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Given the growing need to mitigate climate change and the context of rising energy prices due to a multitude of factors, it appears crucial to adopt clean and accessible energy patterns in energy-intensive sectors. Buildings are the main emitters of carbon dioxide in urban settings. They have the largest energy savings potential and offer the lowest carbon abatement costs compared to other sectors such as road transport, thus suggesting a good fit for their prioritization in energy policy.

Yet numerous obstacles hinder the achievement of a massive and deep refurbishment of the building stock. In the current building retrofit market, traditional energy efficiency projects and even most cost-effective Energy Performance Contracting models do not generate the highest possible value, frequently not delivering the maximum potential for energy savings and cost reduction.

Due to the prevalence of retrofits that do not exploit the full potential of the building, building owners are not always informed about the economic and environmental benefits that comprehensive retrofits can offer. Insufficient market adoption and lack of awareness of innovative and cost-efficient retrofits may undermine the creation of economic benefits and the achievement of the ambitious targets of climate change policies.

In order to incentivize building owners to renovate and contribute to massive and deep refurbishment of existing building stock, a primary need is to find an appropriate contractual framework that aligns the interests of all stakeholders. This paper describes how an innovative model, Integrated Energy Performance Contracting (IEPC), can address renovation challenges and help building owners achieve significant energy and cost efficiency while also reaching environmental goals.

In this paper we demonstrate how the integrated delivery of deep energy retrofit projects, underpinned by lean management practices and performance guarantees, can provide tangible economic benefits for building owners, and could ultimately contribute to a massive uptake of energy retrofits in the building sector.

Showcasing insights gained from project experience and discussions with industry professionals in the U.S. and Canada, we examine the benefits of deep energy retrofits, as well as bottlenecks that may hinder the achievement of comprehensive renovation in buildings. IEPC is the result of two decades of hands-on, in-depth and unique experience with public and private partners. This paper pays special attention to a procurement model based on the highest economic value, which aligns stakeholders’ interests and produces incentives for deeper energy retrofits.

In this paper, the IEPC framework is supported by the case study of an extensive retrofit project of the Montreal Biodôme, which received an international ASHRAE award in 2013. As a result of joint performance targets, the facility has achieved more than 50% energy savings and an 80% reduction in greenhouse gas emissions, as well as significant increases in systems functionality within a constrained budget.

On the whole, this paper demonstrates how cost-optimized whole-building retrofit solutions, paired with innovative contractual models, can successfully support the achievement of the economic goals and climate change targets of all concerned parties.

We hope you enjoy the reading, and we welcome your feedback and questions.
1. NEEDS FOR BUILDING STOCK UPGRADES AND BENEFITS OF DEEP ENERGY RETROFITS

As most of the building stock has already been built, the “greening” of energy inefficient buildings is a key priority. Retrofits in buildings have numerous benefits. First, they help achieve climate targets at the policy level; second, they create financial benefits and improved systems functionality for building owners; and finally, they spur job creation. Renovations of older buildings address government climate change policies and allow building owners and their occupants to achieve comfort as well as energy and cost efficiency.

Pursuing governments’ climate targets to achieve market uptake of energy efficiency in buildings

Many governments across the globe have fixed their short- and long-term climate change targets pursuing the reduction of emissions\(^1\). Scientists, economists and policy makers are appealing for emissions targets of at least 20% below 1990 levels in 2020 and 70-80% in 2050.

Retrofitting of existing buildings holds enormous potential to address the ambitious objectives of these policies. For example, in the U.S. and Canada buildings account for about 40% of total energy use and 35% of carbon dioxide emissions, outflanking road transport which contributes less than 30% of total CO\(_2\). Thus, prioritization of buildings in government energy policies is a large part of the solution to cope with climate change. Moreover, the building sector offers great potential for low-cost energy conservation compared to the transportation sector. The U.S. Environmental Protection Agency (2009) estimated that every dollar invested in energy retrofits can produce $2 to $3 in increased asset value of the building.

Retrofits also address government goals for social development: according to a joint research study by the Deutsche Bank Climate Change Advisors and the Rockefeller Foundation (2011), if retrofit strategies capable of achieving an average efficiency improvement of 30% were carried out, at an investment of $1 trillion over 10 years, more than 3.3 million cumulative job-years of employment would be created.

Value of deep energy retrofits

Energy and climate policies require ambitious energy savings in buildings that can only be reached through the fundamental retrofitting of buildings using integrative design.

Innovative, deep and comprehensive energy retrofitting of public- and private-sector buildings is a cutting-edge approach to the reduction of greenhouse gases and the achievement of energy independence. If implemented properly using an integrated delivery method underpinned with lean management practices and performance guarantees, these deep energy retrofits can reduce energy consumption by over 30%, thus generating significant financial savings. According to projections from the Rocky Mountain Institute (2011), deep energy retrofits can even reduce energy use by up to 70% in certain cases. They can also increase building value, improve interior comfort for occupants, reduce GHG emissions, and spur job creation.

Economic benefits for building owners: Green value and reduced energy costs

The above-mentioned government policies can only be achieved if commercial, institutional and residential building owners are incentivized to undertake retrofitting works and can clearly see the benefits of deep retrofits.

Energy savings, green value, comfort and systems functionality, the need to conform to local and national energy codes, as well as environmental commitments can be the main investment “drivers” to make the benefits tangible.

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\(^1\) Reduction of GHG by 17% by 2020 from 2005 levels in the U.S.; Canadian government’s commitment of 25% GHG reduction target by 2020 compared to 1990.
There are known opportunities to achieve high energy efficiency in buildings while reducing carbon footprint. In fact, while buildings represent the most energy-intensive sector, energy efficiency investments can be financially beneficial for owners in the long run as the costs can be offset by generated energy savings (Natural Resources Defense Council, 2007).

Investment in building retrofits delivers energy savings, reduced energy bills, and improved comfort for occupants and owners\(^2\), and ultimately an increased green value for the building. The incremental green value represents important financial gain for building owners after renovation. Renovation can upgrade assets, increase comfort and rate of occupancy, or make upgraded assets more liquid in terms of sale and attractive in terms of lease in the market. Today, major building owners look for green value that, in addition to its related financial interest, offers a marketing advantage and contributes to the mitigation of obsolescence.

2. BOTTLENECKS OF DEEP RETROFITS IN BUILDINGS

Despite economic benefits for building owners and the clear need to achieve national and global climate goals, building retrofits can be inadvertently marginalized in energy policy discussions. Frequently evoked interrelated barriers to the implementation of deep energy retrofits include high upfront costs, perceived high risk, shortsighted investment logic and a poor alignment of stakeholders’ interests. In addition, lack of understanding of the retrofit process by market actors and lack of accessible financing due to perceived high risks by financial institutions and investors can be a challenge. The main source of these hurdles, however, is the absence in the market of a continuous and collaborative contractual relationship between building owners and industry professionals.

Deep intervention in a building does not represent a major technical challenge per se. A key obstacle is finding an appropriate contractual model that aligns stakeholders’ interests, optimizes overall project value, and embraces the whole building for the entire life cycle of the project.

Currently, conventional methods of contracting prevail, overlooking opportunities for significant cost savings, greenhouse gas reductions and global building improvement. Inefficiencies stem to a great extent from a siloed approach to project implementation, where project phases (feasibility, design, construction, post-construction optimization) are performed by separate teams without sufficient interaction. Another major obstacle is an over-simplified approach to project design. Engineering firms and Energy Service Companies (ESCOs) often focus on measures that mitigate risk on their end, bypassing opportunities for complete building optimization. Furthermore, industry professionals may not actively seek the highest possible energy and cost savings for building owners, as they engage in contracting models where remuneration agreements are not tied to performance.

The structural misalignment of stakeholders’ interests in the building industry has been widely recognized by leading organizations such as the American Institute of Architects (AIA) and the Rocky Mountain Institute (RMI), which promote more innovative models of project design and delivery. Energy Performance Contracting\(^3\) provides an alternate contracting model that ensures that retrofit projects are cost-effective for building owners through guaranteed savings. However, Energy Performance Contracting (EPC) models share many of the same obstacles as traditional contracting. Likewise, Design-Build\(^4\) models do not always embrace the holistic approach needed to achieve deep retrofits.

\(^{2}\) The “split incentive” issue in buildings with tenants (when building owners must bear investments and tenants pay energy bills) is being addressed by partial recoupment mechanisms of investments through energy savings.

\(^{3}\) Energy Performance Contracting (EPC): A contracting model for retrofits that is cost-effective for building owners. A comprehensive energy audit is performed by an Energy Service Company (ESCO) that proposes energy saving measures. The Energy Service Company guarantees that project costs will be paid, over a certain period, through savings generated by reduced energy expenditures.

\(^{4}\) Design-Build: A project delivery system where design and construction are contracted to a single entity.
We have summarized and clarified the most pressing bottlenecks prevailing in the market that stem from the business models used by building owners and industry professionals, as well as legal and political market pre-conditions.

**Bottlenecks of current contractual relationships**

**Siloed project approach**

In traditional contracting models, the project phases—feasibility studies, design, construction, measurement and verification (M&V) and post-construction optimization—are typically performed by separate in-house teams or subcontractors. It is also common under Energy Performance Contracting (EPC) that respective project “phases” are delegated to different entities or teams by the company that oversees the overall implementation of the project. With such a fragmented approach that does not deploy a “begin with the end in mind” philosophy, measures are implemented separately and engineering solutions cannot be optimized by a dedicated team during all phases. This results in inflated global project costs and inhibits the conversion of feasibility studies into real projects with high energy savings potential.

**Compartmental retrofit measures**

Focusing on a single measure (e.g. the replacement of individual equipment or lighting retrofits) is a common market practice. For instance, a non-functional equipment such as a chiller or a boiler is frequently replaced without the deployment of a multifaceted approach that could significantly reduce energy waste and generate drastic cost savings. Building owners may think of retrofitting as only a partial asset renewal project. This is often due to apprehensions regarding significant upfront investments and long payback periods, as well as a lack of awareness of long-term benefits that deep retrofit projects can offer over the lifecycle of the measures. Buildings that deploy “compartmental solutions” cannot be optimized integrally for energy and cost efficiency.

**Unproductive procurement models**

The majority of public-sector retrofit procurement models focus on awarding contracts to qualified energy efficiency suppliers who present low design/construction costs. This approach does not effectively align the interests of building owners and industry professionals when it comes to incentivizing innovative, lean projects that generate the highest possible value to the owner over the lifecycle of the project. Instead, this model tends to encourage industry professionals to opt for simple retrofits, or to pursue a higher construction cost than might be necessary in the interests of covering costs and reducing potential future liabilities.

**Insufficient attention to the design phase**

Often, limited time and effort are spent on the design phase of retrofit projects in order to keep expenses low. Design and construction work awarded based on low bidding price does not allow industry professionals to “dig deeper” during the design phase and establish high performance targets. This problem arises both from building owners and industry professionals. Building owners are often reluctant to pay for deep and detailed feasibility studies and audits, while industry professionals are less interested in investing their efforts since their remuneration is linked to construction costs rather than to the energy efficiency of the building. This represents a problem not only for traditional engineering but also for many Energy Performance Contracting models.

**Inefficient remuneration modalities**

Retrofit projects that currently use a fees-for-services remuneration modality during the implementation phase are mostly based on a fixed percentage of construction costs. Industry professionals proposing a low percentage fee generally win the contract. This model has little to no incentive for results, as it does not reward low construction costs, high savings and a better building (ease of operation, comfort, resiliency, etc.).

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5 This is also the case for many Energy Performance Contracts which use a “cost-plus” formula. Under cost-plus (cost reimbursement) contracts, an engineering company is paid for all agreed expenses plus additional payment for a profit margin.
Oversizing of equipment
Under traditional contracting models, industry professionals’ fees are not linked to energy savings or cost savings targets. Therefore, oversizing of equipment seems to be a preferred solution for industry professionals, as it minimizes liability of thermal loads achievement and reduces design expense and expertise needed to conceptualize more cost-optimized retrofits. Moreover, industry professionals often refrain from reusing old equipment in combination with new equipment (e.g. original piping). This is mainly due to liability issues and vested interests of profits generation triggered by remuneration modalities linked to the size of the project. This inflates the project costs significantly and brings the focus on the replacement of specific equipment, thus making it less attractive to undertake significant retrofits. Moreover, according to the Rocky Mountain Institute’s report, Using Contracting to Improve Building Project Delivery and Achieve Sustainability Goals (2013), it is also frequent in market practices that industry professionals provide ready-at-hand but less efficient equipment only in order to stay on schedule.

Unwillingness to take risks by industry professionals
It is current practice for industry professionals to minimize their risk and focus on “low-hanging fruits” in the design phase i.e. measures with short payback periods—less than 5 years—which usually generate less than 30% savings. Frequently, industry professionals aim to mitigate risk, and thus focus on straightforward measures. Along similar lines, insurance companies encourage industry professionals to limit liability exposure, a mindset that has percolated down to the building retrofit sector and effectively dissuades innovation. According to the above-mentioned report from the Rocky Mountain Institute (2013), concerns over liability and risk make deep energy retrofitting extremely difficult by inhibiting outside-the-box thinking.

Business-as-usual approaches do not attain the highest energy savings and the lowest construction costs for building owners. Many asset renewal projects can face long investment recovery periods and some retrofit projects simply do not occur due to the lack of awareness of the true economic value that they could generate.

If building retrofits continue to be practiced using current traditional models, or using Energy Performance Contracting models that are not sufficiently ambitious or comprehensive, it may not only deprive building owners of economic benefits, but also jeopardize the possibility of scaling up retrofits and attaining climate change targets.
3. INTEGRATED ENERGY PERFORMANCE CONTRACTING: A CUTTING-EDGE APPROACH TO BUILDING RETROFITS

Integrated Project Delivery: a model in construction

Addressing the aforementioned hurdles requires a new model for project delivery driven by innovation, best practices and a holistic vision of building systems.

Integrated Project Delivery (IPD), a leading-edge approach in the construction industry, provides an appropriate and effective delivery model adaptable to building retrofit projects.

IPD unites property owners, architects, contractors, and engineers in projects with shared goals, risks, and rewards. These actors participate in a collective process that encourages problem solving and early contribution of knowledge from all parties, engendering a whole-systems design view and optimized results. The American Institute of Architects (2007) first defined IPD as an “approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.”

IPD is underpinned by lean construction practices, a comprehensive approach that seeks continuous improvements and value increase in all spheres of the built environment, leading to increased productivity, decreased waste and maximum value.

Elements of IPD have found their reflection in some state policies. For example, the state of Colorado (Session Laws of Colorado 2007) promotes public contracting procedures under IPD. The law defines IPD as a “project delivery method in which there is a contractual agreement between an agency and a single participating entity for the design, construction, alteration, operation, repair, improvement, demolition, maintenance, or financing, or any combination of these services, for a public project.”

Conceptualization of Integrated Energy Performance Contracting

While the application of Integrated Project Delivery and lean practices is frequently limited to new construction, this model is highly adaptable to building renovation practices. Integrated Energy Performance Contracting (IEPC) is a customized version of IPD for the building retrofit sector, merged with the concept of Energy Performance Contracting (in which project costs are offset through reduced energy expenditures) and integrative design (which deploys a whole-building approach while addressing a specific renovation need).

IEPC is a contractual relation for full-service deep retrofits based on aligned stakeholders’ interests and continuous collaboration, addressing the whole building and providing performance guarantees that target lowest overall project costs, highest energy savings and GHG abatement, and improved comfort and functionality.

Decades of experience, applied research, and open dialogues with industry professionals allowed the identification of the following seven pillars of IEPC (Figure 1, page 9).
Integrated Energy Performance Contracting is an efficient and promising contractual framework that adds significant value to building renovation projects when compared to conventional models. Using the IEPC framework allows funds to be spent more efficiently while offering a reasonable payback period through generated savings. Using this framework can create a competitive advantage through significantly lower project costs and better comfort in buildings.

It should be noted that the methodology for the implementation of IEPC can vary depending on the nature of a given project or local concerns. For instance, IEPC would represent an optimal framework for Public-Private Partnerships in building retrofit projects by helping to clearly define responsibilities and goals, and by streamlining interests between public and private actors through shared risks and benefits.

Market uptake of the IEPC framework will help unlock the potential for comprehensive renovation and increase overall refurbishment results. It will help building owners target specific renovation needs (e.g. energy savings, cost savings, asset renewal, comfort and functionality, meeting project deadlines), leading to optimal cost and energy efficiency, as well as high environmental goals. In the following section, we describe the seven pillars of the IEPC framework in detail.

**The seven pillars of IEPC**

**Pillar 1. Full-service energy retrofits from inception to completion**

*The highest value and accountability are generated when a single firm directs and optimizes all phases of project development and implementation, with the expertise of a multidisciplinary team.*

IEPC involves taking the project from inception to completion, while staying on schedule without disruption of operations. The highest savings will be achieved if a single company is directly involved with its technical expertise in all project retrofit phases.
INTEGRATED ENERGY PERFORMANCE CONTRACTING IN BUILDING RETROFIT PROJECTS

(feasibility study, design, financing, construction, post-construction optimization, M&V), and also oversees project implementation in a seamless and continuous manner.

Similar to agile management methodology, industry professionals shape every project phase and lead an “evolutionary conversation” by receiving feedback from building operators for necessary adjustments. Engineering solutions continuously evolve and improve to respond to joint targets to achieve lowest costs and highest energy savings. Adaptive planning and rapid and flexible response to change are encouraged at each phase of the retrofit project implementation.

Projects are carried out by multidisciplinary teams that unite in-house energy efficiency experts, engineers, construction managers, financiers, incentive/subsidy specialists, communications personnel, technical instructors, optimization specialists, and building owners and operators. The multidisciplinary team is brought together as early as possible in the design phase of the project, and collaborates to enhance solutions throughout all project phases.

Expertise is not siloed and project implementation is not fragmented as in traditional engineering and some Energy Performance Contracting approaches (Figure 2). In the IEPC framework, expertise is transferred from one phase of the project to another. Any subcontracted expertise is specific, and does not represent an outsourcing of the whole phase.

This integrated multi-phase approach allows continuous optimization of the project results during all stages. Design solutions can be rectified during construction, as new solutions may appear during this phase, thus increasing the potential for savings and functionality. Moreover, the construction phase can overlap the design phase, allowing streamlined delivery. The highest possible value for the building is generated when these phases are merged together as there are no waiting periods between phases. Measurement and Verification (M&V) is an integral part of the process and is not outsourced to external companies. M&V methodology is shared very early during the design phase, giving building owners full ownership and understanding of the approach. The neutral character of monitoring results is not compromised due to the transparency of the process and the level of trust established between the parties.
As in any EPC or traditional retrofit project, financing is an element of IEPC. Support in accessing funds and subsidies to defray capital improvement costs is an important component of IEPC, especially in cases where building owners are unable to mobilize financing. Under IEPC, industry professionals have the ability to work with third parties to secure financing (obtaining direct loans with competitive rates, analyzing packages in the best interests of the clients, and structuring operating and capital leases and energy service agreements), which increases willingness of the building owners to renovate. Additionally, a team of incentive and subsidy specialists can manage all applications on behalf of clients and ensure that maximum incentives are obtained.

Energy retrofitting provided by a single company in close collaboration with building owners and operators leads to high accountability. Industry professionals have the ability to synergize every project phase, including design and implementation with early involvement of the construction team and all stakeholders. This multi-phase approach, carried out by a single firm, subsequently decreases the overall costs of the retrofit project.

**Pillar 2. Whole-building approach and deep retrofits**

*In deep energy retrofits, the building is regarded as an interrelated system. The whole building is taken into account during the integrative design process, to create customized solutions that produce the highest long-term savings and green value.*

The building is assessed in-depth to establish its precise energy profile. Tailored energy efficiency solutions are then developed to address client needs while maximizing interconnections between the building systems.
Re-engineering of the whole building system includes evaluating existing infrastructure and the addition of measures that meet the specific needs of the building and its occupants. Reusing certain parts of the existing system, while taking into account the lifespan of the reused equipment, can considerably reduce initial costs. To ensure the best return on the investment for new installations, right-sized equipment (e.g. chillers, boilers, cogeneration, etc.) must be selected to meet the building’s specific needs and to ensure there are no unnecessary energy losses due to oversized equipment.

The need to replace specific equipment (e.g. an aging chiller or boiler) is a unique opportunity to rethink the whole system around the equipment to be replaced, rather than simply renewing specific assets or changing obsolete equipment. For instance, improving the efficiency of the heating distribution system (such as steam-to-hot-water conversion) can make it possible to downsize the new boilers, since the new heating load is reduced.

Necessary asset renewal can often be financed through the energy savings that result from a holistic approach to deep energy retrofits. In addition to the re-thinking of building systems, deep retrofits target components of the building in a customized way that is adapted for each particular retrofit project:

A. Building technology. Overhaul of energy systems: high performance equipment, regulation, building management and control systems, HVAC (heating, ventilation, air conditioning and cooling), lighting, etc. Building technology retrofits usually offer the highest cost savings and shortest payback.

B. Measures on the building envelope (e.g. insulation, replacing windows, green roof, etc.).

C. Integration of renewable energies and distributed generation (biomass, solar panels, geothermal energy, cogeneration).

D. Awareness campaigns to foster energy efficiency culture among all building occupants.

E. Training for operations employees on use of the new equipment and systems.

Global retrofits offer a tailored and efficient solution for each building, generating optimal energy savings and cost savings that endure over time.

**Pillar 3. Capturing the highest value of a building retrofit project**

The highest economic, environmental and social goals are targeted to maximize overall project value.

As IEPC targets the primary needs of a client (e.g. energy savings, lowest possible project/construction costs, deferred critical maintenance issues, resiliency), the most comprehensive metrics should be identified from the outset of the project to estimate results and shape a fully-fledged proposal. During the procurement phase, one of the most all-inclusive metrics for establishing the highest proposed project value is the Net Present Value\(^6\) (NPV). This is a particularly effective method for measuring the true economic value of a building retrofit, and a useful selection criterion when comparing project proposals. NPV captures the timeline, project costs and savings (construction costs, operational costs, government incentives, energy savings as they occur over time, etc.) and converts them into a single dollar amount. The NPV can be quantified and targeted during the feasibility study to respond to requests for proposals for formal selection processes. The NPV metrics incentivize industry professionals to seek maximization of value for the client throughout the life cycle of the project. This approach is described in detail in Section 4.

Highest energy savings, lowest construction costs, and highest subsidies are the key economic metrics and targets for the project implementation phase. Alongside economic targets, greenhouse gas reduction strategies are included in the design phase, targeting the lowest possible GHG emissions without compromising the economic value of the project. Similarly, increased comfort and functionality are important objectives that are also addressed during the design and optimization process. A list of common metrics to capture the highest value of a retrofit project is presented in the following box.

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\(^6\) NPV indicates what a building retrofit project’s lifetime cash flow is worth today. The NPV calculation captures the project costs and savings. A higher NPV signifies higher value for the client.
**Pillar 4. Joint performance targets**

Building owners and industry professionals collaborate continuously within one project team to reach common objectives and performance targets. The current trend of pay-for-work costs is reversed and excellence is rewarded when targets are surpassed.

Performance targets must be jointly established at the beginning of the project. Reaching the targets brings benefits to both parties, leading to the alignment of interests and goals.

Within the IEPC framework, industry professionals assume a level of responsibility and risk, and can offer contractual performance guarantees for certain targets or a “full guarantee” proposal. These guaranteed targets can include energy savings, construction costs, and third party financing. Besides economic objectives, all parties can collaborate to attain and to guarantee other non-economic performance targets (see Pillar 3). Performance guarantees are crucial for making projects bankable and less risky for building owners, leading to a greater willingness from owners to invest in energy retrofits.

The entire project team works collaboratively throughout the lifetime of the project in order to leverage their knowledge in the development of the project, as well as maximize energy savings and overall value. Constant collaboration and continuous interaction between building owners and industry professionals is required to establish a productive, dynamic and results-oriented partnership reflecting the culture of being committed to results.

In the IEPC framework, the company’s remuneration is tied to performance, aligning the firm’s interests with those of the client. This differs from traditional contracting models, where remuneration is typically based on a fixed percentage of construction costs. One of the goals of the IEPC framework is to reverse the current trend of pay-for-work costs. Excellence is rewarded, and bonus compensation is associated with exceeding the target. The possibility to increase remuneration inspires the project team to invest more time and effort and to be creative in designing the most efficient project possible. This framework fosters collaboration between different actors and allows them to optimize investments during the life cycle of a retrofit project.

To achieve the highest OPV during the project implementation phase (highest energy savings, lowest construction costs and highest subsidies), industry professionals are incentivized to generate more savings and lower implementation costs, as opposed to the traditional approach, where industry professionals are compensated based on a percentage of construction costs or an hourly rate. This encourages industry professionals to seek continuous optimization during all project phases.
Industry professionals may also be held accountable to contractually guarantee all or some of the components of the overall economic project value (which can include project costs, government agency incentives, and savings) and so they assume the risk of achieving their targets.

For example, in the case of guaranteed energy savings, coming short of the guaranteed savings implies that industry professionals will offset any shortage of financial savings, while exceeding the guaranteed savings due to constant optimization can generate increased revenues.

Thus, the success of the team is the success of the project. Partners cultivate mutual trust and a spirit of transparency and open communication. Decisions must be made in a concerted manner, as the risks will be shared as well as the benefits.

**Pillar 5. Substantial time and effort for feasibility studies and design**

Comprehensive and well-planned designs can result in substantial energy and cost savings over the lifetime of the measures.

Significant time and expertise are devoted to feasibility and design in the IEPC framework. An innovative and rigorous design provides optimized engineering solutions with higher savings capacity. Over the lifetime of the measures (25-30 years), upfront and ongoing design efforts can ultimately translate into millions of dollars of energy and construction savings. For instance, consider a baseline scenario where a building owner spends $3 million on energy bills. If insufficient effort is applied during the retrofit design phase, and the potential energy savings are underestimated by 12% (e.g. 23% instead of a possible 35%), the project would miss out on $7.2 million in potential savings over a 20-year period.

The feasibility study is a crucial step, as important decisions are made that will influence the trajectory of the project. During the design phase, extensive surveys are conducted in synergy with operating personnel to understand all aspects of the facility and ensure that the building analysis is based on accurate and verifiable data. Such an extensive design phase, aside from maximizing energy savings and targeting other priorities for the building, can contribute to rectifying existing operational problems experienced by the building operators.

Traditionally, due to compensation models, industry professionals find themselves needing to limit the time and human resources allocated to feasibility and design stages, resulting in greater investments during the construction period (see ‘Insufficient remuneration modalities’, page 6). In the IEPC framework, the greatest effort occurs during the feasibility and design period, and less effort and funds are needed during the subsequent phases due to a well-planned and comprehensive design. Substantial efforts during the feasibility and design period lead to more precise estimates and greater control of project costs. Designs can be optimized and rectified early in the project, generating increased savings later in the project. Design changes needed later in a project due to insufficient planning are expensive and more difficult to implement, which is a limiting factor to optimization in the traditional approach.

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Retrofit project in Beth Israel Brooklyn Medical Center:

For the Beth Israel Brooklyn Medical Center project, joint performance targets included the reduction of total energy costs, increased efficiency for the facility, meeting critical timelines, and offering seamless project implementation in a sensitive environment. The project in Beth Israel Hospital focused on full steam-to-hot-water conversion of the heating system, and the installation of a combined heat and power (CHP) plant that is generating enough electricity to reduce the hospital’s dependency on electrical utilities by 40% and has generated 30% energy savings. The CHP system operates continuously to meet critical hospital electric and thermal needs at efficiencies approaching 85%. Changing from steam to hydronic is a big undertaking in a vacant building and a huge challenge in a “live” building such as a hospital. To retrofit an occupied facility with a critical environment is an enormous task and it was possible due to a high degree of collaboration and strong alignment of interests of all stakeholders.7

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7 Fredric Goldner, NYAEE Chapter Awards Committee Chair and Past International President.
8 Approximate weighted value of typical building equipment lifecycle based on RSMeans, 2013 data.
In monetary terms, an approximate difference between traditional models and the IEPC framework is pictured in Figure 7. As illustrated, traditional models focus less on design. Furthermore, the inefficiencies of a siloed approach to project implementation (see Pillar 1) result in significant “waste” and an underachievement of desired outcomes. With IEPC, even if design costs are higher, estimates are more rigorous and construction costs are lower, bringing significantly more value in terms of energy savings, environmental impact and comfort and functionality over time.
Pillar 6. Lean and agile management practices

Lean management targets cost-optimized solutions with the highest savings capacity.

IEPC is underpinned by lean management practices. Lean management is a results-based approach oriented to delivering more value with less waste for complex projects. It suggests finding the most innovative, reliable and cost-effective technical solutions for modernizing systems using more efficient technology, offering the highest return on the investment and generating significant energy savings (e.g. discovery of hidden energy “deposits”). Rather than simply meeting calendar deadlines, lean management aims for constant improvements in overall efficiency; rather than simply targeting the lowest cost, lean management seeks to increase global project value by optimizing costs and limiting waste. An iterative agile approach helps to tackle issues as they arise throughout the course of the project, introducing necessary changes at the right time and delivering a successful project on time and within budget.

Pillar 7. Innovation pursuit

Continuous innovation and outside-the-box thinking are essential for the development of optimal solutions.

Innovation is the lifeblood of a successful deep retrofit project. Applied breakthrough solutions coupled with academic research will shape measures that bring the most value. The ability to identify new opportunities and solutions, and to smoothly apply them to a particular project, is key for this pillar. Innovation should not be vertical, but embraced at all levels of the project to succeed.

On the whole, the essence of the IEPC framework can be expressed when all elements of the seven pillars are converged, but in a very agile and customized manner. This can only happen when there is an established culture of doing business collaboratively, with a suitable and tailor-made contracting model and a fine-tuned management process.
Challenges of the IEPC framework

Although the IEPC framework has a proven track record of generating high energy and cost savings, this contractual model faces certain challenges, particularly for projects with a formal selection process. Certain hurdles must be addressed by industry professionals and building owners in order to implement the IEPC framework.

Challenges for building managers

Number of qualified proponents
A request for proposals based on the IEPC framework may generate fewer propositions due to the limited number of market actors capable of delivering integrated services, and building owners may be hesitant to request the IEPC framework if concerned about limiting the number of applicants. However, as more building owners request proposals based on the IEPC framework, the number of qualified proponents will increase over time.

Evaluating needs
Before bidding out the project, building owners should evaluate their budget constraints and desired performance goals. This process requires time commitment and in-house or third-party expertise. This is an essential step in developing a request for proposals that orients industry professionals to propose innovative and cost-effective solutions that directly meet the needs of the clients.

Time and cost commitment during the selection process
Building owners who undertake a formal selection process using the IEPC framework may need to invest significant time and effort, particularly those processing large building stock. However, building owners could test this model on a small selection of their building stock, evaluating its benefits upfront and later expanding to other buildings.

Challenges for industry professionals

Willingness to adopt new methods
In order to integrate the IEPC framework, industry professionals must be willing to change their mindset, develop a culture of commitment to results and adjust their business models, which will also impact their internal processes. In particular, current business models are frequently geared toward risk avoidance, a mindset which needs to be changed in order to enact IEPC.

Time and cost commitment for proposals
Project proposals under IEPC include a pre-feasibility study in order to objectively estimate construction costs and energy savings, or to accurately calculate the Net Present Value. This is a time-consuming process, requiring effort and commitment from industry professionals. This also generates costs for industry professionals who participate in the bidding process but who are not awarded the contract.

Comprehensive expertise
Industry professionals may presently lack the necessary expertise to address the whole building and undertake all project phases. This contractual model may also limit the participation of smaller contractors with specific expertise (e.g. audit companies, designers, M&V companies). The merging of different companies or the collaborative project development by companies with complementary expertise could be envisaged as solutions for offering integrated services.

While the adoption of the IEPC framework poses certain challenges and requires new ways of operating during the proposal phase, this initial investment in time and effort facilitates the development and implementation of high-performance deep energy retrofit projects. To alleviate barriers and encourage market uptake, regulations could be developed on a policy level (such as access to subsidies based on energy efficiency targets, as is currently the case in Canada) to incentivize building owners and industry professionals to engage in more innovative contracting models.
4. NET PRESENT VALUE: ALIGNING INTERESTS AND PRODUCING INCENTIVES

An alignment of stakeholders’ interests in the building industry is possible through various mechanisms. One effective tool is a procurement model based on Net Present Value, which compels industry professionals to design and implement projects with the highest overall value for the client, and allows clients to evaluate and compare the merit of each proposition.

Net Present Value captures all costs and savings associated with a project, and converts them into one monetary value (calculated as the net discounted savings of the project minus the present value of the costs of the project). It is the value in today’s dollars of the future cash flows of a project, considering project costs, savings, and incentives. A higher NPV signifies higher value for the client.

Procurement model based on NPV

As NPV reflects the true economic value of a retrofit project, it is an effective tool for clients when comparing proposals with different magnitudes and payback periods (for example, a project proposal of $3 million can be compared to a project proposal of $8 million to objectively determine which will bring the most benefit to the client over time including the lifespan of the proposed equipment, etc.). Building owners can specify the NPV criterion in the call for tenders. Firms are then evaluated on highest value, rather than lowest bidder, and qualified proponents submitting the highest NPV can be awarded the design and construction contract.

This encourages industry professionals to be innovative and to adopt a whole-building approach during the procurement process, spurring competition and innovation from the outset to shape deep energy retrofits that pursue the highest NPV. It should be noted, however, that calculating NPV requires effort and commitment from industry professionals to come up with a full design and reliable estimates before performing the final feasibility study.

The NPV procurement metrics allow for the alignment of interests of all stakeholders, compelling all parties to produce exceptional, concrete results. One of the means to accelerate the market uptake could be the mandatory application or a heavy promotion of NPV for the evaluation of energy efficiency retrofits and new construction projects in the public and private sectors.

It should be mentioned that when the analysis is restricted to costs, as is the case for new construction or for major renovations with energy savings significantly less compared to costs, the Net Present Cost (NPC) can be analyzed. This value takes into account all future cash flows (discounted future earnings and expenses) over the entire period of analysis. Under this second model, following the logic of NPV contracts, the qualified proponent submitting the lowest Net Present Cost for the project is awarded the contract.

In all cases, NPV is not the sole metric, as the contract can be awarded to highest “adjusted-NPV,” the result of the NPV multiplied by the qualitative score of the submitted project.

NPV procurement model adopted in Quebec, Canada

The NPV approach has been adopted as a procurement model in the province of Quebec¹⁰ and the approach has also been developing in other Canadian provinces in new construction and building retrofits. In Quebec, under legislation aimed at building retrofits, the model is currently used for public-sector projects in which building managers partner with a single full-service company, where project costs are reimbursed through guaranteed savings. The weighted economic value on which the proposals are evaluated is obtained by multiplying the economic value of the project (NPV) by a percentage obtained for other quality parameters (value of technical solution, expertise, etc.). Only a few pre-selected companies are invited to bid for the best NPV. This pre-selection ensures that building managers only need to study proposals from companies with solid, relevant track records. A similar formula has also been applied to Public-Private Partnership projects across Canada for the construction of large infrastructure (bridges, hospitals, etc.).

¹⁰ Article 29, of the Règlement sur les contrats de travaux de construction des organismes publics, RRQ, c C-65.1, r 5
Deep energy retrofit projects can be highly advantageous for building owners and contribute significantly to reaching government targets for reduced GHG emissions. The scope and speed of market uptake for deep energy retrofits in the built environment are currently impeded by traditional market practices, lack of awareness of the true value that deep retrofits can generate, and a misalignment of interests among key stakeholders.

Appropriate contractual models are required to significantly improve the scope and intensity of retrofit projects, to achieve climate change goals and render projects feasible and profitable for every party involved. Adopting a model that focuses on results will improve market confidence and encourage building owners and financing institutions to invest in deep energy retrofit projects.

A key element that would trigger market uptake for deep energy retrofits is a wide deployment of the comprehensive Integrated Energy Performance Contracting (IEPC) framework. This framework can help building owners achieve their specific goals, be it significant cost and energy efficiency, drastic carbon footprint reduction, or asset renewal programs leading to an increase in “green value.”

The IEPC framework leads to the convergence of interests of all project parties, who become effective partners with fully aligned incentives. Through a continuous multi-phased process, professionals collaborate to attain the highest economic and environmental outcomes for the project.

To embrace the foundations of the IEPC framework and integrate them into current market practices, the construction industry and retrofitting market will undoubtedly require a technical and cultural shift. Most importantly, it will entail a change in mindset, a willingness to take risks, a true commitment to results as well as the ability to seek innovative solutions to achieving better, greener and economically sound buildings.
Located in the Montreal museum district, Space for Life brings together four natural science museums: the Biodôme, the Insectarium, the Botanical Garden, and the Planetarium. The institution welcomes over two million visitors per year and provides an enriching and educational experience on biodiversity and the interaction between humans and nature.

Housing over 4,800 animals of 230 species and nearly 750 plant species, the Biodôme has a multitude of operational challenges. This 376,000-square-foot building replicates five different ecosystems of the Americas: the Tropical Rainforest, the Gulf of the St-Lawrence, the Laurentian Maple Forest, the Labrador Coast and the Sub-Antarctic Islands. Each ecosystem has unique climatic needs, requiring innovative and customized solutions to address the challenges.

In 2008, the Space for Life project started with a public invitation to tender. Bidders were evaluated based on the project’s Net Present Value (NPV), which combined all expenditures and savings over a 15-year period. Ecosystem was entrusted with the project.

From the beginning, Ecosystem ensured that all stakeholders were aligned to achieve common goals: maximizing the energy performance of the building, respecting the initial budget, and maintaining or improving the climatic conditions of the ecosystems.

A detailed feasibility study was conducted by a multidisciplinary team to determine the project budget and establish the savings targets that would be guaranteed by Ecosystem. Ecosystem successfully minimized costs without compromising the guaranteed savings, as any shortfall would have had to be reimbursed to Space for Life.

During the detailed study, a collaborative and iterative approach with the client and the building operators allowed Ecosystem to offer higher added value. Project improvements responded to a wide range of client needs, which far exceeded a simple reduction of the energy bill. Project managers were provided with on-site offices, and their constant presence led to a stronger partnership with the Biodôme team. The client was constantly informed of project developments.

“What's wonderful about this project is that the cost is entirely covered by the savings,” said Jean Bouvrette, project leader and Head of Technical Services for Montreal Space for Life. “In addition, the project allowed us to replace nearly $2 million worth of old equipment as part of the building’s energy efficiency measures.”
The project underwent continuous optimization during the construction phase to respond to client needs and enhance the overall value of the project. Plans were improved by the project team with the input of specialized subcontractors. These improvements had the effect of optimizing the budget, allowing Ecosystem to significantly reduce implementation costs and surpass energy savings targets by 38%, all while meeting the primary needs of the client. A multitude of factors contributed to surpassing the targets. For instance, energy was cycled between different ecosystems, where heat from the polar ecosystem was captured to warm the tropical rainforest. Moreover, groundwater under the Biodôme was integrated into an open-loop geothermal system to heat and cool the building. With modernized lighting installed, power consumption in the Sub-Antarctic ecosystem was reduced by 88%.

Part of the project budget was used to compensate the client's employees in optimization and control for the extra hours devoted to the project. The operators’ knowledge was integrated in the design process, allowing the operators to become active team members from the beginning. They participated in the design, implementation and verification of more than 1000 control points, as well as the development of operating sequences. They became fully autonomous after project delivery. The Biodôme's employees developed their expertise and contributed to project optimization for a lower cost than hiring an outside company.

Following the IEPC framework, the multidisciplinary team, which was comprised of employees from both Space for Life and Ecosystem, managed the project from start to finish, assessed the building as an interrelated system, and ensured that maximum value was delivered to the Space for Life institution. As a result, one year after project delivery, energy savings reached 138% of the contractual target, the equivalent of $1.1 million or a 50% decrease in energy bills. Greenhouse gas emissions were reduced by 80%, contributing to Space for Life's mission to educate and inform visitors on the protection of natural habitats.


Rocky Mountain Institute, “Deep Energy Retrofit 101.”

Rocky Mountain Institute, “Built Environment: Methods.”


Glossary of Key Terms

Cost Savings
The monetary value of energy savings and savings in construction costs.

Deep Energy Retrofits
Projects that aim to achieve high energy performance in buildings, typically surpassing 30% in annual energy savings, through a comprehensive whole-building approach and integrative design.

Design-Build
A project delivery system where design and construction are contracted to a single entity.

Energy Performance Contracting (EPC)
A contracting model for retrofits that is cost-effective for building owners. A comprehensive energy audit is performed by an Energy Service Company (ESCO) that proposes energy saving measures. The Energy Service Company guarantees that project costs will be paid, over a certain period, through savings generated by reduced energy expenditures.

Integrated Energy Performance Contracting (IEPC)
A contractual relation for full-service deep retrofits based on aligned stakeholder interests and continuous collaboration, addressing the whole building and providing performance guarantees that target lowest overall project costs, highest energy savings and GHG abatement, and improved comfort and functionality in the buildings.

Integrated Project Delivery (IPD)
A leading-edge approach in the construction field that “integrates people, systems, business structures and practices into a process that collaboratively harnesses talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction” (American Institute of Architects, 2007).

Integrative Design
A holistic and collaborative design process that deploys a whole-building approach. In the case of retrofit projects, integrative design can address all building systems while also addressing specific renovation needs.

Net Present Value (NPV)
A metric for procurement and contracting that compels industry professionals to design and implement projects with the highest overall value for the client, and that allows clients to evaluate and compare the merit of each proposition. NPV captures all costs and savings associated with a project, and converts them into one monetary value (calculated as the net discounted savings of the project minus the present value of the costs of the project). It is the value in today’s dollars of the future cash flows of a project, considering project costs, savings, and incentives.