NECESSITY OF ECO-HOUSING IN DEVELOPING COUNTRIES FOR PROMOTING SUSTAINABLE DEVELOPMENT

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1 INTRODUCTION

With its present growth rate (about 150 persons/ min. [1]), as per UN projections, the world population will be crossing 11.25 billion by the end of the year 2100 [13]. As per the projections made, 57% of this population will be urban, out of which 95% contribution will be due to the developing countries. As a result, the population of 24 cities in developing countries will cross the figure of 20 million by the year 2025. Based on the List1 prepared by the UN, 50% of the 34-mega cities are already in developing countries.

LIST 1 - Existing Mega cities with descending Order of population (2020)

S.No.	*Mega City*	*Population*
1.	Tokyo	37.39 million
2.	Delhi	30.29 million
3.	Shanghai	27.05 million
4.	São Paulo	22.04 million
5.	Mexico City	21.78 million
6.	Dhaka	21 million
7.	Cairo	20.9 million
8.	Beijing	20.46 million
9.	Mumbai	20.41 million
10.	Osaka	19.16 million
11.	New York-Newark	18.8 million
12.	Karachi	16.09 million
13.	Chongqing	15.87 million
14.	Istanbul	15.19 million
15.	Buenos Aires	15.15 million
16.	Kolkata	14.85 million
17.	Lagos	14.36 million
18.	Kinshasa	14.34 million
19.	Manila	13.92 million
20.	Tianjin	13.58 million
21.	Rio de Janeiro	13.45 million
22.	Guangzhou, Guangdong	13.3 million
23.	Lahore	12.64 million
24.	Moscow	12.53 million
25.	Los Angeles-Long Beach-Santa Ana	12.44 million
26.	Shenzhen	12.35 million
27.	Bangalore	12.32 million
28.	Paris	11.01 million
29.	Bogotá	10.97 million
30.	Chennai	10.97 million
31.	Jakarta	10.77 million

32.	Lima	10.71 million
33.	Bangkok	10.53 million
34.	Hyderabad	10 million
(Ref. UN Department of Economic and Social Affairs, Population Dynamics, World Urbanization Prospects 2018, Population of Urban Agglomerations with 300,000 Inhabitants or More in 2018, by country, 1950-2035 (thousands). https://population.un.org/wup/)		

As per the above projections, it is quite easy to predict future housing needs. Already there is a global shortage of housing for 2 billion people. This shortage will be becoming more and more acute if no immediate actions/measures are taken. This advocates the need for the development of mass housing projects. This shortage will further increase by the advancing years. But what about the tremendous impact on the field of energy usage of these future developmental projects of mass housing? As per International Energy Agency report 2008, Urban areas account for approximately 70%–80% of global energy demands and greenhouse gas emissions, and thus they are a major contributor to global warming [15].

A study of present processes of development with associated energy usage will help architects in designing mass housing with less energy consumption, leading ultimately to the conservation of natural resources and a less polluted urban environment.

2 THE PRESSURE

It is necessary here, to identify various major pressures, which are generally put on the urban areas by building more mass housing units:

2.1 Land:

As of today the land in the urban metro cities has become very dear & costly; also it is difficult to find new land suitable for mass housing. The alternative of housing in high-rise apartments is leading these urban areas towards chaotic development. They also pose greater pressure on parking and transportation system networks [12].

2.2 Energy:

This is a burning problem of the present era. The present unplanned and uncontrolled growth of housing cares little about energy conservation aspects. Sometimes even providing minimum energy to all households is not becoming possible for the local authorities. Studies reveal that around 18% of the total energy consumption of mankind is in the housing sector. It is necessary to consider energy conservation techniques before, during, and after construction; as energy can be saved considerably in each stage. Over 80% of the embodied energy in mass housing is the energy required to manufacture the materials [7]. Most of this energy usage is for manufacturing only a small number of the (high-energy) materials used in the construction of housing units, principally steel products, cement, concrete products, bricks, and ceramic materials. This embodied energy amounts to several times the annual energy consumption of that same housing in use. Energy is used wastefully in heat recovery processes, insulation techniques, and simple orientation concerns. Architectural lighting & space heating/ cooling are also two of the largest and most visible consumers of energy. A properly designed energy-efficient housing will have a lower initial cost than one planned disregarding energy consequences. This cost advantage derives mainly from smaller building volume & lower energy demands. The conventional centralized energy distribution network accounts for high transmission losses (ranging from 9% to 20% at times). In the Indian context grid loss sometimes reach up to 35%. The energy consumption in residential structures accounts for considerably high than in other buildings, also it is a recurring ever cost increasing phenomenon. It is very difficult to remain in the city and save energy beyond a certain limit without compromising the present-day materialistic lifestyle of the city dweller households.

2.3 Utilities:

The present-day big cities are growing at a faster speed; the utilities & the city of basic amenities for an urban population are becoming increasingly difficult day by day. It is a very complex situation and a major multifaceted problem to cope with such a huge demand. Lack of finance/ civic sense resources is further adding to this precarious condition.

2.4 Environment:

The present-day pollution & lack of basic amenities are proving detrimental to the future growth of residential nature in metro city areas. The polluted air and water, the toxic wastes, and the dangerous fuel emissions from vehicles are further aggravating this situation. The decreasing green areas are bringing changes in the microclimate in these cities, making it more and more uncomfortable for living.

2.5 Transportation:

The public transport systems of almost all these urban conglomerations are running at a loss and it has become increasingly difficult to maintain their effectiveness cleanliness and punctuality, because of overcrowding and the pressure of the daily commuting population.

3 ENERGY EFFICIENCY TO SUFFICIENCY

It had already been established in 1970 that there is no inexhaustible supply of cheap conventional energy sources, available in the world & therefore serious efforts should be aimed at identifying energy conservation methods and a lot of research is being done to effectively use the available non-conventional & renewable energy sources. The future of housing design should rely on not only energy efficiency but towards energy sufficiency. For effectively using these concepts, simultaneous use of various non-conventional energy sources is necessary, which will cover the lean period of generation of energy by one source and will provide a designed uninterrupted quantity of energy all the time. UNCHS recommends, "Housing should be designed with the application of bio-climatic design principle & employment of energy conservation measures will reduce 60% energy consumption in heating/ cooling of buildings."

4 THE NEW CONCEPT

The concept of 'self-sufficient housing' is to minimize the pressures on cities in terms of space, energy, traffic, population, etc. This housing will be in a self-contained commune with a building unit designed to cater to the needs of approximately 15 to 20 families. They will produce their energy for domestic use; grow their own agricultural produces for food, thereby limiting their visits to urban areas for such tasks and products, which are not feasible in this commune. They will be sited in economical rural spaces / natural surroundings [2]. A self-sufficient home is a structure that is designed, built, renovated, operated, or reused in an ecological and resource-efficient manner. These homes are designed to meet certain objectives such as protecting health; using energy, water, and other resources more efficiently; and reducing the overall impact on the environment.

5 The Advantage

5.1 Location & Siting:

These units will be located in rural / country areas & they will be well connected with the possible work centres. The rural natural fresh & unpolluted environment and low cost of land will be the first positive aspect of siting such dwelling units. Protect and retain existing landscaping and natural features. Select plants that have low water and pesticide needs, and generate minimum plant trimmings. Use compost and mulches. This will save water and time. Recycled content paving materials, furnishings, and mulches help close the recycling loop.

5.2 Energy Sufficiency:

The building will be planned in such a way that it will use non-conventional & renewal energy sources totally and will not use any form of external energy source like an electrical grid network or fossil fuels, etc. Here reference can be made to Nottinghamshire’s Hockerton Housing Project (HHP), which is the UK’s earth-sheltered, self-sufficient ecological housing development [8]. Architectural strategies for energy conservation can be:-

- Develop strategies to provide natural lighting. Studies have shown that it has a positive impact well being.
- Task lighting reduces general overhead light levels.

- Use a properly sized and energy-efficient heat/cooling system in conjunction with thermally efficient walls, roofs, and floors.
- Maximize light colours for roofing and wall finish materials; install high R-value wall and ceiling insulation, and use minimal glass on undesired sun exposures.
- Consider alternative and renewable energy sources.
- Passive design strategies can dramatically affect a home's energy performance. These measures include home shape and orientation, passive solar design, and the use of natural lighting.

5.3 Materials Efficiency:

Select sustainable construction materials and products by evaluating several characteristics such as reused and recycled content, zero or low off gassing of harmful air emissions, zero or low toxicity, sustainably harvested materials, high recyclables, durability, longevity, and local production. Such products promote resource conservation and efficiency. Reuse and recycle construction and demolition materials.

5.4 Recycling:

The concept of recycling waste/ water/ garbage will be applied in such a way that it fulfills the need of dwellers without tapping any external services or utility networks. The garbage will be recycled to produce energy through non-conventional methods & end product will become manure for crops. One example of recycling can be using wastewater from washing in fishponds and from there it can be used in fields/ vegetable farms [3]. Some other measures which will improve water efficiency can be:-

- Design for dual plumbing to use recycled water for toilet flushing or a gray water system that recovers rainwater or other nonpotable water for site irrigation.
- Minimize wastewater by using ultra low-flush toilets, low-flow showerheads, and other water-conserving fixtures.
- Use recirculating systems for centralized hot water distribution.
- Install point-of-use tank less hot water heating systems.
- Use micro-irrigation (which excludes sprinklers and high-pressure sprayers) to supply water in non-turf areas.
- Use state-of-the-art irrigation controllers and self-closing nozzles on hoses.

5.5 Space Economy:

This building will be providing minimum adequate living space for 15 to 20 families in an economical rural/ countryside site. This number of dwellers will depend upon local conditions, the extent of the problem, and energy sufficiency parameters along with other factors.

5.6 Environment Friendly:

The main aim of these self-sufficient housing units is to develop such a housing system in which there will be no generation of pollution by any means. Besides being situated in a rural environment these houses will be using recycling of water and all the waste materials. Thus a nature-friendly & ecologically balanced surrounding will be created by these dwellers through these housing systems.

5.7 Employment Generating:

The commune development activities and maintenance of various energy generation equipment will also generate employment for the dwellers & only a handful (one person per family) may have to go to city areas for sophisticated jobs etc. As this concept provides partial food growing facility / zero energy bill along with Other economical advantages; there will be less necessity for a job, and dwellers can engage themselves in an occupation/ vocation of their own choice for better income, while living in the commune.

5.8 Minimizing Transportation:

The dwellers require minimum transportation. As only periodical shopping of merchandise & some other works may require traveling to other areas which are not possible within this commune. Though the scientific application of knowledge of farming will reduce this need to travel. This in turn will decrease the overall stress on existing transportation systems.

6 The Process of Implementation

Here, planning steps are suggested with taking India, as an example of developing country:-

6.1 Selection of a target group representing the largest portion of such migratory population: This selection must be made at the local level considering the nearness of urban areas. This group should necessarily contains people having major skills/vocation (like carpenter, plumber, mason, electrician etc.) needed for running day-to-day activities & proper maintenance of commune.

6.2 Determination of a feasible size of the commune by considering local problems of Siting: Though preliminary studies suggest about 250 families can be a manageable size for Indian conditions, having a maximum of 5 persons per family.

6.3 Proposing living space: For 15 to 20 families in one building, by undertaking anthropometrical studies and deciding space standards, taking along with the study of economical feasibility of the target group [5]. The minimum proposed enclosed spaces required for a family should be consisting of:

- Habitable space: bedroom / living room; utilities: kitchen / toilet / bathroom / store, etc.

In addition to these some common spaces are necessary for community living, which may be:

- Services/electric room/garbage collection room, Kitchen garden / open garden / terrace garden, farming, fishpond, poultry etc. These spaces can be created in common spaces left between the units.

6.4 Estimating space requirements: For energy production by renewable or non-conventional energy sources: - Biogas/biomass plant, wind energy, solar energy. Where feasible tidal energy can be also used.

6.5 Deciding Building fabric and enclosure spaces (including structural considerations): Here due attention must be paid to achieving a structurally safe & maintenance-free construction.

6.6 Earmarking Spaces for recycling plants: For water/garbage/sewerage for energy and manure production. These spaces should be designed with an optimum space utilization concept, though the importance of these cannot be ignored due to their necessity in keeping the pollution level low. Care must be taken to adapt foolproof recycling systems.

6.7 Providing community spaces & common spaces for recreation and other utilities:
Park / school / primary health center / recreation center, roads / pathways, etc.

6.8 Calculating the energy demands: of individual unit and proposing energy sufficiency by tapping non-conventional energy sources. Some of such energy sources under consideration are:
Solar (photovoltaic), Biomass, Wind, Tidal, etc. It may be necessary to install a combination of these energy sources to get the desired result all year round.

6.9 Estimating the necessity of other resources: like water, etc., & proposing their procurement from locally available natural sources. Rainwater must be compulsorily collected & underground water levels must be allowed to charge through natural means.

6.10 Deciding the size of one building unit: cross-checking each of the above-mentioned spaces as per their feasibility and sustainability concerning the number of dwellers and self-sufficiency parameters [4].

6.11 Arriving at a suitable size: as per local conditions/resources availability / willing population.

6.12 Determining the social acceptability: of these relatively new housing systems, through a preliminary survey of various shelter less people, or people suffering from overcrowding in conventional housing [5].

6.13 Replicating the commune: Once, a prototype commune is successful, they can be replicated according to local site/climate conditions.

7 ARCHITECTURAL DESIGN OF HOUSING

The housing design should incorporate energy saving techniques by reducing the energy demands & some major recommendations are:-

7.1 Proper site selection & orientation.

7.2 Use of shady trees to control radiation reaching unwanted places of building envelope.
7.3 Maximum window placement on the side of least sun exposure.

7.4 Minimize exposed surface area for reducing heat transmission.

8 THE CHOICE OF LOW ENERGY BUILDING MATERIALS

Architects of these housing have the opportunity to make a major contribution to the reduction of total energy use in the built environment through some of the strategies enlisted here:

- **Maximum use of low-energy materials.**
- **Selection of lower-energy structural systems**, such as load bearing masonry in place of RCC/ steel frames.
- **Selection of waste/recycled materials**, or manufactured materials, which incorporate these.
- **Use local materials**, involving less transportation.

- **Use more functional windows** (designed as passive solar collectors). Optionally smart windows can be also used, which use anti reflection layers, low emission coatings and switchable films.

9 THE CONSTRUCTION

During the construction process, materials are combined in composite building components such as walls, floors, and roofs. Based on the energy intensity of the materials and the quantities used, it is possible to calculate the energy insensitivity of various types of building materials and construction methods.

Tab. 1: *Energy Requirements for Typical Housing Components*

Components	Energy (MJ/Sq.m.)
Floors:	

Suspended Timber	733
Concrete slab on ground	1014
Walls:	
Timber frame, weatherboard cladding	198
Timber frame, brick-veneer cladding	1284
Concrete block	755
Roofs:	
Galvanized Steel	508
Concrete Tile	176

Similarly, the energy intensity of various house designs can be calculated and compared. Notably, structures can vary up to 60% in **capital** energy requirement, as a result of the architect's choice of materials [6].

10 ECONOMICAL CONSIDERATIONS

A Self Sufficient home may cost more up front but saves through lower operating costs over the life of the home. These homes require fewer trips to the doctor's office. This approach applies a life cycle cost analysis for determining the appropriate up-front cost. This analytical method calculates costs over the useful life of the home. These cost savings can only be fully realized when they are incorporated at the project's conceptual design phase with the assistance of an integrated team of professionals. The integrated systems approach ensures that the home is designed as one system rather than a collection of stand-alone systems. Some benefits, such as improving health and comfort, reducing pollution, and landfill waste are not easily quantified. Consequently, they are not adequately considered in a cost analysis. For this reason, consider setting aside a small portion of the building budget to cover differential costs associated with less tangible benefits or to cover the cost of researching and analyzing Self Sufficient housing options. This development may lead to a school of thought in the inhabitants and they will thrive to become self-sufficient.

11 SELECTED EXAMPLES

Though full implementation of these concepts is rare, some good examples exist in Europe, which partially uses self-sufficient concepts are enlisted herewith:

- The Cropthorne Autonomous Home in the UK which is using renewable energy and as a result, it is carbon-negative [9].
  - Climate Neutral Passive House Estate in Hannover Kronsberg, which is using passive solar techniques along with super insulation technologies [10].
  - Findhorn Ecovillage in the UK is notable for its low carbon and oldest community-based agricultural system [11].

12 ECO-CITY DEVELOPMENT

If the other urban buildings/ infrastructure constructions follow a similar approach, the development of eco-city will become more and more feasible. Further, it is necessary to give importance to these concepts as housing nearly covers 40% to 42% (as per Town and Country Planning norms in India), of serviced urban land areas in developing countries. Many researchers feel the need of a holistic sustainability approach beyond developing only energy efficient housing [14]. So developing Eco-housing based on sustainability principles are definitely the path to future planning strategies.

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