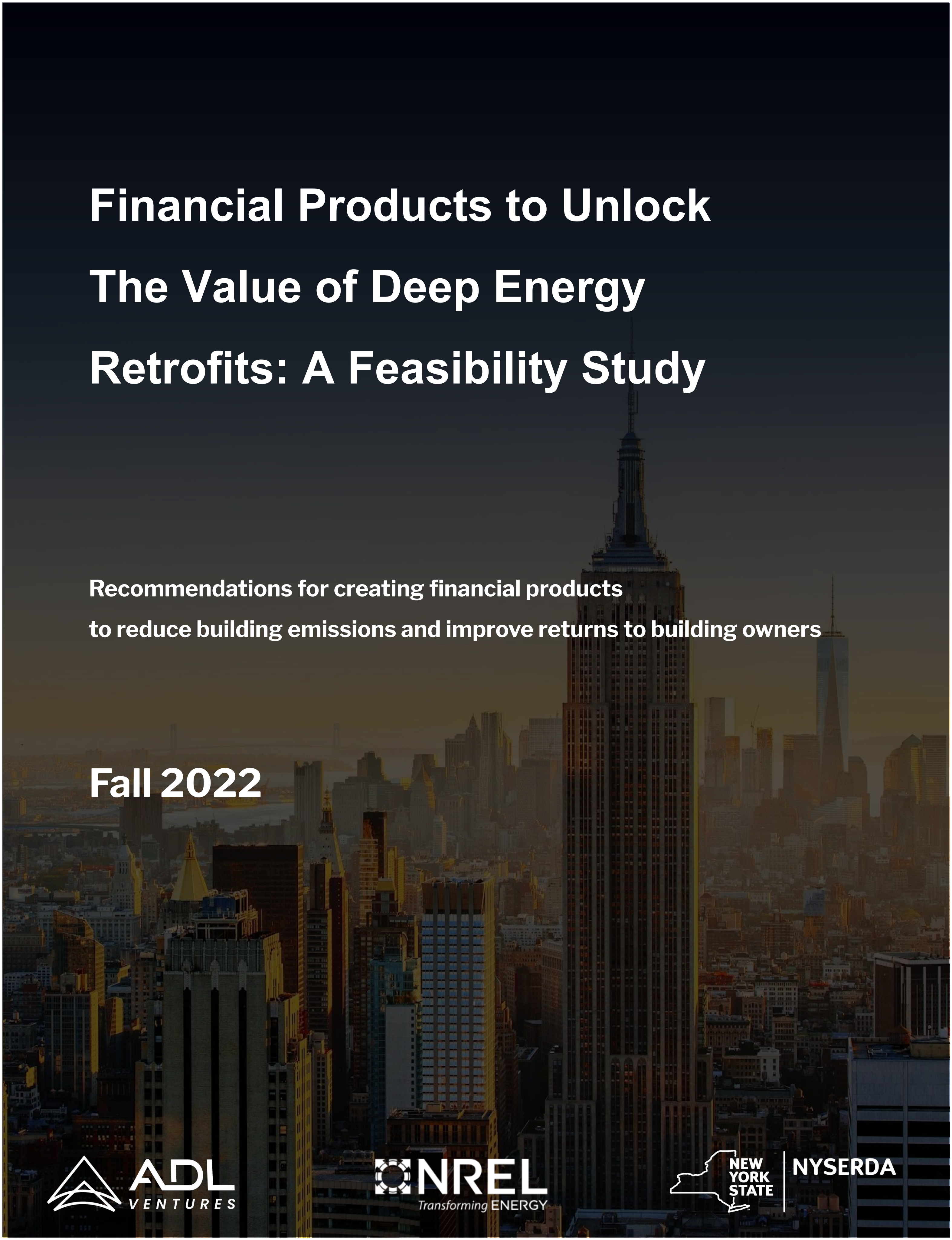

Financial Products to Unlock The Value of Deep Energy Retrofits: A Feasibility Study

Recommendations for creating financial products to reduce building emissions and improve returns to building owners

Fall 2022

ADL VENTURES

NREL Transforming ENERGY

NEW YORK STATE | NYSERDA

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Study conducted by ADL Ventures

Executive Summary

Context

The U.S. building sector is responsible for 40% of greenhouse gas emissions and remains one of the most challenging industries to decarbonize, creating a roadblock on the path to carbon neutrality by 2050.[1] Although new construction can achieve net zero emissions with little to no cost premiums utilizing currently available technology,[2] it is only a piece of the puzzle: 70% of the building stock that will be standing in 2050 has already been built.[3] Emission reduction targets and climate goals will not be achieved without deep, holistic energy retrofits of existing buildings. In New York State, the Climate Leadership and Community Protection Act (CLCPA) targets a 40% reduction in emissions from 1990 levels by 2030, and an 85% reduction by 2050.[4] To achieve net-zero status in buildings, both electrification *and* greater reduction in energy demand must be implemented.

Faced with this challenge, exacerbated by volatile natural gas prices and forthcoming legislation like Local Law 97, developers and building owners are confronted with significant climate and operational risk to their real asset portfolios and are motivated to adopt mitigation strategies. Only advanced envelope deep energy retrofits have been shown to enable electrification of existing gas-fueled buildings without increases in energy costs.

Multifamily housing represents an attractive starting point for deep energy retrofits, combining significant volume in older, inefficient vintages and relatively large project size with consistent, simplified system design. This study centers on solutions for multifamily building stock under 10 stories in height, which represents nearly 50,000 projects, $100 trillion in project costs, and $14 trillion in lifetime energy savings per year in New York State alone, with the national market up to 5 times as large.[5]

The building envelope drives building energy use and overall building performance. Energy lost through the opaque envelope alone is responsible for 25% of building energy use in the U.S., and

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[1] https://www.unep.org/news-and-stories/press-release/building-sector-emissions-hit-record-high-low-carbon-pandemic

[2] https://www.phius.org/cost-data

[3] https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter9.pdf

[4] https://climate.ny.gov/

[5] https://public.tableau.com/app/profile/nrel.buildingstock/viz/USBuildingTypologyResidential/Segments

this value is even higher in residential buildings and older building stock.[6] High-performing building envelopes control energy loss and can protect a building's structural integrity, resist fire and storm damage, maintain comfortable interior temperature and humidity levels, enable greater flexibility in internal load management, and reduce exterior noise intrusion.[7] Deep energy retrofits that include significant envelope upgrades work as a unified system – reducing heating and cooling loads while replacing old systems with LED lighting, heat pump space conditioning, domestic hot water, and energy recovery ventilation. The result is a building with better energy performance that also directly improves tenant experience, increases building revenues, and reduces maintenance costs while mitigating a broad spectrum of risks. However, deep energy retrofits can be challenging due to the high degree of variability in initial conditions, component selection, and design parameters.

Problem

Energy efficiency retrofit measures - such as routine air sealing, HVAC improvements, lighting, and appliance upgrades - can often be financed entirely by energy savings. Deeper retrofits, with additional envelope upgrades, electrification, and energy conservation measures, provide greater opportunities for electrification and economic benefit. However, deep energy retrofits cannot typically be financed by long-term energy savings alone due to high upfront costs. A typical multifamily retrofit can cost between $40 and $200 dollars per square foot, up to $7 million in total, based on our review of case studies. Average incremental costs per-unit average $70,000, but range from $30,000-136,000 per unit, and typically top $90,000 in total, including non-energy related scope.[8] The net present value of energy savings can typically offset between 10 and 20% of this cost. Due to these daunting first costs, deep energy retrofits have not been implemented at scale in the United States. While deep energy retrofits generate significant co-benefits beyond energy savings, they are difficult to quantify and standardize. Standardized quantification of deep energy retrofits co-benefits holds the potential to unlock additional project financing on the order of $1-2 million per project and accelerate project deployment.

Opportunity

To speed implementation and reduce costs, the industry must transition to standardized and quality-assured solutions delivered by a single-party turnkey provider. This method has been shown to reduce costs associated with public housing renovations at scale in Europe, where Energiesprong has completed thousands of retrofit units, reducing cost-per-unit by 20-50%.[9] Using a prefabricated component model, solution providers in European markets have drastically reduced delivery time and improved the performance of technical building systems after

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[6] https://www.osti.gov/biblio/1821413-opaque-envelopes-pathway-building-energy-efficiency-demand-flexibility-key-low-carbon-sustainable-future

[7] https://www.gciconsultants.com/blog/understanding-the-importance-of-your-buildings-envelope/

[8] See Appendix II for case studies.

[9] From interviews with Energiesprong solution providers in the UK (20% savings), France, Italy (25-30%), and the Netherlands (up to 50%).

installation.[10] Beyond these first-order benefits, turn-key, prefabricated delivery of deep energy retrofits is the best way to ensure the quality assurance and standardization across the industry necessary to achieve meaningful scale. Only these repeatable methods allow aggregation of a collection of unique projects into a portfolio of similar assets that can benefit from the financial products described in this study. In the U.S., spurred by RetrofitNY, similar solution providers have emerged. However, such integrated delivery remains in the pilot stage with limited and highly variable data available for U.S. markets.

The study summarized here focused on exploring financial and risk products to accelerate the implementation of productized retrofit solutions to reduce costs.
These financial products are intended to speed market development via three fundamental themes:

1. Re-allocating risk from inefficient risk-averse building owners and lenders to insurers that can more cost-effectively model, price, and spread risk. This can reduce friction between parties, enable more efficient project delivery, reduce transaction costs, and reduce risk premiums.
2. Quantifying and monetizing previously unrecognized value associated with the unique benefits of advanced envelope deep energy retrofits to offset construction costs and unlock additional capital.
3. Provide building owners with confidence in the performance of building systems.

Financial Products
Based on extensive analysis, the following financial products have the highest impact and feasibility.

Different value streams are best monetized through different products: a performance warranty can be the most appropriate financial product to monetize energy savings while a credit backstop may be the most appropriate product to monetize increases in rent premiums, property value, tenant retention, and others that affect Net Operating Income (NOI). The modeling, primary research, and stakeholder interviews conducted throughout this study revealed three product categories to limit risks and secure additional financing.

Once implemented, these products will give building owners confidence in the value of deep energy retrofits and boost demand for these projects while simultaneously bringing liquidity to the retrofit market and making it easier to support financing on a project basis.

1. **Building System Performance & Energy Savings Guarantee:** Traditional technology warranties may be expanded to include other long-term energy savings and occupant-perceived performance elements. Coverage should include traditional ‘repair, replace, or

[10] From interviews with French & Italian providers of Energiesprong retrofits.

refund' language and extend beyond typical 5-year terms to match the financing period of 10-30 years.

2. **Trade Credit Insurance:** Many retrofit benefits accrue to tenants and may lead to increases in occupancy and building-level Net Operating Income (NOI). A credit insurance product based on increased building cash flow could reduce repayment uncertainty for project lenders by paying out in the event of building owner default.
3. **Ancillary Revenue Contracts:** Grid services and carbon credits may be independently structured and monetized by parties other than the tenant, landlord, or lender. We recommend separable bi-lateral, long-term contracts to provide certainty in what can be a volatile market driven by regulation.

Impact

These prospective financial products will make it easier to finance deep energy retrofits. The identified value streams offer the opportunity to narrow the financing gap – in combination with market maturation and delivery model innovation. The products outlined above lower risk to building owners by monetizing these value streams and transferring technology and counterparty risks to a risk pool backed by an insurance company.

Supporting capital invested in developing these products has an outsized opportunity for impact. We estimate that, for a generic market-rate multifamily building in New York City, all of these value streams in aggregate could contribute to an 18% improvement in annual net operating income and up to 43% for an extreme upside case. For a typical 34-unit market- rate project in NYC, with a total project budget of approximately $5 million, this could unlock between $1.0 and $2.8 million in private financing (approximately $30,000 per unit at the low end), accounting for 20-50% of the cost gap projects are currently facing.[11] While the ability to monetize these value streams will vary from project to project, and especially between affordable and market-rate development, these private dollars directly reduce the burden on public subsidies to reach CLCPA goals.

Recommended Actions

ADL has assembled a prioritized, actionable map recommending how each value stream can be implemented to support the financing of deep energy retrofit projects. We have also outlined how NYSERDA and the U.S. Department of Energy (DOE) can drive these products to market and attract private- sector investment capital. Though there is flexibility, these are listed in order of urgency, and generally increasing order of required resource commitment. Recommended actions fall into six categories for public sector support:

1. Aggregating demand
2. Convening stakeholders
3. Supporting product development

[11] More detail on the model and assumptions is provided in Appendix IV.

4. Developing standards
5. Establishing a loan loss reserve
6. Developing the supply chain of capital

While carrying out the actions above, NYSERDA and the DOE should begin to engage insurance providers, Managing General Agents (MGAs), and industry experts to build capacity for underwriting these new products and educating insurers on the benefits of their ESG and impact mandates. This process will take time and require the DOE and NYSERDA to understand insurance stakeholders' positions while serving as an expert resource to provide guidance and data on the technical feasibility of each product category.

Unlocking Deep Energy Retrofit Value

While deep energy retrofits with significant envelope upgrades offer a long-term economic means to achieve electrification, they require a significant upfront capital investment. Costs are exacerbated by a long, opaque value chain with significant information asymmetry, uncertainty around counterparty risks, and consequently high transaction costs. Moving from project-by-project delivery to integrated, prefabricated, and turnkey solutions reduces variability in finished conditions and enables quality assurance that transforms collections of unique projects into a cohesive portfolio, and allows for better risk transfer, enabling the products discussed in this study.

Deep energy retrofits offer benefits beyond improved energy performance. These can include better indoor environmental quality, increased building longevity and resilience, and improved thermal and acoustic comfort. These attributes are notoriously difficult to quantify because of varying building stock characteristics and external environmental and economic conditions that drive the measurable economic value that results from "soft" benefits. The premise of this study is to investigate possible financial and risk-focused products that can quantify the value of the soft benefits of deep energy retrofits to spur additional investment capital into retrofit product capacity.

The Value of Insurance Products

Owner, investor, and lender perceptions of risk and return represent major barriers to the adoption of deep energy retrofits with off-site envelope manufacturing. Though the individual component technologies are mature and well-proven, standardized, rapid, and integrated delivery and long-term whole-building performance are new to key stakeholders and are therefore subject to distorted perceptions of risk and return. This impedes the performance of deep energy retrofit projects in decision-making models and restricts available financing.

Property owners, as a class, are risk-averse; small and medium-sized owners and developers lack the extensive balance sheet and depth of portfolio to distribute risk and can rarely bear even a single loss. Real Estate Investment Trusts (REITs) and institutional owners have larger portfolios but prioritize steady and certain returns: investing and holding for decades and making conservative decisions that favor proven performance at scale and over time. For building owners and investors, the direct energy benefits of a retrofit comprise only a portion of a project's business case. Building owners and investors do not have the capacity to make use of advanced data, modeling, and monitoring around building performance, and thus are likely to overestimate the magnitude of project risks while underappreciating the value these projects create. These misperceptions cause deep energy retrofits to be undervalued in both decision-making and financing models, ultimately hindering widespread deep energy retrofit adoption.

Owners and investors rely on insurance and performance contracts to understand and mitigate project risks. In particular, insurance underwriting and actuarial analysis can facilitate risk transfer through detailed analysis of the frequency and severity of loss conditions over a long period. For new markets and technologies, the historic loss performance of close analogs can be combined with stringent quality assurance, accelerated testing, and real-time monitoring to provide a basis for launch. Insurance balance sheets are designed to withstand losses that may otherwise be highly disruptive for other stakeholders. Consequently, building owners and investors are assured of performance, and risks are redistributed. Insurance providers can approach a portfolio of risk with a higher degree of sophistication, certainty, and preparation to mitigate risk.

In addition, OEMs, equipment installers, building owners, and third-party project financiers may all share in aspects of the risk, but the bounds of these contracts are frequently opaque and fragmented. Solution providers are best positioned to knit together the disparate warranties and contracts on a project to provide a structured summary that outlines the boundaries of liability between parties and communicates to insurers where a project's liability is limited, over what term, and to what value.

Insurance products are a high-impact and inherently scalable intervention. Insurance providers earn returns based on the size of their premium pool and are highly motivated to design standardized products that can rapidly scale to capture growing markets. Because any public subsidy in the form of a capital reserve will be used to enhance insurers' already strong balance sheets, credit, and capabilities, it will command impressive leverage for impact, and multiplicatively larger impact in terms of additional project debt unlocked. Finally, depending on how and when public support is added to the risk tower, a single allocation of funds can cover a larger and larger risk pool over time. Allocated funds may only be used as certain claims are made, and insurers may grow more comfortable with project risks as a larger population of projects develop a longer history to help refine actuarial tables. If project performance is as strong or stronger than expected, decreasing perceptions of risk may outpace the use of the reserve pool, allowing for financial sustainability and drastically increased impact leverage over time.

Quantifying Value Streams

Our analysis rolled up all the disparate value streams into building NOI and value, through increased operating income or decreased operating expense. The way these avenues of value aggregation can be monetized follows in Figure A-III.1.

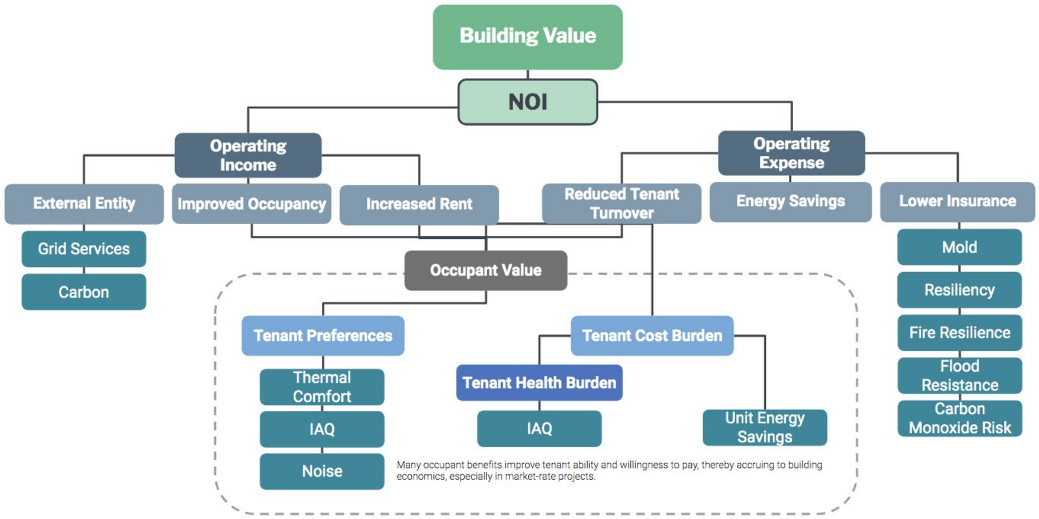

Figure A-III.1. *Building Value Streams*

Ease of implementation varies across the 18 sources of value that were investigated in this study. While some streams have common and accessible measurement methodologies that are clearly tied to building owner revenues, others lack consensus around both claimed value and performance measurement, which serve as a short-term roadblock to monetization. In addition to the broad analysis of each individual value stream, ADL Ventures (ADL) recognized that the value streams naturally "roll-up" into points of aggregation. This means that a portion of the value associated with hard-to-measure or hard-to-value benefits can be captured at a higher-level endpoint. For example, while noise attenuation may not have sufficient evidence to support pricing on its own, it impacts tenant health and preferences, which improve rental pricing and occupancy, thus aggregating to building revenue. While aggregation does not preclude the creation of vehicles for each stream, it provides the opportunity to incorporate hard-to-value benefits via others that may be easier to measure, define, and process claims. Through this framework, ADL has identified four points of aggregation – system performance, ancillary revenues, net operating income, and insurance premiums – to capture a majority of the value provided by a deep energy retrofit. These points of aggregation suggest financial instruments or insurance products that may be feasible for implementation in the near- to medium-term as shown in the following Figure.

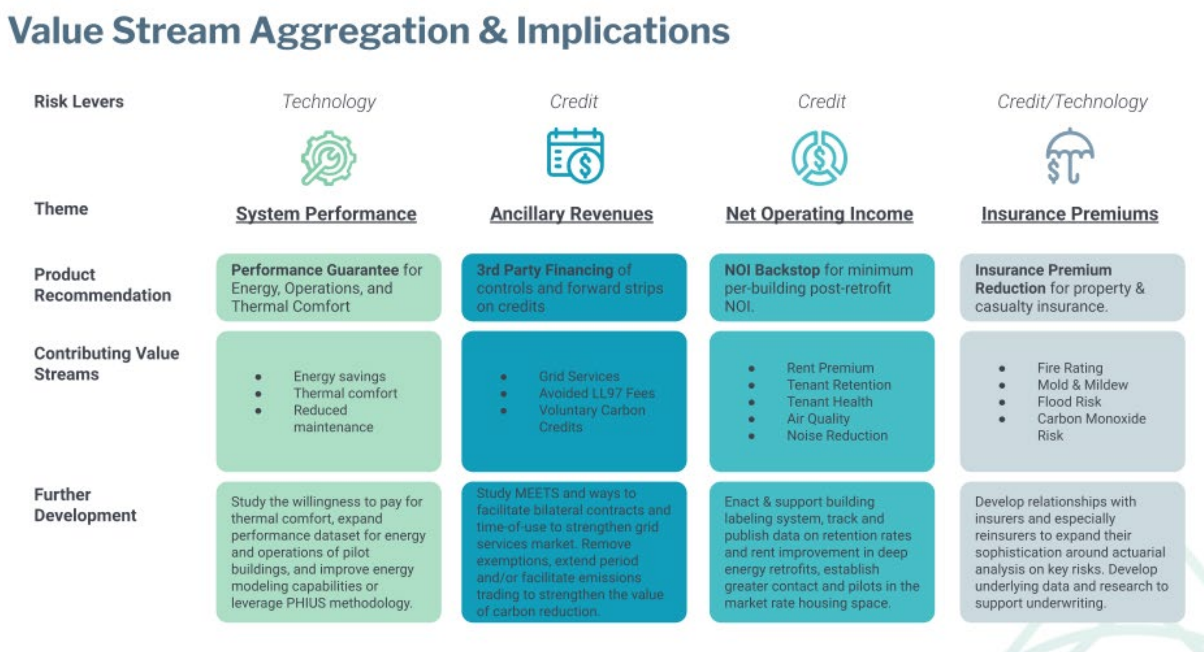

Figure A-III.2. *Product Recommendations and the Supporting Value Streams*

Each of these individual products can be combined to further enhance secondary financing ability.

The key value streams that could be monetized through a performance guarantee are Energy Savings, Thermal Comfort, Noise, Maintenance Reduction, and Indoor Air Quality.

1.1 Energy Savings

Value

Deep energy retrofits provide a 40-90% reduction in energy use[12]. However, lenders are typically only willing to underwrite up to 50% of energy savings in the current market, though some specialty programs offer up to 75%, leaving significant value on the table.[13] Based on our research and modeling, guaranteed energy savings can improve NOI between 5 and 7%, especially in affordable housing where building owners pay utilities. This benefit accrues entirely to the building owner, and amounts to a net present value between 6 and 11% of retrofit costs for our modeled typical project, on the order of $300,000-$600,000. As the most recognized benefit of deep energy retrofits, shoring up valuation and certainty in energy savings can build confidence in overall system performance. The best-in-class product for securing energy savings is through a third-party energy savings guarantee provided by an insurance company or MGA.

[12] Less, Brennan, and Iain Walker. "Deep energy retrofit guidance for the B uilding America S olutions C enter." (2015).
[13] Based on interviews with financiers conducted for this study, Jan 2022-March 2022.

Such a guarantee supports not only the proper function of equipment but also the underlying system design and energy modeling calculations. Energy savings performance is monitored after installation and compared to a modeled baseline, and claims for shortfalls are remediated first through systems adjustment & on-site remediation of design or installation failures. For the building owner, this provides security and removes the burden of redress from a complicated contractual relationship between designers, engineers, and contractors, many of which may have limited creditworthiness. Depending on track record and construction verification method, this instrument could improve the ability to underwrite energy savings from the current norm of 50% to a maximum of 75-90%, extending over a period of up to 10 years, according to our modeling & interviews with specialty financiers.

Implementation

To make meaningful progress on the availability of suitable energy performance guarantees, state and federal agencies should work together to accomplish the following key steps:

- Establish Measurement and Verification (M&V) formulas for retrofits to support modeling and implementation of energy savings guarantees as a standard for funded retrofit projects.
- Work with providers to extend the product to 10+ years which would provide additional comfort to lenders and the potential to further improve lending terms. Offer an appropriately sized risk reserve pool if necessary.

1.2 Thermal comfort

Value

Deep energy retrofits make it easier to provide thermal comfort and tenant satisfaction by improving insulation and HVAC efficiency in a building. Therefore, pricing thermal comfort as a determinant of tenant lifetime value should be part of retrofit financing. Thermal comfort proves the efficacy of the retrofit and new equipment, ensuring that the owner receives the functioning product they paid for. Failing to meet thermal comfort targets indicates faulty design, installation, or equipment and alerts the building owner and materials producers to the issue. Thermal targets have been previously set by many organizations; PHIUS for example, requires indoor temperature to remain between 68 and 77 degrees for certification.[14] Thermal comfort is difficult to assign value by itself but contributes to rent premiums and tenant retention. More importantly, temperature regulation works as a confirmation of correct installation of retrofit equipment. Therefore, the coverage value of thermal comfort is somewhere between 1% and 10% of the incremental cost of a retrofit, so the potential value of a claims loan could range from $19,000-193,000 for our typical modeled project.

Implementation

Thermal comfort is the end result of a chain of systems including air tightness, ventilation, HVAC, windows, and insulation that need to have been installed successfully. The most effective

[14] https://www.phius.org/sites/default/files/2022-03/Phius%20Certification%20Guidebook%20v3.02.pdf

measures to take are establishing target temperature thresholds of 68-72º in winter and 74-80º in summer. Deviations from these ranges for more than five hours per month should result in penalization for the building owner. This goal requires a measurement system (patterned after work by ASHRAE and PHIUS) but also requires a large data gathering system and comes with challenges with protecting tenant privacy while simultaneously accounting for extreme weather events, open windows, and tenant thermostat adjustment.

Conducting and publishing studies around thermal comfort at deep energy retrofits as well as in the standard building stock will help increase public understanding and create a market for accurate valuation.

1.3 Noise

Value

A reduction in background noise levels is an important benefit of deep energy retrofit improvements. Background noise in multifamily units can be separated into three sources: HVAC operation, internal noise transfer from adjacent units, and external sound levels filtered through the thermal envelope. Each of these sources has a specific path for remediation but the benefits to occupants are only recognized in aggregate. Elevated noise levels have been shown to have negative impacts through reduced productivity and hearing loss, and can lead to loss of sleep and elevated stress levels.[15] Acceptable or reduced noise levels are recognized as valuable by the market, however, they are currently most closely linked to location and other factors outside of a project team's control, such as proximity to airports, construction, or major highways. Reducing internal noise levels should be valued as an aspect of tenant comfort, and therefore make up a percentage of rental premiums and tenant retention gains from retrofitting. Though difficult to price separately as of now, as a percentage of the incremental cost of a retrofit, noise reduction could be covered at anywhere between $19,000 to $193,000 for our typical modeled project.

Implementation

Implementation measures for ensuring noise levels could take several potential forms. Measurement can take place on a one-off basis or continuous monitoring. Noise levels can be monitored using decibel sensing equipment either once-off or continuously, in order to ensure that noise remains in the 45-decibel range, the healthiest for indoors.[16] Continuous monitoring is most helpful in determining the effectiveness of retrofit improvements over time and provides more long-term data that can be analyzed, but also requires significant labor and cost around data gathering. For both options, the goal should be a reduction of approximately 30 decibels from the measured level outside. One-time checks provide the benefit of monitoring

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[15] Münzel T, Sørensen M, Schmidt F, Schmidt E, Steven S, Kröller-Schön S, Daiber A. The Adverse Effects of Environmental Noise Exposure on Oxidative Stress and Cardiovascular Risk. Antioxid Redox Signal. 2018 Mar 20;28(9):873-908. doi: 10.1089/ars.2017.7118. PMID: 29350061; PMCID: PMC5898791.

[16]https://archive.epa.gov/epa/aboutepa/epa-identifies-noise-levels-affecting-health-and-welfare.html

without the large cost associated with continuous data collection. These efforts will bring the benefits of noise reduction to a wider audience and create a market that can value it adequately.

1.4 Maintenance Reduction

Value

One of the challenges for maintenance resulting from a deep energy retrofit is that new systems sometimes result in increased maintenance costs. Our financial model indicates that project NOI could actually decrease by $15,352 in a worst-case scenario for maintenance costs and increase by $142,600 in a base- case scenario during the first ten years of a deep energy retrofit on our typical modeled project.

Maintenance expenses could be reduced through fixed maintenance guarantees on system components and the building envelope; the result would be improved cash flow and reduced future uncertainty. A fixed maintenance guarantee reduces the long-term operating costs of a project, which in turn decreases the capital reserves required by mortgage lenders, increases available cash flow to cover debt service, and unlocks higher potential for upfront financing.

Implementation

Existing performance guarantee offerings typically face one of three key roadblocks. First, equipment manufacturer warranties typically fail to reduce overall maintenance requirements. Second, guarantees are shorter than the useful life of the product: for instance, an ESCO contract for a building envelope is 5-7 years but the envelopes' useful life is 15-20 years. Third, performance guarantees create significant risk for contractors; performance failure could have a significant negative impact on their business.

In terms of insurance product design, payout, and cost parameters are relatively simple. There are two specific triggers for payouts outlined below.

1. **A budget threshold cost-based assurance** requires a payout to be made if maintenance exceeds a certain established percentage of the total maintenance cost budget or an agreed upon value over a certain time period.
2. **Performance failure** of a given product would lead to a payout from the contractor or manufacturer of the system. This would only be triggered if performance failure persists within a coverage period for the specific component building system.

Of the options above, threshold cost assurances would likely be the simplest and most desirable for the building owners.

Insurers and contractors would likely push back on both system performance guarantees and threshold cost guarantees, however, sensors could be installed throughout building components to provide more data on building component systems and better predict system failure.

Enacting a performance guarantee requires continuous commissioning or ongoing monitoring of building system equipment. Implementation of IoT and sensors to measure performance for heating, cooling, ventilation, and water systems would support this product. Encouraging building envelope commissioning to leverage drone footage or visual inspections would ensure compliance.

To size and accurately administer a performance guarantee product, more data is needed on the maintenance costs of deep energy retrofit associated building systems relative to carbon intensive systems. Increased data can help get insurers, contractors, and building owners more comfortable with the expected long-term maintenance costs of deep energy retrofits, and to size a guarantee product effectively.

1.5 Indoor Air Quality (IAQ)

Value

Indoor air quality is extremely important to tenant health and productivity,[17] and should be valued among the largest benefits of deep energy retrofit building improvements. However, IAQ is undervalued by tenants and is not always reflected in purchasing or rental decisions. IAQ is relevant to tenant health and comfort but is also an indicator of the success of a retrofit installation and the effectiveness of the equipment installed. Therefore, IAQ should be valued as a portion of the incremental cost of a retrofit. Further information on the direct link between building performance and IAQ may be found at ASHRAE.org. ANSI/ASHRAE Standards 62.1 and 62.2 are the recognized standards for ventilation system design and acceptable indoor air quality (IAQ).[18]

Implementation

IAQ is relatively simple to measure through air flow rates or sensors that track volatile organic compounds, CO2, particulate matter, and CO. States could introduce IAQ standards, which have already been established by several organizations including PHIUS and LEED, listed in the table below.

Particulate Matter	10 micrometers or less in diameter: 50 ug/m3 2.5 micrometers or less in diameter: 15 ug/m3
Carbon Monoxide	Less than 9 ppm
VOCs	Less than 500 ug/m3

[17] https://www.epa.gov/indoor-air-quality-iaq/office-building-occupants-guide-indoor-air-quality#why-indoor
[18] https://www.ashrae.org/technical-resources/bookstore/standards-62-1-62-2

Carbon Dioxide	About 700 ppm above outdoor air levels (usually about 1,000 to 1200 ppm) (ASHRAE)

Source: https://www.iotacommunications.com/blog/indoor-air-quality-parameters/

Table 4. *Examples of IAQ criteria that are well-established in the industry*

Monitoring with IAQ sensors for particulate matter, carbon monoxide, VOCs, or carbon dioxide is relatively easy and non-invasive. Action should only be triggered if IAQ was outside of the healthy zone for more than 10 hours per month. This approach presents challenges around tenant behavior (for example, cooking without ventilation, smoking, etc.), but leeway of a certain number of hours per month should account for the majority of brief IAQ changes. Publication of studies on the improvement of IAQ due to deep energy retrofits in order to push the market toward accurately valuing air quality as part of the retrofit package.

Conclusion and Recommendations

Deep energy retrofits are an effective mechanism to decarbonize the existing building stock to reach emission reduction targets, but require a concerted effort among private and public agencies on a variety of fronts to achieve widespread adoption. Success will depend on effective federal, state, and local regulations to incentivize building decarbonization and public and private investment in the scale-up and standardization of innovative solutions.

This report recommends high-impact and feasible financial product solutions for building owners and policymakers that reallocate the financial risk of these projects to catalyze and transform the market. A robust insurance market for deep energy retrofits has the potential to spur additional investments in the market, including increased manufacturing capacity of standardized prefabricated solutions and commercialization of innovative technologies necessary to achieve nationwide market transformation.