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Assessment of Energy Consumption in Cluster Redevelopment: A Case Study of Bhendi Bazar in Mumbai

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***Abstract*—**Cluster Redevelopment is a new concept in the city of Mumbai. Its regulations were laid down by the government in 2009. The concept of cluster redevelopment encompasses a group of buildings defined by a boundary as specified by the municipal authority (in this case, Mumbai), which may be dilapidated or approved for redevelopment. The study analyses the effect of cluster redevelopment in the form of renewal of old group of buildings as compared to refurbishment or restoration - on energy consumption. The methodology includes methods of assessment to determine increase or decrease in energy consumption in cluster redevelopment based on different criteria such as carpet area of the units, building envelope and its architectural elements. Results show that as the area and number of units increase the Energy consumption increases and the EPI (energy performance index) decreases as compared to the base case. The energy consumption per unit area declines by 29% in the proposed cluster redevelopment as compared to the original settlement. It is recommended that although the development is spacious and provides more light and ventilation, aspects such as glass type, traditional architectural features and consumer behavior are critical in the reduction of energy consumption

***Keywords*—**Cluster redevelopment, energy consumption, energy efficiency, typologies.

I. Introduction

CLUSTER Redevelopment, a concept introduced by the Urban Local Body (ULB) governing Mumbai was introduced in 2009. The scheme entails the clubbing together of buildings for redevelopment on a site which has to be strategically planned and designed leading to redeveloped residential and commercial spaces. The minimum plot size required for cluster redevelopment is 4000 sq.m, defined by a road boundary or drainage line on all its four sides [4]. The cluster redevelopment is applicable in South Mumbai at present and is being considered for implementation in the Eastern and Western Suburbs.

Bhendi Bazaar, which houses a dense and historic urban settlement in South Mumbai, is one of the first projects undergoing Cluster Redevelopment in the city. The present residential as well as commercial density in Bhendi Bazar is very high; 70% of the total residential area comprises units with 150 to 175 sq.ft area, having a common sanitation facility. The ground coverage is presently 110% approximately.

The developer, Saifee Burhani Upliftment Trust (SBUT), has proposed the project with the aim of upgrading the lifestyle of people, currently residing in dilapidated low-rise structures spread over an area of 16.5 acres. The proposed scheme has 9 sub-clusters and is expected to develop high-rise buildings and open spaces along with provision of a luxurious lifestyle in the existing congested locality. Bhendi Bazaar was developed in the 'Chawl' or dormitory fashion designed to house single men who had moved to the city for earning a livelihood.

The project under study promotes sustainable way of living. The entire area will be divided into spaces based on functionality and the buildings rise in height from south to north to minimize heat ingress while maximizing air circulation and natural lighting around the buildings [3].

The increase in height of the building will lead to major formation of open spaces, recreational and green facilities. The narrow roads will be replaced with increased road width with more plantations leading to an organized and smooth pedestrian and vehicular traffic movement. Each sub-cluster will be independent with provisions for their own solid waste and sewage management, power provision and open spaces. The project aims to be resource neutral. It has already been pre-certified LEED 'Gold' by the Indian Green Buildings Council [3].

II. Aim and Scope of Study

In a redevelopment scheme, existing tenements are accommodated in larger spaces while a new saleable area is also constructed to make the project viable. This will lead to an increase in energy consumption. If the Cluster Redevelopment scheme is approved for the suburbs, the energy consumed may affect Mumbai's total electricity supply scenario. This study aims to assess the energy consumption in Cluster Redevelopment Scheme in comparison to the existing settlement through the case of Bhendi Bazaar.

III. Methodology

For the study, Cluster 3, which is undergoing construction and whose magnitude of increase in built-up area is proportional to the total proposed redevelopment, was chosen. It consisted of total of 348 residential units and 106 commercial units. Different typologies were identified in the residential and commercial sector and a sample size was determined for study. Mean was calculated for the existing units based on the typologies leading to a sample size of 44

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houses and 5 shops for the purpose of study in Cluster 3 [2].

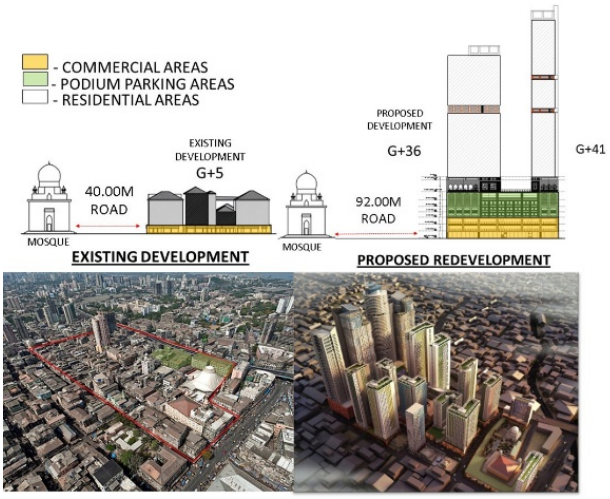


Fig. 1 Existing settlement and the proposed high rise settlement

The assessment comprised of two parts – analysis of the typologies with respect to change in energy consumption, and analysis of change in the building envelope. Stratified random sampling of the commercial and residential typologies was conducted through administration of house-to-house survey questionnaire. People's aspirations, observation of the existing spaces, photographs and analysis of electricity bills formed a major part of data collection. Interviews of major stakeholders, such as SBUT CEO, were also conducted. The total energy consumption – existing and projected - was calculated based on above data and including indoor as well as common areas energy consumption.

IV. Results and Findings

The Cluster Redevelopment Scheme led to an increase in carpet area of 64% from the existing settlement for the Bhendi Bazar Redevelopment project proposal. Residential typologies were established based on carpet areas ranging from less than 100 sq.ft to 1500 sq.ft and more. The houses with carpet areas between 100 – 450 sq.ft comprised the highest number of units and also the maximum energy consumption. In the proposed scheme, minimum size of a housing unit will be 350 sq.ft and more [3].

Existing commercial typologies were found to comprise of 21% foam and upholstery shops, 18% retail cloth stores and 11% office spaces. Heavy-duty repair and hardware and eateries consumed 34% of the total commercial energy consumption. The energy consumed by air conditioners, refrigerators and fans is the highest in the existing settlement. As per survey, demand load for the existing residential sector is more than the designed demand load in the proposed redevelopment by 2%.

With increase in carpet area of 61% in cluster 3, the energy consumption increased by 38% inclusive of common area loads and aspirations in the proposed redevelopment but the EPI in proposed redevelopment (31.85 kwh/m^2/year) decreases by 37% as compared with existing development (50.53 kwh/m^2/year).

It was found that if the use of energy efficient appliances (BEE star-rated) are considered to be used by residents and if the number of appliances increases with addition of aspirations, then the energy consumption increases by 56% in the proposed redevelopment whereas the EPI in proposed redevelopment (35.64 kwh/sq.m/year) decreases by 29% of the existing development.

As per the calculations, the building envelope analysis showed that Window to Wall Ratio (WWR) of the proposed development is 50% which are within norms specified by the Energy Conservation Building Codes (ECBC) 2007 [1].

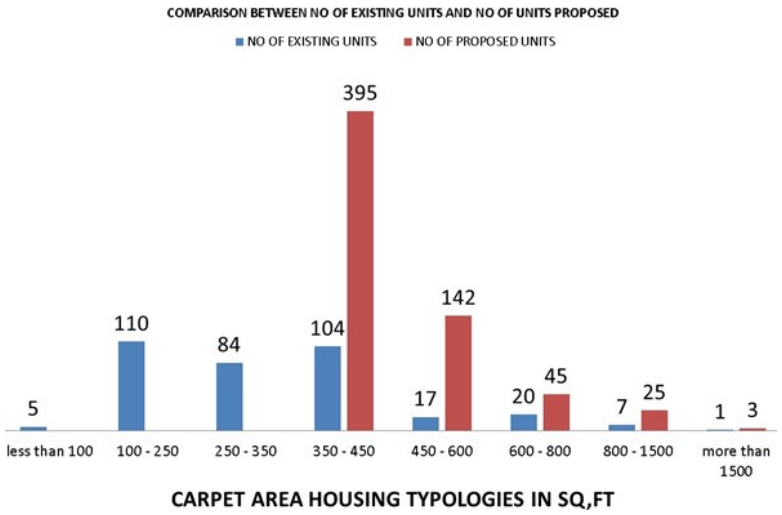


Fig. 2 Total number of housing units in Residential Sector

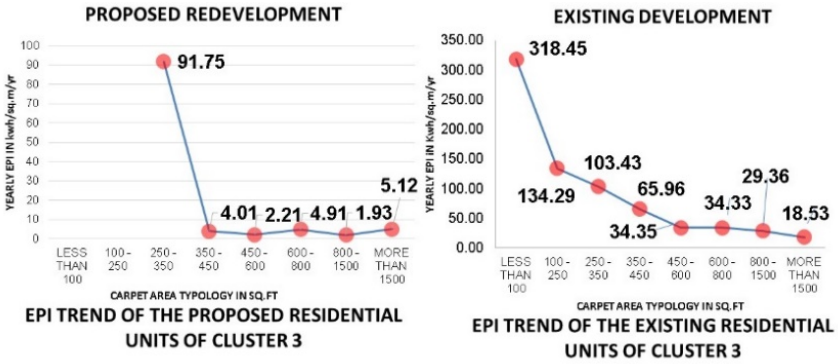
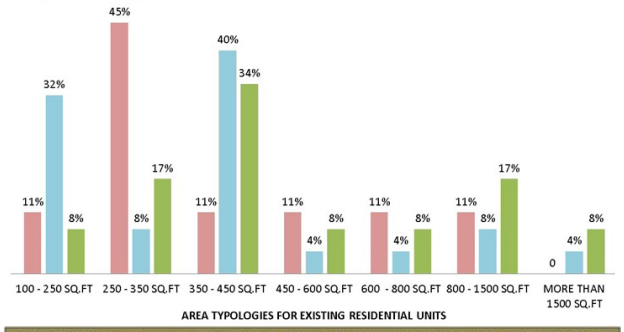


Fig. 3 EPI between existing and proposed scenario for each housing typology



HIGHEST PERCENTAGE OF HOUSES INTERESTED IN FOR THE NEW MODERN LIGHT FIXTURES IN THEIR NEW HOMES		
LIGHTING FIXTURES	CARPET AREA TYPOLOGY IN SQ.FT	HIGHEST PERCENTAGE OF HOUSES
TUBELIGHTS	250 - 350	45%
WHITE LED, CONCEALED AND PANEL LIGHTS	350 - 450	40%
YELLOW LED, CONCEALED AND PANEL LIGHTS		34%

Fig. 4 Aspirations of existing settlement based on survey

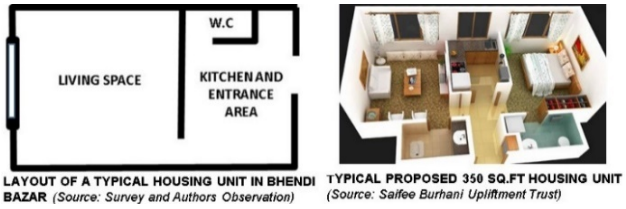


Fig. 5 Typical Existing and Proposed Residential units

As per envelope survey, in the existing settlement the lower carpet area tenements, on lower floors had higher occupants and poor comfort conditions, increasing use of air conditioners and subsequent energy consumption and vice versa for the houses with large carpet areas, on higher floors with sloping roofs and better ventilation.

The proposed redevelopment consists of housing units with lowest carpet area ranging from 310 sq.ft – 350 sq.ft and highest carpet area more than 1500 sq.ft, hence the existing houses of carpet area less than 350 sq.ft in cluster 3 will all be provided a house between the carpet area range of 310 sq.ft – 350 sq.ft because of which the number of houses in the carpet area typology of 350 sq.ft – 450 sq.ft is the highest leading to high energy consumption in the proposed redevelopment with a difference of 70% from the existing development in cluster 3.

Design elements in terms of elevation such as longer overhangs on the eastern side of the building and low emissivity glass with high VLT and Low Reflectance can reduce the effect of external environment on thermal comfort causing reduction in energy consumption. Use of energy efficient measures such as installation of solar panels that are grid connect so that it can offset the energy consumption and star-rated thermal cooling appliances and LED lights can reduce energy consumption by 30%-40% [5].

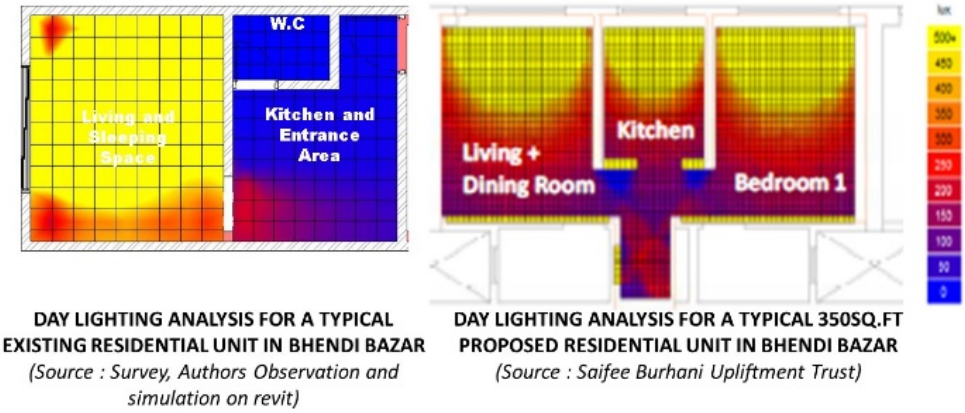


Fig. 6 Typical Daylighting for Typical Existing and Proposed Residential units. (BIM Energy Simulation Software – Revit)

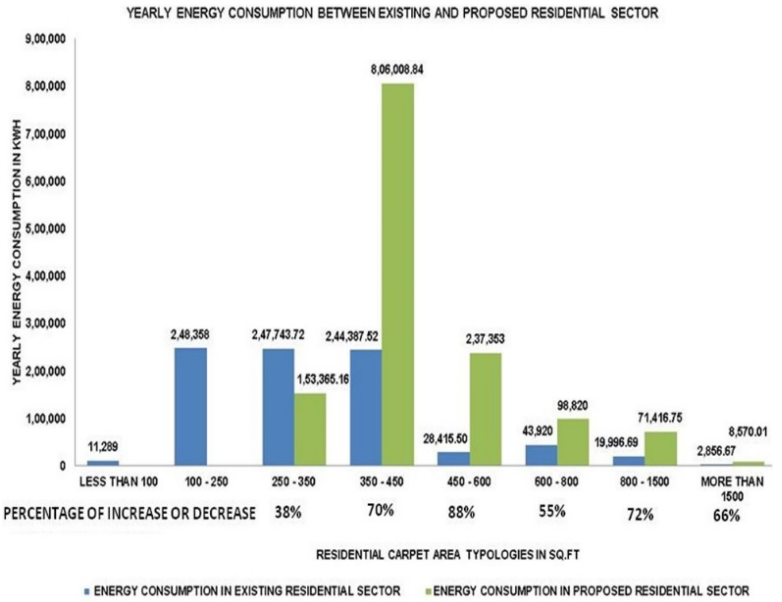


Fig. 7 Energy Consumption in Residential Sector between the Existing and Proposed

V. Conclusions

From the study of cluster 3 of Bhendi Bazaar, it can be concluded that cluster redevelopment in a land parcel can lead to a net increase in energy consumption of up to 56% of existing development; but there is also a subsequent increase in carpet area to the extent of 61% providing more habitable spaces. With increased open spaces and better light and ventilation, as well as use of energy efficient appliances by users, the energy consumption per unit area actually declines by 29%. Thus the scheme can be considered for redevelopment in the suburbs of Mumbai.

Appendix

1. Conversion of usage of the old houses when they will be converted to the new proposed houses in the cluster redevelopment

TYPOLOGY	TYPE OF HOUSES IN EXISTING	TYPE OF HOUSES IN PROPOSED
LESS THAN 100 SQ.FT	1RK	1BHK
100 - 250 SQ.FT	1RK	
250 - 350 SQ.FT	1RK/2RK	
350 - 450 SQ.FT	4RK	1 BHK
450 - 600 SQ.FT	4BHK	2 BHK
600 - 800 SQ.FT	1BHK/4BHK	3BHK
800 - 1500 SQ.FT	3BHK	3BHK/3.5BHK
MORE THAN 1500 SQ.FT	2BHK	3.5BHK/4BHK

Fig. 8 Existing houses usage to proposed housing usage

2. The parameters formulated for the purpose of survey of 50 to 75 houses:

- PARAMETER 1 - Survey in terms of floor plans/ carpet areas & demographical data for existing residential units.
- PARAMETER 2 - Survey in terms of expectations and aspirations of new homes for existing residential units.
- PARAMETER 3 - Survey in terms of building envelope for existing residential units and buildings.

3. Types of Windows in the Existing and the Proposed Development; Picture Credits: SBUT and Researcher

Fig. 9 Comparison of Existing Façade to Proposed Facade

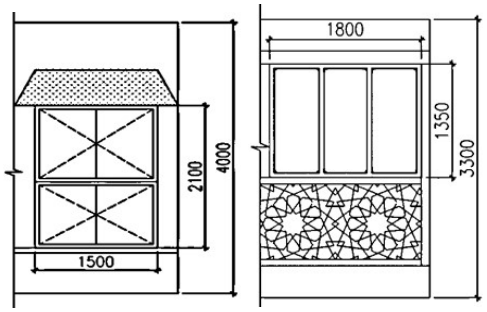


Fig. 10 Typical Window Size and style of Existing and Proposed Development

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