Transforming the Rural Residence System Into a Modern Ecology

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Abstract
Rural housing is a small eco-system consisting of ecological structures, ecological behavior and ecological concepts, which interact with one another and coexist in a symbiotic manner. Based on ecological unity, this paper carries out research on how to transform the rural housing system from its primitive ecology into a sustainable modern ecology, applying the ecological coupling design concept to guide the building of rural housing. The study emphasizes taking advantage of farmers' behavior and consciousness to improve the ecological environment of rural housing, and then extends this further to realize livable residences that embody low consumption.

Keywords: primitive ecology; modern ecology; rural residence system; ecological coupling design

1. Introduction
Differing from the passive consumption pattern of the urban residence, which features the pursuit of enhanced living through material means, farmers have for hundreds of years utilized many forms of labor while actively employing natural resources which are compatible with the local, natural and cultural characteristics of the rural environment to create an ecological living environment under a circular economic (CE) pattern (Armitage, 1999; Boulding, 1966), and has created a lifestyle with low ecological impact which has been considered as the ecological dominance of primitive ecological residence (Ren, 2005). However, due to historical constraints in terms of the availability of materials and technology, houses have typically been constructed crudely to a primitive condition through coarse building craft resulting in a humble environment and facilities, and typically accompanied by a simplistic lifestyle. Such accommodation is unable to fulfill the hopes of farmers who hold aspirations of a more modern approach to life. In order to effectively improve farmers' living conditions, old houses were actively replaced by ones featuring new materials, technology and manners of energy consumption in the present study, which is apt to transplant the industrialized construction mode of urban housing into rural areas (Zhu and Hang, 1999). The resulting comfort and energy saving from this pattern are normally based on the use of energy-consuming equipment and non-renewable resources on a large scale. Meanwhile, pursuing the performance of hardware in this unbalanced manner will generate fresh waste in the form of spent material and energy, while the cost of construction and maintenance also becomes a new financial burden for farmers. On the other hand, although houses are transformed into modern ones, they lack traditional rural context inherited from the rural ecology, and thus a disconnect begins to manifest in respect to the relationship between the farmers, their houses and the environment (Bai, 2010). More importantly, the native humanistic farming ecology, including being courteous to nature and clear to their established values, has been spoiled by imitation of the consumption-based urban residence mode. Therefore, taking the ecology as an integral system, the authors' aim has been to integrate the ecological dominance of primitive residence and the living requirements, behaviors and concept related to modern farmers in an organic manner in order to create a sustainable modern ecological residence system, which will be of value for rural ecological living environments.

2. Transformation of the Ecological System of Rural Residence
The rural residence system can be categorized into three dimensions: ecological structure, ecological behavior and ecological concept. Together, these form a small ecological system through the cycling of materials and energy in which their elements interact and coexist. The eco-system framework and elements are listed in Table 1.
It can be seen that the farmers' ecological system reflects the integrity and diversity of the building and rural residential cultures, which are united in the housing space. The ecological structure provides farmers with a moderately comfortable living space and reasonable living. Consequently, the ecological concept and behavior of farmers also develop and improve the ecological structure in a positive way.

With agricultural modernization, economic multi-polarization and significant improvement of farmers' living standards since the reform and opening up of China's economy, the rural residence with laggard agricultural features has to transform from a primitive ecology into a modern ecological environment. Nevertheless, the characteristics of the primitive ecology residence that allow for low ecological impact and which depend on self-organizing, self-adapting, self-adjusting and cycling are facets that the farmers hold dear and will not easily relinquish (Li, 2010). For example, by relying on the self-adjusting capacity of traditional building facilities in rural areas, the farmers in northeastern China resolve the issue of domestic heating simply by cooking on an open fire three times a day. Production and livelihood are utilized as efficiently as possible in the living facilities, and which should then be recycled. For example, after collection in a cesspit the night soil can be cycled back into the farmland as fertilizer, while farmers have a preference for crop planting and livestock feeding in their courtyards. A conclusion can be drawn that the renewable resources and the farmers' own humanistic values are key to realizing the ecological dominance of the primitive ecological residence, and are also extremely valuable for creating modern rural ecological residences. However, due to the limitations of the traditional structures and materials, low cost has also been accompanied by the scarcity of residential comfort and quality in general, and is thus not conducive to enhancing the farmers' lifestyle. For example, the limited height of the cooking bench...
typically does not allow stand-up cooking due to comfort constraints; moreover, the position of the Kang (heated brick bed) is too elevated for the household, due to the required connection with the stack nozzle. The one-piece construction also restricts the interior layout of houses, which results in the confusion of functional spaces and the consequential primitive living style of eating, sleeping and entertaining on the Kang. Therefore, typical rustic homes are not adequate for the modern ecological rural residence, with the forms of primitive ecology simply preserved or reused in a protective way due to an archeological mentality. It is thus necessary to reshape and integrate the ecological structure, behavior and concept of the primitive ecological residence in order to adapt to the progress of industrial civilization and change based on the modern farmers’ characteristics.

3. Ecological Coupling of the Rural Residence System

Based on the internal connections between buildings, technology and occupants in rural residences, there are multiple relationships of interaction and coexistence among various ecological elements in this ecological system (Liu, 2009; Von, 1973), including self-coupling within the housing ecological structure, strain-reactive coupling and coupling of coexistence between the ecological structure, ecological behavior and ecological concept. Moreover, coupling between subsystems of the same level or at different levels can also lead to the improved performance of new systems. Not only are diversified ecological elements and sophisticated coupling among the elements found in modern ecological residences, but also sound compatibility and coordinated development of the elements at various system levels.

3.1 Self-Coupling Design

Self-coupling design is an intuitive coupling method that can cope with technological problems in terms of the building implements’ aspect by employing various technologies, materials and craftsmanship. For example, new structures can be obtained with all kinds of new building components and relevant traditional technologies. All technological issues related to a certain building’s performance can be harmonized and recombined to improve the function of the residence system based on self-coupling design ideas.

3.2 Co-Existence Coupling Design

Housing and residents are interconnected, becoming an ecology in the residence system allowing for a coexistence relationship that is inter-dependent and mutually beneficial (Naess, 1995). Co-existence coupling is an important means by which to realize farmers’ humanistic values in the residence system, such as the farmers’ participation in energy supply, decoration and interior design, and energy-saving activities. Farmers’ lifestyle preferences and qualities will be gradually improved as a result of the improved hardware in the environment. For wealthier farmers, the process of acquiring an affordable and comfortable house through large-scale interaction with the ecological structure will not only improve their material environment, and elevate their self-esteem and confidence, but will also greatly enhance their satisfaction and sense of belonging to the rural life.

3.3 Strain-Reactive Coupling Design

The self-coupling system formed by the interactions of building elements is resilient to the complexity of construction, building materials and labor costs, consumption standards of farmers and the local building context, etc. The housing style also needs to be consistent with the new economic patterns, rules and local regional planning of development in rural communities. It is clear that the phenomenon of strain-reactive coupling can be considered as the progress of mutual adaptation between the living environment and residents. The quality of the living environment has become an important driver for training modern peasants, while the lifestyle behavior of farmers manifesting from the shifts in their hopes and aspirations are also continuously influencing the ecological structure of the residence. Consequently, the authors propose strain-reactive coupling design strategies based on a behavior-conducive and idea-conducive approach.

4. Ecological Coupling Design of the Modern Ecological Residence in Rural Areas

A rural residence in good ecological condition is reflected in the occupants’ satisfaction, as well as their ability to resolve the lifestyle challenges encountered (Yoshizaka, 1984; Zhou, 2010). For example, both the energy saving capacity of buildings in construction and in daily life directly determine the living cost of farmers; in hot climates, the residential ambient temperature is a pressing issue for farmers who wish to change as it directly impacts on their living standards and health; and the issue of cultivating a new farmers’ image also relates to rural civilization and community development. It can clearly be seen that living problems are the basis on which coupling elements interact with each other in the ecological coupling relations of the rural residence. The complexity of the living issues also determines the complexity of the coupling patterns. If greater coupling elements and levels can be understood, the obtained results of comprehensive design and overall performance of the residence system will be further optimized.

In the process of building a modern residence system, the focus of selecting appropriate technology should not only be based on the economic applicability, which integrates with the local specific requirements and the actual conditions, but also on the ecological suitability that allows for the capability of improving the comprehensive benefit in terms of housing as an ecological environment. The aim of ecological
coupling design is thus to build sustainable residences, and so development is sought through coexistence between farmers and their housing. Traditional technologies and modern technologies are equally important, compatible and platforms for each other; while it is only through achieving a balance in the specific coupling relations of the ecological system of residences that this technology or the new coupled technology can be in accordance with the required outcomes. From this perspective, the authors provided guidance to the construction of a demonstration housing project in Piaojiagou Village in Chentun Town, Gaizhou City, Liaoning Province, China.

4.1 Background of the Project
The demonstration housing project is located in a monsoon belt, with the number of days at which the temperature is below 0°C being between 170 and 210, annually. The extreme minimum temperature is approximately -25°C. The village is 37km from Gaizhou city and is situated in a hilly and seismic zone. The water table can be found approximately 5 meters below the surface. The agricultural production method primarily involves using small mechanical devices, while the universal educational background of the farmers is at the primary school level. It was shown in the comparisons of the exterior of this house before (Fig.1. and Fig.2.) and after (Fig.3. and Fig.4.) retrofit.

4.2 Energy Saving Design of the Building
The wall structure, steel structure, floor and roof have been integrated by employing self-coupling design in this work. Some passive energy-consumption building designs were adopted to construct the building structures with less material, low cost, high degree of seismic resistance, and simple construction technology based on the actual consideration of the local consumption ability for housing. For example, the traditional wooden frame was replaced by using the steel structure presented in Fig.5., inheriting the form of traditional brick components for the building envelope, but replacing the red bricks with slag bricks and a new type of bricklaying as illustrated in Fig.6., where three horizontal bricks and one vertical brick form a type of new lightweight wall construction that is easy for the farmers themselves to build.

Based on the strain-reactive coupling among the buildings and building materials, labor cost and local natural resources, apart from some locally accessible materials and some materials of the traditional roof (Fig.7.), simple and viable construction methods were used for the new roof (Fig.8.), inner enclosure facade and insulation of the floor (Fig.9.), in view of traditional material methods typically being time-
prove`ed and comparatively cheap. Furthermore, a degree of practical interest was afforded to the integration and innovation of the structure between the traditional materials and new materials.

On the basis of the characteristics of small plots of arable land per household, restricted outdoor activity during the cold winter months and the seasonal return of migrant workers in this village, the authors created conditions for farmers to undertake family artisanal sideline activities with strain-reactive space design, according to the coupling relationship between the functional and the behavior-conducive space. The authors planned for a workshop and warehouse space in the western aspect of the house for rural craftsmen to create local products and engage in handicrafts, or as a space where raw materials and tools could be stored. Not only do the separate entrance doors for these two functional spaces provide convenient entry and exit points for farmers, but they also prevent the heat in the living space from dissipating, and thus a comfortable interior environment can also be maintained. The division of working and living spaces has enhanced the comfort of the interaction process between the farmers and spaces, while the tools and furniture were also more conveniently located. At the northeastern corner of the living zone, a multi-function room was established, which could not only be used as a temporary guest room, but also as a storage room for daily miscellaneous items.

Taking advantage of co-existence coupling and strain-reactive coupling, the decoration of the interior walls was through the traditional craft of backing paper, installed by the farmers themselves. The authors replaced the conventional newspaper (Fig.10.) with common packing paper embodying local folklore characteristics and being delicately printed (Fig.11.). This has an elegant appearance and involves reduced cost; moreover, the paper can be repaired or replaced at any time in order to save money on wall decoration and maintenance.

4.3 Thermal Environment Design

To ensure the general thermal environment of the house is well maintained, the authors designed a new type of overall heating system to replace the traditional Kang-oven heating system, which included the self-coupling design among the heat-insulation wall, wallpaper, the heating collection windows, heat-insulation roof, eaves and damp-insulation floor; while
the southward rest area and the windows of various dimensions were also carried out with strain-reactive coupling design based on the space arrangement with the outside environment. For example, the cold-bridge phenomenon is avoided due to the separation of the lightweight steel structure from the building enclosure (Fig.12.); the outside cold air can be effectively prevented from penetrating the roof due to the static air layer in the roof structure (Fig.8.); the heating collection windows (Fig.4.) are more economical in saving homestead material than the common solar sunroom and were derived by us with a self-coupling design between the wall, windows and sunroom; and by sealing the corners of the rooms the wallpaper can also function as a heat insulator.

Regarding the supply of heat, and according to the co-existence coupling relationship between the dwellers and hardware of the thermal environment, some of the cultural features of the Kang in northeastern China were maintained. Inheriting and applying the heat-supplying principle from the food preparation process (Fig.13.), the co-existence coupling design between the Kang, the smoke tunnel, the fire-wall and the oven has been explored. However, the established connection mode between the Kang and the oven was eliminated by the electrically heated Kang being separated from the high-platform oven, the section of new Kang-oven heat-supply system as shown in Fig.14., which can lead to greater flexibility of the interior space arrangement, and the farmers being able to cook their meals comfortably without bending forward. The structure of the oven and its burning method also have the potential to be renovated. For example, the large cooking pans could be smaller in size, while the cooking fuel could also be replaced with a bio-granular fuel emitting less smoke. Furthermore, the previous elementary cooking technique, such as where every dish is prepared with one pot and the stew-based diet structure could be modified into more delicate and varied techniques. The authors also applied the self-coupling design to the oven, smoke-tunnel and wall, i.e., the wall between the toilet and the kitchen, the wall between the partition of the sitting area and the bedroom are connected with the oven via the fire-wall, respectively; moreover, the heat of the oven is transferred to the northern wall of the toilet, the northern and the eastern walls of the multi-

function room, and the eastern wall of the bedroom by using the smoke-tunnel to transmit heat to the various rooms (Fig.4.). This approach differs from the heat-supplying mode of conventional houses which rely on the Kang and oven as the main heating source.

4.4 Energy Saving Design in Daily Life
The design for energy saving in daily life aimed at invoking a subconscious or conscious effort for farmers to conserve energy through the energy-living facilities and guidance on lifestyle changes.

The electric geothermal film in the living room and the electric Kang in the bedroom can perform independent thermal control, which is convenient for farmers to selectively generate heat energy in accordance with their actual activity areas, and also compensates for the attenuation of the thermal effect from the traditional Kang-oven heating system. The effort in this work has shown the strain-reactive coupling design for accommodating behavior-conducive living. In addition, the self-coupling design has been applied in the kitchen under the passive energy-application concept, including replacing the traditional underground cave (used only to store ingredients) with the cabinet built-in cellar and its supporting storage box, which can be lifted and lowered into position and represents a natural refrigerator (Fig.15.). The authors also changed the square interior shape of the traditional oven into that of a circular interior shape (Fig.14.); moreover, there are two pots of large and small size installed on the cooking bench: the small one available for daily cooking, and the other for the rough processing of crops and feed from the backyard, etc.
Based on the coexistence relationship between the building and its dwellers, a potential-energy power-generating device which can be operated simply by revolving its handle (Fig. 16.) was employed to supply electricity for the daily consumption of the house. The authors also designed an energy-saving bathroom to guide farmers toward conserving energy in daily life through subconscious behavior, including the self-coupling design of living facilities such as a toilet with the ability to separate stools from urine (Fig. 17.), a water-saving bathtub (Fig. 18.) with the capability of saving 50% of the water required for a normal family bathtub, and the self-coupling design of building facilities which included a classification processing system for human waste, and a sewage treatment system with no underground plumbing network required. In addition, by storing the filtrated living sewage in the outdoor irrigation pool, farmers can irrigate the plants cultivated in the courtyard (Fig. 19.).

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The nature of modeling farmers is to cultivate their behavior and disposition toward those typical of modern civilization, while they enjoy the material achievements of modernization. The smell of smoke from the traditional oven is an identity mark peculiar to farmers, just like an identifying label, which implies a primitive and poor living environment. Therefore, it is suggested that the first step is to eliminate the firewood-smell of farms to elevate their confidence and encourage a modern living style. Based on the self-coupling and strain-reactive coupling theory, a new type of hearth (Fig. 14.) has avoided the flow of smoke into the inner rooms, while the new kitchen has been positioned apart from the living space; the structure of which can restrict smoke flowing toward the interior; the sealed smoke channels (Fig. 20.) and the fire walls can also prevent smoke from infiltrating through to the interior living spaces.

The cultivation of civilized behavior in farmers, in the authors' opinion, is firstly concerned with personal hygiene and a sanitary living environment. For this purpose, some strain-reactive coupling designs based on behavior-conducive and ideas-conducive living
have been explored, such as the hallway at the entrance door and installing a wardrobe and shoe storage for the convenience of changing coats and slippers. Despite the Kang, which the authors retained for the purpose of cultivating a modernized living style, they divided the functional space into a living room, multipurpose room, bedroom and sitting room, etc. (Fig. 4.) Moreover, the aforementioned building facilities and living facilities such as the energy-saving bathroom, passive kitchen and potential energy power-generating device will be helpful for farmers to observe modern ecological ideas.

5. Conclusion
In this article, the characteristics of the relationship between residents and housing under the modern rural ecological environment system were explored. The authors conclude that the modern ecology of rural residence is the harmonious status of development between the civilized spirit and civilized behavior of farmers, as well as the material civilization of the building structure and facilities. In order to balance livability and energy saving in respect to the modern ecological residence system via the design practices of the demonstration housing project in Piaojiagou Village, coupling strategies under the modern ecological environment for ecological elements were introduced, which result from the ecological advantages of the primitive ecological residence. We also found that the sustainability of the ecological residence not only needs to withstand the test of environment evaluation in terms of physical indicators of hardware, market response, and the economics of natural resources, but must also endure people's evaluation and social evaluation, i.e., the farmers' qualities and personality should be developed synchronously with the improvement of comfort and living quality they actively experience.

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