Strategies for developing tube houses in Vietnam within the framework of “smart city” concept

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Abstract. The becoming of smart cities is an inevitable trend for future cities. Vietnam is in the rapid urbanization process facing many challenges. Smart cities require many criteria, in which providing a convenient living environment for citizens is the top priority. The current situation of urban housing in Vietnam shows a unique characteristic, in which tube houses occupy a large proportion and offer a low quality living environment. This type of construction will play a major role in smart cities. The objective of this paper is to determine the strategies for developing future tube houses within smart cities of Vietnam. Methods used in the paper include: data collection method, analytical – synthetical method and logical method. Results of the paper are shown using appropriate development strategies with necessary criteria and general architectural solutions. In addition, there will be two directions of design solutions: a) renovating of tube houses at existing residential areas and b) new construction of tube houses in new areas. The conclusion drawn from this article concerns designing and building tube houses within the framework of a “smart city” concept. These proposals must conform to practical requirements and should be implemented step by step to ensure sustainable development.

1. Introduction
Smart visions have been researched and built in the world with many different solutions, depending on the actual conditions of each locality. However, smart cities must conform to common criteria. There are many different definitions of smart city, for instance: by Correia L and Wunstel K in report “Smart cities applications and requirements” smart city is a city that links physical capitals with a social one in order to enhance the quality of services [1]; in paper “Foundations for smarter cities” by Harrison et al. smart city is integrating the physical, social and business infrastructures and information technology (IT) into a single framework so as to leverage the collective intelligence of a city [2].

One special thing is that the citizens play a core role in all directions and solutions of a smart city [3]. Socio-economic requirements have always been a difficult problem for urbanization, especially in developing countries, while the requirement of maintaining a high quality living environment is a top priority. Modern housing is usually applied to high-rise apartment buildings, while low-rise independent houses are often a second option. However, independent houses have a long history and are associated with the cultural life of the community.
In Vietnam, tube houses are built on a low-rise scale (2-5 floors) on streets and alleys which have different widths. In addition to the residential purpose, tube houses are also used as trading shops, office services, motels, small factories or other service providers [4]. Tube houses present many inadequacies in building a modern city but contain many socio-cultural elements. Their characteristics make it difficult for change in a new direction.

Vietnam has been building a development program for urban systems using a smart city concept. Tube houses will continue to be a major focus in the housing development of future Vietnam. The difficulties for intelligent and synchronous change are: a) the diversity of functions for tube houses, b) users and owners from all walks of life, and c) the architectural qualities of the houses. Therefore, it is necessary to have a reasonable strategy to develop tube houses established on a scientific basis of influencing factors, feasible solutions and future vision.

2. Literature review
Common criteria of a smart city are defined in many reports and articles, including: smart governance, smart economy, smart mobility, smart environment, smart people and smart living [5, 6, 7]. These criteria serve to improve the quality of life in many aspects such as: living, working, moving, studying, entertainment, future investment... The concept of smart city was born to provide improved quality of life for citizens [8]. Gradually, the emphasis of smart city strategies has shifted from “ambitions to achieve efficiencies in service provision”, to “ambitions for higher quality of life for citizens and more sustainable living” [9].

Experience of developing smart cities in the world shows that different countries build their smart cities to different standards, depending on their sizes, natural conditions, socio-economic and cultural conditions, levels of investment and urban issues faced [10]. Smart city developmental programs around the world have encountered difficult problems in housing for people. This is especially the case in developing countries with high population densities and weak infrastructure conditions [11].

At first, smart city concept was considered as a way of providing infrastructure and applying information technology to urban management and operations. By the mid-2000s, the construction of a new city placed the role of "soft infrastructure" (society, human resources, citizen and business participation) over the role of IT. Since 2010, smart city has been a combination of “hard infrastructure” (IT and technological advances) and “soft infrastructure”, aiming to sustainably provide high quality life and innovation for citizens, services and businesses [12].

Smart city in Vietnam has its own characteristics. Instead of relying entirely on the application of technology, smart city should be formed based on the balanced development of three components: technology, people and governance [11]. It is therefore, perhaps necessary, to make sustainable development a central point of view and the biggest goal for smart city development actions. For example, Ho Chi Minh City has built a city development program since 2017 with the vision of building a smart city until 2025. Slogan of the program: city will develop a relatively high and sustainable economy, based on the best exploitation of resources, with citizens being the center of the city [13].

The urban situation in Vietnam has its own characteristics with tube houses accounting for a large proportion (Figures 1, Figure 2 and Figure 3). It reflects the popularity, diversity and freedom in design and construction. These constructions have become famous and have attracted interest even from foreign researchers. For example, reasons for the strong development of tube houses in Vietnam include:

- Planning is inconsistent and allows the formation of tube houses with high construction density.
- The climate allows the building of small houses with open facades and diverse structures.
- The climate enables motorbikes to be easily used all year round, with direct access to the building and easy parking inside the house [14].

These elements are formed based on the history of tube houses and urban development. The process of changing from traditional garden houses to tube houses took place in many stages. At first,
the front of the house was often used as a place of commerce. Later, many houses were completely used for commercial purposes for all floors and spaces [15]. In the meantime, the value of the urban houses is often very high and ever-increasing over time. An initial review of real estate prices in Hanoi and Ho Chi Minh City suggest that prices are relatively higher in these locations when reviewed against comparable cities in Asia [14].

Figure 1.
Residential areas.
Source: http://ashui.com

Figure 2. Plans.
Source: https://pinterest.com
The architecture and interior design of tube houses show its own characteristics, being reflected in the following aspects:

- Demand of long-term land ownership for inheritance.
- Freedom to design and build house with personal ideas.
- Flexibility in investment and management costs.
- Usage of facades and floors for different functions.

In Vietnam, designing and building codes for tube houses have been developed, applied and updated for a long time, but the current status shows the chaos in construction and the deficiency in the government’s management. The situation of tube houses shows many shortcomings in the quality of interior space, especially microclimate conditions, areas, operating costs and renovations [16]. High building density with a high concrete rate creates high heat absorption from the outside environment into houses. The space behind the house often lacks direct contact with the outer space, leading to the limitation of microclimate conditions. Many tube houses lack the transition space from the outside environment to the interior, such as the front yard, atrium, back yard, balcony, logia, terrace, etc. These characteristics request high operating costs for lighting, ventilation and air condition. In addition, the lack of contact with external nature creates physiological inconvenience for users. It reduces the real value of the inner space.

Author Le Van Dung, in his doctoral thesis, proposes to differentiate the levels of comfort in houses. The author offers solutions to arrange functional spaces in Vietnamese urban housing to meet the necessary comfort. The division of comfort quality is determined based on actual conditions of area, construction envelope, landscape, demographic information, investment cost, infrastructure ... to ensure the optimal quality of comfort [17].

Currently, designers are looking for solutions to develop tube houses in a way that is sustainable and imbued with national identity. With a history of development from traditional houses, tube houses are considered objects of traditional solutions [15]. The value of traditional architecture is highly appreciated in many studies and articles, master and doctoral theses. Author Nguyen Song Hoang Nguyen, in his doctoral thesis, proposes the possibility of converting traditional architectural values into modern solutions for new constructions, especially urban housing projects [18]. These solutions meet many criteria of green architecture, which is applied in Vietnam. Green architecture has suitable features for both the nature and people of Vietnam, making it a viable premise for the construction orientation of a smart city. Modern tube houses in recent cities have appeared to have contemporary designs and follow the green architecture trend.

The application of technology in tube houses is accelerated with the goals of: saving energy, improving comfort and safety, taking advantage of renewable energy, saving water sources, smart control... Solutions of the MEP system have been designed and operated, typically such as solar water heaters, solar batteries, rainwater collection systems, wind power turbines, smart home control systems, security systems…
The application of new materials also raises interest. These solutions are usually developed on an innovative platform with structural construction and spatial organization. Modular materials are preferred for their ease of use. In addition, materials and components manufactured and constructed based on the promotion of traditional architectural values are encouraged to be applied. These solutions are suitable for contemporary architecture trends such as: green architecture criteria, national identity and humanity.

3. Materials and methods
This paper was completed in logical order. Scientific papers, reports, opinions of experts were cited. The research subject is tube house, which is popular in Vietnam. Its features are considered in the aims to clarify research issues. Methods which were used in this paper include:

- Data collection method: Scientific papers and researches on the theme "smart city" were reported to give general views, which provided a basis for determining the direction of the article. The views and experiences of implementing a program of a smart city were considered and studied: (1) perspective on housing development, improving living environment and the role of the citizen; (2) current urban problems in Vietnam are related to the status of tube houses, in which the role of infrastructure has not been properly assessed. Tube houses were considered from many aspects: (A) planning – architecture - interior; (B) culture - society; (C) economic - technical; (D) energy - environmental; (E) local identity. In addition, architectural illustrations of tube houses in this paper provided a reflection of their character. The value of this evidence signifies the urgency of this paper in contributing to the development of tube houses in Vietnam.

- Analytical – synthetical method: The collected information was analyzed and synthesized to clarify the ideas, perspectives and practical experiences. Opinions for “smart city” concepts were analyzed and evaluated to give an initial strategy for Vietnam. The status and history of tube houses were highly appreciated, in order to draw conclusions about attitudes toward their development. The existence and development of tube houses in the future was determined to implement the next solution. In addition, information on the current state of urban planning and architecture was analyzed in order to address their strengths and weaknesses. Aspects which effect the development of tube houses were considered in order to ensure the success of the project and "smart city" program.

- Logical method: The conclusions of this paper range from general to detailed, showing the strategy for the future. The common criteria were determined, thereby providing specific solutions for each different scale of research objects: city, residential area, house and interior. New solutions were considered within the aim to realize each project and program of developing a smart city. New application has to ensure sustainable development. In addition, tables were used to list the main points of the paper's results.

4. Results
Smart cities are the targets of Vietnam. One of the big problems of smart cities is ensuring the quality of living environment and housing conditions. Accordingly, cities need to perform the following tasks:

- Overall planning of cities and urban areas according to actual capabilities and future visions.
- Investing in infrastructure with a view to serving a smart city.

According to historical data, tube houses will continue to be a long-term development in Vietnam. They are still a big asset and their value always increases over time. Addressing tube house issues is the top priority for architectures. However, it is necessary to have an appropriate development strategy for them, in which the project itself must meet the following criteria:

- Criteria of smart city, which have been and will be built separately for each city.
- Housing standards, which are upgraded by planning and according to new requirements of modern society.
- The new design trend of function and form.
• Socio-cultural and economic-technical factors in urban planning, architectural design and interior completion.
• Smart connectivity with regional and city infrastructure systems.

General solutions proposed for tube houses can be:
• The purpose of tube houses will not outside of the following: residential, residential - commercial and commercial.
• Ensuring the standards of living area and reasonable layout.
• Ensuring the microclimate quality inside the house.
• Architectural design in accordance with the trend of green architecture and contemporary style.
• The form of the outer urban area will develop in the direction of homogenization along each road in terms of number of floors, elevation, setback space...
• Application of new solutions for strong connection with smart systems of city.

The actual situation of tube houses in Vietnam shows that there will be two directions of design solutions within the framework of a “smart city” concept: a) renovating of tube houses at existing residential areas and b) new construction of tube houses in new areas (Table 1 and Table 2, respectively).

**Table 1.** Solutions for renovating of tube houses at existing residential areas.

| Scales          | Solutions for renovating of tube houses at existing residential areas |
|-----------------|--------------------------------------------------------------------|
| Residential area| Improve the quality of infrastructure at residential areas         |
|                 | Expanding roads, constructing urban landscapes, investing in micro-climate quality of residential areas, increasing the area of greenery and water surface, space for the community... |
| Tube house      | Improve living environment quality through solutions: ensure microclimate conditions, increase per capita area, improve facade towards homogenization of planning and architectural parameters |
|                 | Apply new structural and MEP solutions in a smart, energy-saving, environmentally friendly and humane way |
|                 | Strongly connect houses with modern infrastructure                 |

**Table 2.** Solutions for new construction of tube houses in new areas.

| Scales          | Solutions for new construction of tube houses in new areas          |
|-----------------|---------------------------------------------------------------------|
| Residential area| Invest in building new residential areas according to the approved plan with a vision for smart city |
|                 | Ensuring the quality of the infrastructure of residential areas according to urban planning |
| Tube house      | Design and ensure the completion of tube houses according to architectural planning in the direction of smart city |
|                 | Ensuring the quality of the living environment according to the new standards |
Apply new structural and MEP solutions in a smart, energy-saving, environmentally friendly and humane way

Strongly connect houses with modern infrastructure

For the realization of a program for a smart city, it is necessary to build an implementation plan for developing tube houses. The fundamental problems are improving existing infrastructure and building new infrastructure. In addition, new standards for tube houses are also built and applied in the corresponding period. Local characteristics are also taken into account to ensure feasibility.

5. Discussion

According to the director of FPT Information System, Phan Thanh Son, the most general and appropriate definition of a smart city for Vietnam is the definition provided by ITU-T Research Organization: “A smart city is an innovative city that uses information and communication technology (ICT) and other means to improve the quality of life, operational efficiency, urban services, competitiveness and at the same time ensures the needs of current and future generations for economic, social, environmental and cultural aspects” [12]. In the context of the Fourth Industrial Revolution, information and communication technology has made great progress and has been applied to address growing pressures in management and service to the municipality [11]. However, in some cities, for example in Helsinki, the core enabler of the strategy is an innovative ecosystem [9]. The unreasonable urbanization process must apply "smart" solutions beyond technology, which is the smart choice in urban planning. Examples of such choices are maintaining and embellishing the nature of the urban center, attaching importance to new development with renovating and upgrading the existing zones, and developing multi-functional centers [11].

Housing is a major concern of cities around the world. Meeting housing requirements is a key factor in shaping socio-economic stability, cultural development and future values. History shows that large and modern cities have always prioritized the stability of people's life, in order to pave the way for the realization of other macro programs such as smart city programs. Housing funds for the present and future is a big concern of every city.

Modern urban housing is divided into many types, in which high-rise apartments are the trend with many advantages suitable for urban space. High-rise apartment buildings are increasingly replicated in both new and developing cities within developing countries. This type of construction is popular in most of these countries and gradually shows the common modern features. However, low-rise housing is often associated with the long time history of each area. Climatic - geographic, cultural - social and economic - technical factors greatly affect the low-rise housing architecture. They can be a spontaneous product born during the urban development process and may also be organized under a complete plan.

Tube houses in Vietnam also have a similar history. They are representative of the typical architectural characteristics. Tube houses are divided into two main groups: a) houses in existing residential areas and b) houses in new areas. Existing residential areas often form and change over time with the history of urban development. The planning of these areas lacks uniformity and diversity. New areas are designed according to the planning of each area so they tend to have a greater level of planning involved. However, the mixed existence of old and new houses creates difficulties in planning. This is also the reason for the existence of tube houses for a long time.

Advantages of tube houses:

- Long-term private ownership for one family or one owner.
- Possibility of building houses with desired designs as long as they conform to the general planning on the number of floors, setback space, elevation...
- Having facade adjacent to the road to facilitate traffic access.
- Ability to use diverse functions depending on needs and ability to meet: residential, residential - commercial and commercial purposes.
Disadvantages of tube houses:
- Difficulty in government’s management because each house is a household, its size and use are difficult to determine.
- Small land area with high-density construction.
- Quality microclimate is not guaranteed: lack of light and ventilation (especially for rear spaces).
- Construction and maintenance costs are high when compared with apartments.
- Access varies from large roads to small alleys, making it difficult to plan the area and ratio of green areas, traffic, infrastructure...

Most people living in tube houses are not living up to the standards of housing design for Vietnam and the world. Housing standard in Vietnam stipulates that each urban person needs to ensure 25 m² / person, meanwhile, the average housing area in Ho Chi Minh City in 2018 is 19.75 m² / person and the target per capita housing area is 22.8 m² / person in 2025 [19].

In fact, the urban area in Vietnam shows that the quality of living environment in tube houses is uneven. There is a large proportion of poor quality houses in existing areas, indicating that the development of tube houses is needed in two directions: a) renovating tube houses in existing residential areas and b) new constructions in new areas. Based on the advantages and disadvantages of tube houses, the following factors must be observed:
- Improve and build infrastructure in the direction of homogeneity and modernity.
- Increasing the usable area.
- Reduce construction density.
- Improve the quality of microclimate in the residential areas and interior.

From this picture, the application of scientific and technological advances to the smart city in Vietnam will not be a priority. The priority is socio-economic issues, habitat quality and infrastructure improvement. The above issues need to be solved according to the implementation phases and need to be done synchronously. The role of the government will be important. Humanity and rationality in technical economics need to be considered. Respect for living conditions, individual buildings and the natural environment will determine the steps to take. In addition, the scientific and legal basis for ensuring the realization of the above developmental directions plays an important role. The rules and standards will be the measure and sanctions for implementation. The support and direction from the government in terms of policies, expertise and information updates will contribute to improving efficiency.

The trend of green architecture has been applied to many buildings. This approach is suitable for small spaces to solve many problems of microclimate, resources, energy, renewable energy and humanity. In Vietnam, unique solutions based on green architecture are also applied in the design of tube houses. Green architecture and similar styles demonstrate many values that are suitable for smart cities [16]. Green architecture can combine with local characteristics to create unique architectural developments for the future. Solutions to promote local traditional architecture bring a lot of value in creating energy-saving spaces, an opening to nature, and increased community connection... For example, there are many energy upgrade potentials of different facade refurbishment options in tube houses [20]. Humanistic values and local identity have been a concern and have now adopted the attitude of diversification to better meet the current status of urban tube houses in Vietnam.

The new design solutions come from the application of scientific and technical advances in structure and MEP system brings many choices for the owner. These solutions can respond to the requirements of new standards and the designer's recommendations. It is a prerequisite for macro applications in connecting each house with urban infrastructure. The reality shows that effective solutions for smart tube houses can be: solar power, solar hot water, smart home systems, environmentally friendly materials...
In addition, it is necessary to promote breakthrough and experimental solutions, in order to create a premise for future replication. Applications in housing operations are considered for investment according to different levels and demands. It will create a consensus on the investment.

6. Conclusions
Cities in Vietnam will be built within the framework of a “smart city” concept and tube houses will play an important role in this process. The architecture of tube house shows that there are many issues which need to be thoroughly addressed. In addition, with regard to the vision for smart cities, tube houses face many challenges, including the current status of planning - architecture, infrastructure and cultural - social issues.

Strategies for developing tube houses should be developed with careful consideration to enhance their feasibility. The existence and the development of tube houses must be implemented in a smart way, in which humans will be the most crucial factor in comparison to the social and scientific aspects. The plan needs to be carried out step by step. Any outcome of each phase will be updated continuously, which is especially necessary when the importance of sharing information and encouraging the participation of citizens and the government needs to be stressed. The legal binds encourage the positive and sustainable change of the environmental quality. New criteria, standards, regulations and research should be applied. Localism needs to be considered to guarantee the success and the sustainability of designing, constructing and operationalizing solutions.

The results of this paper can be applied to other types of buildings in Vietnam. The characteristics of architecture in Vietnam shows to be valuable but also challenging to future urbanization.

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