NRDC CASE STUDY

APRIL 2013
CS: 13-03-A

Saving Money and Energy: Case Study of the Energy-Efficiency Retrofit of the Godrej Bhavan Building in Mumbai

Street View: Godrej Bhavan

"Energy efficiency is not an 'out-of-the-box' concept; it is part of the day-to-day operations of any building. The driver for implementing energy-efficiency measures in any building is to have senior management buy-in and to educate maintenance staff about building-efficiency parameters along with the financial and non-financial benefits of energy efficiency. Energy efficiency is a core characteristic of achieving sustainability in a building's operations."

— Godrej Bhavan Team

Prepared by: Natural Resources Defense Council
and Administrative Staff College of India

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Historic blackouts across India in July 2012 revealed the severity of India's energy crisis. Looking ahead, scaling up energy efficiency promises to be the fastest, cheapest, and cleanest way to help meet India's energy demands. As the country experiences rapid urbanization and its building-occupied area skyrockets, from 8 billion square meters in 2005 to a projected 41 billion square meters in 2030, the country's real estate sector is racing to keep up with the demand for high-rise residential housing and commercial properties such as offices, hotels, and malls.[1] Incorporating energy-efficiency measures in new and existing buildings will help India achieve a reliable energy future and save money while addressing the threat of climate change. Developers, building owners, and tenants are essential to achieving the energy-efficiency benefits of reduced energy use, cost savings, increased worker productivity, higher asset value, and market advantage.

This case study highlights Godrej Bhavan, an iconic office building in South Mumbai, focusing on the strong business case for energy-efficiency upgrades or retrofits. The Godrej Bhavan retrofit shows that greener, energy-saving retrofits are practical and profitable in India's rapidly transforming building market and provides replicable practices for cost and energy savings.

BUILDING BASICS

- **Location:** Fort, South Mumbai
- **Climate Zone:** Hot and humid
- **Building Gross Area:** 3,826 square meters (41,185 square feet)
- **Air-Conditioned Area:** 2,192 square meters (23,595 square feet)
- **Non-Air-Conditioned Area:** 1,634 square meters (17,588 square feet)
- **Number of Floors:** 2 basements, 6 floors, and a rooftop terrace
- **Building Use:** Office space
- **Constructed:** 1972
- **Retrofit Completed:** 2010
- **Building Owner:** Godrej & Boyce (not leased)
- **Retrofit Financing:** Self-financed by Godrej & Boyce (no-debt financing)
- **Project Team:** Godrej's Green Building Consultancy Service and Ingersoll Rand
- **Utility Company:** BEST (Brihanmumbai Electric Supply and Transport) supplies 11 kilovolts (kV) of power via two 250-kilovolt-amperes (kVA) distribution transformers

The building's management system control office

Godrej Bhavan, built by Godrej & Boyce in 1972, is a six-story building that houses the company's chief management. After decades of high electricity bills, Godrej & Boyce upgraded Godrej Bhavan in 2010 to include comprehensive energy-efficiency and sustainability features, such as efficient cooling and lighting systems. Because of the upgrade, Godrej Bhavan is now an energy-saving building that is achieving significant financial and indoor environmental quality benefits for its owner and occupants.[2] The upgrades' high performance measures, including the upgraded heating, ventilation, and air-conditioning (HVAC) system, are already yielding energy cost savings compared with fiscal year (FY) 2009-2010, the year before the upgrade. Godrej Bhavan's post-upgrade energy savings are on track to recover the retrofit costs of ₹5,384,000 ($99,704).[3] Based on the electricity bill savings alone, the upgrade costs are expected to be paid back in 4.7 years.

ENERGY-EFFICIENCY COMPONENT COSTS FOR THE RETROFIT: ₹5,384,000 ($99,704)

The building's retrofit team incorporated high-performing energy-efficiency measures, as described in table 1, which pay for themselves over time by significantly saving on electricity costs.

TABLE 1: ENERGY-EFFICIENCY RETROFIT COMPONENT COSTS

ENERGY-EFFICIENT MEASURES AND AUDIT[a]	COST (₹)	COST ($)
HVAC-system replacement (including the building energy management system)	5,000,000	92,593
Water-flow meters	24,000	444
Energy-metering system	52,000	963
Auto blow down controller at the cooling tower	29,000	537
High-reflectance paint for the terrace surface	62,000	1,148
Energy audit	45,000	833
Lights with energy-efficient tube lights	172,000	3,185
Total Cost of the Energy-Efficiency Measures Installed	**5,384,000**	**99,704**

a The upgrade costs exclude the costs of the double-glazed windows and green roof because the double-glazed windows were installed in 2012, post-retrofit, and the green roof was in existence from the building's inception and hence did not require an additional cost.

Green roof at Godrej Bhavan

RECOVERING RETROFIT INVESTMENT COSTS VIA ENERGY SAVINGS

Just two years after the upgrade, Godrej Bhavan is already reaping cost and energy savings and is on track to recover the costs of installing energy-efficiency measures through lower electricity bills. Using FY 2009-10—the year before the upgrade—as the baseline, electricity use and electricity cost savings for FY 2010-11 and 2011-12 were calculated, as described in figure 1 and table 2. In the first year after the upgrade (FY 2010-11), Godrej Bhavan's electricity use dropped to 527,160 kilowatt hours (kWh), for an 11.4 percent savings in electricity use. In the second year after the upgrade (FY 2011-12), Godrej Bhavan had even greater savings and electricity use dropped to 521,856 kWh, for a 12.3 percent savings in electricity use compared with the baseline.

PAYBACK PERIOD AND ENERGY SAVINGS: THREE SCENARIOS

Based on Godrej Bhavan's energy-saving performance in the two years after the retrofit, three different scenarios demonstrate real-world payback periods and actual cost savings. The payback period is 4.7 years under the Actual Godrej Electricity Bill Scenario; 8.9 years under the Fixed Tariff Scenario; and 9.6 under the Escalating Tariff Scenario.[4]

Actual Godrej Electricity Bill Scenario

The actual electricity bills that Godrej incurred for the baseline year FY 2009-10 and the years following the retrofit show savings of ₹1,342,911 ($24,869) or 26.3 percent, for the first year after the retrofit, and savings of ₹1,464,303 ($27,117) or 28.6 percent, for the second year after the retrofit, as described in table 2.[5]

FIGURE 1: ANNUAL ELECTRICITY USED AND ELECTRICITY COSTS FOR GODREJ BHAVAN (2009 TO 2012)

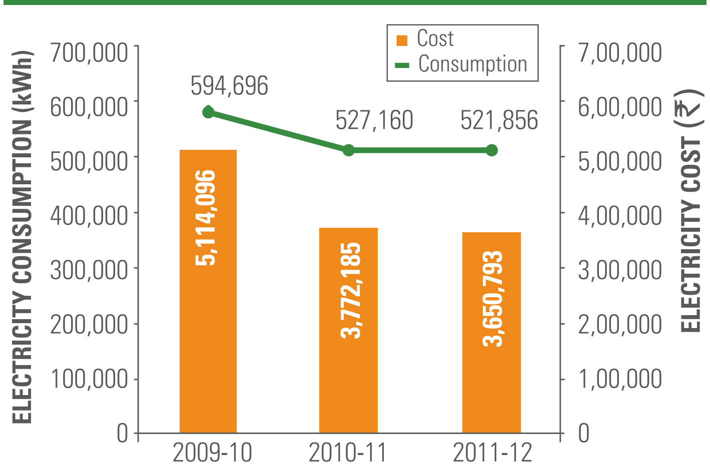


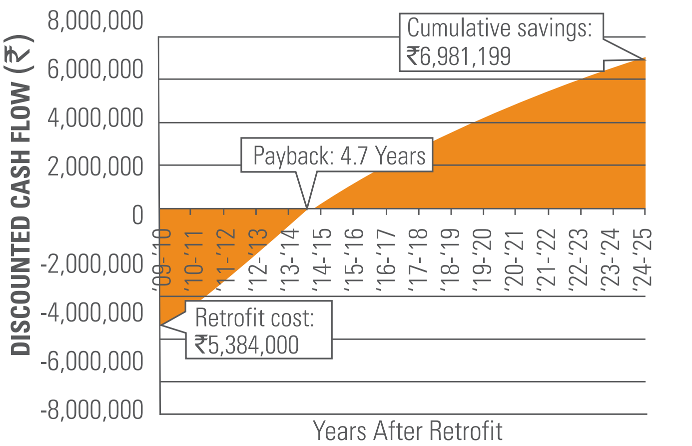
TABLE 2: ELECTRICITY USE AND COST SAVINGS (2009 TO 2012)

Year	Electricity used (KWh)[a]	Electricity used per square meter of conditioned space (kWh/sq.m.)	Electricity costs	Electricity saved compared with baseline	Electricity cost savings compared with baseline
2009 to 2010 (baseline)	594,696	271	₹5,115,096 ($94,724)[b]	n/a	n/a
2010 to 2011	527,160	240	₹3,772,185 ($69,855)[c]	-11.4%	-26.3%
2011 to 2012	521,856	238	₹3,650,793 ($67,607)[d]	-12.3%	-28.6%

a BEST utility meter readings, provided by Godrej Bhavan, FY 2009-12.
b Average electricity unit rate of INR 8.58 ($0.16) per kWh for FY 2009-10.
c Average electricity unit rate of INR 7.81 ($0.14) per kWh for FY 2010-11.
d Average electricity unit rate of INR 7.51 ($0.14) per kWh for FY 2011-12.

Based on electricity bill savings alone, the Godrej Bhavan retrofit would pay for itself in 4.7 years, with cumulative savings of ₹6,981,199 ($129,281) over 15 years as shown in figure 2. This payback period is calculated using the annual average electricity costs for FY 2010-12, following the retrofit, of ₹3,711,489 ($68,731), from 2013 onward over the 15-year period and a 7 percent discount rate.[6]

FIGURE 2: MONEY SAVED ON GODREJ BHAVAN'S ACTUAL ELECTRICITY BILL

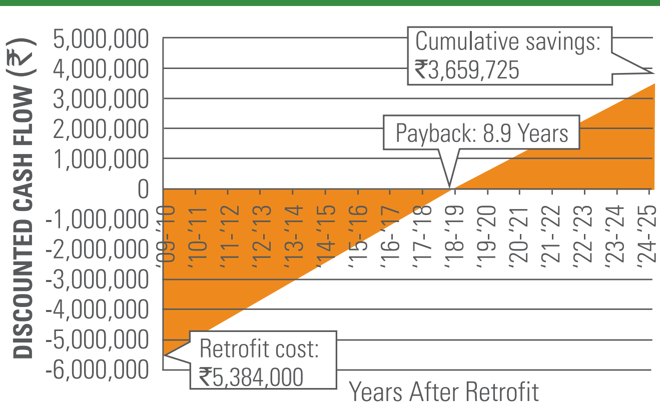


Fixed Tariff Scenario

The average electricity tariff for the baseline year of the retrofit (FY 2009-10) and the two years following the retrofit (up to December 2012) is ₹8.59 ($0.16) per kWh.[7]

Using this fixed-electricity tariff rate, not accounting for any long-term change in electricity tariffs and without applying a discount rate, the Godrej Bhavan retrofit pays back in 8.9 years. The average energy savings—524,508 kWh—following the retrofit for FY 2010-12, are kept constant annually over the 15-year period. As seen in figure 3, the cumulative savings for Godrej Bhavan over a 15-year period are ₹3,659,725 ($67,773).

FIGURE 3: MONEY SAVED FOR GODREJ BHAVAN IN A FIXED TARIFF SCENARIO

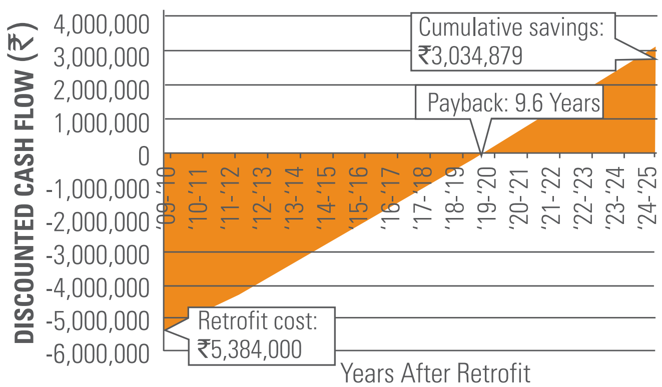


Escalating Tariff Scenario

The actual electricity prices that the utility BEST charged Godrej Bhavan for FY 2009-2012 are used in this scenario. From FY 2013 onward, a fixed tariff escalation of 7 percent is assumed, along with a discount rate of 7 percent.[8]

As described in figure 4, in this scenario the retrofit pays for itself in 9.6 years, and Godrej Bhavan benefits from a cumulative savings of ₹3,034,879 ($56,201) over the 15-year period.[9] The average energy savings in the two years following the retrofit (FY 2010-12) of 524,508 kWh are used from 2013 onward over the 15-year period.

FIGURE 4: MONEY SAVED FOR GODREJ BHAVAN IN ESCALATING TARIFF SCENARIO



BREAKDOWN OF SAVINGS FROM ENERGY-EFFICIENCY MEASURES

Three measures—HVAC, lighting, and the building maintenance system—account for the bulk of the energy savings. The upgraded HVAC system captures the maximum savings of the measures installed, accounting for an average of 32 percent in the overall electricity savings for FY 2010-12.

ENERGY-EFFICIENT RETROFIT: COMPANY BACKGROUND AND MOTIVATIONS

The Godrej Group is one of India's largest industrial conglomerates. Established in 1897, it includes seven major companies with interests in real estate, consumer goods, industrial engineering, appliances, furniture, security, and agricultural products. It is divided into two holding companies: Godrej & Boyce and Godrej Industries. The Godrej Group has a history of supporting sustainable development. It is a founding member of the Confederation of India Industry Sohrabji Godrej Green Business Center, the first Leadership in Energy and Environmental Design (LEED) Platinum-rated building in the world, outside the United States. It was completed in 2004. The company's top management spearheaded the retrofit of Godrej Bhavan to meet high energy-efficiency standards and to create a model and healthy work space for its employees.[10]

Upgraded light fixtures

Double-glazed windows

ENERGY-EFFICIENT RETROFIT: CHALLENGES AND SOLUTIONS

The Godrej Bhavan project team overcame several challenges during the energy-efficiency upgrade. The solutions used to overcome key obstacles are applicable to other similar projects.

- **CHALLENGE:** ***Aging Building with Ongoing Operations***
  The Godrej Bhavan retrofit required implementing new energy-efficiency technologies in an aging office building with ongoing operations. The building's architectural design, façade, glazing, lighting, and HVAC system were already in use, limiting the opportunity to redesign these components. The aging HVAC system, a direct-expansion (DX) system, needed to be replaced. Since two air handling units (AHUs) cooled the entire building, it was difficult to upgrade one floor at a time while keeping other operating floors cooled. For a successful upgrade, the project team needed solutions to these challenges, especially to ensure continued building operations, worker productivity, and building safety, while simultaneously increasing staff awareness on the benefits of the retrofit.

  SOLUTION: ***Implement Upgrade During Non-Working Hours Focusing on Building Operations***
  The retrofit focused on specific equipment and energy-management upgrades instead of redesigning the building. The relatively inefficient HVAC DX system was replaced with an energy-efficient water-cooled screw chiller. Because the building structure did not have feasible sites to locate AHUs on every floor, artificial floors were created (using beams in the masonry shaft and horizontal metal plates) to install new AHUs on each level and to provide the desired temperature conditions for each floor while maximizing energy savings. The HVAC retrofit occurred during non-working hours and weekends to avoid inconveniencing staff during working hours. To ensure continuity of cooling, the old and new HVAC systems were operated simultaneously during the transition.

- **CHALLENGE:** ***Missing Original Drawings***
  The building was constructed four decades ago, in 1972. Many of its architectural, electrical, HVAC, and plumbing drawings and records had not been preserved over the years.

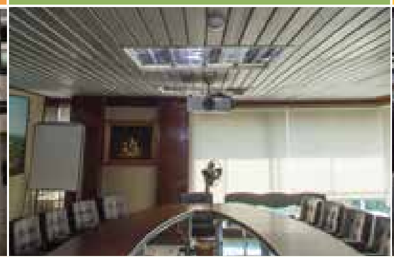
  SOLUTION: ***Create Building Blueprints***
  Instead of expending resources trying to locate the older drawings and blueprints, the project team prepared new drawings for Godrej Bhavan during the retrofit process. These drawing further assist the company in its ongoing and future building operations and management, including energy savings.

- **CHALLENGE:** ***Limited Availability of Energy-Efficient Products***
  Comprehensive information and sourcing of energy-efficient technologies and green materials, such as energy-efficient fluorescent (T-5) lamps with low mercury content, were difficult to procure for the Godrej Bhavan upgrade.

  SOLUTION: ***Source Energy-Saving Materials from Special Vendors***
  The retrofit team sourced efficient technologies and materials from special vendors through investigation and research. Sourcing these energy-saving products for the Godrej Bhavan upgrade increased the overall market demand for efficiency technologies, leading to their availability for a larger portion of Indian customers.

FIGURE 5: ENERGY-EFFICIENCY TECHNOLOGIES INSTALLED

HEATING VENTILATION AIR CONDITIONING AND CHILLER	LIGHTING	BUILDING MANAGEMENT SYSTEM
TRANE	PHILIPS	TRANE




ENERGY-SAVING MEASURES INSTALLED

Because of the energy-efficiency measures installed during the building upgrade, Godrej Bhavan is now reaping energy savings and other benefits such as better indoor air quality for the building's occupants. The HVAC system is the most significant energy-saving measure installed, based on a recent energy audit. The HVAC and building management system was manufactured and installed by Trane, and the lighting system was manufactured and installed by Philips, as described in figure 5.

BUILDING MANAGEMENT AND ELECTRICAL SYSTEM UPDATES

- Installed the Trane Building Energy Management System (BMS) dashboard display with digital energy meters that continuously monitor energy use, check and rectify energy-use discrepancies, and increase maintenance staff accountability and productivity.
- Upgraded the incoming and outgoing electrical systems for high-voltage electricity to a ring main unit system to provide an uninterrupted power supply.[11] Upgraded electrical systems to provide new information for greater building safety, more reliable operations for incoming and outgoing electricity supply, and circuit tripping and faults, which were previously unknown.
- Relocated the electrical power system switch gear to a more accessible switcher room to ease operations and maintenance.
- Upgraded the building's low-voltage system to facilitate metering of the building's electricity load to account for energy use and increase flexibility in operations.

HVAC CHILLER UPGRADE WITH BUILDING MANAGEMENT SYSTEM INTEGRATION

- Upgraded the chiller compressor-condenser unit from a 35-year-old DX system with limited options for energy-efficiency to a new Trane system with a screw chiller, water-cooled condenser, electronic expansion valve, and a high coefficient of performance (COP) of 5.5 from a previous COP of 2.2.
- Replaced the cooling tower motors and fills, installed a conductivity meter, a temperature controller, and a variable primary chiller water pumping system with Kirloskar Brothers Limited pumps and water-flow meters that control the minimum water-flow rate to increase energy efficiency.
- Installed dedicated AHUs for each floor, Vacon variable frequency drives, and chiller water-modulating valves for temperature and relative humidity control in the occupied space.
- Improved fresh air circulation and indoor air quality by planting large trees around the AHU room and the fresh-air intake valves to provide shade during high temperatures. Installed operable windows to allow access to fresh air.
- Configured the BMS to maintain energy efficiency of the water-cooled chiller system by showing real time and historical data on water quality, condenser approach (or the difference between liquid refrigerant temperature as measured on the liquid line, and leaving condenser water temperature), and the total dissolved solids (TDS) level in the circulating water.
- Installed a Trane Tracer Summit building automation system to ensure that the new air-conditioning system delivered efficiency and reliability. Godrej Bhavan also signed a maintenance contract with Trane to ensure smooth HVAC systems operation.
- Increased efficiency by upgrading the refrigerant from HFC R-22 to HFC R-134a, dramatically reducing the refrigerant's ozone-depleting and global-warming potential.

LIGHTING WITH HIGH-EFFICIENCY FITTINGS

- Installed Philips fluorescent tube lamps with high-efficiency T-5 fittings (lamp life of 27,000 burning hours and a low mercury content of 1.4 mg per tube) and electronic ballasts with timers to switch office lights off automatically after hours.
- Provided natural day light and outside views throughout the building.
- Installed double-glazed clear windows and shading devices to reduce heat gain through the windows while still providing light (installed in 2012 after the building retrofit).

GREEN ROOF GARDEN

- Developed the building's original green roof, which had a soil depth of nine inches, by removing the covering of the "tandoor" roof clay tiles. The Godrej team measured a reduction in the roof temperature by 10°C using thermal imaging. The green roof reduces the heat entering the building and cools the top floor that houses the company's senior management.
- Planted trees around the building to maintain a cool microclimate and reduce the heat island effect.

REPLICABLE LESSONS FOR SIMILAR PROJECTS

Godrej Bhavan's upgrade demonstrates the real energy and cost savings from implementing energy efficiency in existing buildings. The retrofit saves operating costs, lowers electricity use, improves building systems, enhances occupant comfort, and increases environmental awareness among building occupants and visitors. Lessons learned from the Godrej Bhavan retrofit for the broader real estate market include:

- *Commitment starts at the top:* Godrej's corporate commitment to sustainability shaped the project's efficiency goals. Top-level support for the high-efficiency and cost-savings targets were critical to the success of the project.
- *Low-hanging savings opportunities*: The Godrej Bhavan retrofit demonstrates the low-hanging energy and cost-saving opportunities. By upgrading HVAC, lighting, and building management systems, Godrej Bhavan is an example of how high performing office spaces can maximize energy-saving strategies with ease of maintenance and improved comfort and air quality.
- *Building operations and maintenance are key:* Beyond installing efficient equipment, Godrej Bhavan also upgraded its energy management system and trained staff to analyze continually overall energy performance, transforming building operations and allowing staff to correct discrepancies and increase energy savings.

LEED Gold Certification Certificate

AWARD-WINNING RETROFIT

2011 LEED AWARD: First building in Mumbai and the sixth building in India to receive the LEED Gold certification from the United States Green Building Council under the Existing Buildings Operations and Maintenance category (version 2).

2011 INGERSOLL RAND ENERGY-EFFICIENCY LEADER AWARD: Energy-Efficiency Leader Award by Ingersoll Rand in recognition of demonstrated initiatives for energy optimization in the air-conditioning system.

NRDC AND ASCI'S BUILDING ENERGY-EFFICIENCY WORK

NRDC and ASCI are working to accelerate efficient building construction in India by engaging business and government leaders to unleash widespread implementation of energy-saving measures. We are engaging with real estate developers on a series of case studies that demonstrate the business case for energy efficiency.

This case study is the result of a partnership between the following organizations. No funds were exchanged to develop the study.

Researchers and authors: The Natural Resources Defense Council (NRDC) and Administrative Staff College of India (ASCI).

www.nrdc.org/international/india

www.asci.org.in

Knowledge and dissemination partners: Godrej & Boyce, Ingersoll Rand and Trane, and the Confederation of Real Estate Developers Association of India (CREDAI).

Funding: Shakti Sustainable Energy Foundation ("Foundation") and others funders. The views expressed and analysis in this document do not necessarily reflect views of the Foundation. The Foundation does not guarantee the accuracy of any data included in this publication nor does it accept any responsibility for the consequences of its use.

Supported in part by

Acknowledgments:

The authors of this case study thank the following people, organizations, and their staff for valuable assistance and insights: Ministry of Power, Bureau of Energy Efficiency, CREDAI's local chapters, Gujarat Institute of Housing and Estate Developers, Indian Green Business Council, U.S. India Energy Cooperation Program, and the efficiency stakeholders met for discussions between August 2011 and December 2012 in Andhra Pradesh, Gujarat, Maharashtra, New Delhi, Pune, and Tamil Nadu. We especially thank Ajay Mathur, David Goldstein, H. N. Daruwalla, Jyotirmay Mathur, Lalit Jain, Mihir Save, Nitika Dhawan, Pavan Bakeri, Rumi Engineer, Shaan Zaveri, Swati Bhattacharya, and Vishal Garg. We thank Bhaskar Deol for the photos for the case study. We would also like to thank Shakti Sustainable Energy Foundation and our other funders for their generous support.

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Endnotes

1 McKinsey Global Institute, *Promoting Energy Efficiency in the Developing World*, 2009, http://www.globalurban.org/McKinsey%20Global%20Institute%20Report%20on%20Promoting%20Energy%20Efficiency%20in%20the%20Developing%20World.pdf.

2 Improved indoor air quality has been qualitatively identified by the Godrej team since the retrofit.

3 Conversions based on 1 USD = ₹54 rate (Jan 28, 2013).

4 The additional maintenance costs of the efficiency measures installed (such as the buying and treating of water for the water-cooled chiller), and the additional savings in the maintenance costs that are avoided by replacing the old systems are not included in the analysis.

5 The charges on Godrej Bhavan's electricity bill include electricity use-based charges, fixed charges based on contracted maximum demand, electricity duty, tax on sale of electricity, and additional charges as levied by the utility BEST and the Government of Maharashtra. The electricity bill savings are realized in part due to a reduction in electricity consumption and in part due to a reduction in electricity tariff.

6 For the actual Godrej electricity bill scenario, if a discount rate of 10 percent is applied, the retrofit will pay back in 5.3 years with cumulative savings of ₹4,642,088 ($85,965) over the 15-year period following the retrofit.

7 Average electricity unit rate of ₹10.46 ($0.19) per kWh for April-December 2012.

8 To account for long-term electricity price increases, Godrej & Boyce's assumption of 7 percent average increase in levelized electricity price is used.

9 For the escalating tariff scenario, if a discount rate of 10 percent is applied, the retrofit will pay back in 11.8 years with cumulative savings of ₹1,138,289 ($21,079) over the 15-year period following the retrofit.

10 Godrej Properties, *Corporate Brochure 2012*, http://www.godrejproperties.com/pdf/corporate_brochure2012.pdf.

11 In electricity supply, a ring main unit system is an electrical wiring technique used for an uninterrupted power supply that also protects the secondary side transformer from the occasional transient currents.