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Energy Efficiency Renovation Financing Models for Homeowners and Net Present Value Analysis: Case Study from India

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Abstract

In India, the lack of financing mechanisms has been identified as a major impediment in achieving energy efficiency (EE) and requires focused research to identify barriers and propose innovative financial models. This paper presents details of selected Government of India initiatives that highlight interlinking strategies of energy efficiency renovations, their financing models, and institutional policies needed for their implementation. These initiatives show that residential buildings have tremendous scope for retrofitting as they successfully attract finances through Energy Service Companies (ESCOs) and Renewable ESCO (RESCO) routes. This research highlights understanding of financial and technical barriers in energy efficiency retrofitting for existing residential buildings. Additionally, it discusses financial models and technical interventions being employed in energy efficiency residential retrofitting projects and demonstrates a retrofitting cost model for an actual case study project for composite climate using various physical and technological interventions. The work includes developing retrofitting scenarios through Government initiatives of technical interventions, then performing energy saving calculations, and finally developing cost model explaining the actual savings and payback periods for the potential intervention's investments. These steps led to the development of a potential cost model which can assist both homeowners and energy professionals in identifying and implementing energy retrofitting measures in the residential building sector.

Keywords: Energy efficiency, financing mechanisms, ESCOs, energy renovations, energy interventions

1.0 INTRODUCTION

The cumulative greenhouse gas (GHG) emissions from construction sector accounts for approximately 40% of total global GHG emissions (WBCSD, 2020). Furthermore, it is estimated that the major contributors are the related to manufacturing of construction materials, heating, cooling, and lighting of buildings and infrastructure. For instance, in the EU, 40% of the total energy consumption is associated with the building sector, out of which residential sector accounts for 25% (Tzeiranaki et al., 2019). Thus, there is a large potential of reduction in energy consumption expected to be achieved in the residential building sector. Similarly, it is estimated that by 2030, urban population of India would go up by 250 million, and they would require 700-900 million square meters of residential and commercial space (Akhoury, 2021).

In India, building sector utilises around 33% of the total energy produced in the country which is second highest after industrial sector (45%) (Shandilya & Ghorpade, 2019). The breakup of energy consumption is portrayed in Figure 1 while Figure 2 depicts a breakup of energy use as per user profile. Therefore, the construction sector has immense opportunities and gains by reducing energy consumption.

Research from energy renovations in existing buildings in the EU highlight the 2challenges plaguing the efforts. A key inefficacy is related to motivational measures to encourage homeowners to renovate when faced with the option (Labanca & Bertoldi, 2018). Amongst the barriers responsible are – inadequate information on costs and perceived benefits, split incentives, higher initial investments, responsibility and decision-making process, lack of access to finance, and shortage of available private capital (Boza-Kiss et al., 2019). From the perspective of financial institutions, the barriers are prohibitive transaction costs, smaller project sizes and higher perceived risks associated with credit or projected energy savings (Cooremans & Schönenberger, 2019). Furthermore, the time length of the financing may not balance the longer pay-back of energy efficiency renovation projects in buildings (Boza-Kiss et al., 2019).

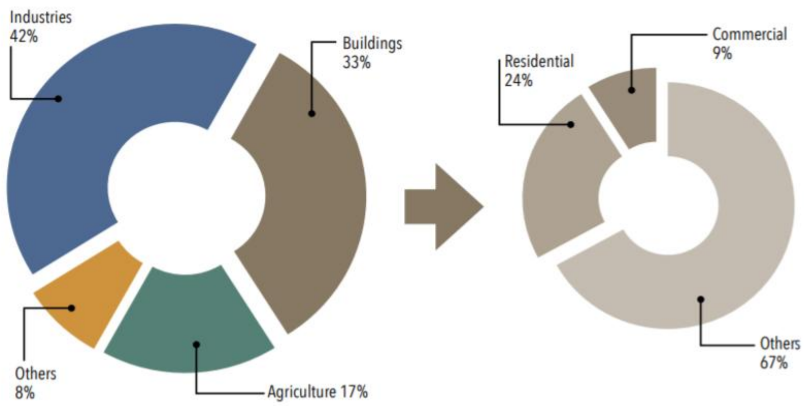

Figure 1 Percentage of energy demand; sector wise (left) and building type (right) in India 2015-16 (Shandilya & Ghorpade, 2019)

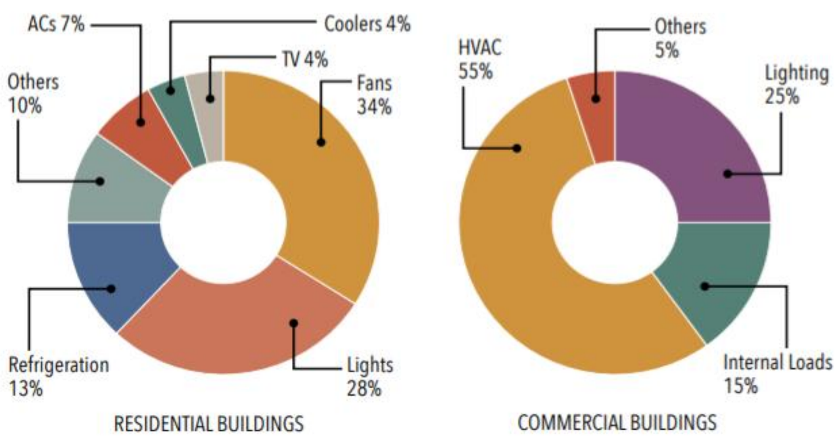

Figure 2 Electricity consumption profile in residential and commercial buildings India (Shandilya & Ghorpade, 2019)

India has been behind of other rapidly developing nations in this regard and needs to identify and implement energy efficiency renovation measures in existing buildings during the current dynamic growth period of its economy. The lack of financing and related policy mechanisms has been identified as major impediments in promoting and implementing energy renovation initiatives. Therefore, this area warrants focused research to identify barriers and study of successfully implemented innovative financial models for building energy retrofits.

1.1 Research Aim and Objectives

The proposed research addresses the existing knowledge gap in the areas of interplay between institutional energy efficiency policy mechanisms and financial models for achieving energy efficiency in the existing residential built environment in India. It identifies financial models for energy efficiency interventions in existing built environment and analyses the net present value of energy savings. The research consists of following objectives.

1. To evaluate the existing policies of energy efficiency renovations, their institutional set-ups, and policy mechanisms from EU and India.
2. To develop an understanding of financial and technical barriers in energy efficiency renovations of existing residential buildings.
3. To analyze the literature and selected Government of India and EU initiatives for interplay between financial policy instruments and energy efficiency renovations policies and assess potential gaps.
4. To develop a retrofitting cost model for an actual case study project for composite climate in New Delhi, India, and propose feasible financial models based on net present value evaluation.

2.0 LITERATURE REVIEW

2.1 Energy Efficiency Renovations and Building Performance

Whilst 'renovation' is used to describe different physical interventions in buildings including modernisations, restorations, or upgrades, an energy efficiency upgrade or renovation deals with the culmination of numerous interventions that generate varying levels of energy savings (Bertoldi et al., 2021). Furthermore, there are relatively few in-depth literature on the 'depth' of renovation (ambition of homeowners) and the comparative energy savings or energy performance generated once the renovation is completed (Economidou, 2011; Shnapp et al., 2013). Therefore, the most widely accepted understanding of energy renovations is related to measuring the energy performance of interventions relating to building envelope or the building's technical systems and can include installations of renewable energy systems as well as energy management systems. This research will identify renovation interventions supported by Government of India to evaluate the energy performance on a case example.

2.2 Building Types

As the benefits and drivers of energy efficiency renovations for each building type differ, the three main building types are elucidated as per Shnapp et al. (2020):

1. Commercial buildings used for business purpose like offices, restaurants, hotels, retail, and hospitals
2. Government owned/leased public buildings
3. Residential buildings like multi-family dwellings, semi-detached and single-family homes

Launched by the Bureau of Energy Efficiency of Government of India in 2017 (see BEE, 2017b), Energy Conservation Building Code (ECBC) classifies all building types into 6 categories as in figure 3 not including the residential sector which is covered separately in Eco-Niwas Samhita (2018) as it considers the significant energy consumption from homes and recognizes the scope in term of energy conservation. This work will briefly touch on the intervention tools for the public sector, whilst focusing largely on the residential sector.

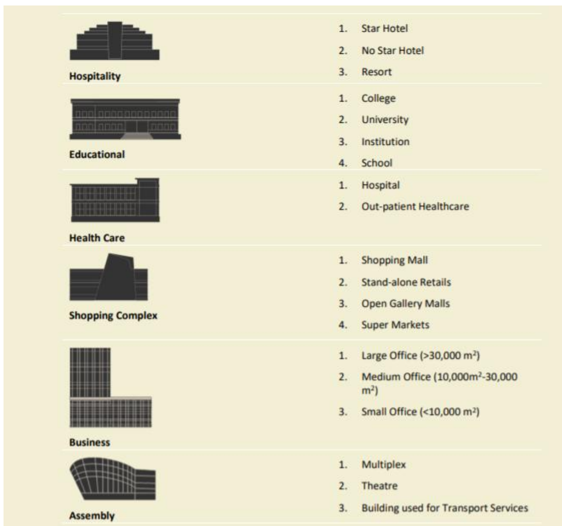

Figure 3 Building classification as per BEE (2017b)

2.3 Energy Efficiency Renovations in the Built Environment: Implementation Barriers

Whilst there is immediate projected investment need of over 133 billion euros per year in building energy efficiency renovations (Shnapp et al., 2020), there are still constraints of technical, functional, demand side and economic nature delaying the uptake of deep renovations (Hamilton et al., 2017). It is found that homeowners are reluctant to take up deep renovations mainly due to:

- Lack of finance
- Lack of knowing about efficient renovation measures
- Lack of evidence on the wider benefits
- Lack of information of whom to contact
- Lack of expertise
- Lack of trust in developers
- Overall complexity of works

As highlighted by Shnapp et al. (2020), the barriers hindering the advancement of energy efficient investments from an investor's perspective include:

- Risk of investment due to lack of information / experience and insufficient robust data
- Dispersed projects impacting investment in smaller projects
- Absence of standardization of measures
- Energy saving benefits not properly monetised

The underlying premise of energy efficiency programmes and policies is that they are commonly designed entirely based on energy savings often leading to an underestimation of full impact from non-energy benefits (NEB) (Shnapp et al., 2020). However, the EA IBC Annex 56 states, "the term co-benefits include all effects of energy related renovation measures besides reduction of energy, CO2 emissions and costs" (Cappelletti et al., 2015). It is only through the inclusion of indicators of both energy renovation benefits and non-energy benefits that can drive existing building standards to near-zero in an economic manner (Gopalan, 2018). A list of micro (private) indicators of multiple benefits is in Figure 4.

Building quality	Building Physics
Building quality	Ease of use and control by user
Building quality	Aesthetics and architectural integration
Building quality	Useful building areas
Building quality	Safety (intrusion and accidents)
Economic	Reduced exposure to energy price fluctuations
User wellbeing	Thermal comfort
User wellbeing	Natural lighting and contact with the outside
User wellbeing	Indoor air quality
User wellbeing	Internal and external noise
User wellbeing	Pride, prestige, reputation
User wellbeing	Ease of installation and reduced annoyance

Figure 4 List of micro (private) factors of multiple benefits
(Source: Shnapp et al., 2020)

A brief chronological review of literature of energy efficiency renovations in the built environment highlight that the main limitations to financing and implementation are intrinsically institutional. This is partially because financial institutions are unable to enforce or govern energy efficiency regulations, thus, the expected impacts cannot be realized (Taylor et al., 2008). Furthermore, many sectors have ''split-incentive'' barriers, where one entity installs equipment while another one, such as an owner or tenant, pays for the electric usage. Engau and Hoffmann (2009) state that if mechanisms could be improved to let firms partake in early stages of policy making process that will allow for more efficient policy implementation. But firms concerned by a new regulation are typically exposed to regulatory uncertainty that is intrinsic to policy formulation (Hoffmann et al., 2009). Furthermore, designing multilateral environmental regulations are particularly difficult as they only specify environmental targets and require specific governments to authorize national protocols to achieve the targets (Christmann, 2004).

2.4 Energy Efficiency Financing and Role of Financial Institutions

Furrer et al. (2012)'s research into the outcome of bank and financial institutions on climate change show that banks are capable of directing investments into green technologies and regulate loan conditions, but very few financial institutions take such substantive action. This is because climate change and its related risks pose potential impacts on their earnings and asset quality in mid to long-term. On the contrary, Conley and Williams (2011) state that the financial institutions routinely, in fact, fund projects which produce significant amounts of greenhouse gases and consume extensive energy like construction and manufacturing. Currently, financial institutions are increasingly facing societal pressures to adopt sustainable business practices and to increase the disclosure of the projects they finance (van Putten, 2008).

In the recent years, varying forms of sustainable finance have grown rapidly in recent as financial institutions are incorporating Environmental, Social and Governance (ESG) investing approaches (OECD, 2021). Furthermore, ESG is now that leading form of sustainable financing in several OECD jurisdictions, having moved away from more traditional models. A report from Bloomberg Intelligence (2021) shows that forms of ESG investing have risen to almost USD 40 trillion in 2021. Moreover, central banks across EU are in the process of assimilating ESG evaluations into investment methods as a tool used to align with change to low-carbon economies (Bernardini et al., 2021; Bua et al., 2021; Lanza et al., 2020).

In 2013, India was the foremost nation to make corporate social responsibility mandatory in its Companies Act of 2013. Furthermore, this precept was included in the National Voluntary Guidelines (NVGs) on Social, Environmental and Economic Responsibilities of Business released in 2011 before being included in the Companies Act 2013. In May 2021, the Securities and Exchange Board of India (SEBI, 2021) replaced Business Responsibility and Sustainability Report (BRSR) with Business Responsibility Reporting (BRR) under ESG global policy. Such standards are critical for encouraging the financial institutions to recognize their responsibility to consider the environmental impacts of the projects they finance.

2.5 Energy Efficiency Policy Evolution in India

The Government of India (GoI) has many programs in place to accelerate the growth of EE in buildings. The Energy Conservation Act (EC Act) was enacted in 2001 with the goal of reducing energy intensity of Indian economy. Bureau of Energy Efficiency (BEE) was established as the nodal body on 1st March 2002 under Central Government to enable the implementation of the EC Act. The Act provides governing decree for standards and labelling of equipment and appliances; energy conservation building codes for commercial and residential buildings; and energy consumption norms for energy intensive industries. In addition, the EC Act guides states to designate implementation agencies for EC Act and promotion of energy efficiency in that particular state. The chronological evolution of energy conservation codes in India is presented in Figure 5.

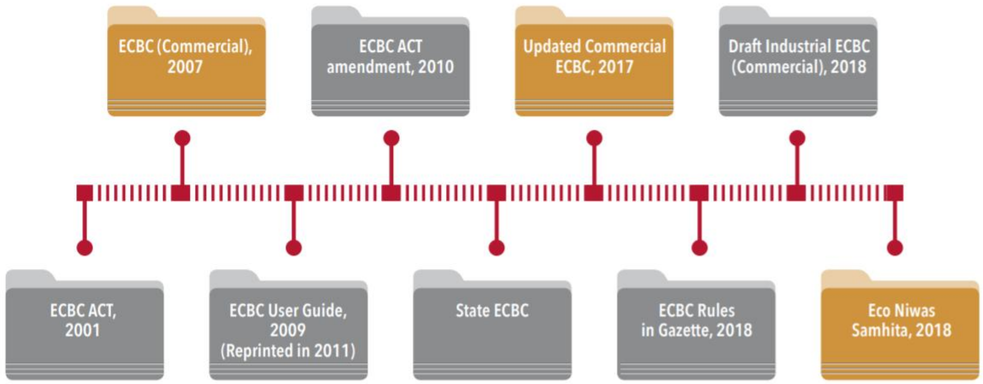

Figure 5 Evolution of Energy Conservation Building Code (ECBC) in India (Shandilya & Ghorpade, 2019)

According to the Bureau of Energy Efficiency of Ministry of Power of the Indian government (see BEE, 2017a), the National Mission for Enhanced Energy Efficiency (NMEE) is one of the 8 missions under India's National Action Plan on Climate Change (NAPCC). NMEEE aims to strengthen the market for energy efficiency by creating favorable regulatory and policy administration and has developed innovative and sustainable business models for the energy efficiency sector. The NMEEE has 4 initiatives to enhance energy efficiency as depicted in Table 1.

Table 1 National Mission for Enhanced Energy Efficiency (NMEEE) initiatives (BEE, 2017)

S/N	Initiative	Description
1.	Perform, Achieve and Trade Scheme (PAT)	It is a market-based instrument for industries. It enhances cost effectiveness in improving the energy efficiency through certification of tradable energy savings.
2.	Market Transformation for Energy Efficiency (MTEE)	It is aimed for replacement to energy efficient appliances in designated sectors by making the products more affordable.
3.	Energy Efficiency Financing Platform (EEFP)	It creates instrument for financing demand side management programmes in all sectors by capturing future energy savings.
4.	Framework for Energy Efficient Economic Development (FEEED)	It is for development of fiscal instruments to promote energy efficiency.

The key components of NMEEE consist of creating and promoting the energy efficiency financing platform through:

1. Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE), and
2. Venture Capital Fund for Energy Efficiency (VCFEE)

PRGFEE is a risk sharing mechanism to provide commercial banks with a partial coverage of risk involved in extending loans for energy efficiency projects (Deloitte, 2013). VCFEE is to meet the requirement of equity investments through venture capital in the energy efficiency projects which eases a significant barrier from the viewpoint of risk capital availability to the Energy Service Companies (ESCOs). It is for this reason that this work will focus on ESCOs as the primary route of energy efficiency financing.

Table 2 Summary of literature findings on energy efficiency financing in India

Source	Summary of findings
Kutan et al. (2018)	This research has explored the role of Foreign Direct Investment (FDI) on promotion of promotion of renewable energy consumption. The authors findings confirmed that a 1% increase in FDI inflows and stock market capitalization raises renewable energy consumption by 0.009% and 0.002%, respectively.
Sahoo et al. (2016)	This research has explored the main legal Government of India enforced Commissions and Acts that are aimed at improving the current energy deficit in the country - the Energy Conservation Act, 2001. This is explored in detail in the current work under 'Government of India Initiatives'.
Sarkar and Singh (2010)	This research explored financing energy efficiency in developing countries to identify key factors of several programmatic approaches and financing instruments successfully applied for energy efficiency solutions. Proposed initiatives as suggested by authors which could be taken forward by international agencies and development financial institutions: 1. International Energy Efficiency Certification Agency 2. "International Year of Energy Efficiency" 2011 Public Campaign 3. Global Energy Efficiency Public–Private Partnership 4. Global Energy Efficiency Programmatic Fund 5. International Industrial Energy Efficiency Technology Financing Facility 6. Global Standard Offer for Demand Side Energy Efficiency 7. Bundle Public Facilities for Scaled-Up Investments 8. Improved Urban Planning and Design
Painuly (2009)	This research explored the experience of a three-country United Nations Environment Programme/World Bank Energy Efficiency Project (involving China, India, and Brazil) for addressing financing barriers for energy efficiency programmes. The study concluded that ESCO industry was advanced in China due to trust of banking sector, but India was more experienced in dealing with energy efficiency projects in general.
Bhattacharyya (2009)	This book explored the above-mentioned three-country United Nations Environment Programme/World Bank Energy Efficiency Project (involving China, India, and Brazil). The second part of the book studies the success and failures of 13 global case studies of various energy efficiency project financing mechanisms including from USA and Canada. The case study from India is on capacitor leasing. Ahmedabad Electric Company (AEC) executed a capacitor leasing program in collaboration with vendor ESCO, Saha Sprague Limited (SSL). SSL received debt financing from Indian Renewable Energy Development Agency (IREDA). Central to this transaction was the performance guarantee that the ESCO was able to offer to the utility.

2.6 Financial Instruments and Energy Service Companies (ESCOs)

Financial instruments for energy efficiency can be either debt or equity financing (Bertoldi et al., 2021). Figure 6 highlights the instruments from conventional (subsidized loans) to emerging models (crowdfunding, dedicated renovation saving accounts etc.). As shown in Figure 6, they are classified according to type (non-repayable rewards, debt financing or equity financing) and level of market saturation (traditional/well established, tested and emerging, and new and innovative). ESCOs are both debt and equity.

Amongst the early research works on energy performance contracts and energy service agreements, three broad financing options for energy efficient renovations have been identified (Bertoldi et al., 2006) – ESCO (energy service company) financing, third party financing, and energy user/ customer financing. ESCO financing for an energy savings performance contract (EPC) is a model where an ESCO achieves energy savings at a property as a service. An ESCO will assess the efficiency opportunity, purchase, and install equipment necessary to improve performance, and perform other energy saving measures. Most ESCOs will provide a financing option for these services as well, but depending on the ESCO, the building owner may be required to seek outside financing. There are two most used models in ESCO financing (IEA, 2018) – shared savings and guaranteed savings (Figure 7).

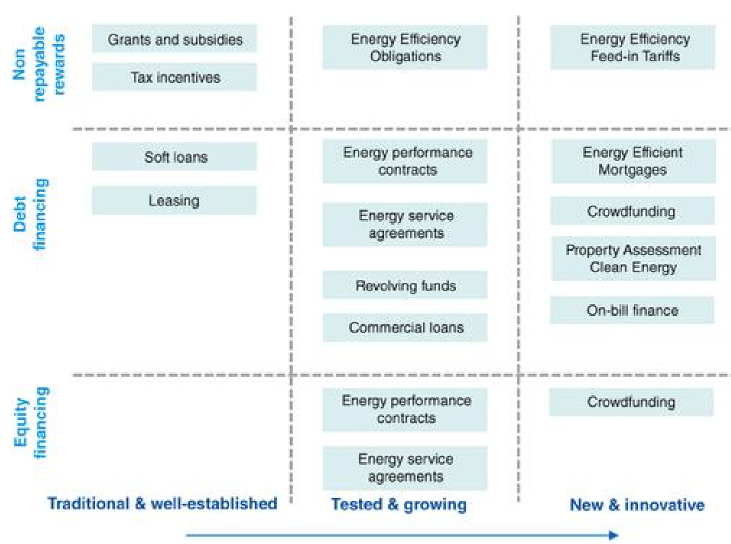

Figure 6 Overview of current financial instruments supporting energy renovations in the EU (Bertoldi et al., 2021)

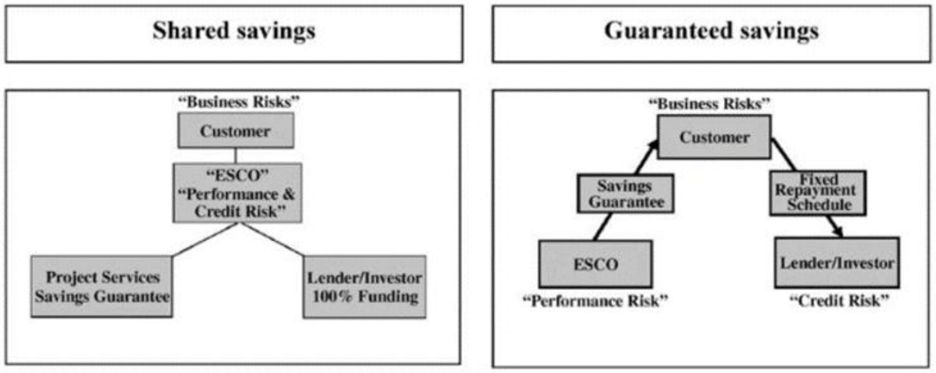

Figure 7 ESCO financing model (Bertoldi et al., 2006)

Generally, the business costs for a ESCO project is higher compared to other financial solutions (Nolden & Sorrell, 2016), partly because ESCOs shoulder the end-user's technical, and financial risks. Thus, ESCO projects are needed to be take on by large energy-consuming end-users, though, there are a few limited examples of ESCO projects in large multifamily and social housing residential buildings in Germany and Singapore (Boza-Kiss et al., 2017).

2.7 Government of India Initiatives

Government of India's initiatives are selected to analyse energy renovation financing models. These were sourced through the database of Bureau of Energy Efficiency, United States Agency for International Development, National Housing Bank, and Press Information Bureau of India. The selected initiatives are from the public sector projects and programmes to understand successful implementation of government programmes.

1. In 2015, NITI Aayog (Erstwhile Planning Commission of India), Central Government agency-initiated energy efficiency interventions for its headquarters in New Delhi, India. The actual process was carried out in two phases through ESCO Shared Saving Model; Phase 1 targeted 60% of saving of actual load (cooling, lighting, and appliances) through solar panels (Renewable Energy Service Company or RESCO), Phase 2 was the retrofitting for the remaining load through replacement with 5-Star Labelled Energy Appliances and LEDs. NITI Ayog as client paid the upfront cost, and Energy Efficiency Services Limited (EESL) a Public Sector Unit of Ministry of Power delivered the project with 10% saving to client and 90% to EESL over 4 years contract. A break-up of financial components for the project is portrayed in Table 3.

Table 3 Financial components calculated for NITI Ayog energy renovation project

Total Capital Cost	Rs. 89.75 Lakhs
Cost accrued due to resold fittings	Rs. 8.53 Lakhs
Net Capital Cost	**Rs. 81.22 Lakhs**
Savings in energy *(Projected till March 2015)*	**4.1 Lakh Units (~19.4%)**
Total Savings in the Electricity Bill	Rs. 18.88 Lakhs
O&M gains	Rs. 2 Lakhs
Total financial benefits	**Rs. 20.88 Lakhs (13%)**
Payback period	**2 years and 10 months**

2. In 2009, GoI launched Bachat Lamp Yojana (BLY), a public-private partnership between Government, private sector CFL suppliers and State level Electricity Distribution Companies to provide CFLs at the same cost as Incandescent Bulbs. The plan was to make up the cost differential through carbon credits earned which could be traded in the international market under Clean Development Mechanism (CDM) of Kyoto Protocol. Upgrading this scheme further and keeping in tune with the technological advancements, the UJALA (Unnat Jyoti by Affordable LEDs for All) scheme for Domestic Efficient Lighting Programme was launched in 2015. The major government owned ESCO, Energy Efficiency Services Limited (EESL), was charged with the implementation of this scheme. Under this scheme, EESL undertook the massive nation-wide disbursement of affordable LED bulbs on either upfront basis or through on-bill financing. EESL procured LED lamps in bulk and initiated a healthy competition amongst LED manufacturers and eventually the price of LEDs went down by almost 90% within a year, thereby making the it consumer friendly. This was a hugely successful scheme by EESL as it led to the replacement of 770 million residential LEDs, a total energy savings of 100 billion kWh, and Green House Gas (GHG) reduction of 80 million tonnes annually (EESL, 2021).

3. This financial model has been replicated at state-levels also, with one example being the LED replacement scheme between EESL and the Electricity Department of the State of Puducherry (2015). The financial model herein is that JERC (joint electricity regulatory commission) allows PED (Puducherry Electricity Department) to provide Rs.2.5/Unit for every unit of energy saved, which is then passed on to EESL that provides LEDs/CFLs to households at a nominal rate. The energy efficiency pay-out helps EESL to recover its initial investments. This has been hugely successful as PED realised further savings even after the EESL payments.
4. An ambitious project by the Government of India is the Grid Connected Rooftop and Small Solar Power Plants Programme (2013 -2022) which is under a national capital subsidy scheme for installation of solar thermal systems. Though incepted in 2013, the scheme it was slow to pick pace, and the first phase ended in March 2017. The financial model here being that Renewable ESCOs install, own, and operate renewable energy systems through financial tie-ups with FIs and then provide energy supply to consumers. There are not many uptakes worthy of successful cases so far in the urban areas, but many rural areas are benefiting from the scheme for roof-top hot water systems and solar cookers.
5. In 2012, KfW-NHB Energy Efficient Homes Programme was launched. This was a joint programme of KfW, the Federal Bank of Germany and National Housing Bank (NHB) of India. Under this program, primary lending institutions were eligible to receive NHB-Refinance for home-owner loans to fund the purchase of certified energy efficient apartments.
6. In 2017, Energy Efficient Model Building (EEMB), an ambitious project of BEE to achieve 1 million sqm of Energy Conservation Building Code (ECBC) compliant commercial buildings across cities located in different climatic zones was launched. Through this project, selected buildings received technical and financial incentives to demonstrate compliance with ECBC. Incentives were given to private developers as ECBC is only mandatory for public buildings. However, the main barrier was that this scheme was only open for newly constructed buildings, thereby leaving out the existing building stock. The above-noted model was partially based on KfW - Gesobau Scheme in Berlin, a modernising scheme for the Märkisches Viertel in Berlin with the aid of promotional loans from KfW Bankengruppe.

2.8 EU Initiatives

Between 2008 and 2015, Gesobau AG invested €480 million to renovate 13,000 that were to consume a fraction of their previous energy usage. KfW Bankengruppe provided low-interest loans schemes to fund the project. In a case study by Bertoldi et al. (2021), they elaborate on an innovative mechanism 'soft loan scheme' wherein public funding is utilized to decrease the cost of loans disbursed by private bank, and this has been successfully adopted by German public bank KfW. Further to the study by Bertoldi et al. (2021), KfW has been disbursing subsidized housing renovation loans for several years and has also come up with a label system 'KfW energy efficient house' which assess existing houses against new buildings for interventions in the envelope. Furthermore, loans are also available for individual measures. KfW also gives grants for engineering and construction supervision of 50 % of costs, or up to €4,000, and for the investment up to €15,000. Grants are often present in soft loan scheme because they reduce the upfront costs for the building owner. Thus, 'soft loan scheme' mechanism can be a reduced risk option for building owners and become a very efficient way to finance energy retrofitting of buildings. This mechanism has high applicability in the Indian context.

In the EU model 'one-stop shops (OSS)', the responsibility in placed hands of a single supplier who is in-charge of the energy renovation project from start (Boza-Kiss et al., 2021). The underlying premise of this model is the transformation of complex decision-making by customers in the renovation value chain to establishing a bridge between the fragmented supply side and the also fragmented demand side. Furthermore, the main difference between ESCO and OSS is that OSS offers pre-defined packages of renovation options for homeowners, collaborate with contractors, and suppliers. Figure 8 presents the OSS model. However, such initiatives are yet to find a place in GoI initiatives. This concept can be equally beneficial to Indian existing building market as the model offers solution to the barriers of energy efficiency renovations.

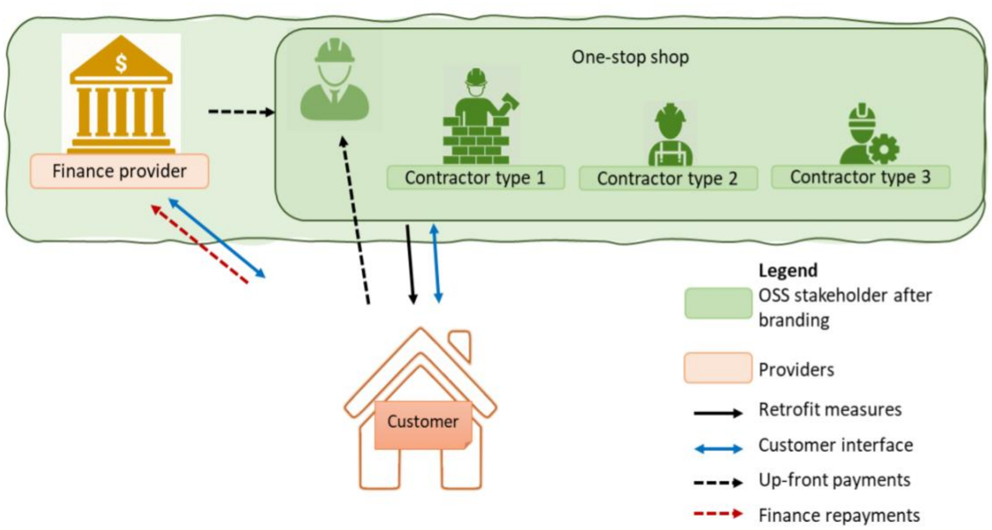

Figure 8 One-stop shop model (Brown, 2018)

3.0 ENERGY EFFICIENCY RENOVATION CASE EXAMPLE

A case study of energy efficiency renovation for a single-family residential project from New Delhi, India (composite climate) is selected for the cost model. The case study project is selected to demonstrate the net present value of the physical interventions. The energy saving calculations were performed on 'EnEffResBuild India' software platform, with various energy conserving measures. For each intervention, total energy saving, upfront cost and payback period is calculated with ESCO financing. The interventions were selected from the literature and government initiatives, and their corresponding products were selected from the market survey. The proposed physical interventions are summed up in Table 4. The financing of the project was done by the clients, whilst ESSL was contracted through shared saving model at 10%-90% sharing between client and ESCO.

Table 4 Proposed physical interventions

National Energy Mission	Description	Product	Cost (INR) Per Unit
Star Rating Program by BEE	BEE 5-star air conditioner	Voltas 1 ton	32,500
Grid Connected Rooftop and Small Solar Power Plants Programme	Ministry of New and Renewable Energy's (MNRE) subsidy through State Bank of India (SBI). 30% of the benchmark cost or the actual project cost, whichever is less.	100-liter flat plate collector base	24,000
		10Wp (watt peak) per panel, 5–7-watt load for 3-4 hrs	108.00/per Wp (watt peak)
EU Directive	Polyurethane spray foam insulation	BASF	80.00/per sq.mt
	Solar control film	Garware Sun Control Film	15.00/per sq.ft
	Cool paint	Eco protect	15.00/per sq.mt

Five (5) intervention case scenarios were developed which have minimal impact on the structure and its occupants. Since the building is covered from all three sides, East and South side treatment will affect energy savings the most, whereas other sides modification will have negligible effect. LED and appliances are included in all scenarios. Table 5 outlines various scenarios of interventions. All five scenarios were analysed various upfront costs, projected energy savings, and net present value analysis (Basu, 2018). The energy analysis was performed with the help of 'EnnEffResBuild India' software tool. This energy efficiency analysis tool was developed by The Energy and Resources Institute (TERI) of India in association with KfW the German Federal Bank, National Housing Bank (NHB) and Fraunhofer IBP. The interventions were identified from the various Government of India schemes. These are non-structural inventions, minimal disruption to the building. Keeping the lighting replacement as constant, the Interventions were individually assessed for energy saving.

Table 5 Energy renovation intervention matrix

National Mission	Unnat Jyoti by Affordable LEDs for All	Star Rating Program by BEE	National Energy Mission	EU Directive	
Intervention sets		Appliances - lighting, heating, cooling, cooking	Renewable energy	Building envelope - exterior wall + roof	Building envelope - openings/ windows
Scenario 1	LEDs	5-star air conditioner (split AC)	-	Cool paint, cool roof (polystyrene layer)	Solar control film
Scenario 2	LEDs	5-star air conditioner	Solar water heater	Cool paint	Solar control film
Scenario 3	LEDs	5-star air conditioner	Solar water heater	Cool paint	Solar control glass (low emitting glass)
Scenario 4	LEDs	5-star air conditioner	Solar panels and solar water heater	Cool paint	-
Scenario 5	LEDs	5-star air conditioner	Solar panels and solar water heater	Cool paint	Solar control film

3.1 Net Present Value (NPV) and Selection of Intervention

Net present value method (NPV) is used to calculate the present value of all the yearly cash flows which are capital costs and net savings that are incurred or accrued through the life of a project, and sums them (BEE, 2017). Costs are denoted as negative values and savings as positive values. The sum of all the present values is known as the net present value (NPV). The higher the net present value, the more attractive the proposed project. Table 6 presents the individual savings from each of the intervention, the % energy savings, and the cost of savings. At the time total energy consumption per year for the project is 26,400 kWh and electricity rate Rs.5.45/ kWh. Table 7 summarizes the investment, savings, and discounted rate (10% assumed from Niti Ayog project). A simple payback calculation has been included to present the comparative analysis between NPV and simple payback for decision-making. The NPV calculations are presented in Table 8.

Table 6 Summary of energy savings and payback period

	Retrofitting Intervention	Scheme	Description of Intervention	Product	No. of Units/Area (No./sq.ft/sq.m)	Cost per unit (INR)	Total cost of intervention	Energy saving (from EnEff model) (%)	Energy saving (from EnEff model) (INR)
a	Appliances - Air Conditioning	Star Rating Program by BEE	BEE 5-star air conditioner	Voltas 1 ton	5.00	32,500.00	162,500.00	37.00	9,768.00
b	Appliances - Solar Water Heater	Grid Connected Rooftop and Small Solar Power Plants Programme	100-liter flat plate collector base	Ministry of New and Renewable Energy (MNRE) subsidy through State Bank of India (SBI). 30% of the benchmark cost or the actual project cost, whichever is less.	1.00	24,000.00	24,000.00	3.00	792.00
c	Building Envelope - Roof	EU Directive	Polyurethane spray foam insulation	BASF	973 sq.mt	80.00	77,840.00	3.00	792.00
	Building Envelope - Openings/Windows		Solar control film	Garware sun control film	2,533 sq.ft	15.00	37,995.00		
d	Building Envelope - Exterior Wall		Cool paint	Eco protect	4,935 sq.ft	15.00	74,025.00	18.00	4,752.00
e	Renewable Energy - Solar Panels	National Mission on Enhanced Energy Efficiency	10Wp (watt peak) per panel, 5–7-watt load for 3-4 hrs.	Ministry of New and Renewable Energy (MNRE) subsidy through State Bank of India (SBI). 30% of the benchmark cost or the actual project cost, whichever is less.	700	108.00	75,600.00	6.00	1,584.00

**Total energy consumption per year- 26,400 kWh and electricity rate- Rs.5.45/ kWh*

Table 7 Summary of energy savings and simple payback period

	Total Cost (Rs.) of Intervention (Rs.)	Energy Saving (Aprx.)	Implementation/ Installation Charges @ 5% of Total Cost (Rs.)	ESCO Financing Charges @6% (Rs.)	Total Cost of Implementation (Rs.)	Saving after Intervention (Rs.)	Payback Period (yrs)
Scenario 1	274,800	59%	13740.00	27,480	316,020	84,889	3.72
Scenario 2	287,040	61%	14352.00	28,704	330,096	87,766	3.76
Scenario 3	358,828	63%	17941.00	35,883	412,652	90,644	4.55
Scenario 4	319,840	64%	15992.00	31,984	367,816	92,442	3.98
Scenario 5	357,040	67%	17852.00	35,704	410,596	96,759	4.24

Table 8 Net Present Value calculations for 10% discount factor

Year	Discount Factor for 10%	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
	Capital investment	316,020	330,096	412,652	367,816	410,596
	Savings per year	84,889	87,766	90,644	92,442	96,759
	Total	400,909	417,862	503,296	460,258	507,355
1	0.91	364,426	379,837	457,496	418,375	461,186
2	0.83	301,016	313,745	377,892	345,577	380,939
3	0.75	226,063	235,622	283,797	259,529	286,085
4	0.68	154,401	160,930	193,833	177,258	195,396
5	0.62	95,883	99,938	120,370	110,077	121,341
6	0.56	54,078	56,365	67,889	62,084	68,436
7	0.51	27,742	28,915	34,827	31,849	35,108
8	0.47	12,956	13,503	16,264	14,873	16,395
9	0.42	5,493	5,725	6,896	6,306	6,952
10	0.39	2,120	2,210	2,662	2,434	2,683

From the payback period calculation, the Scenario 2 presents the best option with the lowest payback period (3.76 years) and reasonable energy savings of 61%. However, with the NPV calculations, it is seen that Scenario 5 is the best option with the maximum value from investment after 10 years of intervention. In addition, Scenario 3 is a close second in terms of returns. In fact, Scenario 3 has lesser upfront investment and good return. From the perspective of homeowner, Scenario 2 can be a low-hanging fruit but with higher investment, there is potential for long-term gains. Thus, from a return's perspective, in ESCO model, either Scenario 3 or Scenario 5 is viable in long-term risk-free decision for interventions.

4.0 SUMMARY AND CONCLUSION

India's venture into energy efficiency in the built-environment sector is in its nascent stage. The implementation of Energy Conservation Act and the introduction of the Energy Conservation Building Code (ECBC) ushered a wave of energy efficiency strategies for new builds. But India has a vast stock of existing buildings, especially public buildings, both commercial and residential complexes. This existing building stock provides an opportunity to achieve energy savings through energy retrofits. However, the retrofitting sector is yet to have the propulsion it requires to jumpstart the movement. Many nations have long realised that their existing building stock is a vast stock of untapped energy savings and have introduced initiatives to unravel this mega reserve.

For existing built-environment, the policy framework in India is limited, as majority of programs launched are appliance-based (e.g., replacement of LEDs etc). This is because of the thinking among policy makers that since the existing building stock is electricity-based, energy savings can be easily obtained if the appliance set can be standardised and retrofitted. This is done instead of customised or semi-customised scenarios for each unique building type. The institutionalisation approach that is being undertaken causes a mismatch of savings expectations.

Many of the above-noted limitations are being solved with the introduction of energy saving companies (ESCOs) and renewable ESCO's (RESCOs). This approach helps to provide customised energy retrofit solutions consisting of focusing on the building typology, undertaking feasibility, and then proposing suitable retrofits. RESCOs are also playing a pivotal role in tapping solar energy as part of the energy retrofit. Successfully completed projects at the central government level are being used as demonstration projects to motivate state-level interventions. Existing residential buildings in India present a large stock of existing buildings and have substantial energy saving potential. Energy savings up to 30-40% can be simply achieved using energy efficient appliances and envelope treatment. Software tools such as EnEffReSBuild India can be easily used by residents to calculate approximate energy saving without going into complex technical consultations. In addition, renewable energy installation can result in substantial energy and cost savings also.

However, the biggest issue observed has not been policy development but implementation because of financial obstacles. This is because homeowners are reluctant to uptake renovation projects due to lack of knowledge. One-Stop Shop Model, the EU initiative has great potential for the Indian market. EESL, the PSU for Ministry of Power, can be one such nodal OSS.

As part of this overall research, authors came up with following four observations/inferences related to the current state of energy retrofitting of existing buildings in India. These observations/inferences can also provide basis for areas of further research.

1. The major barrier is not only financial, but reluctance of homeowners to undertake energy renovation projects due to lack of knowledge. This can be resolved by ESCO/RESCO model and One-Stop Shop Model.
2. Simple payback period calculations for decision-making of selection of intervention can be misleading, net present value or NPV can be a better alternative as cost-based decision making.
3. Though Indian Government has developed robust initiatives for achieving EE but lacks in effective financial mechanisms and policy instruments for implementation.
4. Whilst this study has not covered the behavioural aspects of homeowners in both energy usage and renovation projects, there is a chasm between understanding behaviour and offering solutions.

India is making good progress towards adopting energy retrofitting of existing buildings. The government is helping to address many financial barriers by introducing helpful initiatives, providing incentives and subsidies, supporting ESCO model, encouraging financial institutions to provide grants, low interest loans, and third-party financing. The authors envision that based on the work presented in this paper, the future of energy efficiency in India for new construction as well as existing buildings in very encouraging.

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