Economic Feasibility and Comprehensive Benefit Evaluation of Rural Household Biogas Utilization: Evidence from China

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Abstract: It is of great significance for the scientific formulation or adjustment of rural energy policy in the new era to explore the current situation of rural household biogas utilization and make a comprehensive evaluation of the benefits of biogas and its derivatives. Based on the field survey data of Qionglai, Sichuan Province, this study uses AHP to build a comprehensive evaluation index system, uses financial indicators to calculate the economic benefits of household biogas, and establishes the weight and score of the index system to comprehensively evaluate the economic, ecological and social benefits of biogas and its derivatives utilization in the survey area. The research results show that the economic benefits and social benefits of rural household biogas are good, but the ecological benefits are not up to the ideal level. Under the background of rapid development of new rural construction and urbanization, the government still needs adjusting policies, so as to meet the challenges of structural changes in the domestic energy consumption market.

1. Introduction
China's agriculture is at an important stage of rapid agricultural modernization. It's a practical problem that how to accelerate the transformation of the agricultural development mode under the background of increasingly tight constraints on resources and environment, and how to realize green development and sustainable utilization of resources while ensuring effective supply of agricultural products. As a clean and renewable resource, biogas is of great significance to solve the problem of agricultural pollution, alleviate the lack of natural resources and accelerate the transformation and upgrading of agriculture. The Chinese government attaches great importance to biogas construction. Since the 21st century, the total investment in biogas construction has reached 40.4 billion yuan, which has made great achievements in energy conversion, waste disposal and promoting the construction of rural ecological civilization. The past five years will be a period of accelerating the transformation of agricultural development mode. The situation and market environment faced by rural biogas development will continue to change dramatically. It is very important to accurately grasp the effectiveness of rural biogas energy transformation, evaluate the effect of biogas use, reveal its role in rural economic social development and ecological construction ecological construction, so as to scientifically formulate and adjust regional rural energy policies.

At present, the international evaluation index system of biogas efficiency is relatively mature, and the analysis method of biogas efficiency is also explored. International researches on biogas benefit evaluation are mostly from the perspective of technology and economy, using LEAP model¹, GIS², etc. for overall analysis, or separately evaluated from three directions of economic benefit, energy benefit and environmental benefit³. In the analysis of biogas economic benefits, the academic
community mainly adopts methods such as cost-volume-profit analysis\cite{4}, sensitivity analysis\cite{5}, and fuzzy comprehensive evaluation\cite{6}. Some scholars also creatively modify the traditional cost-benefit method based on energy value accounting\cite{7}. The PPM, NPVR, ICR and IRR are the economic indicators commonly used to calculate the direct benefit\cite{8}. The indirect benefit also includes the change of unit agricultural land output value, production and living cost savings\cite{9}. The analysis method of environmental benefit is mainly to AHP\cite{10}, cost-benefit method, life cycle evaluation method, etc. The evaluation indexes are relatively diverse, including not only qualitative indexes such as natural environment, residential environment, soil environment\cite{11}, but also quantitative indexes such as environmental load rate, system renewable rate, energy value sustainable index\cite{12}, etc. Social benefits mainly select indicators from the perspectives of labor intensity, social exchange efficiency, quality of life, group quality, employment rate\cite{13}, etc., and employment increment, per capita new energy increment\cite{14} are common evaluation indicators. In addition to the three evaluation directions of economic development, ecological improvement and social progress, resource potential and sustainable development are also the focus of the academic community. In the study of comprehensive benefit evaluation, scholars tend to use the static evaluation method\cite{16}, the grey correlation analysis method\cite{2}, the energy substitution method and the clean development mechanism method to analyze the comprehensive benefit of biogas.

To sum up, the academic community has accumulated rich research results for the comprehensive evaluation system and methods of biogas use efficiency, providing a reference for the research, but there are still deficiencies. Scholars usually evaluate the comprehensive benefits of biogas from three aspects: economic, social and ecological benefits. Among them, there are rich researches on the economic and ecological benefits of biogas projects. Due to the short use cycle of small-scale and low benefits of household biogas and the difficulty to quantify the social benefits, the researches on household biogas and social benefits are not comprehensive enough. At present, household biogas is still the main form of biogas in the rural areas of China to absorb the production of domestic waste and biomass energy. The comprehensive analysis of the utilization of household biogas products based on the analytic hierarchy process will comprehensively and objectively reflect the bottleneck of biogas development, help the government to understand the effectiveness of biogas policy and make timely adjustments, and make contributions to the development of rural biogas industry.

2. Current situation of biogas energy utilization
With the global climate warming and the over-development of fossil fuels, the advantages of using bioenergy are increasingly obvious. Many countries and regions are committed to the large-scale production of clean energy represented by biogas, among which the European Union and the United States are the main production regions of biogas. According to the statistical report of the European biogas Association, in 2013, the number of biogas plants in Europe exceeded 14500, and the biogas power generation capacity can meet the annual electricity consumption of all households in Europe and the two countries. In 2014, EU produced 14.9 million tons of oil equivalent biogas, about 17.7 billion m$^3$ of natural gas. In 2015, the market share of biogas in Europe continued to rise, with the number of biogas plants in Europe increasing to 17376, generating 60.6 terawatt hours of biogas, equivalent to the annual consumption of electricity in 13.9 million European households. Europe is expected to reduce greenhouse gas emissions by 20 percent by 2020, increase emissions reduction to 40 percent by 2030, and reach a market size of 2 billion dollar by 2040, with annual installed capacity of more than 14000 megawatts. The development of biogas engineering technology in Europe began in the 1970s. Currently, biogas engineering technology mainly focuses on high-concentration organic waste combined digestion process (CSTR), and most of them realize automatic management and remote monitoring of biogas projects. The process can not only digest livestock manure, kitchen waste, sewage sludge, corn, potato and other energy crops can also be used as raw materials to participate in the biogas project, at the same time through the rational mixing of raw materials to increase the carbon and nitrogen content of raw materials, adjust to the carbon and nitrogen ratio with the highest gas yield. The biogas produced by the biogas project is mainly used to generate electricity. In the process of
generating electricity, a large amount of waste heat is generated for CSTR heating and for heating farms or communities. In addition to generating electricity and heating, Sweden also purified methane as car and train fuel use, and set relevant standards, the purification technology has been mature and formed a good operating mode.

The development of modern biogas engineering in China is relatively late, and there is a gap between biogas technology with developed countries. Under the guidance of central policy and the support of financial investment, the scale of biogas in China is increasing year by year. The number of rural household biogas digesters is growing rapidly, which has become the main force of rural biogas industry. According to the 13th five year plan for National Rural Biogas Development published by China Development and Reform Commission in 2017, during the 13th Five Year Plan period, the state will further increase the financial subsidies for biogas industry, and the total investment in rural biogas projects will increase from 14.2 billion yuan during the 12th Five Year Plan period to 50 billion yuan. According to the medium and long term renewable energy development plan, China's biogas production scale will reach 44 billion cubic meters by 2020, of which the target of large and medium-sized biogas production scale is 14 billion cubic meters. Biogas in rural areas is an important link between aquaculture and planting, and an important facility to promote the development of green circular agriculture. On the one hand, livestock and poultry manure, straw, domestic waste and other materials are used as raw materials. In 2018, the national biogas consumption and treatment of all kinds of production and domestic waste reached more than 2 billion tons, effectively reducing rural non-point source pollution and greenhouse gas emissions of more than 63 million tons, with significant ecological benefits. On the other hand, biogas and its derivatives effectively reduce the cost of agricultural production, improve the quality of agricultural products and soil fertility, promote the material and energy cycle of agricultural production, and play an important role in promoting the development of agriculture.

3. Research design

3.1. Index system and evaluation model

3.1.1. Index system. On the basis of referring to the relevant research results and combining with the actual situation of Qionglai in Sichuan province, the evaluation index system reflecting the comprehensive utilization level of household biogas in rural areas of Qionglai was designed according to the principle of scientificity and feasibility. The specific indicator system is shown in table 1.

| Target | Criterion | Index | Variable | Direction |
|--------|-----------|-------|----------|-----------|
| Comprehensive utilization level of rural household biogas in Qionglai | Economic benefit (A) | Utilization rate of biogas and its derivatives | A1 | + |
| | | Net profit of biogas and its derivatives | A2 | + |
| | | Rate of return on investment | A3 | + |
| | | Investment payback period | A4 | - |
| | Ecological Benefits (B) | Degree of soil improvement | B1 | + |
| | | Fecal sewage reduction | B2 | + |
| | | Pesticide and fertilizer application reduction | B3 | + |
| | Social benefit (C) | CO2 emission reduction | B4 | + |
| | | Promotion degree of environmental awareness | B1 | + |
| | | Promotion degree of professional skills | C2 | + |
In terms of economic benefits, the utilization rate of biogas and its derivatives reflects the satisfaction of farmers' income and expenditure reduction effect, as well as the utilization behavior decision of biogas and its derivatives based on the current satisfaction. Driven by interests, when it is profitable to use biogas and its derivatives instead of traditional production and living energy, farmers will tend to increase the utilization rate. In this process, the net profit intuitively shows the amount of income and expenditure reduction of farmers in the presence of line state. The two indicators of investment return rate and investment recovery period investigate the early investment expenditure and current return of farmers in building biogas digesters and related supporting facilities. The investment return rate is a static indicator to evaluate the profitability of biogas investment scheme, and the investment recovery period reflects the capital turnover speed of farmers' investment.

In terms of ecological benefits, the treatment of livestock and poultry manure is the driving factor for the government to continue to invest and subsidize, and it is also an important way to solve the problem of non-point source pollution in rural areas. Reducing the degree of soil improvement and pesticide fertilizer reflects the biogas slurry renewal application effect, the degree of soil improvement by applying marsh fertilizer agricultural output and quality of efficiency to replace, but in the actual production quality change is difficult to measure, this paper chose the market price fluctuations smaller as the observation object computing selling income change of agricultural products. In rural areas where biogas digesters are not yet widespread, the wrong treatment of livestock and poultry feces and the burning of fuelwood produce a large amount of greenhouse gases. Since the emission reduction of manure can reflect the methane emissions reduced by fermented manure, the carbon dioxide emission reduction by reducing the combustion of fuelwood is selected as the evaluation index.

In terms of social benefits, the improvement of environmental awareness and professional skills reflects the change of farmers' quality in the process of biogas use. On the one hand, the reduction of incidence of livestock and poultry can reflect the improvement of production and living environment, on the other hand, it can reduce the economic loss and labor intensity of farmers. The degree of renewable energy can reflect the change trend of local energy use structure, which is of great significance to the construction of resource-saving society.

3.1.2. Analytic Hierarchy Process. The comparison between judgment matrices is the core of AHP. It mainly refers to the element value determined by comparing two elements of the next level with one element of the above level as the judgment standard. The element $a_{ij}$ in the judgment matrix represents the relative importance of $A_i$ to $A_j$ from the judgment criterion.

**Table 2. Judgment criteria.**

| Two factor comparison                                      | score |
|------------------------------------------------------------|-------|
| Factor I is as important as factor J                        | 1     |
| Factor I is slightly more important than factor J           | 3     |
| Factor I is obviously more important than factor J         | 5     |
| Factor I is much more important than the factor J          | 7     |
| Factor I is absolutely more important than factor J        | 9     |
| Factor I and factor J are between the two results          | 2,4,6,8 |

The relative importance of matrix A on the judgment criteria, the relative weight of each factor, is calculated after comparing and scoring the elements by expert scoring method and Delphi method. Suppose the judgment matrix of comparison is $A$, 

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Degree of biogas meeting domestic energy consumption C3 +
The degree of reduction of animal disease C4 +
```
Each column of judgment matrix $A$ is normalized as follows,
\[
b_{ij} = \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \quad (i=1,2,…n)
\]  

Calculating the maximum eigenvalue of judgment matrix,
\[
\lambda_{max} = \sum_{i=1}^{n} \left( (AW)_{i} / n w_{i} \right)
\]

After the weight calculation of a single indicator is completed, it is necessary to ensure that it meets $A_{ij} = a_{ik} / a_{jk}$, so consistency test is needed to bring the maximum eigenvalue into it,
\[
CI = \frac{\lambda_{max} - n}{n-1}
\]

When $CI \leq 0.1$, the consistency condition can be considered to be satisfied. In order to exclude the influence of the dimension of the judgment matrix, the modified $RI$ is generally introduced, as shown in Table 3. A more reasonable $CR$ is selected as the consistency index of the judgment matrix,
\[
CR = \frac{CI}{RI}
\]

That is to say, only $CR \leq 0.1$ is required, that is to say, the judgment matrix is considered to pass the consistency hypothesis test, otherwise, it is necessary to make two judgments again.

Table 3. $RI$ Numerical table.

| Dimensionality | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   |
|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| RI             | 0   | 0   | 0.58| 0.96| 1.12| 1.24| 1.32| 1.41| 1.45|

Finally, formula $B_{wj}$ is used to calculate the comprehensive importance degree and obtain the comprehensive evaluation score,
\[
B_{wj} = \sum_{j=1}^{m} a_{j} b_{ij} \quad (j=1,2, \ldots m)
\]

3.2. Data source and sample description

In this paper, Qionglai, a key county of modern animal husbandry in Sichuan Province and a big county of pig transfer from China, was selected as the research site. The rapid development of livestock and poultry breeding industry has brought serious damage to the local rural ecological environment. In order to solve the problem of agricultural production pollution, Qionglai started the special treatment of aquaculture pollution in 2014, and carried out a number of pollution treatment subsidies, covering household biogas, large and medium-sized biogas projects and construction projects of septic tanks. By the end of 2018, Qionglai has carried out five construction subsidies for biogas projects, totally subsidizing more than 890 rural household biogas, and 97 large and medium-sized biogas projects, greatly improving the treatment and storage capacity of local breeding manure. In this paper, 300 farmers who successfully applied for Chengdu Municipal Household Biogas subsidies in 2015 were selected as the survey population, and 200 of them were randomly selected as survey objects for questionnaire survey. The questionnaire was uniformly issued by Qionglai municipal government to the township where the farmers live, and then the township supervisor filled in the questionnaire and fed back to the researchers. The research team sent out 200 questionnaires, 161 of which were recovered, with a recovery rate of 80.5%, 132 of which were effective, with an effective rate of 81.99%.

The surveyed households are distributed in 10 towns including Chayuan, Datong, Guyi, Huilong, Linqiong, Nanbaoshan, Pingle, Qianjin, Sangyuan, Shuikou. The basic characteristics of the households are shown in Table 4. From the perspective of individual characteristics of farmers, the age of farmers is mainly 46-60 years old, and the education level is mainly junior high school and primary
school. From the perspective of family characteristics, more than half of the surveyed households have a population of 3-4, and most of them have an annual income of more than 10000 yuan. According to the national bureau of statistics, the per capita disposable income of residents nationwide was 28228 yuan in 2018. According to the survey data, more than 53.79% of the surveyed households have exceeded the average level.

### Table 4. Statistical table of basic characteristics of farmers and families.

| Characteristics           | Classification characteristics |
|---------------------------|-------------------------------|
| Gender                    | Male                          | Female                      |
| Percentage                | 54.1%                         | 45.9%                       |
| Age                       | Under 30 years old            | 30-45 years old             | 46-60 years old | Over 60 years old |
| Percentage                | 0.00%                         | 22.73%                      | 55.30%         | 21.97%            |
| Education                 | Elementary school or below    | Junior high school          | Senior high school | College or above |
| Percentage                | 33.33%                        | 61.36%                      | 3.79%           | 1.51%             |
| Family members            | 1                             | 2                           | 3-4             | 5 or more         |
| Percentage                | 0                             | 20.65%                      | 57.61%          | 21.74%            |
| Household income          | Less than 10000 yuan          | 10001-30000 yuan             | 30001-50000 yuan | More than 50000 yuan |
| Percentage                | 10.08%                        | 36.13%                      | 31.10%          | 22.69%            |
| Breeding scale            | Less than 50                  | 50-100                      | 101-200         | More than 200     |
| Percentage                | 48.48%                        | 46.21%                      | 4.55%           | 0.76%             |
| Biogas pool capacity      | Less than 10m$^3$             | 11-50m$^3$                  | 51-100m$^3$     | More than 100m$^3$ |
| Percentage                | 24.41%                        | 70.08%                      | 5.51%           | 0%                |

### 4. Results and analysis

#### 4.1. Simple benefit calculation

The economic benefit of household biogas is the most intuitive and most stimulating indicator to improve the enthusiasm of farmers in the utilization of biogas. Therefore, this study will be investigated as a whole by farmers, and their profitability will be calculated by using two financial indicators, namely the return on investment and the payback period.

### Table 5. Total amount of household biogas costs and benefits.

| Index                               | Average (yuan) | Minimum (yuan) | Maximum (yuan) | Standard deviation | Total (yuan) |
|-------------------------------------|----------------|----------------|----------------|--------------------|--------------|
| **Investment**                      |                |                |                |                    |              |
| Biogas tank construction (self-raised) | 4930.27        | 400.00         | 28000.00       | 4923.32            | 650795.64    |
| Supporting facilities (pipeline, etc.) | 638.63         | 0.00           | 2000.00        | 430.28             | 84299.16     |
| Electricity fee                      | 281.44         | 0.00           | 3000.00        | 535.39             | 37150.08     |
| Water fee                            | 71.30          | 0.00           | 2000.00        | 242.05             | 9411.6       |
| Maintenance fee                      | 360.31         | 0.00           | 5000.00        | 592.56             | 47560.92     |
| **Life energy cost**                |                |                |                |                    |              |
| Coal                                | 276.30         | 0.00           | 4800.00        | 770.78             | 36471.6      |
According to table 5132 households with biogas digesters, the total initial investment is 735094.8 yuan, the total annual cost of biogas operation is 94112.6 yuan, the total income and indirect income is 426502.56 yuan, and the annual net benefit of a biogas digester is 2518.03 yuan. Considering the biogas used by 132 households as a whole, we assume that the net salvage rate is 5% and the service life of the biogas digester is 10 years.

\[
\text{Return on investment} = \frac{\text{annual net income}}{\text{initial investment}} \times 100\% = \frac{[426502.56-94112.6-735094.8*(1-5%)/10]/735094.8*100\%}{35.72}\%
\]

\[
\text{Investment payback period} = \frac{\text{total initial investment}}{\text{annual net cash flow}}
\]

\[
\text{Annual net cash flow} = \text{annual net income} + \text{depreciation of fixed assets recovered}
\]

\[
\text{Initial amount of self raised funds} \text{ NCF} = -735094.8 \text{ yuan}
\]

\[
\text{NCF} = \frac{[426502.56-94112.6-735094.8*(1-5%)/10]}{735094.8} = 332389.96 \text{ yuan}
\]

\[
\text{Investment payback period} = \frac{735094.8}{332389.96} = 2.21 \text{ year}
\]

That is to say, without considering the changes of time value and cost-benefit of funds, the rate of return on household biogas investment in Qionglai is 35.72%, and it is estimated that in 2.21 years, all self raised funds will be recovered by farmers.

4.2. Estimated index weight

When AHP is used to determine the weights of evaluation indexes at all levels, the method of subjective evaluation is used to collect the scores of experts and scholars, so as to determine the weights of indexes more objectively on a broad basis, construct a judgment matrix, compare and judge the importance of the two indexes, and calculate the weights of indexes at all levels as shown in Table 6 and table 7.

Table 6. Index layer weight of comprehensive benefit evaluation for household biogas.

| Letter | Criterion | Comprehensive weight |
|--------|-----------|-----------------------|
| A      | Economic performance | 0.33 |
| B      | Ecological Benefit    | 0.39 |
| C      | Social Benefit        | 0.28 |

Consistency Ratio (CR) =0.0064<0.1

Table 7. Index layer weight of comprehensive benefit evaluation for household biogas.

| Letter | Index | Index weight | Comprehensive weight |
|--------|-------|--------------|----------------------|
| A1     | Utilization rate of biogas and its derivatives | 0.27 | 0.0891 |
| A2     | Net profit of biogas and its derivatives       | 0.23 | 0.0759 |
4.3 Calculation of comprehensive benefits

The index system constructed in this paper is relatively complex, and there are qualitative index and quantitative index, positive index and reverse index at the same time. Therefore, this study uses Likert scale to assign value to qualitative index, and uses range transformation method to standardize the data and take the mean value. The data processing results are as follows.

Table 8. Data processing results.

| Letter | Min   | Max   | Average | Standardized mean | Weight | Score |
|--------|-------|-------|---------|-------------------|--------|-------|
| A1     | 0.00% | 100%  | 95.75%  | 0.95              | 0.27   | 0.2565|
| A2     | -4300 | 17200 | 3091    | 0.34              | 0.23   | 0.0782|
| A3     | -45.99% | 253.00% | 35.75%  | 0.24              | 0.27   | 0.0648|
| A4     | 0.19  | 11.6  | 2.20    | 0.79              | 0.23   | 0.1817|
| B1     | 1     | 5     | 3.09    | 0.52              | 0.23   | 0.1196|
| B2     | 1     | 1800  | 168     | 0.19              | 0.28   | 0.0532|
| B3     | 0     | 1280  | 104.77  | 0.17              | 0.23   | 0.0391|
| B4     | 0     | 15377 | 1343.35 | 0.23              | 0.26   | 0.0598|
| C1     | 2     | 5     | 4.10    | 0.70              | 0.14   | 0.0980|
| C2     | 1     | 5     | 3.84    | 0.71              | 0.21   | 0.1491|
| C3     | 0     | 1     | 0.94    | 0.94              | 0.34   | 0.3196|
| C4     | 1     | 5     | 1.4     | 0.11              | 0.31   | 0.0341|

Table 9. Comprehensive benefit score of household biogas.

| Criterion          | Weight | Score | Letter | Weight | Assignment | Score |
|--------------------|--------|-------|--------|--------|------------|-------|
| Economic benefits  | 0.33   |       | A1     | 0.27   | 0.95       | 0.5812|
|                    |        |       | A2     | 0.23   | 0.34       |       |
|                    |        |       | A3     | 0.27   | 0.24       |       |
|                    |        |       | A4     | 0.23   | 0.79       |       |
|                    |        |       | B1     | 0.23   | 0.52       |       |
|                    | 0.39   | 0.465 | B2     | 0.28   | 0.19       | 0.2717|
| Ecological benefits|        | 9     | B3     | 0.23   | 0.17       |       |
|                    | 0.39   | 0.465 | B4     | 0.26   | 0.23       |       |
|                    |        |       | C1     | 0.14   | 0.70       |       |
|                    |        |       | C2     | 0.21   | 0.71       |       |
|                    |        |       | C3     | 0.34   | 0.94       | 0.6008|
|                    |        |       | C4     | 0.31   | 0.11       |       |

Social benefits 0.28
4.4. **Analysis of measurement results**

It can be seen from the calculation results that the overall score of household biogas utilization in Qionglai is not high, especially in terms of ecological benefits, the actual reduction effect of fecal discharge rate and pesticide and fertilizer application is not ideal. It is the original intention of the government to subsidize the construction of biogas digesters and the driving factor for farmers to build biogas digesters, but the index score is low. The reason is a large gap between the cultivation scale of farmers and the amount of annual treatment of manure, and the cultivation scale of most farmers and the amount of annual treatment of manure are at a low level. At the end of 2017, many farmers heard that the government would introduce a series of more stringent regulatory measures, such as environmental tax, and then chose to reduce the scale of breeding, making the average Fecal Emission Reduction reduced. On the one hand, farmers do not master the scientific application technology of marsh fertilizer slurry, and the effect of insect control and production increase is not obvious, which reduces the willingness of farmers to use; on the other hand, it is difficult to detect whether excessive heavy metals remain in the marsh fertilizer, and farmers are unwilling to take the risk of excessive use. These two indicators directly reflect the short-term decisions of farmers and farmers in the face of production risks, indicating that there will be great room for improvement in the scores of the two indicators after strengthening production technical guidance, promoting the simple detection method of heavy metals, and exchanging policy and market information.

In the comprehensive evaluation, the economic and social benefits are more significant. The utilization of biogas and its derivatives brings the reduction of production and living costs and the improvement of direct benefits to farmers. Thanks to the popularization of biogas-related science and technical guidance, farmers' environmental awareness and professional skills have been improved, and the improvement of personal quality plays an important role in the formation of green production and energy-saving living atmosphere in the whole countryside. Through the construction of biogas digester, the living energy structure of farmers will be changed, and the living environment and the spiritual outlook of the masses will be improved with the reduction of labor intensity. At present, the development and promotion of household biogas will still be an important measure for new rural construction and rural revitalization. With the maturity and popularization of biogas-related technologies, the evaluation of comprehensive benefits of biogas will be significantly improved.

5. **Conclusions**

This study summarizes the advantages and disadvantages of biogas utilization in China by combing and comparing the current situation of biogas energy utilization at home and abroad. Through on-the-spot investigation interview, Qionglai, Sichuan province rural household biogas users get the benefits of biogas utilization data, using the analytic hierarchy process (ahp) to construct the comprehensive evaluation index system, USES the financial index to measure the economic benefits of household biogas, establish the index system of weights and scores of methane in the survey area and their derivatives using a comprehensive appraisal is made on the economic, ecological and social benefits, the research conclusion is as follows:

1. The development of modern biogas project in China is relatively late, and there is a big gap between the biogas technology and the developed countries in raw material input, biogas utilization and energy storage. With the support and call of the government, methane gas is widely used in rural areas, which effectively reduces the cost of agricultural production, improves the quality of agricultural products and soil fertility, promotes the material and energy cycle of agricultural production, and plays an important role in promoting the transformation and development of agriculture.

2. In the evaluation of comprehensive utilization efficiency of biogas based on AHP, the economic and social benefits get higher scores, which shows that the reasonable utilization of biogas and its derivatives can effectively reduce the cost of life and production, and the production skills, environmental awareness of farmers and the whole life style of rural areas can be effectively improved.
The low score of ecological benefit indicates that the government needs to strengthen technical guidance, policy and market information exchange.

(3) Farmers generally reflect that there are still some difficulties in the use of rural household biogas: high cost of construction and maintenance, lack of terminal subsidies and incentives; lagging biogas service system, imperfect market mechanism; serious loss of rural labor force, and farmers' resistance. These are all problems that the government needs to pay attention to and solve.

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