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# Life-cycle cost and financial analysis of energy components in mass housing projects – A case project in sub-urban India

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**Abstract**

Environmental concern based designs are becoming essential in urban India. Shift of population from rural to urban cities is leading to the associated burden of mass housing facilities. The paper discusses the economic feasibility of using energy conservation green components by performing their life cycle cost analysis (LCCA) in large mass housing projects. A total of six components including solar applications have been evaluated for a case project placed in Mumbai suburban location in India. LCCA is performed from the projections of Wholesale price indices and wholesale market price fluctuations of the commodities. Labour cost projections are performed from minimum wages provided by the ministry. For calculation of savings, exponential increase in electricity tariff is considered. The capital cost of energy components contributes in the range of 5–7% to the conventional built up area cost. LCCA suggests that the significant share of cost is related to maintenance, repair and replacement activities of all components. Financial analysis results suggest that the components provide a payback of 11 years at 8% discounting rate and 7 years at non discounted values. The results of this study are expected to benefit investors in mass housing projects for their financial and budgetary decision making in implementing energy efficient based design.


*Keywords:* Life cycle cost; Life cycle saving; Green component; Whole sale price; Solar Power

## 1. Introduction and objective of the study

India has realised the need for sustainable energy related research and development from 1990. Indian economy is growing fast and to meet the future energy demand, a supply which is equal to 3–4 times greater than the total energy consumed today will be required (Kumar et al., 2010). Indian residential electricity demand in 2010 accounted for 35% of the country's total residential delivered energy consumption. This is estimated to rise to 76% in the next

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**Notations**

| | |
|---|---|
| EXP | exponential value |
| LN | logarithmic value |

two and a half decades (EIA, 2013). At present Ministry of New and Renewable Energy (MNRE) (11th Plan, 2010–2011) is promoting development of solar cities by extending subsidies and low interest loans for the adoption of solar photovoltaic applications (MNRE, 2010–11). High cost of solar panels is a major hindrance for the market capture potential of solar photovoltaic applications (Prakash and Bhat, 2009). However the unit cost of photovoltaic panels is likely to decrease due to an increase in market size associated with production level due to learning effect (Nouni et al., 2006).

Increased stress on the demand side for continuous power supply in metros has resulted in the use of energy efficient luminaries as the load is transferred to inverters. In case of luminaries' type, T12's (linear fluorescent lamp) still dominates the Indian market (LOST, 2006). Light emitting diodes (LED) and T5 lamps consume comparatively very low power for same lumens to be produced by other lamps. However the replacement of incandescent lamps by compact fluorescent lamps (CFL) has the highest opportunity for savings throughout the world (McNeil et al., 2008).

Urban India in conjunction with the energy problem is also facing challenges of waste management Ministry of Urban Development (2010). Census of India, 2011 reveals that rapid urbanisation and demand for mass housing in sub urban Mumbai is rising (Census of India, 2011). Associated burden on Municipal Corporation with respect to solid waste management and energy demand is increasing. MNRE in concurrence to solar cities is also encouraging Waste-to-Energy Program through which financial assistance is provided to commercial projects by way of interest subsidy but no assistance is extended to non commercial projects. The net cost of solid waste management services would almost be eliminated if all the waste generated is treated on-site of generation (Tellnes, 2010). Organic waste can effectively processed through bio degradation by Bio-methanation as on-site treatment. Additionally biogas has the lowest relative carbon footprint which proves it to be a more sustainable energy source combined with the potential to meet energy needs (Bobeck, 2010).

Urbanisation and lack of power are leading to the adoption of energy efficient design approach in residential urban planning. The major hindrance for green design is higher level of capital investment. However by adopting these green designs, the operational cost of the building considerably reduces thereby resulting in higher returns on long term basis.

The study attempts to explore the economic feasibility of energy efficient solutions in mass housing projects in metro cities. The study has taken into account the prevailing conditions of Mumbai, one of the largest metro cities in India as a case approach for the purpose of analysis. Residential urban housing sector has been targeted for the study. Solar photovoltaic application for sustainable energy, Bio-methanation plant for organic waste to energy conversion and energy efficient lighting fixtures are considered in the study.

Standardised methodology of life cycle assessment (ISO 14040, ISO 14041, ISO 14042, ISO 14043 and ISO 14044, 2006) are frequently studied nowadays for finding the impact of material production, processes and systems on environment. Other methods like life cycle energy, life cycle costing and life cycle emissions whose benchmark is not existing at present are also studied to compare the cost to benefit in financial terms (Blackhurst et al., 2010) and also to compare the carbon payback to financial payback (Jamie et al., 2014).

Noam and Dan (2006) while performing an economic feasibility study of green buildings in Vancouver discussed that life cycle costing is a methodology that discounts long term costs and benefits through net present value analysis.

Many studies have focused on life cycle assessment of construction material selection (Asif et al., 2007; Zhang et al., 2006; Kofoworola and Gheewala, 2008). International studies associated to construction processes and systems (Keoleian et al., 2000; Fay et al., 2000; Ochoa et al., 2002; Arpke and Hutzler, 2005; Citherlet and Defaux, 2007; Hasan et al., 2008; Cuellar-Franca and Azapagic, 2014) have all resulted in the dominant share of use phase/-operational phase energy consumption in the life cycle energy analysis.

Where all the above studies were focused on life cycle environmental impact application for product selection, process and systems, Keoleian et al. (2000) while considering a single family house in Ann Arbor, Michigan performed a financial study in terms of life cycle costing for the energy efficient and standard home at discounted and non discounted present values. They concluded that at escalating energy prices the energy efficient home is a slightly better investment at 4% discount rate. Hasan et al. (2008) performed a combined simulation and optimisation of a single family detached house in Finland for life cycle costing. Continuous and discrete variables were considered in the study. The results of the stimulation study were the findings of optimisation of life cycle cost values of selected design variable.

Further transitioning the life cycle costing study from a single dwelling home, Arpke and Hutzler (2005) conducted a life cycle cost analysis for 25- years operational period