

Energy and Housing Conditions in China: The Survey

Study of Zhuhai, South China

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Abstract

China has developed few housing policy reforms and has been in recent years developing policies to promote green strategies and energy saving plans. The urban housing has much benefited from such reforms and plans, while the rural has experienced minimal change in the past few decades. As a result, this study aims to identify and explore these differences, challenges and complications between the three areas of urban, peri-urban and rural in one particular part of China. For this study, selected residential areas in the City of Zhuhai and its peri-urban and rural areas are selected as case studies. A questionnaire survey is conducted to analyse energy and housing conditions across the more prosperous urban, the dynamic and transitory peri-urban and the depriving rural areas. The case studies are analysed as comparative models in a hot and humid subtropical area of Southern China. The study compares energy and housing conditions and argues potential possibilities and challenges for future development of housing policy reforms that are the result of current housing development patterns and green strategy situation in China.

Key words: *Housing Conditions; Energy; Zhuhai; China; Housing Reforms.*

The Overview of Housing in China

Housing is a significant part of the built environment. In the past three to four decades, the Chinese housing system has drastically changed from one dominated type of public housing to private house ownership (Wu, 2012). This includes new development of mid-rise housing, high rise apartments, gated residential communities and cluster of low-rise luxury housing (locally known as villa housing). In regard to this process, Logan et al (2010, p. 101) argue two new ways of housing reform; a) '*privatisation of public housing*'; and b) '*development of new private housing sector*'. Since 1949, both are new to the context of China but have grown immensely since the reforms. Moreover, the change in Chinese housing pattern system and development patterns has major impact on the overall change of household energy consumption, change of living lifestyle and change of well-being and quality of life in the living environments. The impact on geography of space determines the way residents' living and consumption patterns are shaping. This is, in particular, important to China due to its pace and scale of development and growth. These are, to some extent, pressures or even challenges that require careful planning for China's next reforms and development plans.

While in recent years most research on Chinese housing has been on price increase (Wang and Wen, 2012; Zhang et al, 2012; Dreger and Zhang, 2013; Hui and Wang, 2014; Wu et al, 2014), issues of affordability (Dang et al, 2014), sustainability (Zhang et al, 2011) and structure of housing development (Zhao and Ge, 2014) have become critical matters to China's current conditions and the future phase of development. China's '*transition of the housing model from an administrative system to a market-oriented system*' (Zhang, 2000, p. 191) has changed the social structure in many new developments and is also having a major impact on housing typologies and housing design. Furthermore, the rise of household energy consumption determines a definite need for policy makers, designers

and developers to consider energy saving approaches in construction and development (Yang et al, 2004).

Chinese housing market is a unique, and yet challenging, model in developing world. The rapid urbanisation and huge demand for housing has accelerated the process of construction, resulting in poor quality design (e.g. design type and layout), poor quality material selection and with less concern about energy saving principles. Therefore, housing accounts for a major part of China's built environment and construction sectors, particularly that in recent years housing construction is expanded significantly. In March 2011, the Chinese government's objective to build 36 million units of housing by 2015 (The Economist, 15th of October 2011) indicates a major housing construction trend, which is both unprecedented and unpredictable. Therefore, it is important to analyse China's current status and future plans for housing construction, and subsequently evaluate the attributes that will contribute towards the growing energy consumption. All these together will provide a critical overview of China's housing.

1.1 China's Energy Issues and Housing

The steady rise of urbanisation has direct impact on housing development in the urban, the peri-urban and the rural areas. In comparison with the Western standards, energy use in housing has been insignificant (Wirtshafter and Song-Ying, 1987) but the substantial increase in the past few decades has become one of China's major energy issues. The Energy Conservation Law (ECL) in 1997 and then the following policies on green building since 2000 can be considered as the starting points in recognising the position of household energy consumption in housing construction. Since then, the policy reform on housing energy efficiency has been insignificant but has now become part of China's 12th 5-year plan (current 5-year plan). The three pillars of 'energy efficiency', 'low carbon' and

'green development' in China's 12th 5-year plan are considered as direct prescription to the current energy issues in China's construction sector. With the progress on context-specific building code and life-cycle data, the gap in current research on China's housing and energy remain valid and important. As a result, context-specific studies are essential to identify energy-related attributes that are part of future design specification, household energy demand and consumption.

Since 1998 and the change of China's welfare housing system, Chinese housing policy has changed intensely in respect to the issues of affordability and sustainability; one of which is the nationwide (and indeed global) energy issue that is yet to be tackled. In their study on *Dynamics of urban and rural housing stocks in China*, Hu et al (2010) examine potential scenarios for new construction activities based on demographic changes that are expected to occur in both the urban and the rural areas of China. In their study, the authors simulate different development paths depending on major parameters of population change, urbanisation rate, building durability and housing demand (ibid). In each development path, it is clear that housing demand is shaping as a major attribute to the future of China's development. The resource demand analysis helps to represent scenarios for the future challenges that may also involve energy production and consumption. Some data is available in the China Energy Strategy 2000-2050 that project forecasts in the coming decades (Shen et al, 2005). Similarly, Yang and Kohler (2008) calculated China's material and energy implication as part of its future growth and development. Nevertheless, a modelling technique is probably not the most feasible approach to identifying and understanding the current changes and development trends in the context of China. Therefore, this study aims to undertake a more analytical and critical approach to evaluate a particular case of energy and housing in China.

1.2 Objectives of the Survey Study

This is a context-specific housing study for a sub-tropical hot and humid condition in the Southern China. Based on existing conditions and patterns of development in three regions of urban, peri-urban and rural, this study firstly explores the conditions of residential units and then provides a set of data for primary household energy uses during warm and cold seasons. The collected data are then analysed for a further cross-analysis. The questionnaire survey covers several aspects of housing conditions and energy consumption patterns. The survey study is essential for such study as it includes an observational method to the conditions of housing and living environments. A cross comparison between housing models of urban, peri-urban and rural regions promotes a comprehensive understanding of the living conditions and energy-related issues across different social classes of one context. The questionnaire survey includes three attributes of 'housing occupancy', 'housing typology' and 'seasonal household energy consumption'.

The objectives of the study are: a) to develop a cross analysis between urban, peri-urban and rural housing in South of China; b) to analyse between housing models, household occupancy and energy consumption; and c) to identify trends of housing models and their implications on energy demand and consumption.

This survey study was undertaken in October 2013 in a period of eight consecutive days. It includes both questionnaire and observational study of selected residential areas. The participants of the study are residents of three regions (i.e. urban, peri-urban and rural) in the context of Zhuhai, South China. All participants are from low to middle class social groups in one unitary area.

2. Description of Case Study Site: Zhuhai's Urban, Peri-Urban and Rural Study Areas

The City of Zhuhai is one of the earliest and original Special Economic Zones in China and is located on the Southern coast of Guangdong Province, which is also known as the Pearl River Delta (PRD). At latitude of 22.27 °N, Zhuhai has a hot and humid climate. It is one of the key urban areas of Southern Guangdong as it borders Macau Special Administrative Region (by land) and Hong Kong Special Administrative Region (by water). In 1998, Zhuhai was ‘*recognised by the United Nations as the Best model of International Residential Environment Improvement*’ (Sheng and Tang, 2013, p. 70). This was mainly due to the local government’s focus on quality living environments and sustainable development. With three main districts of Xiangzhou District, Doumen District, and Jinwan District, most of current and proposed development areas are mainly considered as coastal areas (figure 1).

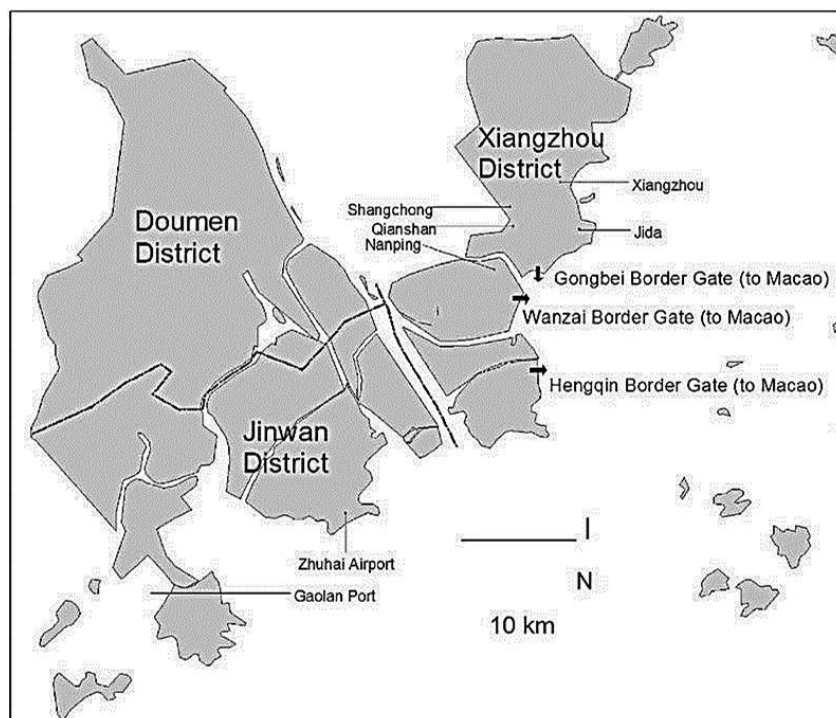


Figure 1 – Zhuhai’s main districts (Source: Sheng and Tang, 2013, p. 71)

The city’s steady economic growth and attraction for tourism activities in recent years, has helped to promote the city’s restructuring as a major urban hub. In return, the population for city’s temporary residents are increasing faster than before (figure 2). This indicates

growing service-based and industry-based employment opportunities, including the job market in both the urban and the peri-urban areas of the city. This demographic change is important to housing demand and construction of mass housing in some parts of the city.

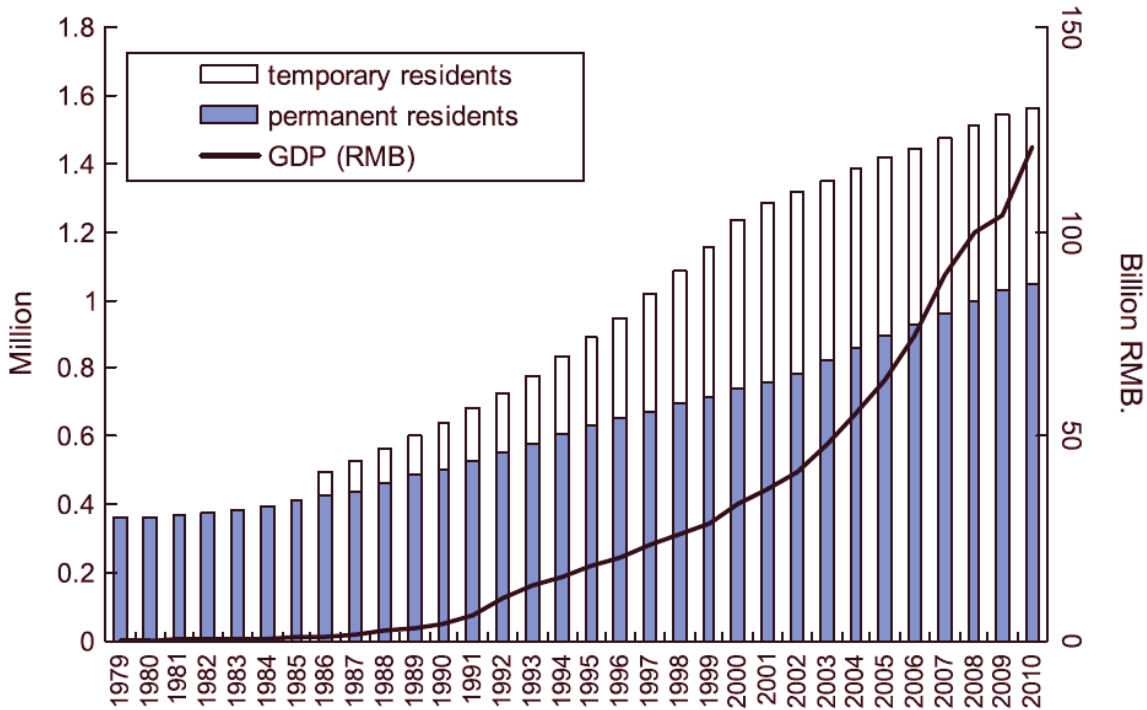


Figure 2 - Demographics and GDP growth (in Billion RMB) in the City of Zhuhai from 1979 to 2010 (Source: data from Zhuhai Statistics Bureau (2011); cited by Sheng and Tang, 2013).

With Zhuhai's energy industry only developed in 2002, the city has had steadily annual increase of energy consumption over the recent years. The data from Zhuhai's local government from 2007 indicates an increase of 12.2% in 2006 alone (Zhuhai's Local Government Website, data from 2007). These figures are indeed remarkable in terms of how the urban developments are major contributors to the rise of energy consumption. Also with the existing Zhuhai Free Trade Zone (Zhuhai FTZ) and five new high-tech and heavy industries, one may argue the city's expansion on its migrant-oriented housing development that are mainly in peri-urban and sub-urban areas of the city and are close to the industrial areas in the region. The rural areas, being under pressure as a result of such

expansion and development, are experiencing decline. In years to come, there is a potential possibility for such rural areas to become new peri-urban areas of a larger Zhuhai. As a result, this survey study, explores a variety of residential development in several built-up communities in three regions of urban, peri-urban and rural.

For this study, the survey areas comprise: a) several urban residential areas in Xiangzhou District; b) two distinct peri-urban communities in between the city core and Jinwan District; and c) few rural communities in the Western part of the city. The analysis is comparative between the three survey areas but is divided in to three parts of 'household occupancy, 'residential conditions' and 'seasonal household energy consumption'. In each part, the author provides a thorough evaluation of housing across three study areas. The survey study includes 143 urban participants, 132 peri-urban participants and 138 rural participants; whom are all temporary and permanent residents in the selected study areas of Zhuhai.

2.1 The Analysis of Household Occupancy Conditions across Three Study Areas

The key factor to any housing survey is the analysis of its conditions, one of which is the occupancy analysis. In this part, all participants were asked about number of residents in their properties. This is specifically important as the collected data indicates a clear overview of demographics in the three regions. The study of housing occupancy is relevant and important to changes in patterns of demographics and energy consumption that are later discussed in the study. The figure below demonstrates the overall data from the questionnaire survey on the topic of household occupancy (figure 3).

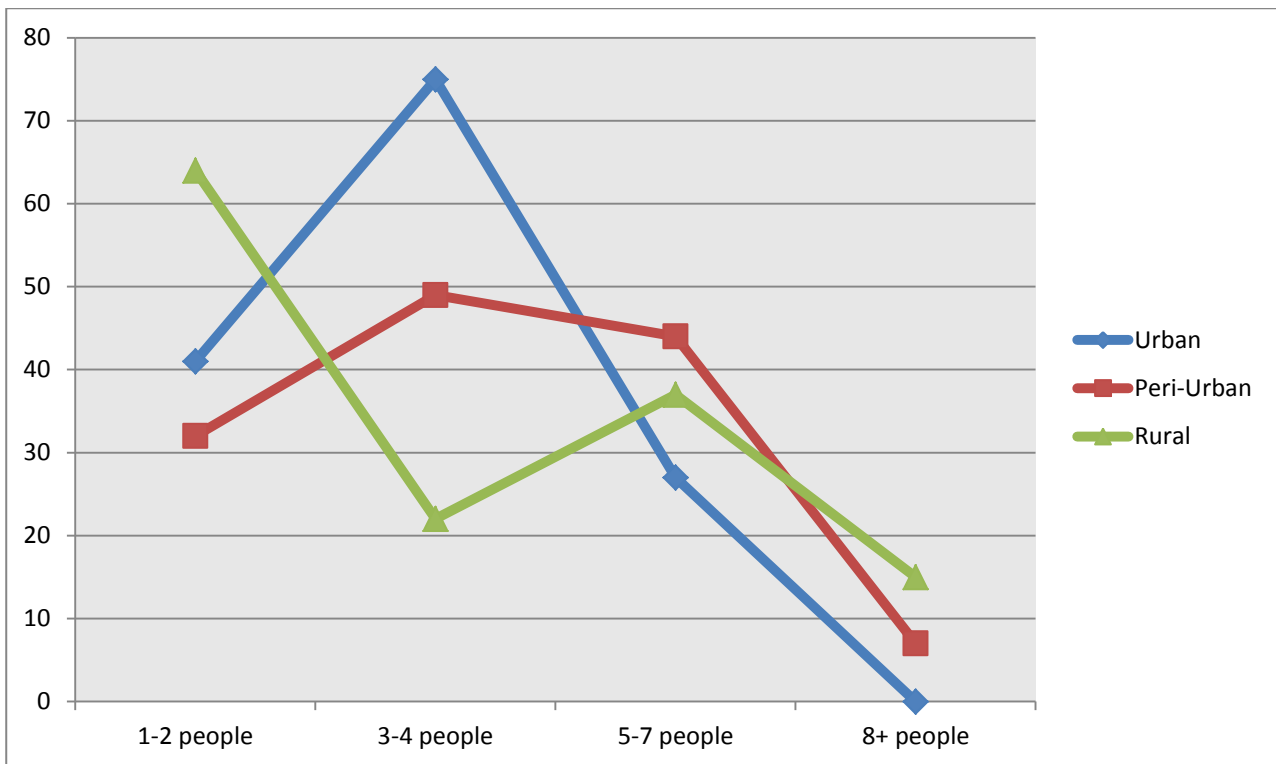


Figure 3 – Demographics and household occupancy in the studied areas of Zhuhai’s urban, peri-urban and rural (Source: author’s own data from survey study).

In the studied urban residential areas, more than half of the participants live in small family structures of 3-4 people per household. This is related to two aspects of one-child policy in China and higher cost of living in the urban areas. The latter can be analysed on the basis of higher housing price (Wang and Xu, 2009) or/and housing policy reforms since 1998 (Chow, 1998). Moreover, based on the collected data, there are not many larger or extended families living in the urban areas. This also can be related to smaller size of dwellings in comparison with the peri-urban and rural areas. Also based on the survey study, majority of peri-urban participants live in houses with higher numbers of occupancy. According to the observation, some of the surveyed houses are occupied by groups of young or middle age labours whom are employed locally. More than half of the participants under this category are migrants coming from other provinces in China. In both urban and peri-urban areas, we can observe similarities in terms of migration and family structure.

Moreover, it is visible that in the rural areas, number of people living either alone or in couples is significantly higher than in the urban and the peri-urban areas. Subsequently, in rural areas we can see a drop in households with occupancy of 3-4 people, while there is still a higher number of households with larger or extended families. Through observation, it is evident that almost all the houses with less number of residents are occupied by the elderly. Some of the elderly also take care of their grandchildren while their children are working in other parts of the region (particularly in the urban areas, where costs of housing and education are significantly higher). However, there remains higher number of household with extended families in the rural areas. In comparison with the urban, in particular, we can observe more family-oriented households that are still part of the rural communities. This is more evident where there are clusters of family members in particular parts of the rural areas. Traditionally, this pattern of living is part of family structure, family businesses and family employment (including farming). Nevertheless, with the current trend of migration from the rural to the urban areas, particularly for the younger generations, these family structures and living patterns are subject to change and even decline. With disparities between the rural and urban residents (e.g. Hukou System), this will remain as a major concern in the context of China. On the other hand, the ageing society of rural communities is a major threat to sustain the maintenance and management of such deprived areas. As the rural expenditure is still much lower than the urban expenditure, the older residents of the rural areas are expected to stay in their communities unless allocated to nearby towns or peri-urban areas.

2.2 The Analysis of Residential Conditions across Three Study Areas

Based on the survey studies, it is identified that there are significant differences in residential conditions of the three studied areas. Each of the three areas has distinct housing development patterns that are subject to detailed study and analysis. The relationship between living conditions and household occupancy can help us to better understand the patterns and demands that are emerging in each area. In this part of the study, the survey covers two aspects of residential conditions: the first is the analysis of number of bedrooms in the residential units/houses; and the second is number of stories for the surveyed residential units. These two aspects are both important to better understanding of potential development patterns and living conditions across three study areas of urban, peri-urban and rural.

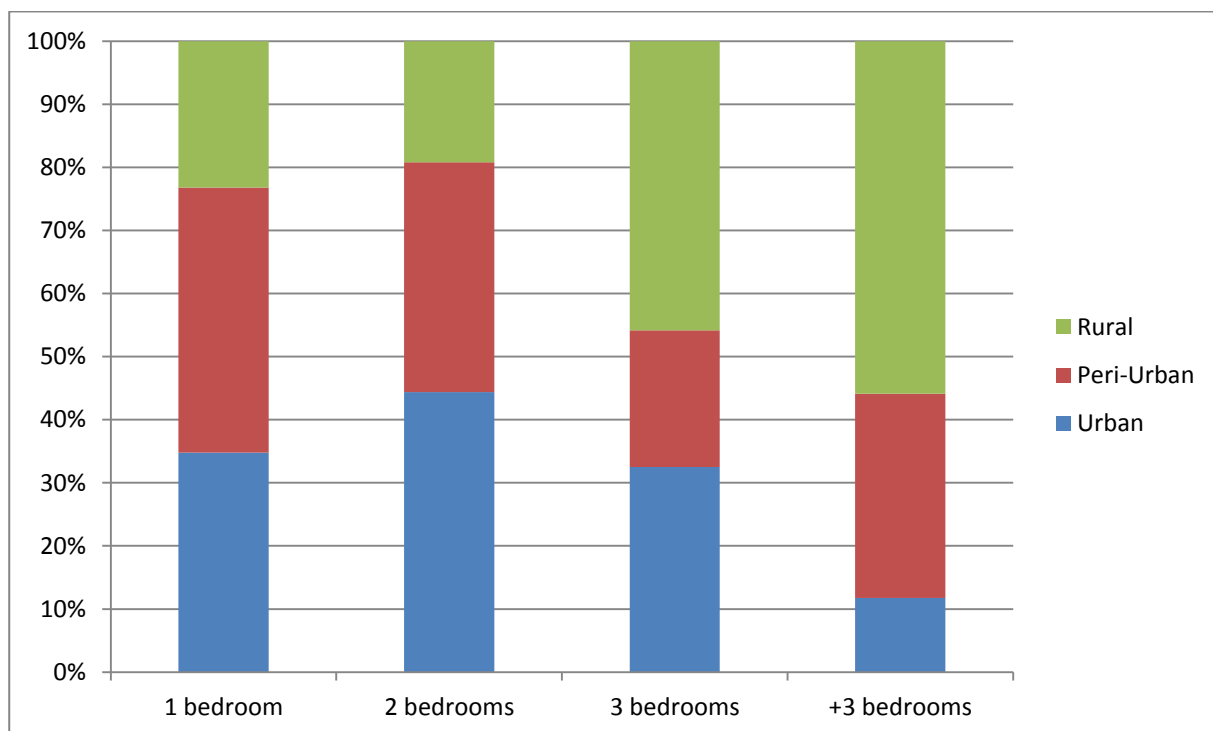


Figure 4 – Number of bedrooms for residential units in the studied areas of Zhuhai’s urban, peri-urban and rural (Source: author’s own data from survey study).

While there is a perceptible growth of China's urban housing stock, which is having severe impact on shrinkage of rural housing (Hu et al., 2010), the urban housing are significantly smaller than the ones in the peri-urban and rural areas. In the urban areas, majority of housing for low to middle class population are comparatively smaller than in sub-urban and peri-urban areas (figure 4). This is due to the increasing rental and purchase prices in recent years. Similarly, Wang and Xu (2009) have studied the case of China's housing prices and have analysed the relationship between urban development and housing prices. In their study, the authors question the requirement for affordable housing as part of sustainable development of China.

Also in this study, it is evident that a trend in urban housing is towards 2 to 3 bedroom dwellings that are suitable for smaller and younger families. In the past two decades, the shift from a '*socialist welfare system to a marketised system*' (Ping, 2012) and housing policy reforms have, to some extent, supported poor urban residents but have not yet tackled housing and poverty issues of the rural migrants. As a result, some of the observed urban residential areas with higher number of rural migrants are populated areas with smaller indoor living environments. Similarly for the peri-urban, apart from the extended family housing, the majority of larger households that were studied were occupied by industrial labours and temporary workers. Yet, in the rural areas houses remain significantly larger due to the traditional family structure and living patterns. Although from the empirical data of the study, rural and peri-urban houses are relatively larger than urban housing, the trend in which the marketised housing system is developing in the urban areas is considerably better than the previous socialist welfare system. This is due to better maintenance and more reasonable spatial configuration of living environments. Furthermore, the demand for smaller housing in the urban areas is deriving the urban housing market towards smaller housing units and compact development patterns.

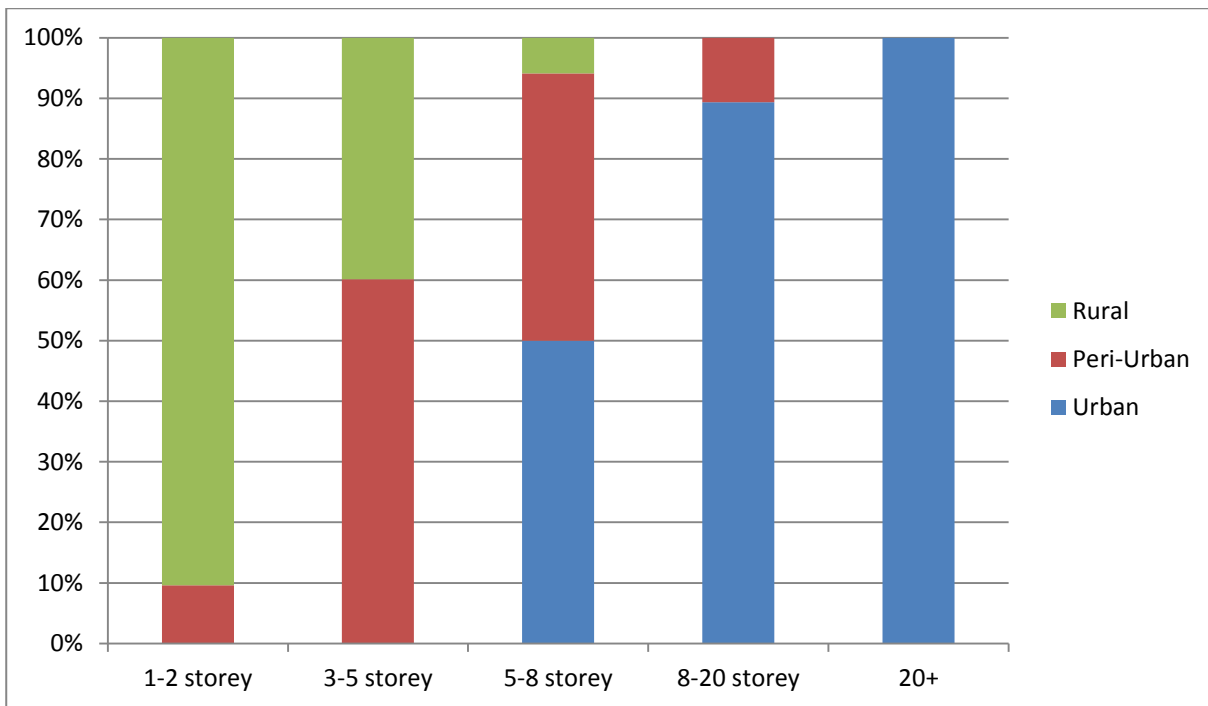


Figure 5 – Number of stories for surveyed residential units in the studied areas of Zhuhai’s urban, peri-urban and rural (Source: author’s own data from survey study).

Also as part of the housing analysis, the heights of residential units were observed and recorded (figure 5). In this respect, we can analyse an overall overview and trend of housing development in three studied areas of urban, peri-urban and rural. Based on the empirical data, the trend of housing is obvious and similar to any other growing city. While the urban has less low-rise houses, we still do not see many high-rise housing developments in peri-urban and rural areas. However, this is not the case in some other parts of China. The mid-rise and high-rise development in urban areas are now become the majority of urban housing in most major cities of China. Zhuhai’s case is no different. Also a trend of mid-rise housing development is appearing in the context of peri-urban areas. While in the rural majority of housing are still low-rise, neighbouring townships (that are larger) often have new mid-rise developments to attract new residents to the regional industrial areas where employability rate is often high. In the past two decades, in particular, the change in urban housing, from low to mid-rise and then to high-rise, has

changed housing typology, housing layout and the housing market of China's urban areas. In the rural, however, majority of housing development are still below five storey buildings but are mostly replacing the traditional one to two storey dwellings.

2.3 The Analysis of Seasonal Household Energy Consumption across Three Study Areas

A major part of the survey study focuses on the analysis of seasonal household energy consumption that fits well with the previous analysis of household occupancy and residential conditions. Based on the questionnaire survey, four key primary source of household energy consumption were identified in the region of Zhuhai, Southern Guangdong. Unlike many parts of China, gas usage is still cheap (due to subsidised prices) and popular for the households. Apart from gas, electricity, combined electricity and renewable energies, Coal (also sometimes firewood) are some of the main sources of household energy consumption. Nevertheless, the consumption is different between urban, peri-urban and rural areas. It is also significantly different in between the two seasons of winter and summer.

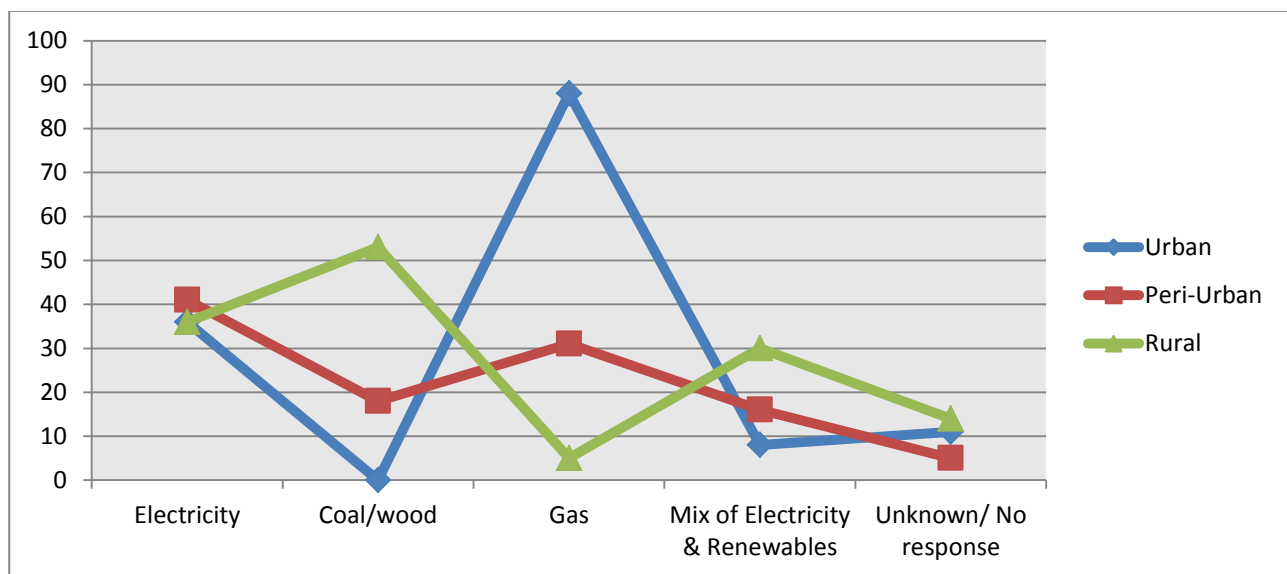


Figure 6 - Primary Source of Household Energy Consumption (including, lighting, cooking heating, cooling and other electrical uses) during winter

During winter, the household energy consumption for gas is significantly higher in the urban areas (figure 6). On the other hand, in the rural the gas consumption is minimal and is mainly replaced by coal (and firewood). Since heating is not required or is less required in the region of Southern Guangdong Province, majority of household energy consumption during winter is for the purpose of cooking and lighting. Hence, gas usage is high for cooking and water heating. Figure 6 above indicates that electricity usage is similar in between the three areas of urban, peri-urban and rural. However, if to take in to consideration the amount of usage based on energy consumption measurement, urban areas would have a higher percentage of electricity use in comparison with peri-urban and rural areas. One indicator and perhaps a major difference between rural and urban is the use of coal in cooking that is still very common in the rural areas. Also during the study survey, it was observed that in the rural areas more solar panels are used for water heating. This is mainly related to the height of dwellings and the importance that the solar panels are more effective in low-rise housing. In the urban areas, only few apartments in the higher floors of mid-rise and high-rise residential units can benefit from the use of solar panels. In general, the overall patterns between the three areas are very similar apart from differences in gas and coal usage. Rural energy development is still one of the crucial energy-related studies in the context of China. Previous studies (Keyun, 1994; Zhen, 1994; Aden and Sinton, 2006) have discussed the topic of rural energy as part of China's policy reforms and development plans.

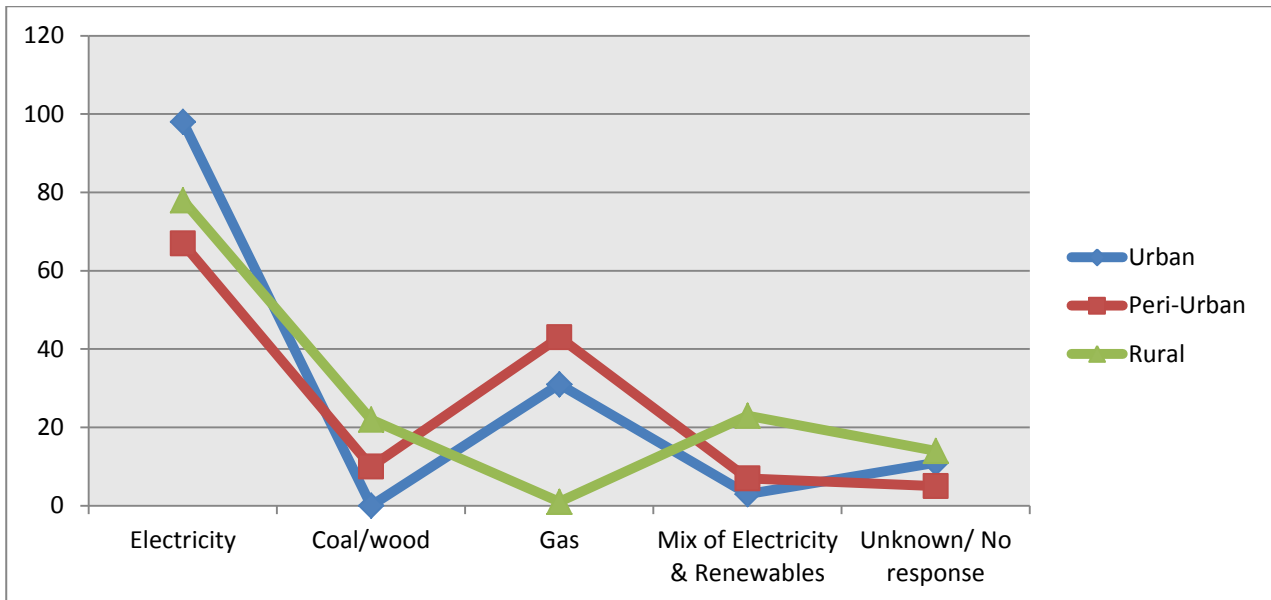


Figure 7 - Primary Source of Household Energy Consumption (including, lighting, cooking, heating, cooling and other and electrical uses) during summer

As part of the seasonal analysis of energy consumption, the questionnaire survey also covers the energy usage of summer period. This is studied predominantly because, during the summer period, household cooling is a major matter for indoor thermal comfort of the residents. In general, household cooling becomes a major demand throughout the region, particularly that relative humidity is high during the summer period and the effectiveness of natural cooling is minimised. This increased demand for cooling changes the energy consumption patterns of all three contexts (figure 7). The electricity usage uplifts substantially as majority of households use either air conditioning or electric fans for the purpose of indoor cooling. In the compact areas, such as compact urban residential areas, this is expected to be higher. In summer, gas usage is no longer the primary source of energy consumption as it is mainly used for cooking and water heating. In rural areas, coal (also firewood) is mainly used for cooking purposes. While the gas usage in the urban households is dropped during summer, peri-urban households have a slight raise in gas consumption. The electricity, however, remains as the main source of household energy consumption. The renewable energies are not effectively operative for the purpose of

cooling; and as a result are mainly used for water heating purposes (i.e. solar panels). Overall, the comparison between the seasonal energy consumptions signifies the increasing demand for cooling during the warmer period of the year.

3. Results and Discussion: Comparisons and Conditions

This study has touched on few relative aspects of change in lifestyle patterns, demands and requirements, seasonal source of energy consumption, and etc. In this study, the focus is on both 'energy' and 'housing conditions' in the context of Zhuhai. The comparison between the three areas of urban, peri-urban and rural is necessary to identify the gaps and analyse the trends of housing development and requirements. In Chinese urban-rural studies, energy issues, including policy reforms, development, affordability, access and security, identify the gaps between different social classes of the country (i.e. the urban and the rural residents). The peri-urban areas are mostly industrial areas of cities and have similarities with both contexts of rural and urban. However, the housing development patterns are still very different in between the three areas.

The conditions of the urban housing can be generalised as the followings: a) development pattern of mid-rise and high-rise housing with majority of the new housing being gated communities; b) increasing energy consumption with relatively small spatial layout (particularly for the low to middle income class) and small family structure; and c) significant consumption of gas and electricity for the purpose of cooking and cooling. In addition, the conditions of the peri-urban housing can be generalised as the followings: a) development pattern of low-rise to mid-rise with majority of houses being individual or in small communities; b) increasing energy consumption with mid-size housing and diverse household structures (i.e. family size or number of residents in one property); and c) generally moderate level of energy consumption with increasing demand for cooling during

the summer period. Finally, the conditions of the rural housing can be generalised as the followings: a) low-rise housing pattern and traditional settlement pattern with the new housing constructed as low-rise or under five stories; b) generally low energy consumption with larger family structure (i.e. mainly extended families); and c) minimal and often no gas consumption but high consumption of coal/firewood for the purpose of cooking.

The cross-referencing between occupancy level and number of bedrooms in houses indicate lack of spaces for majority of houses in the rural and peri-urban areas. Although larger in size, space remains crucial in some parts, particularly in the peri-urban housing. However, for the urban housing the relationship between occupancy level and number of bedrooms is fairly reasonable. While Zhuhai's trend of urban housing is mostly mid-rise to high-rise with less number of bedrooms, the rural housing remains low-rise (mostly 1 to 2 stories) with more bedrooms in dwellings. Most of these rural dwellings are occupied by extended families. On the other hand, peri-urban housing is moving towards mid-rise with either small or very large dwellings (in terms of number of bedrooms). The mid-size housing is less common in the peri-urban areas where residents are mostly labours or migrants from the other regions. In the rural areas, we can observe a gradual shrinking pattern to the family structures, where energy consumption is minimal. In the urban areas, we can observe a higher consumption of gas for cooking and water heating. This is due to having indoor kitchen and also indoor bathroom, where in the rural both are often outside of the main living indoor areas (i.e. bedrooms and living rooms). The poorer rural housings mostly have semi-open or detached kitchen facilities where coal and firewood are used considerably. According to the collected data, the primary source of household energy consumption in between the urban and the peri-urban is following a similar trend. This indicates the considerable transformation of demands and patterns for energy consumption that are taking place in the non-urban areas (i.e. peri-urban in particular).

Finally, based on the analysis of the field survey, there are certain housing characteristics in three studied areas of urban, peri-urban and rural. These characteristics can simply indicate the overall housing development patterns that are specific for the context of South China. The results from seasonal household energy consumption analysis show the raise of energy consumption for the purpose of cooling during the summer. This signifies the need for energy saving plans that are required as part of housing design specifications. Nevertheless, the energy saving development plans are mainly focusing on the urban areas, where a huge market of housing is under progress.

3.1 Complications and Challenges of Housing in China

Since land ownership is still very different in between the urban (i.e. owned by the state) and the rural (i.e. owned by collectives) areas (Ding, 2003 and 2007), it is expected to have two clearly different modes of transformation in housing affordability and land development. The peri-urban housing is expected to follow a mid-rise housing pattern, which is probably more affordable than the urban housing due to the contextual conditions and locations. However, in the sub-urban areas, new low-rise housing is developing as a new pattern, which almost represents the Western urban sprawl. The considerations on energy and housing in China are currently happening at a slow pace and small scale. Since dynamics of housing stocks keep changing in the past three decades, we anticipate further changes in housing development and energy saving patterns. The widespread urban development and the rapidly increasing provision of housing (Chow, 1998) are key players to China's future housing reforms. In their study on *Sustainable Housing and Urban Construction in China*, Zhu and Lin (2003) start to argue on energy efficiency of housing, preserving energy security and optimisation of energy structure that are essential factors in China's housing development.

The empirical data from the survey studies indicate complications such as space and occupancy, and point out major challenges of energy and housing development patterns. Although the study's focus is on energy and housing conditions in a particular context, it provides an analytical understanding of how these conditions can develop into potential cases for consideration of design patterns for future development and regional strategic plans. In this respect, we can argue that the main challenges of housing in China are still 'affordability', 'energy saving plans' and 'new design specifications'. All of these attributes are vital to China's community of developers whom play effective role in housing stock market and development patterns.

In addition, this study has developed a platform to further understand the energy and housing conditions in the region of Zhuhai's urban, peri-urban and rural areas. This comparative study of housing in the three studied areas is essential to further analyse: a) what affordability measures are required and where?; b) how we should proceed with energy saving plans that include not only the urban but the peri-urban and rural areas; and c) how we may develop new design specifications that are suitable to specific contexts?. In this sense, the case of Zhuhai is a general representation of the conditions in the Southern China, where the potential influence on energy and housing policies are strongly required and essential for the future housing development patterns, housing conditions and energy efficient plans. A similar case is the development of China's 'Green Strategy Plan' (Zhang et al, 2011), which is proposed to improve China's current practices and technologies in building design and development. Yet, the current proposals are mainly focused on the urban areas than the rural. Therefore, there remains a substantial gap in housing reforms, strategy plans and implementation mainly between the urban and the rural areas.

4. Conclusions

This study identified the key elements for housing conditions in the region of Southern Guangdong Province, in various areas in the region of the City of Zhuhai. As part of the specific survey study, the collected empirical data represent trends of development and housing conditions in various cases. The housing conditions between the urban, the peri-urban and the rural are not only related to the visual dimension of the built environment but related to their occupancy, living styles/structures, energy source and consumption. The study also pointed out the directions for current development patterns and essential need for housing reforms. This study is also a suitable platform for energy-specific studies in the region of Zhuhai, where the focus is on measuring energy consumption, development of energy saving plans and improvement of housing's energy efficiency.

This study is aimed to provide a better comparative understanding of housing in three areas of urban, peri-urban and rural. The collected data from the questionnaire survey covers the basic knowledge of housing conditions in these studied areas. The cross-analysis of data aimed to identify the needs, demands and trends that are subject to further detailed analysis. The limitations of study, based on time and access to energy-related data, indicate potential research in the fields of energy efficiency and cross-contextual energy saving plans, specific to housing development and support for future design specifications and housing policy reforms. Furthermore, we can conclude how the current housing conditions can help policy makers to come up with strategies and energy saving plans that are comprehensive, detailed and context-specific. Therefore, we can argue that the next housing reform in China needs to incorporate conditions of housing in all areas of urban, peri-urban and rural, where various parameters and approaches are necessarily for better implementation and development that are aimed for a more sustainable future. Based on the study survey and analysis of the collected data, it is important to consider three pillars of 'affordability', 'sustainability' and 'design specifications' and develop them in to a holistic framework of housing reform strategies that include

various elements of living quality, energy saving plans and efficient design or even planning. Finally, it is important to consider cross-contextual analysis of both energy and housing conditions in order to respond effectively to future housing and development strategies that are expected to include major elements of energy consumption plans, energy resource analysis and low-carbon considerations.

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