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Life Cycle Cost Analysis of Mass Housing Project: A Comparative Study of Two Cases

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Abstract: Over time, mass housing projects have emerged as a solution to the problem of urban housing shortage, especially for MIGs and EWS, and continue to do so. Housing is an important indicator of development and mass housing is related to Sustainable Development Goals (SDGs). Along with adequate numbers of houses, basic amenities are the fundamental requirement of comfortable living. A major portion of urban infrastructure is constituted by power. In the year 2022, India faced acute power crisis when daily peak power shortage rose to 10,778 MW and energy deficit reached 5% at the national level. To deal with the shortage of conventional sources of energy, India had set a target in 2016 to reach 175GW of renewable energy by 2022 and by April 2022 it had 95 GW of solar and wind power thus missing its target by 51 GW. Investment decisions of the key stakeholders of mass housing project have heavily relied on the initial construction costs, government subsidy schemes and solving the problem of urban housing shortage. While climate change and energy crisis are a reality today, investments in sustainable development are slow due to the high initial costs. It is necessary for all the stakeholders – from developers to clients, to shift their attention to the long-term performance of a building which includes operational and maintenance costs. This study compares two alternatives of a mass housing project located in Navi Mumbai.

To analyse the profitability of the project and its proposed alternative, Net Present Value or NPV is used. NPV is regarded as the best method to evaluate various building-related options. The total NPV of the project in case 1 at 50 years is 22,28,86,442 Rs. This value is then compared with that of case 2.

Keywords: life cycle cost analysis, mass housing project, cash flow statement, salvage value, Net Present Value

I. INTRODUCTION

A. General

According to the 2011 Census, 30% of India's population lived in urban areas and is expected to reach 40% by 2030. The fast-paced migration of people from rural areas to urban areas in search for better work opportunities and living conditions leads to an ever-increasing demand for housing in the country's cities. However, there is a big gap in demand and supply of housing – both in terms of numbers and quality. Pradhan Mantri Awas Yojana – Urban, a flagship mission of GoI implemented by Ministry of Housing and Urban Affairs addresses urban housing shortage among EWS/LIG and MIG categories.

Over time, mass housing projects have emerged as a solution to the problem of urban housing shortage, especially for MIGs and EWS, and continue to do so. Housing is an important indicator of development and mass housing is related to Sustainable Development Goals (SDGs). Along with adequate numbers of houses, basic amenities are the fundamental requirement of comfortable living. A major portion of urban infrastructure is constituted by power. In the year 2022, India faced acute power crisis when daily peak power shortage rose to 10,778 MW and energy deficit reached 5% at the national level. To deal with the shortage of conventional sources of energy, India had set a target in 2016 to reach 175GW of renewable energy by 2022 and by April 2022 it had 95 GW of solar and wind power thus missing its target by 51 GW.

The Ministry of New and Renewable Energy had set a target of 100 GW of grid-connected solar power by 2022. Government of India launched various schemes to encourage generation of solar power which includes Solar Rooftop System. According to Rooftop Solar Market Q3 Report by Mercom Research India, the cumulative rooftop installations at the end of Q3 2022 reached 8.3 GW. With 23% of total capacity Gujarat became the leading state in solar rooftop installations followed by Maharashtra and Rajasthan. Approximately 73% of the cumulative solar rooftop installations were contributed by the top 10 states.

With the increasing awareness of employing solar rooftop solutions for power generation, many builders and developers are designing residential projects as well as mass housing projects integrated with solar rooftop systems.

It is thus necessary to evaluate the available alternatives from an economic perspective of the project throughout its lifetime.

B. Life Cycle Cost Analysis

Unlike other economic methods, life cycle cost analysis significantly assesses the long-term cost effectiveness of a project by considering initial investment costs, different operating, maintenance, and repair (OM&R) costs. NIST defines LCCA as an economic method of project evaluation in which costs arising from owing, operating, maintaining, and ultimately disposing off a project are considered potentially important for the decision. Energy conservation projects are best examples of application of LCCA. As a direct contrast to the Payback method, LCCA focuses on the time value of money. It is ideal to be applied in cases where the high initial costs are traded for reduced cost obligations in the future. LCCA is extremely useful in decision making when a project comes up with different alternatives that meet all the necessary performance necessities but differ in their initial and operating costs. Though, this method is ideal for comparison between alternatives it is not used for the purpose of budget allocation.

1) *Advantages of Life Cycle Cost Analysis*
a) Enables to understand the long-term worth of any project or asset.
b) Reduces the financial risks in the long-term.
c) LCC is a required credit in many of the green certification programmes.

2) *Disadvantages of Life Cycle Cost Analysis*
a) With new technological advancements and additional attributes, LCCA technique has become complex.
b) Insufficient and fluctuating data due to advancements with time.
c) Inflexible method that does not adapt with market change.

C. Need of Study

Investment decisions of the key stakeholders of mass housing project have heavily relied on the initial construction costs, government subsidy schemes and solving the problem of urban housing shortage. Data suggests the dire need of making these settlements livable and at the same time provide for amenities that deal with the new age problem of energy crisis. This includes installing solar rooftop system for power generation which is one of the crucial part of Government's initiative in promoting use of solar energy, an alternative to conventional energy sources. While climate change and energy crisis are a reality today, investments in sustainable development are slow due to the high initial costs. It is necessary for all the stakeholders – from developers to clients, to shift their attention to the long-term performance of a building which includes operational and maintenance costs.

D. Objectives of Study

1) To identify different costs involved in Life Cycle Cost Analysis.
2) To understand NPV method.
3) To calculate Life Cycle Cost of a Mass Housing Project with 2 different alternatives.
4) To compare the Life Cycle Cost of 2 different alternatives.

II. LITERATURE REVIEW

Some theoretical and analytical investigations performed for the research are listed below.

1) Bojana Petrovi´c, Xingxing Zhang, Ola Eriksson and Marita Wallhagen (2021) explore long-term costs for a single-family house in Sweden during its entire lifetime using life cycle cost analysis. They analysed different cost solutions including various economic parameters in sensitivity analysis. Discounting scheme was used in calculations. Results show that when discount rate is decreased from 7% to 3%, the total costs increased by 44% for 100-year lifespan and 18% for 50 years lifespan.
2) Mingcheng Ren, Clayton R. Mitchell, Weiwei Mo (2020) integrated system dynamics modelling with life cycle assessment and life cycle cost assessment to evaluate the cumulative energy demand, carbon footprint, water footprint, and life cycle cost of residential grid-connected (GC) and standalone (SA) solar PV systems. Results show that for GC design under consideration
3) Ayushi Hajare, Emad Elwakil (2020) integrated life cycle cost and energy simulation for assessing building energy-efficient strategies. The energy simulation models and life cycle models were prepared to establish a trade-off between initial investments and long-term benefits of different energy conservation measures. Results show a 13.5% saving of the building cost employing active strategies and passive design.

4) Akash Dilip Pawar, Walmik Shankar Marathe (2020) conducted the life cycle cost analysis of a residential building by using local state guidelines of maintenance and repair cost. They employed NPV method to calculate the life cycle cost of the building for a duration of 10 years. Results showed that the value of assets at the end of 10 years in terms of net present value was nearly 51% of initial investment. NPV at the end of 10^{th} year was Rs. 26,45,36,819 and the total NPV after reducing salvage value was Rs. 15,94,99,183.
5) Shubham A. Deore, Harshita P. Ambre (2019) calculated the life cycle cost of a G+5 residential building located in Nashik by NPV method. The LCC was found out to be Rs. 86,22,64,309.
6) Renata Schneiderova-Heralova (2018) highlighted the role of life cycle costing in planning phase of construction project in public sector. This summarizes the valuation of building designs in terms of life cycle costs in public sector in Czech Republic along with a few case studies.
7) Shagufta Sajid Mumtaaz Sayed, Priyadarshi H. Sawant (2015) evaluated economic feasibility of using energy conservation green components by performing their life cycle cost analysis (LCCA) in mass housing projects. A total of six energy components including solar applications were considered for a case project located in Mumbai. The results suggest that the components provide a payback of 11 years at 8% discounting rate and 7 years at non-discounted values.
8) Atul A. Dwivedi, Prathamesh V. Bagare, Ajay Dwivedi, Sachin Gupta (2015) conducted life cycle cost analysis of green building emphasizing on maintenance and repair cost analysis of green building materials giving plausible trends for the next 25 years by using District Scheduled Rates (DSR), Wholesale Price Index (WPI) and Consumer Price Index (CPI) for Mumbai city and suburban district. The results showed that the maintenance and repair costs of green building materials increased with time, some linearly and others exponentially.
9) Mitchell Leckner, Radu Zmeureanu (2011) presented a Net Zero Energy House in Montreal that uses available solar technologies to generate at least as much primary energy as the house uses over the year. The energy payback time is 8.4-8.7 years. The life cycle cost analysis show that due to the high cost of solar technologies and low cost of electricity, financial payback is never achieved.
10) Basant Agarwal and G N Tiwari (2010) developed a thermodynamic model to determine energy, exergy and life cycle cost of BIPVT system. The cost of power generation was found to be US $ 0.1009 per kWh which is much closer to that of the conventional grid power.

III.RESEARCH METHODOLOGY

A. General

The life cycle cost of any asset can simply be expressed as –

LCCA = Cash Inflows – Cash Outflows + Scrap Value/Residual Value/ Salvage Value

Steps involved in computing life cycle cost is as follows –

1) Determination of objectives of life cycle cost analysis.
2) Conducting literature survey and defining problem statement.
3) Selection of life cycle cost analysis method – in this case Net Present Value.
4) Data collection of the selected project.
5) Data analysis using the selected method.
6) Calculation of total life cycle cost of concerned project.
7) Formulating the result and comparing it with the proposed alternative.

The equation for LCCA can also be formulated as –

LCCA = R+C+A+N+E+S

Where, R – initial cost

C – Present value of replacement cost

A – Present value of annually recurring maintenance, operating and repair costs

N – Present value of non-annually recuring maintenance, operating and repair costs

E – Present value of energy costs

S – Present value of salvage/scrap/residual costs.

B. Net Present Value

To analyse the profitability of the project and its proposed alternative, the capital budgeting tool - Net Present Value or NPV is used. NPV is regarded as the best method to evaluate various building-related options. It compares the future cash flows with the initial investment. It is calculated as the difference between the present values of both cash inflows and cash outflows over the time period of the project. The option considered is profitable if the difference is positive and vice versa.

Formula for NPV –

$$NPV = \sum_{t=0}^{n} \frac{Rt}{(1+i)^t}$$

where

NPV – Net Present Value

Rt – Net cash inflows-outflows during time period t

i – Discount rate (in decimals)

t – No. of time periods

C. Data Collection

The data is collected from a mass housing project at Bamandongri Station. Out of 43 buildings, one G+15 building is considered with 1BHK 120 domestic units for life cycle costing of two cases –

Case 1 – LCCA of residential building without solar PV rooftop system installation for power generation.

Case 2 – LCCA of residential building with solar PV rooftop system installation for power generation (common area electrical consumption). The life of the building is considered to be 50 years. According to the local laws of Maharashtra, the guidelines by MOFA, MAHARERA and bye-laws, the maintenance and repair cost is taken as 0.75% of the total construction cost and the sinking fund or emergency fund is taken as 0.25% of the total construction cost. The depreciation rate to calculate salvage value is taken as 10%. The discounted rate for real estate falls in the range of 6% to 12%.

For case 2, 11KWp rooftop solar PV system is considered for power generation required for common area.

IV. RESULTS AND DISCUSSIONS

A. Calculation of Salvage Value

The initial cost of the project is Rs. 30,00,00,000.

Total Maintenance cost = 0.75% of initial cost = 0.75% * 30,00,00,000 = Rs. 22,50,000/-

Total Sinking Fund = 0.25% of initial cost = 0.25% * 30,00,00,000 = Rs. 7,50,000/-

Salvage value is the estimated value of a project at the end of its useful life.

Salvage Value = P(1-i)^y

Where, P – total investment i – depreciation rate (10% in this case) y – no. of years

TABLE I

SALVAGE VALUE OF PROJECT FOR 10 YEARS

Year	Depreciation Rate	Salvage Value
1	10%	27,00,00,000
2	10%	24,30,00,000
3	10%	21,87,00,000
4	10%	19,68,30,000
5	10%	17,71,47,000
6	10%	15,94,32,300
7	10%	14,34,89,070
8	10%	12,91,40,163
9	10%	11,62,26,147
10	10%	10,46,03,532

Salvage value at the end of 50 years = 15,46,132.56 Rs

B. Calculation of NPV

The NPV calculations for 50 years duration is carried out in MS-Excel. Sample calculations for 10 years are given in Table II below.

TABLE II
NPV CALCULATION FOR 10 YEARS

Year	Cash Inflow	Cash Outflow	Net Cash flow	Net Present Value
0	0	30,00,00,000	-30,00,00,000	-30,00,00,000
1	20,00,00,000	7,00,000	19,93,00,000	18,62,61,682
2	43,00,00,000	35,00,000	42,65,00,000	37,25,21,618
3	0	35,00,000	-35,00,000	-28,57,043
4	0	35,00,000	-35,00,000	-26,70,133
5	0	35,00,000	-35,00,000	-24,95,451
6	0	35,00,000	-35,00,000	-23,32,198
7	0	35,00,000	-35,00,000	-21,79,624
8	0	30,00,000	-30,00,000	-20,37,032
9	0	30,00,000	-30,00,000	-19,03,768
10	0	30,00,000	-30,00,000	-17,79,223

NPV at the end of 50 years = 22,44,32,574.6 Rs
Total NPV = NPV at the end of 50 years – Salvage value
= 224432574.6 – 1546132.56
Total NPV = 22,28,86,442 Rs

V. CONCLUSION

The total NPV for the case 1 of the project is positive. Hence the project is feasible and developer may accept it. The results from case 1 are then compared with case 2 for choosing the best alternative.

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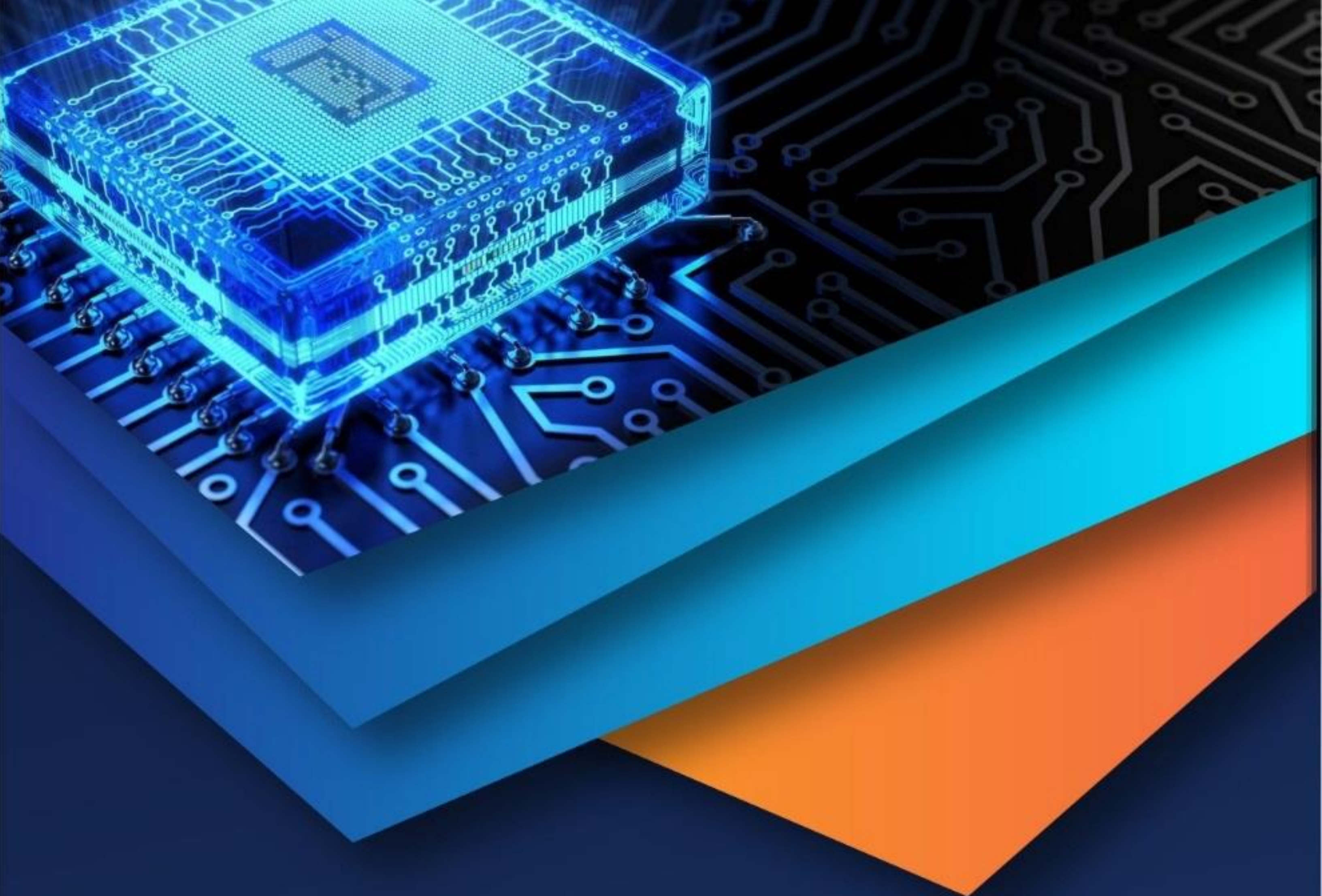

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