Comprehensive Benefit Analysis on Development Models of Circular Agriculture in Wangcang County of Sichuan Province

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Abstract Taking Wangcang County of Sichuan Province as an example, this paper made comprehensive benefit analysis on models of circular agriculture in Wangcang County. Major models include "pig - biogas - fruit", "pig - biogas - vegetable", and "pig - biogas - tea". It made cost benefit analysis of economic, social and ecological benefits. Through benefit analysis charts, it obtained that the net present value of each household building biogas pool is 6029 yuan. In this way, it significantly improved ecological environment and social benefits, and the agricultural economic development model gradually changes to sustainable development model. However, there are still problems of insufficient government input and single model of agricultural circular economy. Therefore, government should increase input and develop diversified agricultural circular economical models in accordance with local situations, to realize sustainable agricultural development.

Key words Circular agriculture of Wangcang County, Development models, Cost benefit analysis, Development recommendations

From 2003, Wangcang County of Sichuan Province started developing circular agricultural economy with biogas as link in all suitable towns. With more than 10 years of development, circular agriculture of Wangcang County has begun to take shape, but there are still problems of slow development and low efficiency. Through cost benefit analysis on development models of circular agriculture in Wangcang County from the perspective of sustainable development of county-wide agriculture, it is expected to come up with pertinent recommendations for efficient advance and scientific development of circular agriculture in Wangcang County.

1 Documentary overview

1.1 Overview of circular agricultural economic models of Sichuan Province Typical models of circular agriculture in Sichuan Province are "pig - biogas - fruit" ecological agriculture and its derivative models. Zeng Xiaolan (2009) stated that natural conditions of Sichuan Province is suitable for developing "pig - biogas - fruit" model with biogas as the link. This model mainly uses mountain area, farmland, water and courtyard resources, combines biogas pool, hogpen, toilet, focuses on leading industry, and carries out comprehensive use of biogas, biogas dregs, and biogas liquid. Taking Shehong County as an example, Luo Qing and Deng Ziyuan (2009) pointed out that circular agriculture in central Sichuan mainly takes biogas as the link and is based on superior industries. For example, pig raising, grain crop planting and wine making are superior industries in Shehong County, so major models of Shehong County is "grain - pig - biogas - fruit" and "grain - wine - biogas - grain". Zhao Jianjun and Guo Lingli (2009) stated that "pig- biogas - fruit" is a typical model in southern rural areas. The development of circular agriculture in Sichuan Province is mainly based on biogas.

1.2 Overview of benefit analysis methods In evaluation and analysis of circular agriculture in Sichuan Province, most researches touch upon overall circular agriculture of the whole province, while few are related to county-wide agricultural economic model. Liu Xiaoling (2012) made evaluation and analysis on benefits of utilization of biogas pools in Huixian County. Yang Lirong, Chen Wenkuan and Mu Peisong (2009) studied agricultural economic efficiency of Shehong County based on data envelopment analysis (DEA) [1].

In the evaluation of circular economy of agriculture in Sichuan Province, different scholars adopted different analysis methods, mainly including Delphi method, Analytic Hierarchy Process (AHP), comprehensive index evaluation method, and DEA method. Sun Yanling and Li Ming (2009) made evaluation of sustainability of agriculture in Sichuan, revealed existing problems in Sichuan, and came up with recommendations and policies for strengthening sustainable development ability of Sichuan Province in accordance with actual situations of China and Sichuan Province, using DEA method. Using fuzzy comprehensive evaluation method and combining actual situations of agricultural development in two model areas, Huang Caian (2012) established a pertinent performance evaluation indicator system for circular agriculture, and made performance evaluation on circular agriculture of Ya'an City using AHP and Delphi method. The above analyses are established on the basis of massive data.

In benefit analysis method of county-wide agricultural circular economical models, most use cost benefit method and analyze ecological and social benefits in a quantitative way. In the evaluation of benefits of biogas pool utilization in Huixian County, Liu Xiaoling (2012) held that economic benefits should combine with cost benefit analysis method and emergy analysis, ecological benefits

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are analyzed by AHP, and energy replacement benefits and social benefits are discussed by comparative analysis on the basis of survey [2]. In the benefit evaluation and analysis of biogas in Jiangyou City, Zhao Jianjun and Guo Lingli (2009) stated that economic benefits can be measured by money, while it is difficult to accurately measure social and ecological benefits [3]. They made technical economic analysis on "pig - biogas - fruit" model using cost benefit analysis method.

2 Development models of circular agriculture in Wangcang County of Sichuan Province

2.1 General situations of agricultural economic development of Wangcang County Wangcang County (105°58′24″E-106°46′2″E, 31°58′45″N-32°42′24″) is situated in northern Sichuan Province and contiguous to Shaanxi Province. With subtropical humid monsoon climate, it features distinct vertical climate, large annual temperature range but small monthly temperature range, average annual temperature is 16.2℃, annual sunshine hours is 1352.52 hours, annual rainfall is 1142 mm, and average annual frost-free period is 266 days. The soil is mainly mountainous yellow soil and mountainous yellow brown soil, with total area of 2976 km^2. Wangcang County is a state-level poverty stricken county and its agricultural economic development is lower than the average national level. In 2014, per capita net income of farmers in Wangcang County was 7812 yuan, while the per capita net income of rural residents in the whole country was 9892 yuan, showing a certain gap. Grain crops in Wangcang County are mainly rice and corn, and cash crops are mainly tea, fruit trees and traditional Chinese medicinal plants. Animal husbandry, forest and fruit, sericulture, and traditional Chinese medicinal plant industries are five largest industries supporting county-wide rural economy. By 2014, there have been 9 agricultural model parks in Wangcang County, the construction area was up to 100000 mu, and increase of farmers' income exceeded 2000 yuan on average.

2.2 Development models of circular agriculture in Wangcang County of Sichuan Province Major models of circular agriculture in Wangcang County include "pig - biogas - fruit", "pig - biogas - vegetable", and "pig - biogas - tea". In recent years, rural biogas projects implemented in Wangcang County are mainly national debt, provincial level, and conceding the land to forestry. The subsidy amount is respectively 2000 yuan, 1200 yuan and 1500 yuan for a biogas pool at central government and provincial finance level, and farmers only need 2000 – 2500 yuan.

The development of biogas industry in Wangcang County is excellent. From agricultural information network of Wangcang County, from 2003, energy-saving technology with rural biogas as major part was gradually known and accepted by farmers. The number of biogas pools built in the whole year was 7000; in 2008, it rose to 190000 and the biogas household entrance rate reached 18%; in 2010, it completed construction of biogas pools for 8589 households and the whole county has built 31000 biogas pools; in 2013, the whole county built 45922 biogas pools, accounting for 81% of total households suitable for construction of biogas pools; by 2014, the whole county has built 48000 biogas pools and the penetration rate was up to 83%. As shown in Fig. 1, it takes on gradual growth trend.

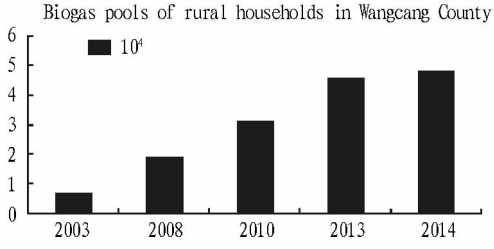

Fig. 1 Bar chart for biogas pools of rural households in Wangcang County

2.2.1 Pig - biogas - tea model. The pig - biogas - tea model takes pig manure and domestic manure as raw materials of fermentation to generate biogas, biogas liquid and dregs. Generated biogas can be used for domestic use, biogas liquid and dregs are used as nutrients of tea trees, and biogas liquid can feed pigs.

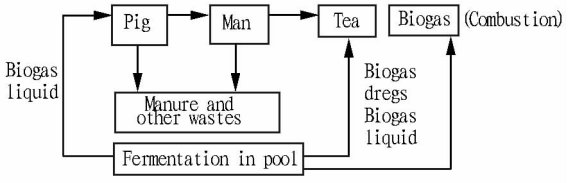

Fig. 2 Pig - biogas - tea model

2.2.2 Pig - biogas - fruit model. The pig - biogas - fruit model takes pig manure and domestic manure as raw materials of fermentation to generate biogas, biogas liquid and dregs. Generated biogas can be used for domestic use, biogas liquid and dregs are used as nutrients of fruit trees, and biogas liquid can feed pigs. Wangcang County is situated in subtropical humid monsoon climate zone, suitable for planting orange, walnut and peach trees. Cultivation range is mainly distributed in Donghe Town and downstream townships with lower altitude.

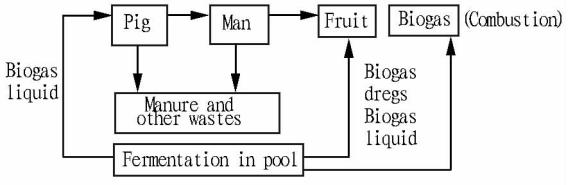

Fig. 3 Pig - biogas - fruit model

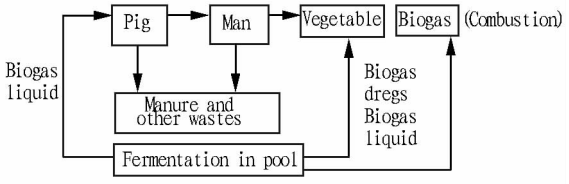

Fig. 4 Pig - biogas - vegetable model

2.2.3 Pig - biogas - vegetable model. The only difference with the above model is that biogas dregs and liquid are used for ma-

nure of various vegetables planted by farmers. However, this model is more adapted and widely applied in rural areas of Wangcang County. Rural areas with too low temperature and too high altitude are not suitable for installing biogas facilities, because generation of biogas needs certain temperature condition.

3 Cost benefit analysis of circular agriculture in Wangcang County of Sichuan Province

3.1 Economic benefits

3.1.1 Costs. (i) Construction of biogas pools. In recent years, farmers in Wangcang County generally build 8 m^3 biogas pools. Here, only costs for construction of biogas pools are calculated, excluding costs for three kinds of transformation and neglecting difference in freights of distribution areas. Construction costs include building material (equipment, cement, sand, and standard bricks) cost, labor cost and freight. The total costs are 4250 yuan approximately, including 2450 yuan material cost, 1200 yuan labor cost, and 600 yuan freight.

Table 1 Estimation of investment of rural household biogas pools

Item	Description	Brick-concrete structure		
		Unit price// yuan	Amount//yuan	Q'ty
Material cost	Cement// m^3	1.5	400	600
	River sand// m^3	3	150	450
	1/4 brick// m^3	3	150	450
	Standard brick// pcs	1000	0.5	500
	Biogas cooking utensils and auxiliary products// set	1	300	300
	Extracting piston and foot valve// pcs	1	30	30
	PVC fittings// pcs	1	150	150
Labor cost	Piece work// work-day	4	200	800
	Odd job work// work-day	5	80	400
Freight	Cargo truck// pcs	2	300	600
Total		–	–	4250

(ii) Management cost and maintenance expenses. Management cost mainly includes labor cost for maintenance of biogas pool (once every two years) and labor cost for complete discharge (once every year), about 200 yuan annually; maintenance cost mainly includes costs for replacing materials and elements of biogas pools and auxiliary facilities, about 50 yuan annually. Management and maintenance costs constitute operating costs of biogas pool, about 250 yuan annually.

3.1.2 Benefits. According to calculation, building a 8 m^3 biogas pool in Wangcang County and raising 3 – 5 pigs, it is able to provide 350 m^3 biogas and provide 16 – 20 m^3 biogas fertilizer.

(i) The biogas can satisfy more than 80% living fuel demands for a family with 3 – 5 members for one year. In Wangcang County, farmers generally adopt firewood as fuels. Using biogas will save firewood as high as 2.5 tons annually. Without considering saving the time for cutting firewood and ecological benefits, it can save lighting expenses as much as 100 yuan annually.

(ii) Biogas dregs and liquid can be used as fertilizer and save 25% chemical fertilizers. Farmers in Wangcang County have 2.5 mu farmland on average and apply chemical fertilizer about 1000 yuan annually. Using biogas dregs and liquid can save 250 yuan for chemical fertilizer. Besides, using biogas dregs and liquid can improve quality of agricultural products and increase the benefits about 100 yuan.

(iii) Biogas liquid can be taken as feeds of chicken, fishes, pigs, and cattle and can save feeds about 20%. The annual feed cost of each household is about 1000 yuan, using biogas dregs and liquid can save feeds about 200 yuan, and it can increase benefits about 300 yuan through selling the pigs.

In sum, the annual economic benefit is about 950 yuan.

The service life of biogas pool is 20 years. According to current loan rate, the base earnings ratio is 6%. In recent years, rural biogas projects implemented in Wangcang County are mainly national debt, provincial level, and conceding the land to forestry. The subsidy amount is respectively 2000 yuan, 1200 yuan and 1500 yuan for a biogas pool at central government and provincial finance level, and farmers only need 2250 – 2500 yuan. Therefore, costs and benefits of biogas pool with government subsidies are shown in Table 2.

3.1.3 Payback period of investment. The payback period of investment refers to the time required for the return on an investment to repay the sum of the original investment. According to the above values, the payback period of investment = (4 – 1) + | – 128.9|/(425.57 + 128.9) = 3.23 years.

From the above calculation, we know that the net present value of building an 8 m^3 biogas pool with government subsidies is 6029 yuan, and it is able to recover the cost in 3.23 years. Such circular agriculture with biogas pool as link has excellent economic benefits.

3.2 Ecological benefits Developing circular agriculture not only brings economic benefits, but also brings ecological benefits. Construction of biogas pools in rural areas can transform farmers' traditional production and living style and improve their living conditions. An 8 m^3 biogas pool can generate biogas as much as 350 m^3. This can basically satisfy living energy demands of a three-member family, effectively transform rural energy consumption

structure, replace 2500 kg firewood, protect forest land 3.5 mu, reduce water and soil loss 2 m^3, and reduce CO_2 emission 2 tons. Farmers in Wangcang County generally use firewood as fuels. With biogas developed, farmers will cut down less firewood, forest land will be protected to a certain extent, and water and soil loss will also be reduced to a certain extent. Besides, it will reduce pollution of CO_2 and SO2 to air. In addition, use of biogas manure reduces chemical fertilizers and pesticide, reduces farmland pollution and water pollution. Also, it reduces incidence of rural diseases and improves farmers' living environment.

Table 2 Cost benefit analysis with government subsidies

Time year	Investment cost // yuan	Benefits yuan	Net benefits yuan	Discount factor	Present value of cost // yuan	Present value of benefits yuan	Present value of net benefits // yuan	Present value of accumulative net benefits // yuan
0	2000	0	-2000	1.0000	2000.00	0.00	-2000.00	-2000.00
1	250	950	700	0.9434	235.85	896.23	660.38	-1339.62
2	250	950	700	0.8900	222.50	845.50	623.00	-716.62
3	250	950	700	0.8396	209.90	797.62	587.72	-128.90
4	250	950	700	0.7921	198.03	752.50	554.47	425.57
5	250	950	700	0.7473	186.83	709.94	523.11	948.68
6	250	950	700	0.7050	176.25	669.75	493.50	1442.18
7	250	950	700	0.6651	166.28	631.85	465.57	1907.75
8	250	950	700	0.6274	156.85	596.03	439.18	2346.93
9	250	950	700	0.5919	147.73	562.31	414.33	2761.26
10	250	950	700	0.5584	139.60	530.48	390.88	3152.14
11	250	950	700	0.5268	131.70	500.46	368.76	3520.90
12	250	950	700	0.4970	124.25	472.15	347.90	3868.80
13	250	950	700	0.4688	117.20	445.36	328.16	4196.96
14	250	950	700	0.4423	110.58	420.19	309.61	4506.57
15	250	950	700	0.4173	104.33	396.44	292.11	4798.68
16	250	950	700	0.3936	98.40	373.92	275.52	5074.20
17	250	950	700	0.3714	92.85	352.83	259.98	5334.18
18	250	950	700	0.3503	87.58	332.79	245.21	5579.39
19	250	950	700	0.3305	82.63	313.98	231.35	5810.74
20	250	950	700	0.3118	77.95	296.21	218.26	6029.00

3.3 Social benefits According to local characteristics of Wangcang County, the "pig - biogas - fruit", "pig - biogas - vegetable", and pig - biogas - tea" models have a lot of social benefits. Since the circular agriculture with biogas as link was advocated in 2003, farmers' living conditions have been greatly improved. Developing rural biogas realizes change of firewood to gas as fuel, effectively solves the problem of random stacking of coal and dust, reduces multiplication of mosquitoes and flies, and brings rural areas to develop towards healthy, sanitary and clean direction. Besides, use of biogas supplements energy for living, saves time for firewood cutting and tending the kitchen fire, liberates women from heavy housework, increases labor, and creates favorable conditions for accelerating transfer of rural surplus labor, increasing farmers' income, and maintaining social stability, showing considerable social benefits.

3.4 Graphic analysis As shown in the graph, farmers' demands are definite and F denotes utilization volume of resources. In this study, it refers to take firewood and coal as living fuels. F * stands for optimum utilization volume of the society. In this study, it refers to use of biogas pool under the leadership of government. Obviously, in spontaneous action of farmers, resources are used excessively, FF * is the part of excessive use and stands for marginal social cost. When government advocates building biogas pools and provides certain amount of subsidies, F will gradually move towards F * and the reduced marginal cost will become ecological, social and economic benefits.

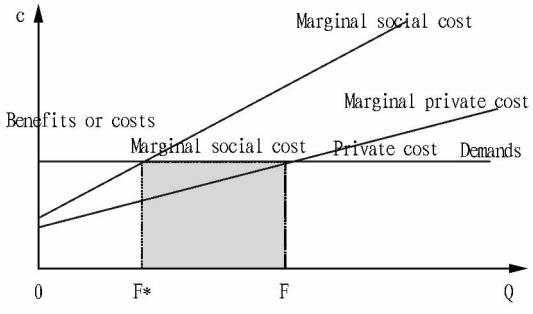

Fig. 5 Marginal social cost reduced from use of biogas pools

4 Existing problems in development of circular agriculture in Wangcang County of Sichuan Province

4.1 Low amount of state subsidies In recent years, rural biogas projects implemented in Wangcang County are mainly national debt, provincial level, and conceding the land to forestry. The subsidy amount is respectively 2000 yuan, 1200 yuan and 1500 yuan for a biogas pool. In recent years, building a biogas pool needs higher input, because costs for bricks, sand, stones, cement and steel bars and labor costs are constantly rising. Apart from government subsidies, farmers need inputting 2000-2500

yuan.

4.2 Difficulty of farmers in raising funds restricts advance in three kinds of transformations Government asks farmers to transform kitchens, toilets and hogpens, but provides no subsidies. To implement three transformations, farmers need spend 10000 yuan. This is far beyond their financial ability. As a result, the rich people look down upon three transformations, while the poor people are incapable of building biogas pools. There are still no large scale three transformations in Wangcang County.

4.3 Weak awareness of farmers for sustainable development In Wangcang County, most farmers still use firewood as major living fuels and keep using ground stove and wood-fired oven. Farmers have the tradition of using firewood for several thousand years and are difficult to adapt to use of new energies. Besides, a lot of farmers have biased opinion of construction of biogas pool project. They think that the cost for construction of biogas pools is too high, the construction is complicated, and biogas generation rate is low. As a result, they are unwilling to build biogas pools.

4.4 Technologies for building biogas pools are not perfect At present, there are still many problems to be solved in the construction and use of biogas pools in Wangcang County. In the construction process, the installation is not specialized. In consequence, there is no generation of biogas in the subsequent use. Also, the maintenance and inspection system of biogas pools in Wangcang County is not well improved. In addition, lack of technicians makes the above problems difficult to be solved. As a result, many farmers abandon their biogas pools and it leads to huge waste of resources.

4.5 Too single model of circular agriculture The model of circular agriculture in Wangcang County is too single and it is difficult to really realize sustainable agricultural development. Thus, circular agriculture with biogas pool as link can not be taken as the single model of circular agriculture in Wangcang County. With development of urbanization and constant increase of migrant workers, rural areas start to lack labors. Fewer and fewer farmers are willing to raise pigs. Lack of raw materials for fermentation, the utilization efficiency of biogas pools is low and leads to idle in a great number. This leads to waste of resources and restricts sustainable development of agriculture. Slow development of rural circular agriculture aggravates outflow of rural labor, forming a vicious circle. Besides, many areas are not suitable for building biogas pools, so it is necessary to develop new circular agriculture models in accordance with actual local conditions. Therefore, Wangcang County should introduce new circular agriculture models in accordance with local situations, to realize diversified development of circular agriculture.

5 Recommendations for promoting development of circular agriculture in Wangcang County of Sichuan Province

5.1 Increasing the amount of subsidies for building biogas pools Circular agriculture of Wangcang County is mainly relied on biogas. This model not only brings huge economic, ecological and social benefits, but also promotes development of agricultural economy, and boosts development of secondary and tertiary industries to a certain extent. Therefore, to promote development of biogas project, government should increase the amount of subsidies for biogas construction especially in mountain areas, to ensure steady advance of biogas construction project. It is recommended to increase subsidy amount in the process of building biogas pools and transformations of kitchens, toilets and hogpens in accordance with actual situations of mountain areas.

5.2 Enhancing propaganda of biogas project Government should enhance propaganda to raise awareness of farmers for sustainable development. It is recommended to spread propaganda through television and radio, to create favorable atmosphere. Besides, it is recommended to carry out one-to-one propaganda to farmers through going to and visiting villages. In addition, it is recommended to assign specialized technicians to make detailed explanation of principle and operation methods of biogas pool, to promote farmers to accept biogas pool project from the bottom of the heart.

5.3 Strengthening introduction of technologies Government should introduce advanced technologies, personnel and methods to improve existing problems in construction and use of biogas pools. It is recommended to introduce advanced construction methods and improve unscientific process in the construction of biogas pools. Besides, it is recommended to arrange technicians to provide mobile after-sales services in towns and villages, to solve possible problems in the use of biogas pools.

5.4 Improving the biogas pool service system Government should establish and improve biogas service system, enhance service site construction, and expand coverage, to help every household to feed back and enjoy regular inspection and timely maintenance services.

5.5 Developing diversified models of circular agriculture in accordance with local situations At present, development of circular agriculture in Wangcang County is relatively backward and single. It is recommended to develop diversified models of circular agriculture. In areas with low temperature and altitude not suitable for building biogas pools, it is recommended to develop other models of circular agriculture, such as paddy field ecological breeding and integrated use of agricultural wastes [4], and developing ecological farms in flat downstream areas [5]. Through diversified development in accordance with actual local situations, it is expected to really realize sustainable development of agriculture in the whole areas of the county.

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party may not make lump sum payment and can obtain indirect financing; village banks can obtain business income through acceptance bill; when the acceptance bill expires, the supplier can obtain payment in time; the third party logistics enterprise can obtain warehouse, supervision and evaluation expenses.

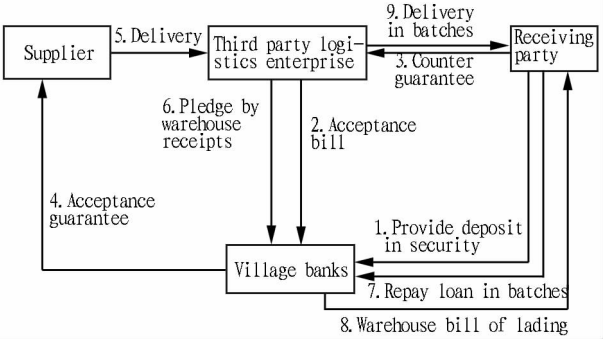

Fig. 4 Confirmation warehouse model

4 Conclusions

Guangxi, situated in the connection area of Southeastern Coastal Economic Belt, Southwest Economic Zone, Central Economic Zone, and ASEAN economic zone, enjoys preferential policies of coastal areas, western development and minority autonomy. In recent years, with Baise City becoming new industrial base and third pole of tourism in Guangxi, Baise City has made outstanding achievements in rapid development of logistics with the aid of scientific and technological and talent advantages of national agricultural scientific and technological park. Besides, Baise City is a model of China's new rural financial reform. Village banks in Baise City have realized considerable development, mainly manifesting in increase in number, improvement in scale, constant expansion of services, and strengthening of standardization and regulation. Village banks mainly serve county-wide areas, while financial institutions are reducing in county-wide areas and the service intensity is insufficient. Rapid development of the logistics mainly relies on great support of funds of financial institutions. Therefore, Baise City can draw support from new rural financial institutions, especially village banks, to develop the logistics finance.

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