Energy usage, problems and policy proposals: evidence from distinctive villages in poverty-stricken loess areas

Xinglong Xie¹ and Weixian Xue
Xi’an University of Technology, Xi’an 710048, China.

¹long86886@aliyun.com

Abstract. The aim of this paper is to examine energy consumption among poverty-stricken loess areas of middle Gansu, and put forward a settlement to energy upgrading and meanwhile mitigating environmental contagion and shaking off poverty. Energy consumption of 371 households from 3 distinctive categories of landform is explored. The surveyed data investigation displays that energy consumption composition is marked by clear dissimilarity of power mix, with stalk(41%) and coal(32.3%) acting as the major form, fire grass a powerful supplement, and the remaining power resources playing a tiny part for the mountain; coal(52.45%) being the dominant power, dry grasses(20%) and stalk (17.6%) performing a supplemental part, other resources of power being at the insignificant position for the semi-mountain; beside which there being a similar energy pattern on the plain except stalk composing a tiny share of 7.5%. This energy mix is mainly attributed to economic poverty, and provokes a list of ills such as plant damage, water loss and soil erosion, ultimately posing a formidable threat to sustainable development. A fresh energy engineering mode termed quaternity-dominating pattern is introduced and addressed, which can lift the sample areas out of poverty both in economics and energy. The paper concludes with pointing out practical proposals on launching and running this energy engineering project for the sample areas. This paper contributes to the growing body of knowledge by exploring energy use among poverty-stricken regions, usually being disregarded in most studies of China.

1. Introduction
Energy has evolved into a major element required to reduce poverty, increase the standard of living and promote social-economic advancement [1]. The swift pace of economy gives rise to strong energy demand and spending having connections with challenges and negative consequences among developing nations. A considerable number of them have suffered a severe power plague for decades, with some countries lacking of access to electricity. More seriously, rural and remote areas in those middle-low income countries have undergone painful crises including inadequate or no public energy provision [2]. Typically, among vast rural regions of bulky population in China, a representation of high economic growth among the developing world, energy is consumed at a substantial volume, with the power composition taking on diversity in rural and urban areas. Massive direct combustion of biomass such as stalks and fuel woods is central to power spending in the rustic life [3]. Alarmingly, this extensive pattern has provoked an enormous devastation to the ecological environment as well as low levels in energy efficiency [4]. Hence, promoting optimization of the rural energy mix for environment betterment has triggered attention from economists, government and public and evolved into a strategic issue over bucolic development [5].
The aim of this paper is to contribute to the growing body of literature on rustic energy spending and patterns by answering key research questions based on areas with dissimilar landform features in Northwest China. To this end, this paper focuses on exploring the existing scenario of rural energy and regional differences, and presenting patterns of rural power development. This analysis employs data on 371 households from 13 natural villages of 10 towns in 3 counties of middle Gansu, northwest China, which gives this study a uniqueness compared to other similar investigations for countryside energy consumption. We consider landform variety, type of widely-spent energy sources, consumption volume, consumptive purpose and cost. These five aspects allow this study to deal with many of the economic questions set out in existing energy studies. Another important contribution of this paper is that energy composition is determined and compared for three categories of loess regions: hilly mountainous, semi-mountainous, and plain, which have not been considered in the literature to date. This empirical analysis thus provides a broad evaluation of power composition in northwest China and a regional-specific settlement to energy shortage.

Three land regions of a loess hilly area in the middle of Gansu as the subject were chosen and investigated as the land is a specific and typical place for northwest China’s rural regions. First, the loess hilly area of central Gansu, with tattered landforms and dense gullies, has degenerated into the most severe area of water loss and soil erosion [6], undergoing a cruel fragility in the ecological environment. Next, bearing lack of energy, families here have to draw on local natural resources such as stalk, wood and weed for cooking and heating purposes [7].Frighteningly, such excessive bioenergy exploitation has provoked a growing ecological deterioration [8]. This, plus more population and less arable land, and low levels of productivity in agriculture, trigger the region to have degenerated into northwest China’s impoverished representation, with net annual income per capita at $201.3 below the poverty criteria of $333.3 stipulated by Chinese government (the 2010 year being base line). Thus, for many years it has been in the awful state of economic underdevelopment, ecological fragility and energy famine. Third, more seriously, the heavy demand of the large population for energy poses an enormous menace to an appropriate utilization of resources and environment protection, wielding grievous restrictions on local sustainable development. Fourth, due to landform complexity and economic conditions’ disparity, villages characterized by dissimilar terrains are distinctive from each other in the composition of plants, energy and resource endowments. Therefore, dealing with energy consumption differentiation among those rural communities with distinct geographic features is getting particularly necessary and imperative to provide theoretic support for local government in formulating region-worthy policy packages, which could return rural energy in those communities into a healthy track of development and spending. Finally, notwithstanding a considerable quantity of studies on rural energy consumption in China’s mainland [9-11], most of them concerned macroscopic issues, usually at the national or provincial or China’s relatively advanced regional level, and, suffered a shortage of first-hand figures, which may provoke a decrease in data trustworthiness, comprehensiveness and precision. Additionally, impoverished areas at the county tier or community tier as an investigated object fall into a disregarded predicament by most of current literature in China. This study seeks to fill this blank and make an extension via dealing with features of the rural sample areas’ energy spending and put forward a region-specific settlement to a successful tackling of power poverty under ecological balance preservation.

2. Data availability and areas investigated
Geographically, the surveyed regions are subdivided into three types: hilly mountainous, semi-mountainous and plain areas, representing distinctive geographic and economic landscapes. During the year 2013, 15 university undergraduates and graduate students, after strict training, were dispatched to 13 villages of 10 towns in 3 counties of Tongwei, Qingan and Gangu to survey householders. The family investigation carried out by means of uniform printed questionnaire mainly embraced family background, type and consumptive amount of energy and biomass harvest yield. Overall, 371 families were visited and inquired into, representing a proportion of 10.25% of the aggregate households, ranging from well-off to poor, from large-sized to mini-sized, from depending on mainly consuming
methane and solar energy to conventional power. Specific figures were developed on the income, planting structure, livestock breeding composition, and fresh energy spending, whereby to probe into the current status concerning energy consumption and related factors. Furthermore, the staffs including governors at local energy departments were interviewed to verify sampling figures for times regarding their robustness and reliability. Note that for figure comparability regarding dissimilar classes of power, the standardized coal coefficient, authorized by countries such as China and Japan, is employed to calculate the amount of each class of consumed energy (table 1). Tables 2 and 3 report consumption percentage by energy type and proportion by purpose.

| Energy           | Stalk | Fire grass | Fuel wood | Dung | Coal | Power | Methane | Solar energy | Liquefied gas | Sum   |
|------------------|-------|------------|-----------|------|------|-------|---------|--------------|---------------|-------|
| Cooking          | 452.5 | 16.6       | 245.1     | 2.24 | 41.4 | 75.0  | 0.81    | 833.7        |               |       |
| K-warming        | 380.7 | 240.4      | 125.8     | 31.0 | 1.00 |       |         |               | 778.9         |       |
| Furnace          | 15.2  | 379.2      |           |      |      |       |         |               | 394.4         |       |
| Teaing           | 10.2  | 0.55       |           |      |      |       |         |               | 10.75         |       |
| H.E.appliance    |       |            |           |      |      | 7.90  |         |               | 7.90          |       |
| Lighting         | 5.0   |            |           |      |      |       |         |               | 5.0           |       |
| Sum              | 833.2 | 240.4      | 42.0      | 125.8| 655.2| 16.7  | 41.4    | 75.0         | 0.81          | 2031 |
| Percentage       | 0.41  | 0.118      | 0.021     | 0.062| 0.323| 0.008 | 0.02    | 0.037        | 0.0004        | 1    |
| Semi-mountain    |       |            |           |      |      |       |         |               |               |       |
| Cooking          | 184.2 | 75.4       | 44.6      |      |      | 1.4   | 97.2    |               | 860.7         |       |
| K-warming        | 154.5 | 311.2      |           |      |      | 57.7  |         |               | 523.4         |       |
| Furnace          | 19.7  |            | 491.9     |      |      |       |         |               | 511.6         |       |
| Teaing           | 5.0   |            | 2.0       |      |      |       |         |               | 7.0           |       |
| H.E.appliance    |       |            | 11.7      |      |      |       |         |               | 11.7          |       |
| Lighting         | 7.2   |            |           |      |      |       |         |               | 7.2           |       |
| Sum              | 338.7 | 386.6      | 69.3      | 1007.4| 22.3 | 97.2  |         | 1922         |               |       |
| Percentage       | 0.176 | 0.201      | 0.036     | 0.000| 0.524| 0.012 | 0.000   | 0.051        | 0.000         | 1    |
| Plain            |       |            |           |      |      |       |         |               |               |       |
| Cooking          | 64.9  | 87.3       | 35.9      | 583.3| 1.5  | 114.8 | 5.5     |               | 893.2         |       |
| K-warming        | 97.6  | 352.3      |           | 96.0 | 0.2  |       |         |               | 546.1         |       |
| Furnace          | 27.0  |            | 675.4     |      |      |       |         |               | 702.4         |       |
| Teaing           |       |            | 4.2       |      |      |       |         |               | 4.2           |       |
| H.E. appliance   |       |            | 11.5      |      |      |       |         |               | 11.5          |       |
| Lighting         | 9.3   |            |           |      |      |       |         |               | 9.3           |       |
| Sum              | 162.8 | 439.6      | 63.0      | 1354.7| 26.6 | 114.8 | 5.5     | 2167         |               |       |
| Percentage       | 0.075 | 0.203      | 0.029     | 0.000| 0.625| 0.012 | 0.000   | 0.053        | 0.0025        | 1.00 |
Table 2. Energy consumption proportion and quantity for the same region (unit: kgce).

| Region            | Proportion | Coal    | Fire grass | Clean energy | Other energy | Total |
|-------------------|------------|---------|------------|--------------|--------------|-------|
| Mountain          | 0.41       | 0.323   | 0.118      | 0.066        | 0.083        | 1     |
|                   | 833.2      | 655.2   | 240.4      | 133.91       | 167.8        | 2031  |
| Semi-mountain     | 0.176      | 0.524   | 0.201      | 0.062        | 0.036        | 1     |
|                   | 338.7      | 1007.4  | 386.6      | 119.5        | 69.3         | 1922  |
| Plain             | 0.075      | 0.625   | 0.203      | 0.068        | 0.029        | 1     |
|                   | 162.8      | 1354.6  | 439.6      | 146.9        | 63.0         | 2167  |
| Average for the three regions | 0.221 | 0.491 | 0.174 | 0.065 | 0.049 | 1     |
|                   | 444.9      | 1005.7  | 355.5      | 133.4        | 100.0        | 2039.6|

Table 3. Energy consumption proportion by purpose.

| Energy purpose | Mountain | Semi-mountain | Plain |
|----------------|---------|---------------|-------|
|                | Amount  | Proportion    | Amount | Proportion | Amount  | Proportion |
| Cooking        | 833.7   | 0.411         | 860.7  | 0.448      | 893.2   | 0.412      |
| K-warming      | 778.9   | 0.384         | 523.4  | 0.272      | 546.1   | 0.252      |
| Furnace        | 394.4   | 0.194         | 511.6  | 0.266      | 702.4   | 0.324      |
| Teaing         | 10.75   | 0.005         | 7      | 0.004      | 4.2     | 0.002      |
| Device-powering| 7.9     | 0.004         | 11.7   | 0.006      | 11.5    | 0.005      |
| Lighting       | 5       | 0.002         | 7.2    | 0.004      | 9.3     | 0.004      |
| Total          | 2031    | 1             | 1922   | 1          | 2167    | 1          |

3. Empirical analysis

3.1. Energy consumption composition
The investigation discovered that numerous families normally use several or more varieties of power, except very few drawing on just one or two kinds. This reveals that combination of dissimilar fuels is universal in household rural energy utilization. Moreover, differentiation to a certain degree can be found between areas.

Concerning the household consumption composition, it is found not to be optimized for the sample areas as a group, with clean energy representing a small proportion of 6.5%, compared with 8.5% in Gansu province’s and 24% in China’s total rural regions as a whole [12-13]. For percentage by energy category, coal makes up 49.1 of all for the sample regions as a group on the household basis, much higher than 15% in the rural region of China and 35.3% in Gansu. Regarding bi-energy including stalk and fire grass, the whole of sample areas represents 44.5% on the household average, lower than Chinese rural regions as a unit (61%) and Gansu’s countryside (54.1%), mainly as extensive planting of fruit and vegetables gives rise to moderate stalk output on the plain and the policy of prohibiting abusing plantations for preventing water loss and soil corruption in the surveyed mountain and semi-mountain areas has been put into effect.

The most-used energy by hilly, mountainous communities is stalk, followed by coal, fire grass, clean and other classes of power resources. Being self-sufficient in the areas, stalk is consumed at an
average of 833.2kgce per family, representing a large proportion of 41% in the overall energy consumption. Traditional crops are planted in these areas with the arable land per capita being abundant, so generating massive volumes of stalk. Another significant energy is coal, accounting for 32.3% of all to 655.2kgce. Coming at 240.4kgce making up 11.8%, fire grass also performs a considerable role. Relative to massive consumption of the above three energies, droppings and firewood turn out to be at a tiny size of 167.8kgce accounting for 8.3%. The utilization of sanitary power, consisting of solar energy, methane, electricity and liquefied gas, falls in the least at 133.91kgce making up 6.6 percentages.

Generally, stalk serves as the chief energy form, and, coal and stalk are forcefully auxiliary while clean energy and other resources play a feeble role. For the semi--mountain, coal, employed as a principal resource of power, is central to daily life, with stalk and dry grass acting as a vigorous complement, solar energy, methane, electricity, liquefied gas, firewood and droppings playing an auxiliary role. On the average of family annual consumption, coal ranks top of all energy resources, reaching 1007.4kgce (52.4%), grass in the second place with the figure at 386.6kgce (20.1%) and stalk in the third place with the figure at 338.7kgce (17.6%). Followed by clean energy, the amount comes in at 119.5kgce (6.2%) while other energy is ranked at the bottom, merely 69.3kgce (3.6%). By and large, energy usage features the dominance of coal, the vital supplement of stalk and arid grasses, and the weak role of the remainder including electricity.

A parallel pattern exists on the plains. The energy resource with the highest expenditure for living purposes is coal, making up 62.5% and annually averaging 1355kgce for each family, largely caused by poor payment capacity restricting on commercial power use, the lack of self-sufficient energy, and the scarcity of noncommercial, usable energy. Ranking the second position, burnable grass in this region is found to reach about 439.6kgce (20%), mainly boiling down to Kang, whose heating during winter mostly leans on grasses with insufficient stalk and less droppings from residents infrequently raising big livestock. Unlike considerable utilization in the mountain and semi-mountain, stalk on the plain experiences a tiny volume of 162.8kgce (7.5%). Similar to the other two sample places, here clean energy consumption is found to be quite marginal, only 146.9kgce (6.8%). Concerning other kinds of power resources, the plain turns out to expend 63kgce (2.9%), the least of all, indicating those energies have paled into insignificance for local citizens’ routine life, an anxious scenario.

Overall, rural energy use within the sample period areas is dominated by coal and stalk. Notwithstanding, rankings could vary for dissimilar regions (within top 2), supplemented by fire grasses, three parties as a whole capturing over 85% in the total expenditure for each area, even reaching 90.3% on the plain, while hygienic energy receives limited utilization, representing less than 6.8%. Such an energy mix can trigger a substantial burning of coal, which may contaminate air, and, blazing of stalk and grasses, which may ruin local water and land. This, eventually, leads to ecological imbalance and injures sustainability of nature, environment, economic and social development.

3.2. Energy purposes

3.2.1. Cooking In rural life, energy is dedicated to a list of aims including cooking, heating, illumination and powering domestic devices such as TV and DVD. Calculated on the data of the second row of table 3, it is found that cooking records an average of 862.5kgce on the household basis for the surveyed areas as a whole, exceeding 41% of total energy expenditures of its own, with a tiny differentiation between the sample areas. Table 3 reveals that the plain region has the highest expense at 893.2kgce, followed by the semi-mountain at 860.7kgce and the hilly mountain with 833.7kgce. Concerning the percentage of cooking power in all, the semi-mountain, coming in at 44.8%, is the maximum while the two remaining areas are roughly at the almost identical magnitude, 41.1% for the hilly mountain and 41.2% on the plain. Accordingly, cooking has evolved into a major energy-consuming event.

3.2.2. Heating By counting the figures from the k-warming and furnace rows on table 3, it is discovered that heating–objective household energy averages1152.3kgce in all the sample areas,
making up a large proportion, 56.4%, in the energy-spending aggregate. The area with the largest consumption is the plain with 1248.5kgce (57.6%), followed by the mountain 1173.3kgce (57.8%) and semi-mountain at 1035kgce (53.8%), computed on the data of the two same rows on the table. Kang represents two-thirds of all warming-based energy resources for mountainous households while stoves are crucial to home warm-making on the plains, exceeding 60% of heating-oriented energy consumption. Regarding the semi-mountain, Kang-heating and stove-heating turn out to expend 523.4kgce (27.2%) and 511.6kgce (26.6%), with a narrow margin. Consequently, warmth-seeking in winter, mainly through kang and stove heating, has dominated the activity of energy spending across the areas.

3.2.3. Other purposes and energy resources Based on table 3, it can be figured out that lighting, household electrical device powering, and teaining (make tea of boiled water) all cost a tiny amount of energy resources, averaging at 7.2, 10.4 and 7.3kgce for households of the three sample areas as a whole. According to table 3, lighting on the plain turns out to consume electricity in the quantity of 9.3kgce (0.4%), slightly higher than 7.2kgce (0.4%) for the semi-mountain and 5kgce (0.2%) for the mountain. Concerning electricity utilization by household appliances, the figure arrives at 11.7kgce (0.6%) in the semi-mountain and 11.5kgce (0.5%) on the plain, both above 7.9kgce (0.4%) in the mountain. Obviously, the two items, lighting and device powering, totally account for less than 1% of all energy used, an insignificant fraction, in any kind of sample area.

Meanwhile, it is found that an annual average of home energy consumption aimed at boiling Jar jar tea (an established drinking habit), is trifling, arriving at 7.3kgce (0.37% in all) for all surveyed villages, 10.75kgce (0.5%) in the mountain, 7kgce (0.4%) in the semi-mountain and 4.2kgce (0.2%) on the plain. Distinctions, however, are that the mountain mainly depends on firewood for heating the tea, the plain electricity, and the semi-mountain both resources in an approximately equal quantity. Clearly, those sources of power, which reveal high levels of living standard, are spent minutely across the sample regions. This implies that the surveyed rural communities suffer low quality of life, slender incomes and less economic development and environmental exacerbation.

Still more, it is found that methane, a category of hygienic power, has commenced to be turned to practical account by some mountain inhabitants but none use it on the plain and in the semi-mountain. How might the divergence have occurred? A major explanation is that the mountainous region, compared to the two other areas, has a comparative advantage for developing methane: an abundant supply of stalk resources and the habit of breeding cattle, especially large-sized animals like oxen.

Generally, the rural energy composition in middle Gansu’s loess hilly areas turns out not to be optimal, with coal, stalk and fire grass dominating energy consumption and clean energy receiving a spot of utilization, and, the consumptive level is lower-status, mainly satisfying the basic wants and needs of life- cooking and heating. This power consumption pattern, signifying that substantial quantities of grasses, stalk and coal are burnt up, can trigger a list of ills such as air pollution, water loss and land erosion. This, coupled with economic poverty, has posed formidable threats to sustainability of social, economic and environmental development. Thus, it is getting increasingly imperative to seek out an energy engineering system, which should comply with principles from the sustainable development ideology and must pave the way to upgrading of power resources, alleviating poverty, and aiding economic growth and environmental conservation. A fresh energy engineering model, termed the quaternity-dominating pattern (Q.D.P), is put forward for these sample areas.

4. Quaternity-dominating pattern of fresh energy engineering

4.1. Structure of Q.D.P.
This structure (see figure 1), built in a rural household court, arrays a piggery, a toilet and a greenhouse in the form of word “one”, with a methane tank constructed below the piggery, a feed inlet connected to the entrances of human & animal droppings and the discharge hole stretching into the indoor. The methane-generating pit is responsible for fitting together planting, livestock breeding,
agricultural production and rural life as well as generating methane acting as a category of energy. With regard to the solar greenhouse, it can be used to cultivate crops such as vegetable without being confined by seasonal shift and make agreeable illumination, temperature, and humidity for the methane tank and the swine pen or fowlery. For the toilet, its role is to furnish the biogas-generating pit with excrement, a category of raw material for the purpose of fermentation. In addition to providing raw materials, the swine pen is devoted to pig raising for domestic earning improvement and enhancing its temperature by increasing the CO2 density in the interior of the green house.

Figure 1. System layout of Q.D.P.
Note: 1 fence, 2. trough for spilling water, 3. orifice for charging stock, 4. toilet, 5. inlet pipe for charging stock, 6. passage, 7. methane tank, 8. swine pen, 9. discharging hole, and 10. solar greenhouse.

4.2. Effects
This energy engineering can exercise considerable positive effects if one rural household makes investment in building this energy engineering. A significant outcome is economic benefits. Methane, being a category of hygienic fuel, generated in the energy engineering system serves, rural household activities such as cooking and heating, thus causing decrease payment for other forms of energy with similar functions such as electricity. The temperature inside the greenhouse’s canopy, ranging from 10 to 30 ° Centigrade fits in with planting of two times per year and pigs raised in the hog house can be mature in half an year, so doubling domestic earnings annually. Second, manufactured methane marsh gas is utilized to perform household activities such as cooking, consequently resulting in a reduction of coal or biomass spending and ecological environment betterment. Furthermore, methane fertilizer can contribute to rising of organic matter contents, the permeable rate and the water retention and fertility preservation capacity and, ultimately, improvement in the chemical and physical quality of land [14-15]. Additionally, biogas both liquids and residuals, including amino acid and antibiotic factor, are endowed with functions such as getting rid of insects and bacteria, including aphids, which might be destroyed through biogas liquids being sprayed on leaves, thus contributing to reduction of plant diseases and insect pests, further to less utilization of chemical pesticides and eventually to production of healthier vegetables. Third, successful running of this energy engineering project for achieving expected results, lays great requirements on rural citizens, who must, by training and doing, get familiar with and put into practical application various agricultural knowledge and skills ranging from related equipment operations, to biogas generating, to greenhouse vegetable and pig cultivating, to the planning of investment and capital budget. This, undoubtedly, would trigger an increase of scientific and technological qualifications for these rural residents, an establishment of the correct idea that sustainable development in agriculture is carried out through advanced technologies, and a mastering of modern agricultural marketing skills.
5. Conclusions and policy proposals

The contribution of this paper is to provide a specific evaluation of poor rural areas’ energy consumption, which is often forgotten and receives little attention in current literature. We extend existing studies by analyzing a unique dataset arising from investigations. Furthermore, the paper proposes a novel energy engineering project, Q.D.P, which would be capable of liberating the sample areas from double poverty in energy and economy under environmental conservation to achieve sustainability of energy, ecological, economic and social development. Here are new insights into energy consumption in the poverty-stricken countryside. (1) For villages in sample areas, energy consumption is embodied by clear dissimilarity and marked by distinctive combinations of power. In hilly mountain regions, it takes on being dominated by stalk and coal, supplemented by fire grass, and, playing a slight part by livestock dung, solar energy, and firewood and methane subsidiary. Energy use among semi-mountainous areas features coal dominance, complement of burnable grasses and stalk, and other forms of energy resources such as firewood conducting a tiny role. A similar structure is found for the plain except a weak effect from stalk. Substantial combustion in stalk and coal has triggered negative effects such as water loss, land erosion and environmental exacerbation and this has posed a threat to local economic and social development sustainability. (2) Concerning energy objectives, keeping warm and cooking dictates the surveyed loess regions, representing a proportion of over 98% of all energy spending. For keeping warm, a major form of energy expenditure during winter, it is mostly reliant on Kang heating (2/3 warming-purpose energy) in the mountain, Kang and stove heating (each supplying half) in the semi-mountain, and, stove heating (3/5 warming-oriented energy) on the plain. Cooking power expended by these areas is over 830kge, mainly stemming from stalk for the hilly mountain, from coal and stalk for the semi-mountain, and coal for the plain. Besides, lighting and household electrical appliances represent a tiny ratio of less than 1% of all energy resources used. Additionally, notwithstanding consuming a tiny quantity of power, boiling Jar Jar tea, a drink which has been a long-run habit, mainly counts on firewood in the mountain, electricity on the plain, and, firewood and electricity for the semi-mountain. (3) Looking forward to energy prospects, the study suggests that those regions should develop a fresh sort of energy engineering model termed quaternity-dominating pattern(Q.D.P), which incorporates a methane-generating pit, a pig or poultry house, a sunshine greenhouse and a household court to shape into an ecological system of energy under the closed condition, generating methane (a kind of hygienic energy), planting crops such as cucumber and cultivating livestock such as pigs and ultimately enhancing an upgrading of energy spending, an alleviating of poverty and an accomplishing of ecological balance among the loess hilly areas, which have undergone energy famine, economic poverty and environmental deterioration. (4) Embarking on a project of Q.D.P energy engineering, the three types of areas could make an appropriate amendment of the depicted structure by adding to facilities according to their specific conditions. For the mountainous villages, which have suffered water famine and dry climate for a long-run, two water cellars should be established to bolster crops to be irrigated in the greenhouse. Since the plain is endowed with stream resources, mini-sized hydro stations could be installed to enlarge the supply of electric power to relieve the supply-demand imbalance, and meanwhile a solar stove is imperative to be equipped in the kitchen, leaving the cooking-aimed energy consumption to shrink. Likewise, semi-mountainous households, with more energy expenditures for food preparation than mountainous families, ought to put into use energy-efficient solar ovens. If such facilities can be well embedded into the illustrated Q.D.P complex in accordance with each area’s particular scenario, the Q.D.P style would lead the entire region to move toward energy composition optimization, ecological improvement, and poverty alleviation.

To initiate and spread an engineering scheme concerning the quaternity-dominating mode, there are a few proposals. First, a certain number of innovation-minded villagers, who are competent and pioneering, should be organized to make an on-the-spot investigation of successful sites in practicing this new energy mode to stimulate their enterprise-seeking desire. Then, those natives need to be imparted systematic knowledge associated with methane, planting, breeding, marketing and circular economy via inviting experts or technicians to teach them, enabling them to have corresponding
techniques including management, which are a prerequisite for triumphant operations of this engineering. Third, governmental grants such as low-interest loans and financial funds ought to be furnished for those rural households, not moneyed, since massive resources of manpower, material and finance are necessitated by constructing this engineering project. Finally, it is particularly pressing to reinforce establishment of a service network, as the maintenance and use of each equipment in this project leads to great demands for technical services in each of these corresponding areas, and the operation of each activity such as fermentation, crop planting, livestock raising and marketing of products to be manufactured by this engineering puts new demands on professional service sectors for their growing complexity.

Acknowledgment
The authors are grateful to financial support from the national social-scientific fund No.17BJL005.

References
[1] Ershad U K and Andrew R M 2016 Renewable and Sustainable Energy Reviews 62 247-59
[2] Barnes D F, Khandker S R and Samad H A 2011 Energy Policy 39 894-904
[3] Chen Y, Yang G, and Sweeney S 2010 Renew Sustain Energy Rev 14 545-9
[4] Qiu H G 2015 China Soft Science 299 28-38
[5] Fuller J F, Fuchs E F and Roesler K J 1988 IEEE Trans. Power Delivery 3, 549-57
[6] Yang L Z, Wang G F, Wang A J, Yao Y H, Hu Y H, Li Y W, Liu Zh R, Guan H W and Liu J H 2016 The Chinese Journal of Geological Hazard and Control 227 39-48.
[7] Li G Z and Dong D X 2010 Renewable Energy Resources 28 115-9
[8] Li G Z, Nu S W and Yang Z 2008 Journal of Natural Resources 23 15-24
[9] Deng G Y and Zhang Zh J 2016 Journal of Arid Land Resources and Environment 30 19-23
[10] Tian N Sh 2016 Energy of China 38 25-9
[11] Zhou Z R, Wu W, Wang X, Chen Q and Wang Q 2009 Renewable and Sustainable Energy Reviews 13 187-93
[12] Hu C R and Chan M R 2013 Gansu Agriculture 05 9-11
[13] Tian Y Sh 2016 Energy of China 38 25-9
[14] Rivard C J, Rodriguez J B and Nagle N J 1995 Biochemistry and Biotechnology 52 125-35
[15] Li Y B and Wang Q L 2011 Modern Agricultural Sciences and Technology 20 291-5