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Study on Biogas Development in the Qinba Mountain Area in the Background of Developing Ecological Civilization

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Abstract: Biogas is a clean energy source with high value for the comprehensive development and utilization of the Qinba Mountain area. Promoting biogas in the Qinba Mountain area can effectively solve the energy dilemma in the construction of a new socialist countryside. However, the promotion and usage of biogas are faced with economic, technical, and policy obstacles. The government and farmers of the five provinces and one municipality in the Qinba Mountain area have invested time and resources to build household biogas pools and related supporting facilities. Whether these facilities can continue to play a role or not has become the most important issue faced by these farmers. Based on the inputs and outputs of biogas processes in the Qinba Mountain area, we present an analysis of the factors affecting the construction, maintenance, operations, and utilization of biogas in this area, and put forward relevant suggestions for the healthy and sustainable development of household biogas in the Qinba Mountain area.

Keywords: the Qinba Mountain area, energy poverty alleviation, clean energy, sustainable development, institutional studies

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Introduction

The Qinba Mountains range from the eastern edge of the Qinghai-Tibet Plateau in the west to the southwest of the North China Plain in the east, spanning the Qin Mountains and Daba Mountains. The Qinba Mountain area contains the largest number of provinces involved in the new round of poverty alleviation and development which is a combination of old revolutionary base areas, large-scale reservoir areas, and natural disaster-prone areas. The climate type in the Qinba Mountain area is various, and the vertical change is remarkable. The climate type includes the North Asia Tropical marine climate, the subtropical-warm temperate transition monsoon, and the warm temperate continental monsoon, and it also has an annual average precipitation of 450-1,300 millimeters. It spans the Yangtze River, the Yellow River, and the Huaihe River. It is the birthplace of the Huaihe River, Han River, Dan River, and Luo River. It has a well-developed water system and abundant runoff resources. Its forest coverage rate is 53 percent, and it is an important ecological functional area of biodiversity and water conservation in China. The area contains diverse biomass of raw materials with large reserves and great development potential. The area includes 80 counties (cities and districts) in six provinces, including the cities of Henan, Hubei, Chongqing, Sichuan, Shaanxi and Gansu (see Table 1). The total land area is 2,250,000 square kilometers. At the end of 2017, the population was approximately 42.3 million, of which 30.5 million were rural and 0.56 million were ethnic minorities.

The program for the *Outline of Poverty Alleviation and Development in China's Rural Areas (2011–2020)*, the Central Committee of the Communist Party of China (CPC) and the State Council's opinions on the further implementation of the strategy for the development of the western region, the national plan for major functional areas, and the circular on the distribution of the list of counties with special difficulties all contain clear proposals to promote the construction of green energy demonstration counties, to develop rural biogas construction in an orderly way, to actively promote solar energy, to upgrade coal stoves and to strengthen technical services. Therefore, it is necessary to popularize household biogas or centralized gas supplies in the Qinba Mountain area to solve the energy poverty problems in this vast rural area.

Table 1 Administrative Areas of the Qinba Mountain Area

Province (Municipality)	City	County (City, District)
Sichuan	Mianyang, Guangyuan, Nanchong, Dazhou, Bazhong	Beichuan Qiang autonomous county, Pingwu county, the Chaotian district, the Zhaohua district, Yilong county, Wangcang county, Qingchuan county, Cangxi county, Lizhou district, Xuanhan county, Wanyuan district, Tongjiang county, Pingchang county, Nanjiang county
Chongqing		Chengkou county, Yunyang county, Fengjie county, Wushan county, Wuxi county

Province (Municipality)	City	County (City, District)
Shaanxi	Xi'an, Baoji, Hanzhong, Ankang, Shangluo	Zhouzhi county, Taibai county, Nanzheng county, Chenggu county, Yang county, Xixiang county, Mian county, Ningqiang county, Lueyang county, Zhenba county, Liuba county, Foping county, Hantai district, Hanbin district, Hanyin county, Shiquan county, Ningshan county, Ziyang county, Langao county, Pingli county, Zhenping county, Xunyang county, Baihe county, Shangzhou county, Luonan county, Danfeng county, Shangnan county, Shanyang county, Zhen'an county, Zhashui county
Henan	Luoyang, Sanmenxia, Nanyang, Pingdingshan	Song county, Ruyang county, Luoning county, Luanchuan county, Lushan county, Lushi county, Nanzhao county, Neixiang county, Zhenping county, Xichuan county, Xixia county
Gansu	Longnan	Wudu district, Wen county, Kang county, Tanchang county, Li county, Xihe county, Cheng county, Hui county, Liangdang county
Hubei	Xiangyang, Shiyan	Danjiangkou district, Yunyang district, Yunxi county, Fang county, Zhushan county, Zhuxi county, Zhangwan district, Maojian district, Baokang county

Note: Data are from the *Plan for Regional Development and Poverty Alleviation in the Qinba Mountain Area (2011-2020)*

The Present Situation of Methane Exploitation and Utilization and the Legal and Policy Guarantees in the Qinba Mountain Area

The development and utilization of biogas in China has gone through several twists and turns but has finally been highly valued by the state and governments at all levels, and has been vigorously promoted in agricultural and animal husbandry areas throughout the country. At present, it is an important part of the energy consumption structure of rural residents. However, for the Qinba Mountain area, which is relatively deficient in traditional mineral energy, sparsely inhabited with scattered populations, but rich in biomass energy, there are abundant objective conditions to promote biogas in the rural areas. The development of biogas directly relates to the interests of farmers, and is supported by the governments of the five provinces and one municipality in the Qinba Mountain area. For this purpose, corresponding regulations and development plans have been formulated (see Table 2). "Five provinces and one municipality" and their subordinate cities (districts) have specially formulated and promulgated policies for the Development and utilization of rural energy in accordance with their specific local conditions. At the same time, the "five provinces and one municipality" in the Qinba Mountain area have also formulated a special plan for the development of rural biogas according to their own reality, to promote the construction of household biogas pools throughout the whole the Qinba Mountain area to provide clean biogas for farmers in these remote mountain areas (see Table 1). At the same time, centralized power supply projects in rural areas and eco-campus projects are being built in areas where conditions exist for large-scale development and utilization of biogas. Hundreds of rural biogas service outlets (see Table 2) are being established and sound household biogas technical service systems are being provided too. And the construction area of a single solar greenhouse is 40m², combined with vegetable cultivation (Mao, Guan, Huang, Li & Ai, 2009).

Table 2 Table of Laws and Policies Related to Biogas Development in the Qinba Mountain Area

Province (Municipality)	Name	Time	Main Content
Sichuan	<i>Regulations on Prevention and Control of Pollution Caused by Large-scale Breeding of Livestock and Poultry</i>	2014.1	Stipulate the existing situation and solving measures of pollution in rural breeding industry
	<i>Measures for Checking and Acceptance of Rural Household Biogas Construction Projects at the Provincial Level</i>	2017.3	Stipulate the checking and acceptance procedures after the completion of rural biogas construction
	<i>Rural Energy Regulations of Sichuan Province</i> ^①	2017.7	Comprehensively stipulate the development and utilization of rural energy in Sichuan
	<i>The Code for the Construction of Facilities for the Resource Utilization of Livestock and Poultry Manure in Large-scale Livestock Farms (for Trial Implementation)</i>	2018.1	Stipulate the treatment of farm manure in rural areas
Chongqing	<i>Development Regulations of Energy Conservation in Chongqing</i> ^②	2013.7	Regulate the development and conservation of energy resources in Chongqing Municipality
	<i>Measures of Chongqing Municipality on Centralized Biogas Project Management and Construction</i>	2015.10	Make overall regulations on the construction of central gas supply projects in Chongqing
Shaanxi	<i>Opinions of the General Office of Shaanxi Provincial People's Government on Speeding up the Construction of Rural Marsh Gas</i>	2008.6	Further clarify the rural biogas construction procedures
	<i>Regulations of Shaanxi Province on Conservation of Energy Sources</i> ^③	2015.1	Provide for the development, utilization and conservation of energy resources in Shaanxi Province
	<i>Transformation and Upgrading Work Plan of Rural Biogas Project in Shaanxi Province</i>	2015.6	Clear steps and plans have been made for the upgrading of rural biogas engineering construction projects
	<i>Measures for the Administration of Rural Biogas Construction in Shaanxi Province (for trial implementation)</i>	2015.7	The related management procedure of the further development of rural marsh gas
	<i>Detailed Rules for the Implementation and Management of Rural Biogas Project Construction in Shaanxi Province (for trial implementation)</i>	2016.7	Further refinement of management measures for rural energy construction projects in Shaanxi Province
Henan	<i>Measures for the Administration of Rural Energy Construction Projects in Shaanxi Province (for trial implementation)</i>	2017.12	Further refinement of management measures for rural biogas construction in Shaanxi Province
	<i>Detailed Rules for Construction and Management of Rural Biogas Project in Henan Province</i>	2015.8	It further details the relevant details of rural biogas construction
	<i>Energy Development Planning of Henan Province during the 13th Five-Year Plan (2016-2020)</i>	2017.5	Clearly plan the development direction of rural energy sources in Henan Province during the period of the 13th Five-Year Plan
Gansu	<i>Regulations of Henan Province on Conservation of Energy Sources</i> ^④	2017.12	Overall planning of energy implementation in Henan Province
	<i>Implementation Measures for Establishment of Rural Biogas Service Network in Gansu Province</i>	2012.12	The implementation rules (for trial implementation) for the construction and management of rural biogas projects in Gansu Province are further detailed
	<i>Rural Energy Regulations of Gansu Province</i> ^⑤	2014.7	The development and protection measures of rural energy in Gansu Province are comprehensively stipulated

Province (Municipality)	Name	Time	Main Content
Gansu	<i>Measures of Gansu Province for the Administration of Government Investment Projects</i>	2016.1	Stipulate the fund management and other aspects of government investment project
	<i>Detailed rules for the Implementation and Management of Rural Biogas Project Construction in Gansu Province (for trial implementation)</i>	2016.2	Further refinement of the construction and management measures for rural biogas projects (for trial implementation)
	<i>Measures for the Construction and Management of Rural Biogas Projects (for trial implementation)</i>	2016.8	The corresponding details of rural biogas construction are introduced
	<i>Measures for Project Management of Large and Medium Scale Biogas Engineering Construction in Breeding Farms in Gansu Province (for trial implementation)</i>	2017.8	Corresponding regulations are made on the construction of biogas in rural breeding farms
Hubei	<i>Measures for the Management of Rural Biogas Projects in Hubei Province</i> ^⑥	2017.1	The regulations on fund management of rural biogas project are made clear
	<i>The Implementation Outline of the Construction of New Socialist Countryside in Hubei Province During the 13th Five-Year Plan (2016-2020)</i>	2017.8	The direction of rural energy development during the “13th Five-Year Plan” period was defined

Note: The translations of laws and regulations in Table ①②③④⑤ and ⑥ are from Pkulaw.com, while other policy documents are translated by the authors of this paper.

Table 3 Biogas Construction Statistics in the Qinba Mountain Area

Region	Sichuan Province	Chongqing Municipality	Shaanxi Province	Henan Province	Gansu Province	Hubei Province
Biogas Situation						
Total number of built biogas households (households)	116.3	98.5	102	136.5	89.6	102.4
Total number of suitable biogas plants (million households)	102.5	82.83	94.94	106.64	74.1	98.63
Proportion of biogas construction households in total households (%)	52	86.81	83	60	83	79

Note: Data comes from the rural biogas development plan of the five provinces and one municipality.

Table 4: Development Statistics of Different Types of Biogas in the Qinba Mountain Area

Construction of Biogas	Quantity of Built Biogas (Ten thousand units)	Centralized Gas Supply Project in Breeding Area (units)	Large-scale Comprehensive Utilization Project of Biogas (units)	Biogas Service Outlets
Region				
Sichuan province	96.3	469	55	2114
Chongqing municipality	88.5	302	49	1582
Shaanxi province	79	450	53	1753
Henan province	111.98	451	63	1738
Gansu province	58	140	34	896
Hubei province	97.6	432	49	1986

Note: This data comes from the rural biogas development plan of the five provinces and one municipality.

According to related data, the total energy consumption in the Qinba Mountain area was approximately 218.643 billion KWH in 2016, the annual per capita energy consumption was 0.7 tons of standard coal, and the annual wood consumption per household for cooking and heating was about 5 tons, which would destroy 4.5 hectares of vegetation. With the economic advancements in the rural areas and the targeted poverty alleviation in the Qinba Mountain area, by 2020 the per capita income of the rural residents was close to the annual income of urban residents, according to the relationship between residents' income and energy consumption. Given current energy development and utilization technologies, energy consumption demands from traditional sources will decrease in rural areas of the Qinba Mountain area. In addition to high-grade energy sources such as solar energy, wind energy, water energy and geothermal energy, the development and utilization of biomass energy will basically meet the energy demands of the vast rural areas (Wu & Zhuang, 2011), and bring far-reaching influence to the natural ecological environmental protection of the Qinba Mountain area, while it will promote the rural areas to enter the track of ecological and environmental protection and cycle development.

In the relevant plans of rural biogas construction formulated by the five provinces and one municipality in the Qinba Mountain area and the governments at all levels, it is clearly proposed that huge investments should be made to construct rural biogas. In the Qinba Mountain area, 5,313,800 household biogas digesters will be built, and household biogas construction has become the focus of the Qinba Mountain area in promoting the construction of a new socialist countryside and poverty alleviation, however, due to the relatively high altitude and the low temperature in the Qinba Mountain area, there is a relatively short production cycle and high transportation costs for raw materials compared to the surrounding areas. According to the experimental results of the pilot area for the popularization of biogas in the Qinba Mountain area, the construction costs of the biogas digesters and related equipment per household will be about RMB5,800. The central financial subsidy is RMB3,000, and the supporting financial subsidy from local governments at all levels is RMB1,400, which leaves RMB1,400 for each farmer to finance. The total funds needed for household biogas construction in the Qinba Mountain area are estimated to be RMB3.082 million, of which RMB1.594 million will be subsidized by the central government and RMB0.744 million will be provided by the local governments at all levels, and the amount of self-financing funds raised by rural households will be RMB0.744 million.

In addition, the central government, the "five provinces and one municipality" and the governments of all cities, counties and districts have also invested heavily in the construction of centralized biogas supply projects, the construction of centralized biogas supply projects in aquaculture areas and biogas service outlets at all levels (see Table 3 and 4). From the experience of the biogas pilot project, if biogas development in rural areas is not supported by reliable technology, the service life of the biogas digesters would be only three years (Tang & Chen, 2016). Therefore, many problems urgently need to be solved before the healthy and sustainable development of biogas in the vast rural areas of the Qinba Mountain area can be implemented.

Table 5 Table of Investment Estimations for Biogas Construction in the Qinba Mountain Area

Construction Project	Construction Scale (units)	Unit Cost of Construction (million dollar)	Total (billion dollar)
Household Biogas Digester	531.38	0.58	0.03082
Centralized Gas Supply Project in Breeding Area	2,244	100	22.44
Large-scale Comprehensive Utilization Project of Biogas	303	40	1.212
Construction Project of Biogas Service System at all Levels	10,069	8	8.0552

Note: This data comes from the rural biogas development plan of five provinces and one municipality.

Table 6 Fund Sources of Biogas Construction in the Qinba Mountain Area

Projects	Financial Situation	Construction Scale (units)	State Investment (billion yuan)	Supporting funds from Governments at All Levels (billion yuan)	Funds Raised by Farmers (billion yuan)	Total Investment (billion yuan)
Household Biogas Digester		531.38	0.01594	0.00744	0.00744	0.03082
Centralized Gas Supply Engineering in Aquaculture Area		2,244	20.196	2.244	—	22.44
Eco Campus Project		255	0.98	0.2	—	1.18
Construction Project of Biogas Service System at all Levels		10,069	4.83312	3.22208	—	8.0552

Note: This data comes from the rural biogas development plan of five provinces and one municipality.

Factors Restricting the Sustainable Development of Biogas in the Qinba Mountain Area

Limited Knowledge About the Benefits and Sources of Investment

During the 11th Five-Year Plan (2006-2010), five provinces and one municipality in the Qinba Mountain area formulated and implemented relevant plans for the construction of rural biogas, and explicitly proposed the construction of household biogas digesters in the vast rural areas, the construction of centralized gas supply projects and ecological campus projects in aquaculture areas, and the establishment of a comprehensive biogas service system at all levels of the construction projects. During our specific investigation, we learned that the vast majority of farmers and herdsmen generally believed that the biogas construction had brought them real benefits. Judging from the simple relationship between biogas input and output, farmers can effectively save RMB500 of fuel costs per year by building the RMB5,800 biogas digesters, and the payback period of the investment is about 12 years. In the vast and remote rural areas where the economy is relatively backward, it is exceedingly difficult for farmers to spend this huge amount of money. More importantly, since the average service life of the biogas digesters is three years, the vast majority of farmers and herdsmen hold a wait-and-see attitude towards the development of biogas. The real benefits of biogas construction should include the comprehensive benefits such as ecological and environmental

protections brought about by the construction of biogas, rather than simply saving fuel costs. For example, according to the criteria of the central government's subsidy of RMB5,800, the governments at all levels in Sichuan province subsidizing RMB1,400, and farmers themselves contributing RMB1,400, and the per capita income in northeast Sichuan Province, there will still be some farmers who cannot afford biogas (see Table 7).

Table 7 Rural Household Biogas (per Household) Construction Funds in the Qinba Mountain Area

Province (Municipality) Financial Subsidies at Various Levels (yuan)	Sichuan Province	Chongqing Municipality	Shaanxi Province	Hubei Province	Gansu Province	Henan Province
Central People's Government	3,000	3,000	3,000	3,000	3,000	3,000
Provincial (Municipal) Government	800	800	900	750	600	800
Municipal (County) Government	600	600	500	650	800	600
Farmer Household	1,400	1,400	1,400	1,400	1,400	1,400

Note: This data comes from the rural biogas development plan of five provinces and one municipality.

Technical Innovations and Utilization of Biogas Development and the Imperfect Service System

Compared with the surrounding areas, the Qinba Mountain area is a large area with a sparse population, which is influenced by factors such as a high altitude and low temperatures. Even in the same area, different farmers have different utilization requirements for biomass energy. For example, farmers who engage in farming can only use crop stalks to ferment to produce biogas. Also, different management of biogas digesters will lead to different gas production of biogas digesters of the same type. The gas production of the better-managed biogas digester is about 2.5 times that of the poorly-managed biogas digester (Yuan & Gao, 2008). Therefore, the equipment for making biogas must be installed in accordance with the specific conditions of different areas, farmers and herdsmen. At present, the household biogas digester construction in the northeast of Sichuan province is built by using the unified standard and the same drawing, ignoring the specific conditions of each area and the differences in farmers and herdsmen, and the concrete practicability of the digester is poor. In addition, the professional and technical personnel, the technology research and development units of the development and utilization of biogas, and the technical personnel in government departments at all levels related to the development and utilization of biogas are relatively scarce.

Goal Orientation of the Development of Biogas in the Rural Areas of the Qinba Mountain Area—Energy Consumption of Farmers

The development of the social economy in agricultural and pastoral areas will inevitably lead to the influence on the farmers' energy consumption structure and total consumption, and with the rapid growth of high-quality clean energy (wind energy, water energy, solar energy, etc.) the average annual electricity consumption in the vast rural areas will grow to RMB186.5, nearly double that of 2005. Without biogas, the energy consumption in the whole the Qinba Mountain area will come mainly

from wood and would account for about 60 percent of the entire energy consumption. In the vast remote rural areas, fuelwood accounts for about 73 percent of the energy consumption, straw accounts for about 17 percent, and crop straw accounts for about 10 percent. Electricity accounts for only 0.12 percent. Therefore, to break through the constraints on biogas capacity, the design of biogas digesters should provide enough space for fermentation, the introduction of solar energy as a supplement to the development of biogas should be initiated as early as possible, relevant biogas storage equipment should be set up to ensure the stability and balance of biogas supplies, and centralized gas supply projects should be set up in areas where conditions permit to ensure that biogas can meet the energy needs of farmers and herdsmen.

Lack of Risk-sharing Mechanisms of Biogas Investments in the Qinba Mountain Area

The key to the popularization of biogas construction in rural areas lies in the support of the government, the core being the financial subsidies and technical services provided by the government. In recent years, commercial biogas service providers and biogas equipment manufacturers have arrived in the Qinba Mountain area, but the development is relatively slow. Under the current risk mechanisms of biogas operations, farmers bear the greatest investment risk. Whether the household biogas implemented in rural areas can get the expected results and whether the biogas can be used normally after completion are the main and the most worrisome risks for farmers thinking of investing in biogas (Wu, Sharla & Cheng, 2016). In the vast rural areas, biomass energy sources (livestock waste, crop straw, etc.) are abundant, relatively cheap, and have been used for generations as the main source of energy for daily use. At the same time, livestock manure and crop straw are also used in most fields to improve soil fertility. Compared with the direct combustion of biomass raw materials into heat energy, the construction cost of biogas is relatively high and the social and economic nature of the investment is substantial. The annual amount of gas produced, and the short service life of the biogas digesters are the main risks that can lead to investment failure and the losses after the investment failure cannot be effectively compensated for.

Study on the Mechanism of Sustainable Development of Rural Biogas in the Qinba Mountain Area

A Power Mechanism Should Be Established for Farmers Who Use Biogas

The main body developing and utilizing biogas in rural areas is farmer households, and the return expectation is the motive force of farmer households using biogas. In the case of an insufficient supply of energy from the northeast resulting in rising commodity prices, farmers will pay more attention to the price of energy when choosing the type of energy they use. According to the latest research, when consumers spend 10 percent of their total living expenses on energy, they will actively seek new alternative energy sources and new ways to save energy (Gao, 2016). Traditional agriculture

has a harvest period of about half a year, and most farmers consider it too risky to invest in projects that are higher than their annual income if the return period is more than three years. In the early investment analysis process, if there are any accidental, or uncontrollable factors that are likely to lead to investment failure, the failure of the investment will negatively affect the normal life of the whole family. Farmers generally believe that the government should increase the subsidies for rural biogas construction and extend the loan period. In areas where the economy is more developed and the proportion of commercial energy is higher, there are more economical uses for crop straw, for example, to grow some vegetable crops such as mushrooms. The development mode of “crop straw” helps the vast number of farmers, through their own personal experience and calculations after the initiative, choose the use of biogas. Thus, the Qinba Mountain Area biogas can become a fully popularized endogenous energy.

Responsibility-driven mechanisms should be established for governments at all levels in the Qinba Mountain areas to promote rural biogas construction.

The development of a new socialist countryside is the key to solving the problem of agriculture, rural areas and farmers in the remote parts of the Qinba Mountain area. The governments at all levels can improve and protect the natural ecological environments in rural areas, change the appearance of rural areas, improve the living standards of farmers, and improve the quality of agricultural products (Liu & Eugene, 2012). The key to carrying out the building of a new socialist countryside in the Qinba Mountain area is a huge amount of capital investment and the support of government departments at all levels. The five provinces and one municipality in the Qinba Mountain area have carried out biogas pilot projects in some rural areas, which have helped participating farmers realize the real benefits brought about by biogas construction. However, for popularizing biogas throughout the Qinba Mountain area, it is necessary to carry out comprehensive propaganda and popularization of biogas knowledge so that the farmers can truly understand the benefits of biogas and choose to use biogas on their own initiative. Also, the promotion of biogas in the Qinba Mountain area requires a large amount of input from the central government and the Qinba Mountain area involving five provinces and one municipality and the governments at all levels under them in the areas of human, financial and material resources. It is also necessary to further dredge the financing channels of biogas construction in rural areas, and the financial subsidy funds of governments at all levels must be in place on time. Finally, the current evaluation system for government officials at all levels has not been a good indicator for efficient and adequate energy construction in rural areas (Wang, 2008). Therefore, it is necessary to establish a responsibility assessment and evaluation system for government personnel at all levels in the construction of biogas in the Qinba Mountain area and to clarify the responsibilities of governments at all levels in the promotion and guidance of biogas construction in rural areas. Government departments at all levels should learn and understand the importance of biogas construction in rural areas for solving the problems of energy use in farmers’ daily lives and strive to disseminate relevant knowledge of biogas development and utilization to farmers through various media and create an atmosphere of support, research, and development for the use of biogas.

We also need to make clear the government's support and responsibility for the development of rural biogas and to adjust the structure of the public financing expenditures of governments at all levels in the Qinba Mountain area and define the financial support of governments at all levels for biogas construction in rural areas. Policies regarding the development of biogas in rural areas must be formulated and implemented, including active investment and financing policies for biogas in rural areas (Liu & Bian, 2000). In addition to encouraging relevant policy banks and relevant rural financial institutions to provide long-term loans for biogas construction in rural areas, we should also further improve the management of biogas construction in rural areas and the corresponding technical service systems. Finally, the governments at all levels must support the processes of technological innovations and fulfill their responsibilities for ensuring safe and efficient results. To do this, the development of biogas in rural areas must rely on advanced science and technology. The technological innovations in the development and utilization of biogas in rural areas have a strong public welfare nature. Therefore, we shall rely on the governments at all levels to undertake the innovation, research and development of the technologies needed for the development and utilization of biogas in rural areas, enhancing the innovative ability of biogas development and utilization in rural areas.

Establish corresponding mechanisms to attract various market entities to participate in biogas construction in the Qinba Mountain area.

According to the basic requirements of popularizing rural biogas in the Qinba Mountain area, the Qinba Mountain area will form an energy market of several hundred million yuan. With the development and utilization of biogas in the rural area becoming increasingly mature, the vast majority of farmers will find that investing in biogas will bring them higher profits thus reducing their need to rely on the central financial sources, and the five provinces and one municipality as the subordinate levels of government financial subsidies will actively choose biogas as a major living energy. At the same time, more market players will also participate in the construction of biogas in the Qinba Mountain area, as it grows into a huge market, and will make investments in research and development of technologies and equipment, even as large numbers of funds will be invested directly in rural areas to develop large and medium-sized biogas construction projects. From the experience of the development and utilization of solar energy, wind energy and water energy in the Qinba Mountain area, the effect of giving full play to the attraction of the market to the main body of the market is far better than that of the government providing financial subsidies (Liu, 2004). Therefore, we should actively explore various measures to enter the market of biogas in the Qinba Mountain area. First, we should formulate an overall plan for the development of biogas in the Qinba Mountain area and corresponding policies. We should also increase financial subsidies for biogas construction at all levels and provide preferential treatment to market participants in the development and utilization of biogas in rural districts in taxation, financing, and credit. Second, through the form of government procurements, the market entities for the development and utilization of biogas in rural areas should be screened and enterprises with advanced technology, highly effective management, and relatively reasonable prices should be established as biogas suppliers in rural areas, thus establishing a dynamic

management mechanism adapted to local conditions. We must also ensure that the corresponding enterprises can get government financial and policy support to promote the development and utilization of rural biogas enterprises so they can become larger, stronger, and more effective. Finally, the comprehensive development and utilization of biogas products in rural areas must be encouraged. It should be mandatory to establish biogas facilities for farmers with a certain scale (Liu & Yang, 2015), and to formulate a corresponding purchase system for small-capacity biogas power generation in rural areas and corresponding tariff management measures to increase the proportion of biomass power consumption in the overall energy consumption structure of rural areas by encouraging the development and utilization of by-products of biogas fermentation, using biogas liquid and biogas residue as fertilizer and by implementing corresponding measures of encouragement and protection, continuously extending the chain of biogas development and utilization while promoting the organic combination of biogas construction and eco-efficient agriculture.

Conclusion

The comprehensive implementation of biogas construction in the Qinba Mountain area is an important measure needed to develop a green, low-carbon and environmental-friendly agricultural circular economy. Vigorously promoting biogas construction projects in rural areas can effectively ease the contradiction between energy supply and demand in rural areas, promote the rapid development of aquaculture in rural areas, improve the quality of agricultural products, and increase farmers' economic incomes. Ultimately, developing a stable and reliable biogas energy source is a good way to improve the relatively fragile natural ecological environment in rural areas. Through the transformation of heat utilization, the utilization efficiency of biomass energy could be improved, and energy consumption could be reduced. The key to the establishment of a sound mechanism is to promote the development of biogas in the Qinba Mountain area to fully mobilize the enthusiasm of farmers and obtain the maximum benefit through the efficient, comprehensive utilization of rural biogas. However, as the promotion of the rural biogas project by the government is the principal and external, motivating force for the development of rural biogas, the various responsibilities of the governments at all levels in the process of rural biogas construction in the Qinba Mountain area should be clarified. If we could produce a good result in the promotion including technical support and financial support for rural biogas construction, we can attract more investment from energy enterprises through the huge market for the biogas industry in the Qinba Mountain area, and give full play to the role of the government and various market participants, then the supply and demand structure linked by biogas in rural areas and the eco-agriculture and animal husbandry industries in the Qinba Mountain area could be mutually promoted to achieve comprehensive sustainable development.

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