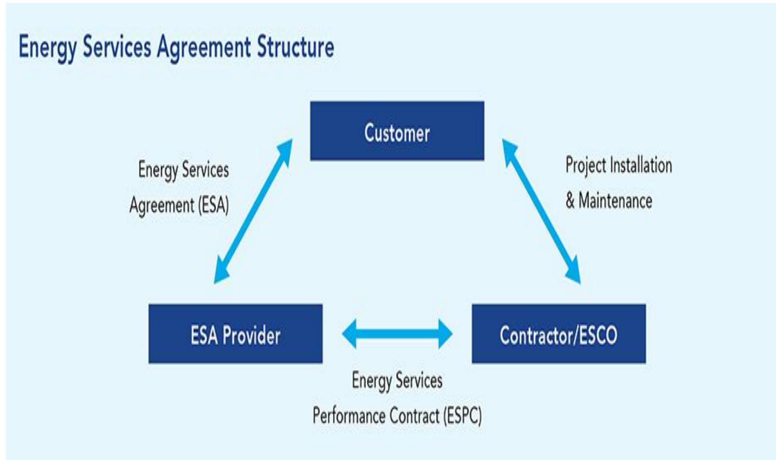
While acknowledging different viewpoints, this policy analysis focuses on tackling the financing barrier of high upfront costs associated with energy efficiency in commercial settings, along with the critical role of risk mitigation strategies.

EXISTING MECHANISMS

In numerous localities across the United States, the Commercial Property Assessed Clean Energy (C-PACE) program stands out as a pivotal financing mechanism. By leveraging private capital, C-PACE provides upfront funding for these improvements, with repayment facilitated through special charges added to the property tax bill. The funding for these programs can come from various sources such as private lenders, municipal bonds, and public funds, and requires a senior lien on the property as security for the borrower. Repayment is made through a property tax assessment, integrating seamlessly into the property owner's existing financial obligation (Dearson et al., 2016; U.S. EPA, 2023a). A notable example of this program's impact is seen in Milwaukee's C-PACE financing for The Marlow Hotel, where a $2.5 million investment is set to drastically reduce utility costs and energy consumption. The project is expected to nearly halve annual utility costs and save over 3 million kBTUs per year (PACE Financing, n.d.)

Another common mechanism for financing energy efficiency in commercial buildings is Energy Savings Performance Contracts (ESPCs). This model involves a service provider, typically an Energy Service Company (ESCO), installing energy-efficient equipment at no upfront cost to the property owner. The cost of these upgrades is then recouped over time through the energy savings generated by the new, more efficient systems (U.S. DOE, 2022). These savings result in lower utility bills for the property owner, with a portion of these savings allocated to repay the service provider (Kirkpatrick & Bennear, 2014). This arrangement will continue until the full cost of the installation has been recovered.

ESPCs are especially advantageous because they shift the financial risk of the energy-saving measures to the ESCO, which is incentivized to ensure that the installed systems perform optimally to generate the promised savings (Liu et al, 2015). Moreover, these contracts often include long-term maintenance and operational services for the installed equipment, ensuring its efficiency and longevity. ESPCs are particularly effective in commercial settings for several reasons. First, they enable large-scale energy efficiency projects that might otherwise be unfeasible due to high upfront costs. Second, they allow commercial property owners to upgrade their facilities with the latest energy-efficient technologies, improving operational efficiency and reducing environmental impact without affecting their capital budgets (Performance Services, 2019).



(U.S. DOE, n.d.)

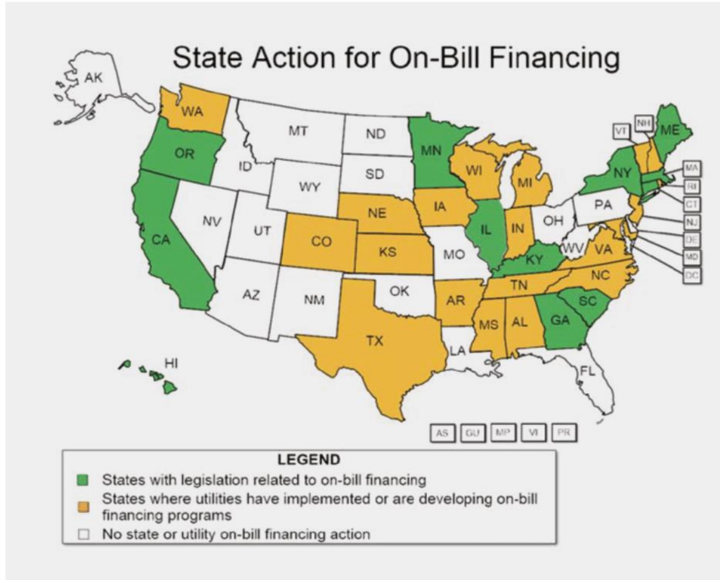
EFFECTIVE FINANCING ALTERNATIVES

PUBLIC FINANCING: ON-BILL FINANCING

Within the residential building sector, On-Bill Financing (OBF) has become a key instrument in advancing energy efficiency measures. OBF enables homeowners to pay for energy upgrades through regular payments on their utility bills, with the premise that the energy savings from such upgrades will meet or exceed the repayment costs. This method has been associated with a reduction in loan default rates, suggesting that bundling loan payments with familiar utility bills may enhance the likelihood of timely repayments compared to other forms of financing. This method is seen to reduce the risk of loan defaults, suggesting that combining loan obligations with utility bills—a routine expense for most buildings—may encourage more consistent repayment behaviors (Burr & Carlson, 2007; Gillingham & Palmer, 2014; Palmer et al., 2012).

Moreover, OBF addresses the split incentive problem, which poses a significant barrier to energy efficiency investment for commercial building sectors. This problem arises when building owners are hesitant to invest in energy-efficient improvements because it is the tenants who typically reap the utility savings benefits. OBF navigates this issue by linking loan repayments directly to the property's utility meter, rather than to the owners or tenant (Bell, Nadel & Hayes, 2011). As a result, the financial responsibility for the energy upgrades is assumed by the current occupants who enjoy the upgrade to ensure that the costs and the benefits are equitably distributed.

These programs are designed to be consumer-friendly, offering financial terms that often include low or no interest and extended repayment periods, thereby making energy upgrades more accessible to a wider demographic (Block et al., 2014). Some OBF programs use the energy savings achieved post-upgrade as a form of security for the loan, which not only incentivizes energy efficiency but also aligns the financing with the actual energy savings(Johnson et al., 2016). This mechanism ensures that the benefits of energy improvements are directly experienced by the borrower, thereby reinforcing the link between energy conservation and financial savings.



Legislative environment for OBF by state in 2022. Source: (Wu, 2022)

OBF initiatives also strategically extend credit opportunities by evaluating utility payment histories rather than traditional credit scores, thus democratizing access to energy efficiency financing. This aspect of OBF is particularly impactful for communities that historically have limited access to credit due to socioeconomic barriers(Andersen et al., 2015; Mundaca & Kloke, 2018). By categorizing the loan as a part of the service bill, OBF programs avoid encumbering consumers with additional reported debt, thus preserving their ability to seek credit for other purposes.

PRIVATE FINANCING: ASSET-BACKED SECURITIES

Private financing plays a crucial role in supporting projects across a wide range of sectors, offering an alternative to traditional bank loans and public funding sources. Within conventional markets, Asset-Backed Securities (ABS) stand out as a compelling mechanism for raising capital. It converts illiquid assets, such as loans, leases, receivables, into liquid securities. The essence of ABS is to create a financial product that investors can buy and sell, offering a way for the original owners of the assets to gain immediate liquidity and access to new funding sources (Fabozzi & Kothari, 2008).

Once the assets are pooled together, they are typically transferred to a separate legal entity known as a Special Purpose Vehicle (SPV), established specifically for the securitization process. This SPV issues securities backed by the pooled assets, which are then introduced into the capital market. (Gorton & Souleles, 2005) The issued securities are typically rated by credit rating agencies to provide investors with an indication of their risk level. Higher-rated securities are considered safer but may offer lower returns, while lower-rated securities carry higher risk but the potential for higher returns (KBRA, 2012; Guggenheim Investments, 2023). By selling these securities in the capital market, the SPV enables a broader spectrum of investors to participate and fund the project. The payments made by borrowers on these assets generate cash flow, which is then passed on to the investors holding the securities.

The concept of leveraging cash flows through Asset-Backed Securities (ABS) has established a strong precedent in the energy sector, especially within the solar industry. This financial mechanism secures the consistent cash flows from residential solar installations, bundling future revenue from energy production or lease payments into securities for investor purchase (O'Sullivan & Warren, 2016; Yin et al., 2021). Solar securitization pools these cash flows, allowing investors to support renewable energy with the prospect of stable returns, while providing solar providers a new avenue for capital at potentially lower costs than traditional finance methods. This approach streamlines the deployment of solar projects by efficiently raising capital through the financial markets. Repayment of this funding is typically done through two main avenues: Power Purchase Agreements (PPAs) and leasing models. In PPAs, building owners agree to purchase the electricity generated by the solar panels at a predetermined price for a specific duration (U.S. EPA, 2024). This arrangement ensures a reliable cash flow from the sale of electricity. Alternatively, in leasing models, solar panels are leased to homeowners or businesses, who then pay a fixed monthly fee for the use of the solar panels (O'Sullivan & Warren, 2016).

RISK MITIGATION

In the realm of energy financing, risk is a dominant financial consideration for investors. These investments inherently carry perceived risk due to technical failures, market fluctuations, regulatory changes, and energy price volatility. Each of these outcomes adds a layer of uncertainty to returns on investment, which influences investor or financial entities' decisions (Kaminker & Stewart, 2012). To increase investments and accessibility, energy financing initiatives must address risk factors.

In economics and finance, diversification is a corporate strategy focusing on distributing financial assets across promising business areas to enhance sustainable growth. The underlying premise of diversification is that different investments will, on average, yield higher returns and pose a lower risk than any individual investment within the portfolio (Evans, 2006). In the energy sector, diversifying across various energy sources and technologies dilutes the risk associated with any single energy asset. By balancing investments in the solar installation industry, electrified HVAC systems, and the electric vehicle industry, investors can mitigate risks tied to industry-specific regulatory changes, market demand fluctuations, and technological disruptions, ensuring a more stable and predictable return on investment (Gitelman, Kozhevnikov, & Visotskaya, 2023).

Canada's energy landscape is an example where diversification of energy sector reduces investor risk. By broadening its energy portfolio to include substantial investments in renewable energy technologies, Canada mitigates the economic and regulatory risks tied to the fossil fuel sector (IEA, 2022a). For investors, this creates opportunities to engage with a more balanced and less volatile market, as the blend of energy sources diversifies income streams and reduces dependence on the global oil and gas market's fluctuating prices. Another example of diversification is seen in Norway's approach. In addition to hydroelectric power, Norway is expanding its energy portfolio by investing in wind and solar energy (IEA, 2022b). The diversification strategy reduces investment risks associated with environmental regulations and carbon pricing. From 2010 to 2022, there has been a consistent decline in its carbon emissions, accompanied by increased investments in energy efficiency programs (IEA, 2022b; Tiseo, 2023).

Building on the concept of diversification, another strategic approach to bolster investor confidence and support sustainable energy investments is the adoption of guarantee instruments, a method borrowed from the World Bank's Guarantee Program. It typically involves a third party, such as a government or financial institution, providing guarantees to cover potential losses (World Bank, n.d.). By assuring lenders and investors of some level of protection against defaults or underperformance, this model encourages investment in projects that might otherwise be considered too risky.

Besides the World Bank Guarantee Program, an example of this model can be seen when purchasing green bonds. To improve the level of purchasing for clean energy project bonds, the Climate Policy Initiative recommended a first-loss protection instrument designed to insulate investors from initial financial losses (Lorentz et al., 2023). A funding institution or governmental party bears the highest risk of loss upon default and protects other investors to make these projects more attractive, especially in emerging markets. For clean energy projects, including those involving advanced HVAC systems, achieving bankability is crucial. Guarantees play a vital role, especially in emerging technologies and markets lacking maturity (D'Olier-Lees et al., 2023). Governments or third parties often provide these guarantees to safeguard against defaults and revenue losses as a means to encourage investors from adopting eco-friendly HVAC systems in the building. If such parties have creditworthiness built up, it may also increase the project's attractiveness to investors by reducing concerns over liquidity risks, especially when projects are pooled under a single protective mechanism (Hervé-Mignucci et al., 2013).

LIMITATIONS OF THE STUDY

The primary limitation arises from the voluntary nature of participation in energy efficiency financing programs, which hinders the ability to establish causal relationships between program availability and the actual adoption of energy-efficient HVAC systems (Palmer et al., 2012). The lack of random assignment in participant selection means that results from these studies are at best quasi-experimental, unable to definitively prove causality. The voluntary nature of these programs also implies that participants, often households already inclined towards making efficiency upgrades, might not represent a cross-section of the broader population, particularly moderate-to-low-income households (Alberini & Towe, 2015). This raises questions about the true accessibility and impact of these financing options, necessitating the collection of data after implementation to evaluate their impact accurately.

Moreover, the scarcity of comprehensive data on energy savings and market behaviors poses a significant challenge to thoroughly evaluating the effectiveness of various financing programs for energy efficiency upgrades. Research has consistently shown that engineering predictions often overestimate the actual energy savings realized post-upgrade, largely due to the "rebound effect" where increased affordability of energy use leads consumers to use more energy than before, thus reducing the actual savings (Gillingham & Palmer, 2014).

EVALUATIVE CRITERIA

The following criteria will be used to evaluate policy alternatives designed to reduce financial barriers and enhance the energy savings potential of energy efficiency upgrades for commercial building HVAC systems, thereby aligning with GSA mission to enhance the sustainability and operational efficiency of commercial buildings.

BENEFIT COST ANALYSIS

This criterion employs a quantitative approach, estimating the net present value (NPV) of each policy option over a 25-year period, applying a discount rate of 7 percent. It will undertake a benefit-cost analysis (BCA) to monetize the advantages and expenses, Energy savings prioritizing market prices for valuation while resorting to shadow pricing for measurable benefits and costs lacking market values. Additionally, a sensitivity analysis will assess how different baseline assumptions (such as the discount rate, electricity price, and the number of participants) might influence the BCA results. Refer to Appendix A for detailed BCA assumptions.

The BCA will calculate the monetary value of each alternative. The option yielding the greatest NPV will be deemed the most favorable according to the BCA criterion.

Benefits will include:

- Energy Savings (accounted for the "rebound effect")
- Reduced healthcare costs resulting from improved indoor air quality
- Improvement in quality of life attributable to efficiency improvements

Costs will include:

- Operational costs incurred by program administrators (such as labor, office space,)
- Costs associated with resources for energy efficiency upgrades for HVAC
- Opportunity Costs associated with allocating city funds to this program
- Deadweight Loss (DWL)[2] from market distortions due to program interventions.

EQUITY

The equity criterion will assess the potential of policy alternatives to enhance the affordability and accessibility of energy efficiency upgrades across different states , with a particular focus on states that are falling behind the average adoption rate. The evaluation will draw from policy literature and case studies, considering how costs and benefits are distributed among stakeholders. This criterion will categorize alternatives as yielding high (5), medium (3), or low (1) equity levels based on the following standard

- High (5 Points): The alternatives achieving a 'High' grade are those that demonstrably and significantly improve conditions for disadvantaged groups and states, either by providing substantial benefits with minimal costs or by greatly enhancing access to credit. These policies

[2] Inefficiencies in the market resulted from energy efficiency financing program and involuntary money transfer

are characterized by a strong alignment with equity objectives, showing clear, measurable outcomes that substantially outweigh any associated costs.

- Medium (3 Points): A 'Medium' grade is assigned to alternatives that offer noticeable improvements in either cost-benefit distribution or credit access but still face certain limitations or barriers that prevent them from fully realizing equity goals. These policies make progress towards equity but indicate areas where further adjustments could amplify their impact.
- Low (1 Point): Alternatives receiving a 'Low' grade are those that make minimal advancements in addressing the disparities faced by disadvantaged groups and states. Whether through insufficient benefits compared to costs or inadequate improvements in credit accessibility, these policies fail to significantly move the needle towards equity and may maintain existing barriers or inefficiencies.

ADMINISTRATIVE FEASIBILITY

The assessment of administrative feasibility will focus on the state government and relevant stakeholders'—like utility companies, property owners, and residents—ability to effectively execute policy options. This criterion will categorize alternatives as yielding high (5), medium (3), or low (1) levels of administrative feasibility based on the following standard

- High (5 Points): Alternatives that exhibit a 'High' level of administrative feasibility are those for which the GSA, in collaboration with state governments and relevant stakeholders, can implement with clear, streamlined processes. These policies demonstrate a robust infrastructure and resource allocation plan that ensures smooth operation and minimal disruption.
- Medium (3 Points): A 'Medium' grade is assigned to alternatives where the GSA and its partners have a reasonable but not optimal capacity for implementation. Challenges might exist, such as minor resource constraints or procedural complexities, but these are not insurmountable and can be addressed with manageable adjustments.
- Low (1 Point): Alternatives receiving a 'Low' grade are characterized by significant implementation challenges that the GSA and stakeholders might struggle to overcome. This could include substantial resource shortages, complex regulatory environments, or lack of stakeholder buy-in, making successful execution difficult

FINANCIAL RISK

This criterion will assess the financial risks inherent in different alternatives, particularly focusing on the risks of changes in payment terms and default rates. It will evaluate how these risks might influence the overall financial viability of the policy alternatives, considering both the lenders' and borrowers' perspectives. This criterion will categorize alternatives as yielding high (5), medium (3), or low (1) financial stability levels based on the following standard

- High (5 points): A ‘High’ grade is assigned to alternatives that demonstrate a low risk of default and minimal likelihood of significant payment term changes. These mechanisms are characterized by strong financial models and risk management practices, ensuring the sustainability and resilience of the financing mechanism over time. Such options typically have robust mitigation strategies in place to manage potential financial uncertainties effectively.

- Medium (3 Points): A 'Medium' grade is assigned to alternatives that exhibit moderate financial risks, including a certain susceptibility to payment term changes or defaults. However, they benefit from having reasonable mitigation measures that can address and manage these risks adequately. While these alternatives may be affected by economic fluctuations or market conditions, they have mechanisms in place to mitigate severe impacts on the financing mechanism's stability.
- Low (1 Point): The alternatives will be graded 'low' if they are significantly exposed to financial risks on their own, with a high likelihood of experiencing adverse payment term changes and a considerable risk of default. Such options require either supplementary mechanisms or a substantial enhancement of their risk management practices to improve financial resilience and reduce the risk of instability.

ALTERNATIVE 1: ON-BILL FINANCING

With this alternative, the GSA will propose the expansion of On-Bill Financing (OBF) programs to include commercial buildings across the United States, leveraging municipal utilities and energy service providers. The program would operate by providing upfront funding for HVAC installation within commercial buildings. This funding would be sourced from a combination of federal initiatives, municipal utilities, and designated energy service providers, with the goal of ensuring broad access to the program regardless of location (Durkay, 2016). To manage and distribute these funds effectively, a national framework would be established, allowing for flexibility in addressing the specific needs and regulations of different states and utility jurisdictions.

On-Bill Financing operates through a partnership with utility companies to allow building owners or renters to finance energy-saving upgrades and repay the investment via their monthly utility bills. This approach capitalizes on the utility's established relationship with its customers and removes the initial upfront cost barrier of HVAC installation, offering a seamless avenue for financing that aligns repayment with the accrual of energy savings (Bell, Nadel & Hayes, 2011).

One of the key benefits of OBF is that it can be accessible to more people. Instead of relying on traditional credit checks, some OBF programs consider whether customers have been paying their utility bills on time, making it easier for more customers to qualify for financing (Collaborative Efficiency et al., 2015). Also, because people tend to pay their utility bills reliably, investors see OBF as a secure way to fund energy efficiency projects, which can bring more money into these programs (Burr & Carlson, 2007).

For this alternative, the GSA can set terms to require commercial property owners to engage with the program by applying for financing for eligible energy-saving projects. Eligibility for the program would be determined based on factors such as a business's utility bill payment history and the projected energy savings of the proposed project. The selection of projects would be guided by energy audits or assessments to ensure that the proposed HVAC upgrades offer significant energy savings potential (Henderson, 2012). Once a project is approved, the property owner would work with certified contractors to carry out the necessary installations or retrofits. The cost of these projects would then be repaid up to 15 years at zero percent interest through an additional charge on the property's monthly utility bill (Yanez-Barnuevo, 2020). This charge would be carefully calculated to ensure that the energy savings generated by the upgrades would, at minimum, match the repayment amount, adhering to the principle of bill neutrality. This ensures that the financial impact on the business is neutral or positive, encouraging wider participation in the program. Moreover, to increase adaptation and investment in HVAC updates, the program will adopt a tariffed model where the repayment obligation is tied to the property meter rather than the individual business owner (Mundaca & Kloke, 2018). This means that if a business were to move or sell the property, the subsequent occupants would continue the repayment while also benefiting from the reduced energy costs(Henderson, 2012). This feature mitigates the risk for initial investors and supports the long-term sustainability of the program.

- Benefit Cost Analysis

  This alternative has been evaluated at the state level with a Net Present Value (NPV) of $ 7,298,891,671.93 and a score of 4. The On-Bill Financing (OBF) program presents a multitude of benefits, notably in terms of energy conservation and enhanced comfort for the 4,000 commercial buildings (1% increase) undertaking energy efficiency improvements. Furthermore, the program contributes to significant healthcare savings, attributable to the diminution of air pollution. Conversely, the cost includes the resource expenditure for efficiency upgrades, the opportunity cost associated with governmental fiscal allocations, and the administrative expenses related to the program's execution, which include marketing initiatives, workforce compensation, and office operational costs.

- Equity

This policy option is highly effective in addressing equity concerns, earning a score of 5. It cleverly circumvents traditional credit scoring by assessing a company's utility payment track record for program qualification. This is particularly advantageous for businesses that might have fluctuating credit scores, ensuring that those with a consistent history of paying their utility bills on time are eligible for the OBF program (Beer et al., 2018). This approach removes the hurdles of initial financial outlays, the accumulation of new debt, and credit checks that could negatively impact a company's ability to secure future financing (Mundaca & Kloke, 2018).

The distribution of benefits under this policy is notably equitable, offering advantages to both property owners and tenants within the commercial realm. Owners see a boost in their property's value following the implementation of energy-efficient measures, while tenants benefit from immediate reductions in energy expenses (Nadel et. al, 2011). This setup effectively resolves the issue of divergent interests between tenants and landlords regarding investment in energy efficiency, with the utility company assuming the upfront costs. These expenses are then gradually recouped through a charge on the benefiting business's utility bill, ensuring those who enjoy the savings contribute to the costs. Additionally, by associating the investment with the property's utility meter rather than with the business itself, the program facilitates access to energy efficiency upgrades for all tenants and ensures that benefits like lower energy costs are passed on to successive occupants should the original tenants relocate (Gillingham & Palmer, 2014) .

- Administrative Feasibility

The administrative feasibility of implementing an On-Bill Financing (OBF) program for the General Services Administration (GSA)’s consideration is medium, warranting a rating of 3 out of 5. Given the GSA's extensive experience in managing large-scale federal projects and contracts, it has a high level of administrative capacity. However, the unique nature of OBF programs, which involve close coordination with utility companies and energy service providers, could present some underlying issues. For national wide implementation, the OBF program must collaborate with existing financial and property management systems. This includes ensuring that billing systems can accommodate the additional charges associated with OBF projects and that energy savings and repayments are accurately tracked. Currently, not every state’s main powder company has the desire to push this implementation. On the positive side, the GSA's current infrastructure or leased buildings likely has the flexibility to support such integration, though it may require upgrades or modifications. Moreover, GSA is not subject to local and state codes due to federal preemption. Thus, we do not have to consider the difference in familiarity of each state. The GSA has expertise to ensure the program complies with all relevant federal regulations, including those related to energy efficiency, procurement, and financial management.

- Financial Risk

This alternative excels in managing financial risk, achieving a high rating with a score of 5. This success is largely due to OBF's low default risk, as repayments are integrated into utility bills—a priority payment for most consumers given the critical nature of utility services. The default rates for utility bills are significantly lower compared to other types of unsecured consumer debt (Burr & Carlson, 2007). This is partly because the consequence of non-payment is the discontinuation of essential services, which most consumers strive to avoid. The structure of On-Bill Financing is often straightforward and designed to avoid significant changes in payment terms that could jeopardize the financial stability of the payer. Additionally, the repayment terms are usually clearly defined at the outset, with mechanisms in place to ensure that the financing does not lead to substantial increases in monthly utility bills(U.S. EPA, 2019; Henderson, 2012).

Alternative 1	**Benefit Cost Analysis**	**Equity**	**Administrative Feasibility**	**Financial Risk**
On-Bill Financing	Score: 4 NPV:$ 7,298,891,671.93	High(5): Reduces limitations on credit access, improves cost-effectiveness, and equitable benefit	Medium(3): Low administrative feasibility for some states	High(5): Defined terms prevent major payment shifts; low default risk for utility bills.

ALTERNATIVE 2: GUARANTEE FACILITY MODEL

With this alternative, the GSA will propose leveraging a Guarantee Facility Model to mitigate financial risks for lenders and investors. This alternative contains two critical components: project pooling and first-loss protection.

Initially, the GSA should identify and prioritize prospective energy efficiency projects, including but not limited to those involving the installation or upgrade of electrified HVAC systems. The focus should be on projects within its portfolio that are poised for significant impact and could serve as high-visibility pilot initiatives across various energy efficiency domains (Prasad et al., 2022). The model incorporates the concept of project pooling, where multiple energy efficiency projects, including those aimed at installing or upgrading to electrified HVAC systems, are aggregated into a single portfolio. This strategy serves to dilute the risk associated with any single project (Taminiau et al., 2021).

Once the project is deemed viable and falls under the umbrella of the model, GSA will partner up with financial institutions to provide the capital needed for the upfront installation costs. The GSA, leveraging its role as a federal agency, will provide a guarantee that covers the first-loss exposure. This guarantee acts as a catalyst, encouraging banks, financial institutions, and private investors to allocate capital towards these projects with reduced apprehension regarding potential losses (World Bank, n.d.; Lorentz et al., 2023). Essentially, if a project fails to generate the expected financial return and cannot meet its debt obligations, the guarantor covers a portion of the losses as per the terms of the guarantee. This safety net makes lenders more willing to finance these projects. This layer of protection is critical in building investor confidence, as it significantly lowers the entry barrier to funding projects with high upfront costs and long payback periods (Hervé-Mignucci et al., 2013).

The presence of a guarantee typically results in more favorable loan terms for building owners undertaking energy efficiency upgrades. This is because the guarantee reduces the lender's risk of financial loss, making them more inclined to offer loans with lower interest rates and extended repayment periods (U.S. DOE, 2023). Consequently, lower interest rates decrease the cost of borrowing, while longer repayment periods allow for the costs of the project to be spread out over time (Delaney, 2023). This can improve the building's cash flow, making it easier for owners to manage expenses and repayments without compromising the financial viability.

- Benefit Cost Analysis

  This alternative has been evaluated at the state level with a Net Present Value (NPV) of $ 8,153,256,622.66 and a score of 5. This program’s benefit includes energy conservation benefits and enhanced living conditions for the 4,000 households that undertake energy efficiency improvements, alongside savings in healthcare costs. The cost includes the direct costs of the upgrades themselves, the deadweight loss associated with government expenditure on these upgrades, and operational costs borne by both the government and private lenders. Operational costs for the government and private lenders encompass employee salaries and office space. Additionally, private lenders incur marketing and transaction costs, the latter of which also affects investors. (Please see Appendix A for more information)

- Equity

  This alternative performs poorly with regard to the equity criterion and receives a rating of medium with a score of 3. The guarantee instruments are designed to mitigate investment risks and could theoretically make it easier for commercial building projects. This can theoretically include projects in underserved communities or in buildings that serve critical public needs. However, the complexity and scale of these mechanisms might favor larger projects or those with significant backing, potentially sidelining smaller projects or those aimed at serving less commercially attractive areas (Bilotta & Colantoni, 2018). Also, the GSA manages a vast portfolio of federal buildings across the country, including in regions that might benefit significantly from energy efficiency upgrades or renewable energy installations. The typical structure of guarantee instruments does not automatically prioritize projects based on their location in underserved communities or their potential social and environmental impact (Omoju, 2020; Duma & Muñoz Cabré, 2023). Without intentional design and criteria that highlight equity and community benefit, investments may naturally flow towards projects that are less challenging and more financially secure, potentially bypassing those in regions where the upgrades could have a profound impact. Moreover, benefits of energy projects in the U.S. are already concentrated among a narrower group of projects or regions, leaving behind those with potentially higher impacts on federal sustainability goals and community benefits. The actual distribution of this alternative's impact will depend significantly on the criteria used to select projects for guarantees.

- Administrative Feasibility

  This alternative performs well with regard to the administrative feasibility criterion and receives a rating of medium to high with a score of 4. One question asked by many ESCOs is whether government can take on more risk to enhance their capacity to undertake more ambitious projects, such as achieving net-zero greenhouse gas (GHG) emissions in buildings. In 2021, the U.S. Department of Energy's (DOE) renewed commitment under the Biden Administration to support clean energy projects through a loan guarantee program (Richter, 2021). With up to $40 billion in loans available for renewable energy projects, there is a trend for the federal government to address the risk barrier associated with widespread HVAC installation. Moreover, the GSA possesses a strong institutional framework and administrative capabilities to manage complex programs and contracts. The GSA already oversees various sustainability and energy efficiency initiatives. Its experience and existing infrastructure provide a solid foundation for administering guarantee instruments. The integration of guarantee instruments into ESPCs would likely require minimal additional administrative overhead. Moreover, as a federal agency, the GSA benefits from government backing, which enhances its ability to offer and manage guarantees (FDIC, nd). This backing reduces perceived risks and streamlines the GSA's ability to assess and manage those risks by enhancing trust and financial stability.

- Financial Risk

  This alternative performs well with regard to the financial risk criterion, earning the rating of high with a score of 5. Its main agenda is to address the concerns of default risk and the likelihood of significant changes in payment terms. Specifically, the mechanism of first-loss protection acts as a financial buffer and reduces the immediate financial exposure of lenders and investors, thereby lowering the overall risk of default. Concurrently, the strategy of pooling multiple energy efficiency projects into a single portfolio effectively spreads out the financial risk. This diversification ensures that the failure of a single project has less impact on the overall investment (Cronk & Aktipis, 2021). In combination, the model's structure prioritizes stability and reduces the likelihood of unexpectedly altering payment terms.

Alternative 2	**Benefit Cost Analysis**	**Equity**	**Administrative Feasibility**	**Financial Risk**
Guarantee Facility Model	Score: 5 NPV:$ 8,153,256,622.66	Score:3 Selective accessibility; Unbalanced allocation	Score:4 High administrative strength; Sufficient risk management capability	Score: 5 Financial buffer; Diversified portfolio

ALTERNATIVE 3: ASSET-BACKED SECURITIES (ABS)

With this alternative, the GSA will propose a novel approach to enhance the adoption rate of electrified HVAC systems in the U.S. through the utilization of Asset-backed Securities (ABS). The process initiates with the origination of loans or leases, a fundamental step where property owners secure financing agreements with lending institutions. These agreements serve as the foundation that enables the subsequent pooling of these financial agreements into a larger, aggregated portfolio (Ashcraft, Malz, & Pozsar, 2012; Guggenheim Investments, 2023). Following origination, these individual financial agreements are aggregated into a larger pool. This pooling not only simplifies the investment structure but also prepares the assets for the critical stage of securitization, where the pooled assets are transformed into securities. These securities are organized into different categories based on the level of risk and potential profit to match investors' risk profiles. Once these securities are structured, they are offered to investors in the capital markets. The capital raised by investors provides the necessary upfront funding for these projects. The return on investment for these securities is closely tied to the repayment of the underlying loans or leases, as property owners begin to realize energy savings from their upgraded HVAC systems. As these financial agreements are repaid, cash flows are distributed to investors, ensuring a return on their investment (Cuthbert, 2013). This distribution process first directs payments to the highest-rated groups, ensuring that investors who prefer lower risks get paid quickly. Meanwhile, investors taking on more risk have the chance for higher returns, but only if the money invested in energy efficiency projects is successfully paid back(Ashcraft, Malz, & Pozsar, 2012).

The success of this proposal ultimately depends on whether the loans or leases for energy efficiency projects are paid back (Campolongo, Jönsson, & Schoutens, 2013). This repayment creates cash flow, which is then given to investors as their return. If the loans or leases are not repaid, it means that the projects have failed to achieve the expected outcomes due to underperformance of the energy efficiency upgrades or other financial difficulties faced. In such scenarios, the cash flow to investors would be reduced or potentially halted. This reduction or halt in cash flow can lead to a cycle where investors see these investments as riskier, thereby demanding higher returns in the future, which in turn makes it even harder for building owners to repay (Zhao et al, 2021; Kumar, 2014).

To avoid the cycle of increased risk perception and demand for higher returns, the GSA can propose a focused approach where the repayments of ABS are directly tied to the performance of energy efficiency upgrades. This strategy ensures that investors' returns are closely linked to the actual energy savings achieved, creating measures that are more tangible and predictable.

- Benefit Cost Analysis

  This alternative has been evaluated at the state level with a Net Present Value (NPV) of $ 7,248,992,804.37 and a score of 3. The benefit of Asset-Backed Securities (ABS) mechanism includes energy savings and enhanced comfort, as well as healthcare savings. The cost includes the resource expenditure for efficiency upgrades, the opportunity cost associated with governmental fiscal allocations, and the administrative expenses related to the program's execution, which include marketing initiatives, workforce compensation, transaction cost, and office operational costs. Considering the requirement for a securities attorney, the costs also encompass legal fees, registration fee, and salary of compliance officers to ensure asset's compliance with relevant laws and regulations.

- Equity

Regarding its performance on the equity criterion, this alternative is rated as low to medium, achieving a score of 2. The structuring of ABS allows for the distribution of risk among investors, which can make funding more accessible for projects deemed too risky or too small by traditional financing standards. On paper, this could lead to more capital flowing into energy efficiency projects, indirectly benefiting a wider range of commercial properties (Riachi & Schwienbacher, 2015). Moreover, ABS distributes risk among investors, which will lead to more stable financing for HVAC projects across areas in the commercial building sector. This distribution of risk can facilitate investment in regions or projects that might be deemed too risky if evaluated individually. However, the complexity of ABS transactions and the potential lack of transparency could favor larger, more sophisticated investors and property owners, potentially leaving smaller players at a disadvantage, especially if the cost are passed on to the borrowers (Lemmon et al., 2013). The purpose of implementing ABS financing is to lower the cost of projects compared to traditional loans, making well-structured securities more feasible for HVAC upgrades across a wider array of commercial buildings. If investors are confident in the structure and management of the ABS, and if the securities are rated favorably, the implementation can lead to broader participation and support for HVAC projects across diverse property types and owners. Nevertheless, the market for asset-backed securities has experienced a slowdown over the past year, attributed to increasing interest rates, consumer pressure, and additional contributing factors (Hasse, 2023). As investors become more risk-averse, there is increased scrutiny on the credit quality of underlying assets in securitization pools, which means only high-quality loans are included in ABS.

- Administrative Feasibility

This alternative performs fairly well with regard to the administrative feasibility criterion and receives a rating of high with a score of 5. The growing interest in sustainable and green investments significantly enhances the feasibility of implementing ABS for HVAC upgrades. In the past, conditions of market, regulatory guidance and quality of the underlying assets serve as external variables that influence the administrative feasibility (Lu, 2018). The success of green bonds in financing environmentally beneficial projects already offers valuable lessons for ABS. Green bonds necessitate transparency and accountability to develop standardized metrics. This is a positive sign for the implementation of ABS because the growing market acceptance of green bonds, evidenced by the increasing volume of issuance and investment, indicates that the market is receptive to securities that are tied to measurable environmental benefits (Piñeiro-Chousa et al., 2021; Wang, 2022). On the regulatory side, the GSA has the capacity and experience to engage in such a mechanism. Proposed legislation like the Public Buildings Renewal Act suggests there is interest in using private investment for public infrastructure improvements (Cortez Masto, 2021). By encouraging private investment in public projects, the legislation serves as a model for public-private partnerships (PPPs) that utilize ABS for financing. Moreover, Standardizing asset quality for ABS under ASHRAE Standard 90.1 should not present a significant issue. ASHRAE 90.1 is a widely recognized and adopted standard for energy efficiency in buildings, offering detailed requirements for HVAC systems among other components (Zhang et al, 2021). The GSA can use it as a benchmark for evaluating asset quality in ABS financing models.

- Financial Risk

This alternative performs moderately well with regard to the financial risk criterion, earning a score of 3. By aggregating loans or leases into a larger pool and converting them into securities for sale to investors, the model introduces a layer of complexity that can influence the risk profile (Campolongo, Jönsson, & Schoutens, 2013; Kumar, 2014). While the pooling of financial agreements in the ABS model does offer risk diversification, the overall stability and the risk of default are heavily reliant on the consistent repayment of the underlying loans or leases. Without additional mechanisms or a performance-based repayment structure to enhance the predictability and reliability of these repayments, the alternative inherently carries a moderate level of risk. The strategy of linking repayments directly to the performance of energy efficiency upgrades is a notable risk mitigation measure. This approach can make returns more predictable and tangible, reducing the uncertainty around cash flows. However, the success of this strategy also depends on accurately measuring and verifying energy savings, which introduces its own set of challenges and potential for variability (Grueneich, 2015).

Alternative 3	**Benefit Cost Analysis**	**Equity**	**Administrative Feasibility**	**Financial Risk**
Asset-Backed Securities(ABS)	Score: 3 NPV:$ 7,248,992,804.37	Low-Medium(2): risk distribution, investor bias concern	High (5): High administrative feasibility due to GSA's experience, favorable market conditions, and transparency	Medium(3): Potential for variable investor returns

OUTCOME MATRIX

Alternative	Benefit Cost Analysis	Equity	Administrative Feasibility	Financial Risk	Overall Score
On-Bill Financing	Score: 4 NPV: $ 7,298,891,671.93	High (5) : Reduces limitations on credit access, improves cost-effectiveness, and equitable benefit (split incentives)	Medium (3): Low administrative feasibility for some states	High (5): Defined terms prevent major payment shifts; low default risk for utility bills.	Score: 17
Guarantee Facility Model	Score: 5 NPV: $ 8,153,256,622.66	Medium(3): Selective accessibility, Unbalanced allocation	Medium-High (4): Strong administrative strength, High risk management Capability	Score: 5 Financial buffer; Diversified portfolio	Score: 17
Asset-Backed Securities	Score: 3 NPV: $ 7,248,992,804.37	Low-Medium(2): risk distribution, investor bias concern	High (5): High administrative feasibility due to GSA's experience, favorable market conditions	Medium(3): Potential for variable investor returns	Score: 13

SENSITIVITY ANALYSIS

When the discount rate increases from 5% to 7%, the NPV for all three alternatives decreases more than proportionally. The higher elasticity for the OBF model indicates that it is slightly more sensitive to changes in the discount rate, which means that the cash flows from the OBF model are expected further in the future than those of the other two alternatives . From the 5-7% range to the 5-10% range, the magnitude of the elasticity decreases for all models. This implies that the initial increase in the discount rate from 5% to 7% has a larger impact on reducing the NPV than the subsequent increase from 7% to 10%. This could be because the initial cash flows are weighted more heavily at lower discount rates, and as rates increase, the impact of later cash flows is reduced. As far as GSA's concerned, this observed reduction in elasticity signifies a shift towards a more stable risk profile for projects at higher discount rates, suggesting that the impact of further increases in rates on project valuations may be less pronounced than initially anticipated.

Moreover, the NPVs of all three alternatives for each financial model exhibit near-perfect elasticity with respect to participant count variations. The elasticity values close to 1 across both participant ranges for each model indicate that the NPVs adjust almost proportionately to the changes in the number of participants. In other words, as the participant volume increases or decreases, the NPVs of the alternatives correspondingly rise or fall in near-perfect alignment. The result implies a stable financial outlook for each alternative, as the expected cash flows remain virtually unchanged in proportion to participant fluctuations. Consequently, the financial viability of these options can be considered consistent, with participant numbers having an almost directly proportional impact on their respective NPVs

For all three alternatives, analyses across various factors—energy savings percentage, annual Increase in electricity Rate, marketing cost, non-energy savings (including health and safety), and the rebound effect—all demonstrate inelastic responses. The elasticity values for each factor are very close to 0. This implies that changes in these variables have little to no impact on the number of participants in each model. In practical terms, program administrators can expect predictable participant behavior and can plan their resources and strategies accordingly, without the need to significantly adjust for these variables. It also suggests that these factors are not strong motivators or deterrents for participant decision-making within these models.

RECOMMENDATION

This analysis recommends the implementation of **Alternative 1: On-Bill Financing (OBF)** as the optimal strategy within the U.S. commercial building sector and GSA's authority.

From the result of Benefit-Cost Analysis, the Guarantee Facility Model displayed the highest NPV. The OBF and ABS frameworks exhibited similar NPVs, lower than the Guarantee Facility Model. The decision to favor OBF over the Guarantee Facility Model, which has shown superior financial metrics, rests on a comprehensive evaluation of the overarching objectives, with a particular emphasis on equity and the facilitation of widespread technological adoption. The OBF model is particularly adept at addressing this concern because it enables property owners and tenants to finance energy-saving upgrades through their existing utility bill structures. This approach significantly lowers the barrier to entry for adopting energy-efficient HVAC systems by removing the need for substantial upfront capital investments, which can be prohibitive for smaller businesses or those in underserved communities.

Moreover, the adoption of energy-efficient technologies faces hurdles not just in financing but in market penetration and the readiness of consumers to adopt new technologies. The Guarantee Facility Model, while offering favorable financial returns and risk mitigation for investors, may not directly address these adoption barriers and the split incentive problem. This disconnection between who pays for the improvements and who benefits from them can significantly reduce the motivation for landlords to invest in HVAC upgrade (Hill, Dirr, and Harrison, 2020). OBF, by contrast, directly ties the repayment of the financing to the utility bill, effectively linking the investment with its returns in energy savings, thereby encouraging a broader uptake of energy-efficient systems.

Prioritizing OBF over ABS is a decision that focuses on immediate barriers to energy efficiency adoption rather than solely on accessing broader capital. ABS, while effective in mobilizing large-scale financing and appealing to sophisticated investors, does not directly tackle the upfront cost barriers and misaligned incentives between property owners and tenants that OBF addresses. OBF provides a more straightforward approach for financing energy-efficient upgrades, linking investment directly to utility bill savings and ensuring that benefits are felt immediately by those making the improvements. This direct link promotes a broader and more equitable adoption of energy-efficient systems, closely aligning with the objectives of achieving widespread environmental and economic benefits.

However, the recommendation to focus on OBF does not preclude the use of ABS as a complementary mechanism to expand financing options. ABS could serve as an effective tool for aggregating and refinancing existing energy efficiency loans, thereby freeing up more capital for new OBF projects. This dual approach could harness the strengths of both models: OBF's effectiveness in addressing upfront cost barriers and facilitating broad-based adoption, and ABS's capacity to mobilize large-scale investment through the capital markets.

OBF program has seen application in residential buildings across several states, providing valuable experience and insights. The existing frameworks, successes, and challenges encountered in residential settings offer a foundational understanding that can be adapted and scaled for commercial applications. Thus, this prior knowledge can make its implementation for commercial buildings nationwide more straightforward.

While the OBF program mitigates the initial financial barriers of efficiency improvements, it alone does not stimulate demand for energy efficiency upgrades. Besides leading by example, this analysis recommends GSA accompany the OBF program with information campaigns to increase consumer awareness and offer technical guidance for the entire commercial building sector.

IMPLEMENTATION

To move forward with the proposed policy option, the General Services Administration (GSA) should first develop a detailed proposal for the On-Bill Financing (OBF) program, detailing a projected timeline for its rollout and providing recommendations for its structure. The first step involves forging a robust internal framework by assembling a cross-departmental team within the GSA. Specifically, the GSA should bring together expertise from the Office of Federal High-Performance Green Buildings, the Office of Government-wide Policy, and the Federal Buildings Fund. While the Office of Federal High-Performance Green Buildings ensures the sustainability of OBF's rollout, Office of Government-wide Policy and Federal Buildings Fund can offer insights on policy compliance and finance for national-scale implementation. Armed with this information, the GSA can pinpoint areas in need of improvement and adjust its proposal as needed.

Following this, the GSA should initiate partnerships with major federal utility service providers, including the Tennessee Valley Authority (TVA) and regional utilities that serve a significant number of federal facilities. These partnerships are crucial for integrating OBF mechanisms into existing billing systems, allowing for the recovery of investments in energy efficiency directly through utility bills. Negotiations should focus on creating agreements that make the inclusion of energy improvement costs in billing both feasible and efficient, ensuring customers can repay these investments over time seamlessly. The initial funding for upgrades, occurring in 2026 and based on calculations involving 4,000 participants at the state level, amounts to $418,200,000. To supplement the funding available from the Federal Buildings Fund and other budget allocations, the GSA must seek partnerships with financial institutions experienced in energy financing and committed to sustainability. Banks and entities like the Green Investment Group, Bank of America's Environmental Business Initiative, or the World Bank can offer loans or lines of credit tailored for HVAC installation. The GSA should focus on establishing terms that favor long-term sustainability and financial viability.

Alternatively, the GSA could propose the program directly to Congress and lobby for legislation that mandates federal utility providers to implement an OBF program. Nonetheless, the program stands a better chance of success if the federal utility providers agree to administer the program through internal procedures and negotiations, since a utility's commitment to OBF significantly influences its success (Mundaca & Kloke, 2018).

Moving to program design and planning, it is recommended to tailor the OBF program specifically to the unique needs of federal facilities. The GSA will need to develop inclusive eligibility criteria, favorable financing terms, and identify impactful energy efficiency measures (EEMs). Thus, pilot projects in a selection of federal buildings will serve as crucial testing grounds, while the GSA continues to collaborate with facility managers, sustainability officers, financial institutions, and ESCOs.

If federal utility providers do not accept the proposal, the GSA might consider creating an internal fund dedicated to energy efficiency projects, similar to a green revolving fund, where savings from energy efficiency projects are reinvested into new projects. This self-sustaining fund could support ongoing energy efficiency improvements without relying on external utility providers. Alternatively, the GSA could recommend the Guarantee Facility Model to allow ESCOs or government to absorb a significant portion of the project risk so that the utility providers will be more likely to cooperate.

Upon the initiation of the OBF program, the GSA's role will encompass program marketing and evaluation. The OBF program often faces challenges generating demands, resulting in lower than anticipated market penetration (Bell, Nadel & Hayes, 2011). To address this challenge and enhance the program's reach, the GSA should form strategic partnerships with federal utility providers to initiate a comprehensive informational campaign. This campaign should focus on promoting energy efficiency benefits specifically to facilities most likely to see significant improvements, including those in underserved communities. In this case, the GSA has the influence to lead by example in demonstrating the efficacy of the OBF program. For example, having OBF program successfully implemented within its managed facilities, the GSA can provide tangible evidence of the program's effectiveness in reducing energy consumption and costs to help build confidence in the program among potential participants.

To increase consumer awareness, it is more effective to leverage psychological principles that influence decision-making and behavior rather than approach it from the marketing side. By showcasing real-life testimonials and case studies from early adopters who have already benefited from the program, the GSA can use social proof and illustrate the tangible impacts of energy efficiency improvements as indirect encouragement for others to participate. When individuals see that peers or entities similar to them have successfully implemented energy efficiency measures and are enjoying the benefits, they are more likely to feel that participating is a good decision (Venema, Kroese, Benjamins, & de Ridder, 2020) .

Furthermore, the GSA should emphasize stories demonstrating how specific energy-saving measures have resulted in significant savings and improved comfort within federal buildings, as these narratives can strongly appeal to potential participants. Leading this informational campaign, the GSA should also prioritize the collection and analysis of data on the OBF program to assess the program's cost-effectiveness over time.

CONCLUSION

In conclusion, the electrification of HVAC systems in commercial buildings is a crucial step towards achieving substantial reductions in energy use and greenhouse gas emissions, aligning with national energy reduction goals. However, significant financial barriers hinder this transformation, emphasizing the urgent need for effective financing solutions to overcome these challenges and facilitate widespread adoption. The analysis of three alternatives: On-Bill Financing (OBF), Asset-Backed Securities (ABS), and the Guarantee Facility Model, shows a promising yet complex field. OBF stands out as the optimal approach by effectively addressing both equity issues and upfront cost barriers. This recommendation, however, does not overshadow the potential contributions of ABS in broadening the financing landscape or the robust financial returns and risk mitigation offered by the Guarantee Facility Model.

This study's analysis reveals two primary limitations that affect the appraisal of financing options for energy-efficient HVAC systems. Firstly, there's the challenge of formulating robust assumptions and acquiring empirical data needed for an accurate annual cost-effectiveness assessment. This difficulty is amplified by the unpredictable market responses to financial mechanisms, which obscure the ability to reliably predict their long-term impacts and effectiveness. Secondly, the study's national scope fails to account for the variability in state and regional building codes. Such variability means that a financing strategy proving effective in one state might not replicate its success in another with less stringent building codes. Even though GSA projects may not be directly subject to local codes, the broader market dynamics and the ecosystem of contractors, suppliers, and commercial entities the GSA interacts with are influenced by these local regulations.

Moreover, as the commercial sector continues to evolve, so will the dynamics of financing energy efficiency. Future research must remain attuned to these shifts, exploring the scalability of successful models, the integration of emerging technologies, and the adaptability of financing strategies to new regulatory landscapes. The path forward is one of continued innovation, data-driven analysis, and policy alignment, with the ultimate aim of fostering a commercial sector that not only thrives economically but also contributes to the global imperative of environmental sustainability.

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APPENDIX A

The tables below present the analysis assumptions used for the CEA calculations and the breakdown of costs for each alternative. This analysis evaluates the effectiveness and costs of each alternative using a 7 percent discount rate and a 25-year time horizon from 2024 to 2049. This BCA includes many assumptions, most of which are derived from relevant research and are cited accordingly. Other assumptions are generated by the author. While the sensitivity analysis addresses certain unpredictability within the assessment, this BCA primarily serves as an instrument for contrasting the different options available.

The following table illustrates general assumption for selected years in the 25-year time horizon from 2024-2049.

Parameter	Value	Source
All costs occur at year end (standard practice)	year end	Standard practice
All $ are in 2024$	2024$	Author decision
Discount rate	7%	Author decision
Number of new commercial buildings participating in program each year	4000	Author assumption
Program lifetime (of upgrade offerings) in years	10	Typical standard
Average loan amount/cost of efficiency upgrade per building	$ 104,550	(Sanalife, 2021)
Average rebound effect per household	0.2	(Cleary & Palmer, 2020)
maximum loan term in years	15	
Average rent per square foot of office space per year	37.35	(CommercialEdge, n.d.)
Standard cubicle size in square feet	64	(Voss, n.d.)
Deadweight loss factor for government spending	1.25	(Campbell & Brown, n.d.)
Forecasting interest rate	5%	(Conway, 2023)
The median of commercial building size(sq ft)	5100	(National Institute of Building Sciences, 2014)
$/kWh price of electricity in 2024	$ 0.1255	(YCharts, n.d.)
Average value of comfort as a percentage of utility bill savings	15%	(Russell, Baatz, Cluett, & Amann, 2015).
Average annual energy savings as a percent of total energy use	40%	(Srivastava, 2022)
Annual value of non-energy savings per building (health, safety)	$ 14,148.00	(Tonn, Rose, Hawkins, & Conlon, 2014)

Targeted number of commercial building(90% retrofitting goal)	24,444,000	(Office of Energy Efficiency & Renewable Energy, 2020)

Baseline Energy Assumption

The following table illustrates baseline energy savings assumption for selected years in the 25-year time horizon from 2024-2049.

Parameter	Value	Source
Annual increase in $/kWh (electricity price)	2.36%	(Zientara, 2023)
Average annual electricity consumption in kWh per sq ft for commercial building	15	(IotaComm, 2020)
Average monthly electricity consumption in kWh per sqft for commercial building	1.25	Author's calculation
Average Size of Commercial Building in sqft	16,400	(DOE, 2018)
Average monthly electricity consumption in kWh per building	20,500	
Price elasticity of electricity demand	-0.4	(Burke & Abayasekara, 2017)
Response of electricity consumption	-0.012928	

Additional Assumption

The following table illustrates additional assumptions for each alternative

On-Bill Financing	Value	Source
Estimated salary for finance officer	$ 101,971.00	(Salary.com, n.d.)
Number of additional employees for program operation	10	(The Energy Efficiency Institute, Inc., 2016)
Cost of marketing per participant	$ 241.00	(Mundaca & Kloke, 2018)
Additional hours spent on repayment each year	0	Author assumption
Guarantee Facility Model		
Loss compensation rate	90%	
Default rate	4.50%	Author assumption
Estimated salary for U.S. government finance officer	$ 124,400.00	(U.S. Bureau of Labor Statistics, 2022)
Estimated salary for financial institution employee (lenders)	$ 80,566	(Salary.com, n.d.)
Number of additional government employees for program operation	40	Author decision based on (The Energy Efficiency Institute, Inc., 2016)

Additional hours spent on repayment each year per building	1	Author assumption
Minimum wage (U.S.)	$ 7.25	(Delouya, 2023)
Number of additional financial institution employee (lenders)	40	Author decision
Asset-Backed Securities		
Estimated salary for finance officer	$101,971.00	(Salary.com, n.d.)
Number of additional employees for program operation	10	(The Energy Efficiency Institute, Inc., 2016)
Additional hours spent on repayment each year	1	Author assumption
Minimum Wage(the U.S. average)	$ 7.25	(Delouya, 2023)
Annual Salary of Security Attorney	$ 90,787.00	(Salary.com, n.d.)
Number of Security Attorney for program operation	16	Author assumption: 1 attorney per 250 participants (ceiling to the next integer)
Minimal fees for registering the securities per participants	$ 150.00	(Division of Investment Management, n.d.)
Annual Salary of Fulltime Compliance Officer	$ 86,304.00	(Salary.com, n.d.)
Number of Security Fulltime Compliance Officer for program operation	27	Author assumption: 1 officer per 150 participants per year. Source: (Goldwasser & Vivekananda, 2020)

ALTERNATIVE 1: ON-BILL FINANCING

The table below outlines the present value of various cost and benefit categories for the OBF program, aligning the method of calculation with assumptions detailed in the table above. Except for employee salary and office space costs that commence in 2025 (year 1), all other benefits and costs are projected to start in the following year, 2026 (year 2). This is based on the premise that while the program's initial setup will kick off immediately upon receiving funding approval in fiscal year 2025, the actual financial resources for efficiency upgrades will only be accessible starting in fiscal year 2026.

Costs	
Efficiency upgrade resource cost	$ 2,745,104,486.37
Opportunity cost of government spending on upgrades plus deadweight loss	$ 978,646,973.91
Employee salary cost	$ 11,883,275.30
Office space cost	$ 278,567.25
Marketing cost	$ 6,327,787.48

Opportunity cost of government spending on marketing plus deadweight loss	$ 1,581,946.87
Benefit	
Energy savings	$ 4,648,027,164.88
Improved comfort	$ 697,204,074.73
Healthcare + Safety savings	$ 5,697,483,469.50
PV Benefit	$11,042,714,709.1198
PV Costs	$ 3,743,823,037.19
NPV	$ 7,298,891,671.93

ALTERNATIVE 2: GUARANTEE FACILITY MODEL

All projected benefits and costs for the Guarantee Facility Model are set to initiate in 2027 (year 3), apart from employee salary and office space expenses, which are anticipated to begin in the preceding year, 2027 (year 2). The extended timeline for operational commencement is attributed to the necessity for the GSA to engage in regulatory frameworks and compliance with city government. Thus, one additional year will be required for the program to become fully functional.

Costs	Money Value
Efficiency upgrade resource cost	$2,565,518,211.56
Opportunity cost of government spending on upgrades plus deadweight loss	$208,444,148.93
Employee salary cost for government	$53,337,762.61
Office space cost for government	$1,024,908.26
Marketing cost for lender	$5,913,820.08
Transaction cost for investors	$856,564.16
Employee salary cost for private lender	$53,337,762.61
Office space cost for private lender	$1,024,908.26
Benefit	
Energy savings	$4,648,027,164.88
Improved comfort	$697,204,074.73
Healthcare + Safety savings	$5,697,483,469.50
PV Benefit	$11,042,714,709.1198
PV Costs	$2,889,458,086.46

NPV	$8,153,256,622.66

ALTERNATIVE 3: ASSET-BACKED SECURITIES

The table below presents the present value of benefits and costs for the Asset-Backed Securities program. Except for employee salary and office space costs that commence in 2025 (year 1), all other benefits and costs are projected to start in the following year, 2026 (year 2).

Costs	
Efficiency upgrade resource cost	$ 2,745,104,486.37
Opportunity cost of government spending on upgrades plus deadweight loss	$ 978,646,973.91
Employee salary cost	$ 11,883,275.30
Office space cost	$ 278,567.25
Marketing cost	$ 6,327,787.48
Opportunity cost of government spending on marketing plus deadweight loss	$ 1,581,946.87
Transaction costs for participants	$ 2,919,617.98
Legal Fees	$ 15,570,339.08
Compliance Officer salary cost	$ 24,977,508.26
Registration Fee	$ 6,431,402.24
Benefit	
Energy savings	$ 4,648,027,164.88
Improved comfort	$ 697,204,074.73
Healthcare + Safety savings	$ 5,697,483,469.50
PV Benefit	$ 11,042,714,709.12
PV Costs	$ 3,793,721,904.75
NPV	$ 7,248,992,804.37

ADDITIONAL INFORMATION

The underlying assumptions for valuing improvements in comfort and healthcare savings are extracted from the breadth of existing literature. Energy efficiency enhancements not only lead to direct energy savings but also elevate the comfort and health levels within households. The inclusion of such co-benefits in the analysis is pivotal because they serve as significant motivators for households contemplating investments in energy efficiency improvements, thereby considerably enhancing the net present value of benefits.

Transaction costs borne by building owners who participate in policy alternatives are estimated by employing the national minimum wage as a proxy for the opportunity cost of the program participants' time. This approach assumes that the time spent by building owners on program-related activities could otherwise be used for labor compensated at the minimum wage rate. It is important to note that the transaction costs for owners of commercial buildings are anticipated to be higher than the national minimum wage, which has been used as a benchmark in the analysis due to the lack of a more precise alternative wage rate for valuation.

Additionally, the estimation of healthcare savings per household leverages findings from a study examining the Department of Energy's Weatherization Assistance Program (WAP). This study provides crucial insights into the economic value of non-energy benefits, specifically in the realms of health and safety improvements, on a per-building basis. The average annual value of these non-energy benefits for a commercial building is assessed to be $14,148. It's important to note that this number may vary significantly based on the specific uses and occupancies of the buildings.

For a detailed analysis and calculations, please see the attached spreadsheet.

https://docs.google.com/spreadsheets/d/1ZG-U_-hmz628z_smBEQZb1j4PmMFZavR/edit?usp=sharing&ouid=104630788960818842729&rtpof=true&sd=true

SCORING SYSTEM INFORMATION

The scoring system for evaluating policy alternatives is structured to facilitate comparison and elucidate the trade-offs involved. Each policy is assessed across various criteria and assigned integer scores. For equity, administrative feasibility, and financial risk, these scores translate into qualitative assessments: a score of 1 indicates low, 3 medium, and 5 high performances. Scores of 2 and 4 are used for alternatives that fall between low-medium and medium-high, respectively, in these criteria. These scores reflect anticipated outcomes for each policy alternative.

In the context of the benefit-cost analysis, the scoring mechanism is designed to underscore comparative performance and importance of criteria. The policy alternative with the greatest net present value (NPV) is awarded a score of 5, whereas the one with the lowest NPV gets a score of 3. This approach is used to reflect the close range of NPVs among the policy alternatives, ensuring a nuanced comparison based on their financial outcomes.

In the design of this evaluation framework, the final decision rests in the hands of policymakers, who may have varying priorities and focuses. Thus, weights have not been assigned to the scores of each criterion. This decision was made to maintain a uniform approach to comparing the policy alternatives without biasing the evaluation toward any particular criterion.