TECHNICAL AND NON-TECHNICAL FACTORS FOR THE APPLICATION OF RENEWABLE ENERGY TECHNOLOGIES IN THE RURAL AREAS OF CHINA

LIU Yu[1], SHEN Yihe[1], ZHANG Yifei[2]

[1]Sustainable Building and Environmental Research Institute/Northwestern Polytechnical University, Xi'an (China)

[2]Department of Power Engineering/Xi'an Aerotechnical College, Xi'an (China)

1. Introduction

To balance urban and rural development, the Chinese government has initiated a New Village Construction movement from the early of 21st century. Since then, the vast rural areas that involves a huge number of villages have been undergoing a reconstruction/renovation process. From around the same period, renewable energy technologies (RETs) have been greatly promoted in the country as one of the most important ways to deal with the contemporary energy and environmental problems. Combing the above two aspects, how RETs have been applied in the village reconstruction/renovation process and what are the problems and or barriers for their application in such areas become questions that are worthy of investigation. Based on preliminary field investigations and questionnaire surveys, this paper identifies and discusses some technical and non-technical factors related to the above questions, hoping to provide references and insights for further researches in the relevant areas.

2. Reconstruction/renovation of villages in China

There are about 3.2 million villages in China (Tsinghua Building Energy Research Center 2007). By the end of 2008, the building construction areas in the villages remain up to 22.1 billion square meters, which accounts for 56% of the total building construction areas in the country.

In the long past history, due to the substantial difference of economic and living conditions between urban and rural areas in China, energy consumption of buildings in the rural settlements/villages has been much lower than that in the cities. However, alone with the high speed economic growth as well as the ever increasing urbanization in the recent decades, living conditions and standards in the rural areas have been constantly improved and many rural areas have quickly changed into suburbs of cities. Large scale migration of young people from villages to cities, either temperately or permanently, has largely increased the communication and interaction between rural and city communities; as a result, rural life styles have become more and more closed to that in the cites.

The 2009 Annual Report on China's Building Energy Efficiency (Tsinghua Building Energy Research Center 2009) states that the rural areas in China have moved quickly into a reconstruction stage, which implies both great opportunities and challenges for the development and application of RETs in China (Bing-Di 2006).

3. Field investigaitons about RETs' application in the rural areas of China

China possesses rich renewable energy resources, including solar, wind, hydro, biomass and geothermal energies etc and has long promoted RETs for its large population in the rural area (The World Bank 1996). In the recent 10 years, more efforts and larger amount of funds have been put on developing new RETs in the country, a Renewable Energy Law has been put in place with the target to boost the use of renewable energy capacity up to 10 percent by the year 2020 and new development of RETs have greatly added to the options available for energy supplies in the new village construction process in the country.

With this background and supported by the Ministry of Housing and Urban-Urban Development of China, the Natural Science Basic Research Plan of Shaanxi Province (project number:2010JM7014) and the Shaanxi Province Key Lab of Western Architecture & Technology (project number: 09KF2), a series of preliminary field investigations have been conducted in the newly constructed villages. The aim was not to get precise statistic results but to understand the large and basic conditions, to identify general problems and barriers, and to provide effective advices for further promotion of RETs and other energy-saving technologies in the rural areas of China.

This paper introduces part of the results of the investigations which are especially helpful in identifying barriers and problems for RETs' application in the rural areas of China. The discussion are focused in two aspects: the active RETs and the passive design of buildings

3.1. Active application of RETs

Results of the field investigations show that a variety of RETs have been actively applied in the rural areas of China, including solar water heating, solar cooking, PV lighting, small scale wind electric power generation and biogas lighting/cooking systems, etc (Fig.1). So far the most widely applied ones are the solar water heating systems and the biogas lighting/cooking systems, while the least applied ones are the PV/wind electric power generation systems. The later ones are usually applied either in the selected demonstration villages or isolated villages that are located far away from existing infrastructures and are hard to construct new ones due to their natural environmental conditions (e.g. in the remote mountainous areas, etc.) and they are mostly sponsored by the central or local governments.

Fig 1 A variety of RETs been applied in the rural areas of China

Face to face interviews in the investigated villages reveal that the benefits for applying RETs, especially solar energy technologies for improving indoor thermal comfort and reducing heating costs in wintertime, have been well recognize by many rural residents in the newly constructed villages. Many rural residents have interests in applying solar water heating system in their household and those raise domestic animals or plant corns, vegetables and or fruits also express interests in applying biogas systems as long as they are reliable and affordable.

3.2. Passive design of buildings

Passive design of buildings is investigated as a special and important type of RET in this research as it can help in utilizing renewable energies (e.g. solar, wind and geothermal energy) in the buildings.

Passive design and construction methods have been practiced in vernacular buildings in China's long past history. For example, the heavy clay structures have been dominate building structures in the large rural areas for thousands of years. However, results of the field investigations show that they have been abandoned quickly in the new village construction process and replaced by a simple brick and concrete structure that have spread widely all over the country (Fig.2), although their energy-saving capacity and indoor thermal performance of the former ones are still widely known and well recognized.

Fig 2 Heavy clay structures (left) replace by simple concrete and brick structures (mid and right)

Face to face interviews reveal that this is happening mainly because that comparing to the simple brick-concrete structures, the old heavy clay structures usually take longer time to build, occupy more structure spaces, provide less flexibilities for indoor space arrangements and cost similar or even more to build. And

above all, looked old and out of date, the heavy clay structures are seen as a symbol of the past poor rural lives. Although the young generations of rural residents were born and grew up in the villages, many of them have worked and or studied in the cities for some time. They know more about city life styles, have more income comparing to the older generations and expect to build new style houses than represent better living conditions.

Some research have been done in developing new styles of passive housing in the rural areas, the performance of which still need to be tested and proved by users over time.

3.3. Problems and barriers for the application of RETs

The problems and barriers for active application of RETs and passive deign of buildings in the investigated regions are mainly revealed as the following:

(1) For active application of RETs

- Although many programs have attempted to extend renewable energy supplies to rural area, the costs for installing such systems are still unaffordable for many rural households in China. For example, the PV solar systems been promoted in many demonstration projects are still unsuitable for the vast normal rural consumers because of their high costs and relatively low efficiency.
- Some suitable RETs may change into unsuitable due to climate change over years. One example in the field investigation shows that a wide afforestation campaign in the mid north China area have caused a distinct reduction of wind speed, a joint consequence of which is that the small scale wind electric power generation system been applied in the demonstration projects in that region became useless after only 1-2 years of installation.
- The seasonal low efficiency of some RETs can add troubles to their users. The field investigation shows that, for the many rural families who live in the cold and severely cold regions and use biogas stoves, they have to install a second stove which can use alternative fuels (e.g. coal, firewood, gas, etc.), so that when the production of biogas generation system becomes very low and unstable in the cold wintertime, they can still cook their meals.
- The suitability of RETs can be affected by the availability of other natural resources. For example, the solar water heating system depends not only on solar energy but also on water resources. The field investigations shows that, in some rural areas in China, lack of reliable water supply equipment is a factor that limits the use of solar water heating systems.

(2) For passive design of buildings

- For the traditional rural houses, although possessed many advantages from the passive design point of view, they are not attractive to the younger generations in the rural areas anymore for many reasons (e.g. they take longer time to build, require more labor cost, looks out of date and represents fall behind and poor living conditions of the past time).
- For the carefully designed new passive rural houses, due to insufficient instructions and guidance to the users, some of them may not perform as expected (e.g. the opens or tunnels for natural ventilation may be sealed or blocked during the renovation process or even normal daily activities).

To summarize, problems and barriers for the application of RETs in the rural area of China mainly includes but is not limited to the following: (1) economic affordability; (2) technical reliability; (3)natural resource availability; (4) culture acceptance; (5) user guidance.

4. Questionnaire survey about RETs' application in the rural areas of China

To further understand rural residents' perceptions regarding the relative importance of different factors relating to RETs' application in the rural area, a small scale questionnaire survey was designed and conducted after the field investigations. To limit the realm at the same time ensure the effectiveness of the results of the survey, registered university/college students who originally came from rural areas of the country were selected as the targeted population for the survey. This is based on the consideration that these

group of people can best represent the young generations of rural residents who have experience of both rural and urban lives, have more knowledge of RETs and usually play important roles in their extended families. 350 questionnaires were sent out and 287 replies were identified as valid for the purpose of this research.

Results of the survey reveals the following:

- First, majority of the respondents（96.6%）stated that they had applied one or more RETs (mostly solar energy technologies) in their families and have certain knowlege and experience about RETs application.
- Second, 40% of the respondents considered economic affordability as the most important factor for application of RETs in their family. This is followed by the effectiveness (22%), safety (21%) and reliabilty (9%) of the technology (Fig.3).

  A related respondence shows that, to effectively promote RETs in the rural areas, the three most important factors for decision making are deames as goverment subsidy(48%), large increase of energy cost (24%) and decrease of price (19%) (Fig.4). At the same time, if a passive house possesses better energy-saving performance but would require more construction cost comparing to a normal one, about half (49%) of the respondents would not accept it, 29% were not sure, only 22% would accept.

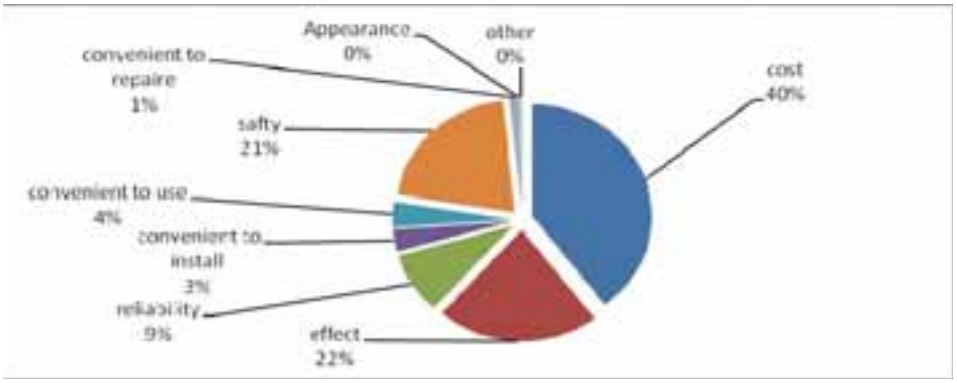

Fig 3 Factors that affect the application of RETs

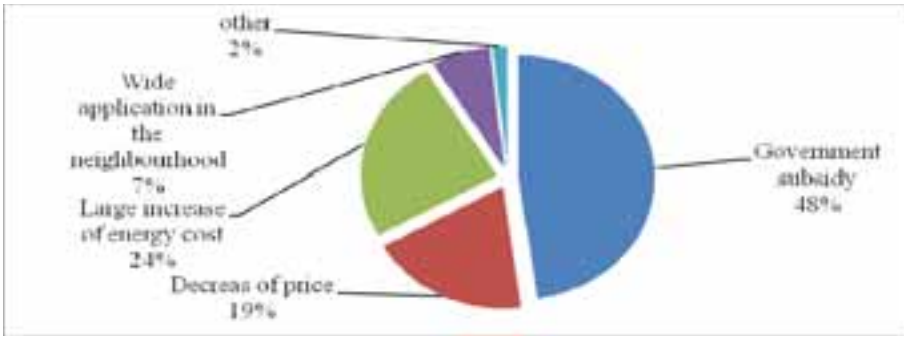

Fig 4 Factors that may help to encourage the application of RETs

- Last but not least, the style and apperance of building play an implicit but important role in the application of RETs in the rural areas of China.

  The appreance of the RET device or system itself w s not considered as an important factor to the rural residents (Fig, 3); however, if the appearance of the building style would be affected due to application of RETs, only 44% of the respondents would still accept it, 29% were not sure, 27% would not accept. For traditional housing styles, although recognizing their better energy-saving performance, more than half (58%) of the respondents would not accept them, 23% were not sure, only 19% would accept.

5. Conclusions and further research

The overall results of the investigations and surveys in this research show that a variety of RETs have been applied in the broad rural areas in China especially in the newly construted villages. Some of the technologies have been widely applied by normal rural households, some are more adopted in government

spongsored demonstration projects. Economic affordability, technical reliability, natural environmental conditions, culture acceptance and user guidance are the five major factors that affect the application of RETs in the rural areas of China.

In order to effectively promote RETs in the rural areas in China, further reseraches are recomended to be concentrated not only on the technial fators (e.g. efficiency, reliability and safey of the techinical systems), but also on the non-technical factors, such as economic affordability, culture accpetance etc. For example, more efforts should be put in establishing more feasible and comprehensive economic intensive systems, and in developing new generations of rural passive houses that not only abstract wisdoms from the past, but also fit into the needs of furture rural style. The building styles should be accpeted and welcomed by the rural residents, especialy their younger generations, and the operation of the buildings should be properly guided.

6. References

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