Smart Homes: Architectural and Engineering Design Imperatives for Smart City Building Codes

Sameek Ghosh
Business School
NSHM Knowledge Campus – Group of Institutions
Kolkata, India
sameek.ghosh@gmail.com

***Abstract*— Smart homes are the fundamental blocks of Smart cities. There is no requirements espoused by the government to make these homes support the Smart city infrastructural features. This paper explores and defines the areas where architectural and engineering codes are required to be built in the building codes of Smart cities. In absence of such code will not lead the cities to a sustainable living space. As all the infrastructural issues are related to the fundamental building blocs that is our homes and apartments, we must by codes to guide them toward smarter homes. And these codes should lead us to water and waste management, green building, safe and healthy living environment. This research work shows how various Smart city infrastructural initiatives are directly related to architectural and engineering discipline and the need to have a strong Smart city specific building code at the national and local level.**

***Index Terms*—Smart City, Smart home, Architecture, Engineering, Building information modeling, urban planning, architectural design, engineering design.** *(key words)*

I. INTRODUCTION

Smart City is the thrust area of the government as 63% of countries GDP is contributed by the urban centers [1]. The net outlay towards projects has been over 1.89 lakh crore impacting over 9.5 crore population [2]. The reach and government expenditure clearly signifies the importance of Smart City in the present time.

Interestingly, there is no standard definition of Smart City in the literature and policy statements. A Smart City can be different in different geographies, say in Europe and India. In this paper we will limit ourselves to Indian context and will follow the definitional boundaries as stated by the Government of India [3].

A city comprises of city dwellers and as per their aspiration, a smart city should contain a superior level of infrastructural facilities – physical, economic, social and institutional. The list of infrastructure demand depends on the city dwellers level of aspiration. To address such levels of needs of the citizens, government and planners are ideally aiming at developing an entirely modern urban living space, which primarily focuses on the core infrastructure of water supply, electricity supply, sanitation, solid waste management, urban mobility and public transport, affordable housing, robust IT connectivity, digitalization, e-Governance, sustainable environment, safety and security, health and education [4].

These are long term goals which urban local bodies will work towards developing the aforementioned infrastructure in a time phased manner, becoming 'smart city' incrementally. Development of infrastructure is dependent on effective planning for future expansion and new projects accommodation. As the facilities and infrastructures will be used by the resident people, we foresee a steady demand of housing sector in the Smart Cities. Individual house or apartment will form a crucial unit of Smart City, with having a Smart homes the objectives of Smart city will never be met. However, a review of policy documents reveals there are little thoughts which has gone in this area and gap exists. This paper seeks to bridge the gap by addressing architectural and engineering design imperatives for smart homes, looking both at the standalone homes and apartments.

II. URBAN PLANNING

Urban planning is a complex exercise which mostly setup policies, guidelines, rules and regulations which govern all the future expansion and developmental endeavors. The governing factor of such futuristic developments is the building codes. For homes in smart cities building codes needs regeneration to accommodate technological advancements and integrate with the other modern infrastructures.

Dwellings of the Smart city is encircled by the following components.

Smart Buildings, Water, Transport And Waste	Clean and Green Energy And Energy Preservation	Smart Retail, Healthcare and Education	E Governance

Figuare 1: Components of Smart City Urban Development

Cities are built by humans who are the residents of the same city and at the same time producer and consumers of good and

services of the city. It is a symbiotic relationship. Government's policy on Smart city mandates housing for all but lacks any details on the "smartness" of these housing.

Urban planning categorizes housing in two broad categories – Stand-alone homes and apartments. A clear mandate to make these two categories of housing smart in missing in the government's policy papers.

This is a major issue as at the atomic level smart homes matters the most for the sustainability of Smart cities. Homes makes ward, ward makes zones, zones make municipalities. Hence the importance of having smart homes for the success and sustainability of Smart Cities cannot be ignored, rather to be stressed up. Rest of the paper explores how architectural and engineering designs are essential for smart cities and what modifications to be done in the building codes of the Smart cities.

III. ACCOMMODATING SMART SOLUTIONS

The Smart City features are targeted to be achieved through strategic Area-based development in the Smart Cities. These developments can be in the form of "Smart Solutions" (refer Table 1). The strategic area based development components are city improvement (retrofitting), city renewal (redevelopment) and city extension (greenfield development). Added to these three development city-wide initiatives will be launched in which Smart Solutions will be covering larger parts of the city. Smart solutions can be any intelligent solutions delivering common good and not restricted to the list mentioned in Table 1.

TABLE I. SMART SOLUTIONS FOR A SMART CITY [4]

E-Governance and Citizen Services 1. Public Information, Grievance Redressal 2. Electronic Service Delivery 3. Citizen Engagement 4. Citizens – City's Eyes and Ears 5. Video Crime Monitoring	**Energy Management** 13. Smart Meters & Management 14. Renewable Sources of Energy 15. Energy Efficient & Green Buildings
Waste Management 6. Waste to Energy & fuel 7. Waste to Compost 8. Waste water to be treated 9. Recycling and Reduction of C&D Waste	**Urban Mobility** 16. Smart Parking 17. Intelligent Traffic Management 18. Integrated Multi-Modal Transport
Water Management 10. Smart Meters and Management 11. Leakage identification, Preventive Maintenance 12. Water Quality Monitoring	**Others** 19. Tele-Medicine & Tele Education 20. Incubation / Trade Facilitation Centre 21. Skill Development Centres

Retrofitting, Redevelopment and Greenfield Development will warrant architectural, structural and engineering modification. A uniform building code for these endeavors is essential to help the government bodies achieve the Smart City features.

IV. ARCHITECTURAL AND ENGINEERING REQUIREMENTS

Greenfield development and Redevelopment need architectural inputs and Retrofitting warrants more inputs from the engineering disciplines, though architectural inputs are ruled out in case of retrofitting, but the scale is expected to be less. These inputs must align itself with the specific requirements for Smart city. The re-design and new designs should be such that it accommodates the smart solutions seamlessly. A one-to-one mapping of architectural inputs with the Smart city features and smart solutions is required.

A. Architectural contributions for Smart homes in Smart city

A home is smart only when it effectively contribute to the society at large. In the internet age, Smart homes are often related to internet enabled, censor powered intelligent electro-physical appliances and applications controlling the various aspects of the house. The smart homes are required to support the smart city features to become "Smart" in true sense. Following table illustrates the architectural inputs for smart homes supporting smart city infrastructure and features

TABLE II. ARCHITECTURAL INPUTS FOR SMART HOMES [4]

Components of Smart City (Features)	**Architectural Contributions (Examples, not limited to)**
Adequate water supply	Rainwater harvesting
Assured electric supply	Green building
Sanitation & Solid Waste	Zoning planning for redevelopment and greenfield development
Mobility	Space Planning
Affordable housing	Design re-engineering, Eco-friendly and low cost local materials
IT connectivity	Zoning for better line of sight
Sustainable environment	Green Zone, Green Buildings
Safety	CCTV grids
Health	Zoning, easy access to buildings, cycling and walking zones, parking

Home is the fundamental unit, the occupants consumes water, energy, generates waste, requires safe and healthy environment, mobility, security and a sustainable living. Hence, concentrating on homes is a primary requirement for a successful Smart city.

Infrastructural issues are required to be addressed during planning phase, for all retrofitting, redevelopment and green field development endeavors. For redevelopment and green field development the city should have building codes which complement the components of Smart city.

From Table II, we can see adequate water supply can be effectively achieved if we have the water table of the city replenished, irrespective of the water source(s) of the city. Like water electric supply fast depletes our natural resources and power cut is a common phenomenon across the country.

For a sustainable healthy city our design of buildings must minimize power consumptions, save water, manage waste with zero pollution, these are possible with mandated use of green building technologies for apartments and standalone houses are adapted. Even zoning for green field developments are required for seamless wireless connectivity, enabling internet enabled physical devices act seamlessly.

From Table II we can summarize the smart initiatives for building as Green building and infrastructure, Multi-Mode Transport, Video Surveillance of city, Centrally managed Public utilities, Integrated safety and communication, Clean Air, Soil and Water, Electric driven public transport. Similarly the following also falls in the jurisdiction of architecture Solar Energy and LED Lighting, Ample Natural ventilation, Waste Management and recycling, Smart Garbage Disposal and compost area, Rainwater Harvesting and Soil conservation, Wind and Hydro power with ample plantation and free space.

Hence, it is evident that, the field of architecture has a space for contribution to make the smart city features successful, what is required is incorporating those in the building codes.

B. Engineering contributions for Smart homes in Smart city

Like architectural inputs, similarly various engineering disciplines are having impact during the design stage. There are essential entities which needs to be incorporated during design of homes to support Smart city features.

Engineering disciplines namely Electrical, Plumbing, Heating Ventilation & Air-Conditioning, Fire Protection will play a pivotal role in designing of Smart cities. Projects of redevelopment and green field will need their involvement from the very first day.

TABLE III. ENGINEERING INPUTS FOR SMART HOMES [4]

Components of Smart City (Features)	**Engineering Contributions**
Adequate water supply	Rainwater harvesting, Leak management
Assured electric supply	Solar panel, LED lights,
Sanitation & Solid Waste	Zoning planning for redevelopment and greenfield development
Mobility	Centrally managed traffic control.
Affordable housing	Electrical and plumbing design
IT connectivity	Seamless, grid based wireless
Sustainable environment	Green building analysis, heat load calculations, ventilation
Safety	CCTV,
Health	Centralized air monitor, easy access,

Adequate water supply is a major issue, which needs careful planning for uninterrupted supply. Ground water monitoring, river water purification can only be governed by policies set up by the authorities. Engineering design inputs are required during the design phase. Similarly, solid waste management of households and societies requires mandated procedures to be followed so that the city remains clean and unpolluted.

Engineering and structural design can contribute in bringing down the construction cost to support affordable housing. A better zoning plan for seamless and cost effective wireless connectivity can be achieved by zoning the high rise buildings to keep the light of sight uninterrupted.

Building information modeling a newest development in the computer aided design and drafting space can generate high performance design validation reports for large building in a fraction of second including green building analysis [5]. Mandated use of such modeling tool during design phase will enhance sustainability of the homes, in return the cities.

V. IMPERATIVES FOR BUILDING CODES

From the section IV A and IV B it is understood that a robust building code is essential for developing sustainable Smart City, which has to start from the drawing board. A home is a fundamental block of a city making it smart by not only thorough internet enabled physical devices but also through architectural and engineering interventions.

These architectural and engineering interventions can come through building codes. From the analysis the following incorporations are suggested in the local as well as national building code.

The building code to have mandatory and optional clause for the apartments and standalone buildings. Since sustainability is a major concern and will ensure healthy and happy living, green building analysis and report submission to be mandatory for apartment complexes, commercial and industrial buildings, in the codes. Keeping the cost of analyzing and certifying in mind it can be optional for standalone properties.

Assured electric supply can be assured only we save and generate green energy simultaneously. Buildings have roof tops which can be mandated for a certain percentage of the roof using solar panel. The excess electricity to be feed back to the grid. This to be optional for individual ownership buildings and mandatory for everybody else.

The Floor Area Ratio to be elaborated to help plan for ample natural ventilation. For personal homes, spaces between homes to be mandated.

For Waste Management and recycling mandatory segregation of waste at the gate for both apartments and standalone homes is required. Community collection centers to use compactors. Large complexes and housing societies must have sewerage treatment plants.

In the era of global warming rainwater harvesting should be mandatory for all kinds of buildings. Building plans must not be approved without this facility. This will help regenerate the underground water table for river dependent and underground water dependent cities.

Though plantation cannot be made mandatory in the housing sector, but can be incentivized and encouraged by the local bodies. The incentives can be in the form of holding tax discounts.

For safety video surveillance and video recording to be submitted with the plan, without which it will not be approved. However, standalone home owners can be kept out of this purview.

Public utilities like drainage, sewerage, electricity, communication cables to be placed underground. For green field projects these must be centrally controlled. Meters for electricity, water, gas to be installed in apartments. Water meter to be mandated in both apartments and home.

With these incorporations, homes will become Smart homes and will truly add to the Smart city.

The following table summarizes the proposed building codes for a Smart city.

TABLE IV. ENGINEERING INPUTS FOR SMART HOMES [6]

Smart Home features	Proposed Building Code Mandates for Smart City
1. Green building	For Apartment complexes mandatory analysis; Optional for standalone property.
2. Solar Energy and LED Lighting	Percentage of roof to be utilized for Solar, can be incentivized through buy back; Street lighting, common space lighting for large complexes to use LED.
3. Ample Natural ventilation	Elaboration of FAR
4. Waste Management and recycling	Mandatory segregation at the gate for both apartments and standalone homes
5. Rainwater Harvesting	Mandatory for all kinds of buildings
6. Plantation	Incentivize
7. Video Surveillance of city,	Apartment CCTV mandatory; Standalone optional
8. Centrally managed Public utilities,	Centralized Underground utilities for greenfield development a
9. Integrated safety and communication,	CCTV, Intercom, Single emergency number.
10. Sustainability	Use of recycled material for a certain percentage of the project

CONCLUSION

It is imperative that Smart homes being the fundamental block of Smart cities needs to build, modified and planned in such a way to support the Smart City features and infrastructural requirements. Except the support of individual dwelling unit it will be difficult to sustain a smart city. To make the homes, irrespective of individual standalone duplex or large apartment complexes, the support towards Smart city should be inbuilt in design.

This is only possible if there are Smart city specific Building Codes developed in lines with National Building Codes or Local Urban Bodies building codes. Such codes are available internationally, which speaks only on building codes for Smart cities in Euro-Mediterranean countries [7].

While developing the codes both architectural and engineering issues to be addressed, as Smart city features are dependent on both architectural and engineering inputs. Issues like green buildings needs regulations for both architectural and engineering side. Heating, ventilation, illumination all affect green building, so only architectural inputs will not suffice, engineering regulations are also required during the design and approval phase.

Only such mandated building codes will ensure that the required infrastructural issues are addressed in the homes and apartments creating a sustainable safe and healthy city as espoused by the Smart City initiative.

ACKNOWLEDGMENT

The author likes to acknowledge the guidance of Prof. Suresh A, at Amrita School of Business, Kollam and Mr. Abhik Bhattacharjee of Smeaton and Watt. During the development of the paper their comments has helped to improve the paper.

REFERENCES

[1] "SMART CITIES MISSION, Government of India", Smartcities.gov.in, 2017. [Online]. Available: http://smartcities.gov.in/content/. [Accessed: 30- Dec- 2017].

[2] "Smart Cities Network | Smartnet", Smartnet.niua.org, 2017. [Online]. Available: https://smartnet.niua.org/smart-cities-network. [Accessed: 30- Dec- 2017].

[3] What is Smart City. Delhi: Government of India, 2017. Available:http://smartcities.gov.in/upload/uploadfiles/files/What%20is%20Smart%20City.pdf [Accessed: 30- Nov- 2017].

[4] Ministry of Urban Development, Government of India, "Smart Cities - Mission Statement & Guidelines", New Delhi, 2015.

[5] I. Reychav, R. Maskil Leitan and R. Mchaney, "Sociocultural sustainability in green building information modeling," Clean Technologies and Environmental Policy, vol. 19, (9), pp. 2245-2254, 2017. Available: https://search.proquest.com/docview/1954558307?accountid=38661. DOI: http://dx.doi.org/10.1007/s10098-017-1409-y.

[6] Ministry of Urban Development, Government of India, "Smart Cities - Mission Statement & Guidelines", New Delhi, 2015. pp 6

[7] G. Manzano Garcia, "Smart rules for smart cities, managing efficient cities in euro-Mediterranean countries," Foresight: The Journal of Futures Studies, Strategic Thinking and Policy, vol. 18, (2), pp. 187-192, 2016. Available: https://search.proquest.com/docview/1823128363?accountid=38661.