

Development Strategy Research of China's Rural Biomass Energy Based on SWOT Model

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Abstract : Rural biomass energy possesses a very important position in the whole energy system as renewable energy, it is not only a strategic measure to relieve contradiction between energy supply and energy demand, but also an important responsibility to promote sustained development of economy in rural area as well as the whole society to vigorously develop and utilize rural biomass energy. On the premise of expounding development status of China's rural biomass energy, this article made a qualitative analysis to advantage, disadvantage, chance, threaten of rural biomass energy development by SWOT matrix, and analytic hierarchy process (AHP) was also introduced, furthermore, an SO strategy referring to Chinese rural biomass energy development was proposed by quantitative analysis, including to speed up exploitation, demonstration, popularization and application etc of biomass energy transformation and utilization technology.

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Key words: Rural Biomass Energy; SWOT Matrix; AHP

1. Introduction

Developing bio-fuel has become an important measure to improve energy security, reduce greenhouse-gas emission, cope with climate change all over the world along with increasingly outstanding of global environmental problems as well as steadily rising of petroleum price since 1970s of the oil crisis. Chinese energy consumption had been more than 1.4 billion tons of standard coal with the economic development at the last twenty years of 20th century, and China had become the second energy consumption dominant country. However, China was faced with traditional energy issue, for example, excessively depending on fossil fuels in the field of energy development, therefore, China must positively extend renewable energy no matter from the view of environment protection or energy crisis^[1], biomass energy could not be neglected in this aspect. Rural biomass energy possessed an important position in the whole energy system as an initial ingredient of renewable energy, vigorously developing and utilizing rural biomass energy were not only a new energy way to for China, but also an important responsibility to resolve issues concerning agriculture, countryside and farmers and ensure sustained development of economy and society^[2].

2. Present Situation of China's Rural Biomass Energy

The Chinese government issued Medium and Long-term Development Scheme of Science and Technology in 2006, and published Development and Design Scheme of Biological Industry, both of which put research and development of biological energy on the important position. During The 11th Five-Year period, National Pillar Program, High-tech Development Plan and Plan for The Development of High-tech Industries increased research-and-development capital to biological energy one after another, Ministry of Science and Technology, all of the National Development and Reform Commission, the Chinese Academy of Sciences, Ministry of Agriculture had set up special fund for biomass energy, a total of more than 0.8 billion RMB was spent on research and development. The Chinese Government specially issued Medium and Long-term Development Scheme of renewable energy in September of 2007, and took the biological energy as an important ingredient of renewable energy, and it also made the concrete development objectives of China's biological energy until 2020, the exploitation of China's biological energy was meeting an unprecedented historical development opportunity.

Table 1 Current situation of China's biomass feedstock resources

(Data source: China Statistical Yearbook 2006)

Organic waste	Annual energy/ a hundred million ton			Marginal land	area /ten thousand hm ²	Annual energy/ a hundred million ton	
	Available physical quantity	Equal standard coal	proportion/%			Equal standard coal	proportion/%
Crop straw	3.90	1.96	52.8	Reserve land suitable for farming	734		
domestic animals and poultry manure	7.15	0.75	20.2	Current Marginal land	2000	1.13	26.7
Forestry remnant	0.07	0.40	10.8	Reserve land suitable for forest	5704	1.75	41.2
Collecting woody firewood	0.38	0.22	5.9	Current firewood forests	303	0.13	3.0
Industry waste	0.62	0.35	9.4	Current oil forests	343	0.06	1.5
Municipal organic refuse	0.16	0.03	0.8	Current bush forest	4530	1.18	27.6
Total	12.91	3.71	100.0	total	13614	4.25	100.0

At a preliminary estimate, the annual total amount of available biomass energy resources was about 0.5 billion tons standard coal in the near future. China's biomass energy generation total installed capacity was 2,200,000 kW until the end of 2006, among this, the co-production of thermo-electricity by bagasse was 1,700,000, the power generation by agriculture and forestry refuse, agriculture biogas, direct combustion of garbage and landfill gas was 500,000 kW. State and local National Development and Reform Commission approved amount to 39 biomass energy direct combustion power generation item, total installed capacity was 1,284,000 kW in 2006, estimated investment was 10.03 billion RMB, 54,000 kW was completed in 2006.

Furthermore, a power generation of 30,000 kW was completed by biomass gasification and landfill gas in 2006, and another 90,000 kW was completed by projects currently under construction. 18,700,000 rural household bio-gas pools have been constructed by Chinese government until the end of 2006, and 140,000 biological sewage purification bio-gas pools were built, more than 2,000 husbandry industry and industrial wastewater bio-gas engineering were built, the annual bio-gas was about 9 billion cubic meter, providing high quality living fuel for approximately 80,000,000 rural population.

Chinese has exploited multiple fixed bed and

fluidized-bed gasifier, taking crop stalks, wood chips, rice hull, branch as raw material to product fuel gas. At present, more than 800 sets machines were used to dry wood and subsidiary agricultural products, approximate 600 centralized stalk gasification supply system of village and town were used, annual production of biomass fuel gas was 20,000,000 cubic meter. More than 20 sets biomass energy gasification power generation system have been popularized and applied. During the 11th Five-Year period, Chinese National Programs for High Technology Research and Development has supported to build biomass energy power generation demonstration project of 6 MW scale. In recent year, crossbreed sweet sorghum was planted experimentally all over the country, and a kind of high glucose and high product breed was obtained, and the straw yield per mu was more than 4 tons. Juice of sweet sorghum was high quality raw material to produce alcohol, during the 11th Five-Year period, utilizing the supporting of Chinese National Programs for High Technology Research and Development, technology to obtain alcohol was exploited by utilizing juice of sweet sorghum, cornstalk cellulosic fibre refuse and so on, the construction of pilot-plant and research experiment were also completed, a industry demonstration project of annual 5000 tons scale was built to obtain ethanol fuel by sweet sorghum, pilot-plant facilities

of annual 600 tons scale was built to obtain ethanol fuel by cellulosic fibre refuse. Biodiesel fuel was a kind of high quality biological liquid fuel, it was also a development direction of China's biomass energy industry, and now it is in a state of experiment research and small scale production and application.

Ministry of Science and Technology has put biological diesel oil technology into the 11th Five-Year Chinese National Programs for High Technology Research and Development and International scientific and technological Cooperation.

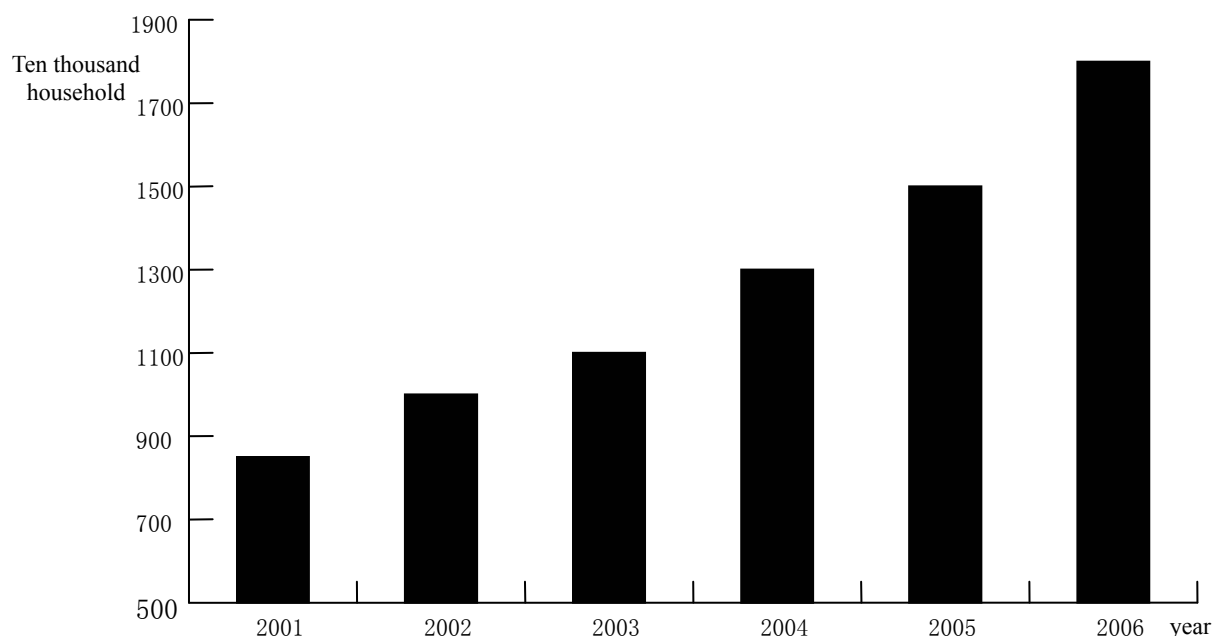


Figure 1 China's rural household biogas development scale (2001-2006)
(Data source: China Statistical Yearbook 2007)

3. SWOT Matrix Qualitative Analysis of China's Rural Biomass Energy Current Development

3.1 Advantage of China's Rural Biomass Energy Development (strengths)

3.1.1 S₁ Resource Advantage

China's rural biomass energy included several

main types, such as crop straw, human and animal manure, by-product of agricultural product processing and energy crop and so on, rural biomass energy resources possess many varieties, great amount, and were widely distributed.

Table 2 China's rural available biomass energy resources potentiality(unit: a hundred million tons standard coal)
(Data source: National agricultural and rural economic development in the 11th Five-Year Plan)

category	2005	2010	2020	2030	remarks
crop straw	0.69	0.88	1.43	2.34	Entity amount increased to five hundred million tons
domestic animals and poultry manure	1.07	0.71	0.91	1.16	Calculating as annual growth to be 2.5%
Energy source crop straw	—	0.04	0.25	0.34	Reserve land suitable for farming and exploitation rate of winter slack farming field gradually increased to 10% until 2010
Total	1.76	1.63	2.59	3.84	

According to measure and calculation by Chinese Ministry of Agriculture, annual production of rural straw was about 0.39 billion tons, this data will increase to 0.726 billion tons, which is equal to 0.5 billion tons standard coal, measure and calculation by the development speed during the 11th Five-Year period, China's main agriculture crop straw yield will reach about 0.9 billion tons

predicting to 2015, and approximate a half yield can be used as raw material of rural biomass energy among this. Agricultural product processing industry refuse (including rice hull, corn cob, peanut shell, bagasse and so on) exceeded 0.1 billion tons, domestic animals and poultry manure and agricultural product processing industry organism waste water were about more than 1.8 billion tons^[3].

3.1.2 S₂ Foundation Advantages

China's rural biomass energy has possessed excellent development foundation by approximate more than ten years' construction, and the biomass energy industry has begun to take shape, establishing solid foundation for the further development of industry. Household biogas and large and medium-sized biogas program will get into the initial stage of industrialization development, biomass gasification and solidification technology get into the stage of enlarging scale to reduce the cost, biogas kitchen stove, power generation by biogas, biogas

heating house have get into the stage of demonstration or generalization.

3.1.3 S₃ Technical Advantages

China's rural biomass energy transformation technology was increasingly matured. At present, there were four main transformation technologies: direct burning technology, materialized transformation technology, biochemical transformation technology, vegetable oil technology, and it can also be concretely divided into different subdivides.

Table 3 Current Development Stage of China's Rural Biomass Energy Main Transformation Technology

Technology	Development Stage	Further development	Development potentiality
Biofuel	Mature technology	Looking for low cost raw material	good
Biogas technology	Mature technology	Generalization	good
Gasification technology	Comparatively Mature technology	Power generation	Relatively good
Burning technology	Mature technology	Power generation	Relatively good
Compressing and shaping technology	Comparatively Mature technology	Technology practicability	Relatively good
biofuel cell	Initial starting	Mature technology	good
Technology of hydrogen production	Initial starting	Mature technology	good

As described by above table, generally speaking, China's rural biomass energy technology has been in a mature stage, and with the development of technology, China's rural biomass energy will inevitably obtain greater development and more extensive application.

3.2 Weaknesses of China's Rural Biomass Energy Development

3.2.1 W₁ Unsoundness of Management and Service System

At present, China's rural biomass energy property management and service system was not founded completely. For example, property service was hysteresis to biogas consumers, a phenomenon of stressing construction but slighting management existed in some program construction; standard management system was deficiency in utilization and maintaining of energy facilities, independent rural energy institution was scarce in some region; the whole diathesis and business level were low in rural energy procession, especially speaking, foundation service organizational strength was weak and construction technologist was insufficiency.

3.2.2 W₂ Channels of Investment and financing were comparatively single

Because of several reasons, such as the higher cost of China's rural biomass energy or equipments, the limited China's rural biomass energy marketing and so on, most of domestic energy companies which

were abundant in capital and technical efficiency were unwillingness to put there capital to the field of China's rural biomass energy. China's rural biomass energy program was not brought into each class financial administration normal appropriation or loan channel as normal energy construction program, so besides several big energy companies, small companies and farmers were more short of financing channels to exploit China's rural biomass energy products.

3.2.3 W₃ Market Competitive Ability of Biological Fuel Oil Products Was Weaker

Because of the influences of several aspects in China, such as raw material sources, production technology and industrial organization, the fuel alcohol production cost was higher, at present, the fuel alcohol production cost by means of aging food as raw material was about 4000 RMB per ton, the national annual financial subsidy to 1.02 million tons fuel alcohol was about 1.5 billions, at the current technical and marketing conditions, it need great fund subsidy to enlarge fuel alcohol yield.

3.3 Opportunities of China's Rural Biomass Energy Development

3.3.1 O₁ China Strongly Supports and Thinks Highly of Rural Biomass Energy Construction

Because rural biomass energy construction tightly connected with the raising of farmer living standard and the improvement of rural ecological

environment, it had become an important constituent of building socialism new village. The central has issued documents for continuous three years, putting to speed up rural energies, such as biogas as one of the construction engineering to strengthen rural infrastructure constructions. The suggestion concerning the 11th Five-Year Plan of Central Committee, Chinese Communist Party passed by the Fifth Plenary Session of the Sixteenth Party Central Committee explicitly indicated that rural biogas should be widely spread, and clean energy characteristic of countryside should be developed positively, the Plan also issued many policies and regulations.

3.3.2 O₂ Cooperation Mechanism of CDM Program

CDM program provided serial chances for stakeholder of China's interest: as for Chinese Government, CDM program could provide capital and technology promotion to carry out the necessary scientific development view for keeping economic growth; as for domestic enterprise, CDM program was an positive motivator (supernumerary resource of foreign capital) to promote Chinese enterprise to voluntary assume the social responsibility of enterprise, and strengthen competitive advantage by improving utilization rate of resources^[4]. Up to December 30, 2008, there were 1797 CDM programs approved by Chinese Government, and up to February 4, 2009, the amounts of registered programs were 399, which represented 28.98% of global total registrations.

3.3.3 O₃ Guarantee of Regulations and Laws

The new issued regulations and laws provided powerful guarantee for speeding up rural biomass energy constructions, Renewable Energy Law practiced on January 1, 2006 identified that exploiting and utilizing biomass energy, such as biogas and son on, were the responsibility of governments at all levels,. The National Energy Office formally announced Energy Law to external and solicited opinion draft on December 3, 2007, and this meant that the draft work of Energy Law was also entered into a new stage.

3.4 The threaten of China's Rural Biomass Energy Development (strengths)

3.4.1 S₁ Characteristic of Uncertainty of CDM Program

Although the Kyoto Protocol had become effective all over the world at present, United States, the biggest global carbon emission country, did not formally joint in this protocol, furthermore, the legal effect of Kyoto Protocol was questioned, so the

CDM program processed Characteristic of Uncertainty. However, CDM itself had an "additional" concept, this made the emission reductions of this program was hard to generate under the conditions without CDM. Moreover, because of the requirement of "additional", most of the CDM programs were not by-products, which could only sell emission reductions amount after investment, these investments probably had no benefits under the conditions of uncertain approval results^[5].

3.4.2 S₂ Investing Obstacle of Foreign Company in China

Although China need a large amount investments at the aspect of developing rural biomass energy, great challenges were still confronted by China no matter technical support or direct investment by foreign companies. These challenges included that unreal tariff, low repay rate of investment, lack of the hard currency, practice of protective policies, improper protection of intellectual property rights, opacity and cracked rule bureaucracy, as well as deficiency of policy support, and the financing limit was the biggest problem to be overcome if the foreign company intend to develop in Chinese energy market.

3.4.3 S₃ Imperfect of Support Policy

Although Chinese Government had published Renewable Energy Law, reasonable and effective encourage policies were deficient in the aspect of financial administration, monetary, market opening and so on, for example, biofluid fuel that took non-food crops as the raw material could not enter market and share government subsidy, the pricing mechanism of biomass energy did not reflect the factors of environment profits; there were also the problems such as insufficient concordant, policies were hard to implement and so on among relevant policies, the prolonged action mechanism of supporting rural biomass energy industry sustained development was not yet formed.

4 SWOT Matrix Quantitative Analysis of China's Rural Biomass Energy Development

Carrying out quantitative analysis to SWOT matrix by introducing analytic hierarchy process can provide evidences for strategy selection of China's rural biomass energy development and could effectively avoid blindness and subjectivity of strategy formulation.

4.1 Constructing Compare-Judgement Matrix

After building SWOT strategy analytic hierarchy process model of rural biomass development, the subjection relationship between the

two elements of superstratum and substrate was decided. As for the same level element, applying higher element as standard to compare by pairwise comparison, the comparable results were expressed by AHP-9 rating scale method: 1 represented equally important; 3 represented slightly important; 5 represented obviously important; 7 represented intensively important; 9 represented extremely

important; the medium class between both sides was expressed by 2, 4, 6, 8. This article evaluated the intensity importance of each element relevant to influence rural biomass energy development during the process of qualitative analysis to SWOT, and four co-occurrence matrices by pairwise comparison A, S, W, O can be obtained.

Strategy development compare-judgement matrix A

	S	W	O	T
S	1	4	5	8
W	1/4	1	2	5
O	1/5	1/2	1	2
T	1/8	1/5	1/3	1

Subroutines advantage compare-judgement matrix S

	S1	S2	S3
S1	1	4	9
S2	1/4	1	2
S3	1/9	1/2	1

Subroutines disadvantage compare-judgement matrix W

	W1	W2	W3
W1	1	2	2
W2	1/2	1	1
W3	1/2	1	1

Subroutines chance compare-judgement matrix O

	O1	O2	O3
O1	1	2	7
O2	1/2	1	3
O3	1/7	1/3	1

Subroutines threaten compare-judgement matrix T

	T1	T2	T3
T1	1	4	9
T2	1/4	1	2
T3	1/9	1/2	1

4.2 Hierarchy Order and Completing Consistency Checking

The maximum characteristic root λ_{max} of compare-judgement matrix and corresponding normalized characteristic vector were calculated by root method, and deciding if it could pass consistency checking according to the values of C.I.、R.I.、C.R. When

$$C.I. = \frac{C.I.}{R.I} < 0.1, \quad (C.I. = \frac{\lambda - n}{n - 1})$$

it was considered that the consistency of compare-judgement matrix was accepted. Detailed calculation see table 4.

Table 4 Hierarchy Order and Completing Consistency Checking

matrix	n	maximum eigenvalue	C.I.	R.I.	C.R.	normalized characteristic vector
A	4	4.098	0.033	0.9	< 0.1	(0.67, 0.215, 0.216, 0.052)
S	3	3.004	0.002	0.58	< 0.1	(0.737, 0.177, 0.088)
W	3	3	0	0.58	< 0.1	(0.498, 0.251, 0.251)
O	3	3.006	0.003	0.58	< 0.1	(0.613, 0.293, 0.094)
T	3	3.003	0.002	0.58	< 0.1	(0.734, 0.179, 0.734)

Building coordinate system by taking S, W, O, T variables as four semiaxis of plane coordinate,

deciding respectively corresponding point of the total advantages, total disadvantages, total chances and total threatens about SWOT analysis relevant to rural biomass energy development, and then a strategy quadrilateral was formed, calculating the center of gravity of quadrilateral many times, $P(x, y) = (\sum x_i / 4, \sum y_i / 4) = (0.03, 0.01)$, $i=1, 2, 3, 4$. The center of gravity of P was the equivalent abstract made to each disintegration factors. The strategy type could be decided according to the placed quadrant of barycentric coordinates, because the barycentric coordinates placed in the first quadrant, SO strategy was adopted^[6].

5. Development Strategy of China's Rural Biomass Energy

The above combined SWOT qualitative analysis and AHP quantitative analysis to study rural biomass energy development, and the strategy of combining self-advantages and external opportunities was obtained to develop rural biomass energy. Based on above, the following four aspects strategies could be adopted to develop China's rural biomass energy.

5.1 Accelerating biomass transformation and utilization technology exploitation, demonstration and popularization and application

The government should further strength support to biomass energy basic research, accelerate exploitation steps of new energy technology possessed independent intellectual property, fend to occupy commanding point in multiple technology competitive of global biomass energy. The key point was to introduce from abroad the advanced technology and management expertise and strengthen scientific and technological research to several problems such as quick-wearing of straw solidification mould, high content of gasification tar, product store and transportation and so on, and develop research at the aspect of energy consumption transformation of crop straw from high-energy efficiency to low expenditure, producing fuel alcohol by cellulose, providing biomass raw material by transgenic technology, striving for making breakthroughs at the aspects of new breed, new raw material, new technology, new equipment, gradually forming a cooperation system among industries, universities and research institutes of technical design, demonstration and extension and industry service^[7].

5.2 Establishing prolonged action input mechanism

Establishing prolonged action input was the key point of rural biomass energy development and could be implemented by the following two steps. The first

step was to implement government subsidy policy to rural biomass energy program. Giving subsidy to rural biomass energy program constructed by household and possessed significantly ecological benefit and comprehensive profit but the lump sum investment was comparatively large and the direct profit was not obvious. Striving for establish stable increasing mechanism of supporting rural biomass energy construction capital for financial administration, ensuring local match fund for national debt program of "eco-household project", gradually shaping stable fund resources for rural biomass energy construction; the second step was to actively explore, innovation mechanism, activating investment main body. With the promise of due benefits to investors, and leading enterprise, society and farmer to increase investment to energy construction, the government should gradually build a investment mechanism of all-direction, multi-layered and multi-channels.

5.3 Strengthen Market Exploitation of rural CDM program

In recent year, the amount of Chinese renewable energy resources CDM program accounted for 70% of total development amount, but only accounted for more than 22% of total emission reductions, however, the rate of renewable energy resources CDM program accounting for total emission reductions was gradually increasing from the view of development tendency. So the exploitation of renewable energy resources CDM program will become one of the main increasing resources of Chinese CDM program exploitation in future, the rural area will become the main exploitation market of CDM program because of resource advantages.

In addition to above discussed factors such as advantages, disadvantages, chances, and threatens, there was other factors influencing the implementation of CDM program, such as the approve of Kyoto Protocol by United States, the fluctuation of international carbon transaction market, and the implementation conditions of CDM program by other developing country and so on. Chinese government should also think highly of this factors at the same time to implement CDM program using rural biomass energy, developing international cooperation, winning competition victory, gaining more long-term development.

5.4 Constructing and Consummating Service Security System

During the process of rural biomass energy development, the government should pay more attention to integrate resources, consummate

technology and industry service system, overall improving innovation ability and industry service level of rural biomass energy technology. Meanwhile, the government should also positively exploit generalization service mechanism of biogas technology, striving for declination of national funds, leading and shaping three classes service network including countries, townships, villages, providing full scale service during the process of construction, management and utilization, ensuring sustained, sound development, and gradually established industry service system of crop straw collecting and delivery. The government should positively lead farmers to develop professional cooperation organization to grow energy crop, collect and pretreatment of crops straw, constructing product and logistics system.

6. Conclusion

The article carried out a qualitative analysis to China's rural biomass energy development using SWOT model, and pointing out that its development possessed three aspects advantage in resource, foundation, technology by the view of internal, and several disadvantages such as unsound management service system, single investment and financing channel, weaker competitive power of biological fuel oil product market; meanwhile, there were three aspects chances of the government strongly supported and thought highly of rural biomass energy construction, cooperation mechanism of CDM program, possessed regulation and law security in developing rural biomass energy in external environment; there were also uncertainty of CDM program, obstacle of oversea companies investing in China, threatens of unsound support policy.

Applying AHP to decide the intension of advantages, disadvantages, chances, and threatens as well as total advantages, total disadvantages, total chances, and total threatens on the basis of above, forming strategy quadrilateral, conforming comparative matrix and completing consistency checking, the results showed that a strategy combing self-advantages and external chances should be adopted by China's rural biomass energy development, proposing strategy measure from fore aspects such as constructing rural biomass energy

development prolonged action input mechanism, enforcing exploitation of rural CDM program market and so on.

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