An analysis on the competitive advantages of garbage incineration power plant

Xiaomei Guo,Center for Accounting Studies of Xiamen University/School of Management, Xiamen University, Xiamen,PR of China, ydxmguo@tom.com
Luhe Wang, Jinjiang Cugu E&P resources development company, Xiamen,PR of China, wangluhe@126.com

Abstract

Advances in garbage incineration technology have made it possible to turn waste into energy. However, launching such a plant will require huge amount of investment, and the cost of operation is expensive. So it is not easy for municipal governments to adopt such technology in widespread due to shortage of fund. Private capital can be a source of fund, but return should be ensured. In this paper, the authors carried out a case study in a solid waste incineration power plant located in Jinjiang, PRC, to explore the sources of competitiveness. With value chain analysis and other strategic cost management tools, the authors find that competitiveness of such plants lies in its differentiation strategy. Premium comes from favorable rate of output, and tax benefits. The authors also make some recommendations on sustaining its competitive advantages.

1. Introduction

With rapid urbanization and development, the amount of solid municipal waste is on the rise, posing a big problem to many governments. Many new technologies can be used in the treatment of garbage (Chambal et.al, 2003, Onion, 2007). However, compared with the traditional way of landfills, these technologies seem to be fairly new and expensive. Yet as garbage grows, the cost of using landfills is growing due to scarcity of real estate for landfill and increased cost to deal with the land contamination and other environmental problems. At the same time, tighter environmental standards have prompted a greater willingness in many countries and areas to try new technology, one of which is garbage incineration, with the emitted heat to generate power. Many solid waste incineration power plants have been built in cities of China. However, the cost of investing and operating such a plant is very large. How can such a plant compete with landfills? In this paper, based on a case study of a garbage incineration power plant in Jinjiang, a southern city of China, the authors analysis the competitive advantages and cost of such a plant with value chain analysis and other strategic cost management techniques, hoping to find the sources of competitiveness. Some policies suggestions are also given.

The concept of value chain, the set of value-creating activities from basic raw material sources to the ultimate product or service that is delivered to consumers, was first put forward by Porter (1980). Later, with value chain analysis; strategic positioning and cost driver analysis, Shank and Govindarajan (1993) found opportunities and threats faced by business. To understand the sources of profitability of an industry, the "Five Powers Model" put forward by Porter will also be examined. For carrying out value chain analyzing, and understanding of the cost of activities will be necessary. Activity based costing techniques (Cooper, 1989) will also be applied. The guideline published by the United Nations(2001) and IFAC (2005) define principles and procedures for Environmental Management Accounting (EMA) with a focus on techniques for quantifying environmental expenditures or costs as a basis for the development of national EMA guidelines and frameworks. The guideline explains the range of environmental costs in detail and provides some suggestion on how to gain environmental data from financial accounts and costs allocation. EnviroWise (2002) provides a practical guideline on how to use the general ledger to identify costs and potential savings; It also provides details on business areas and data sources to consider when gathering more detailed information from a company. Schaltegger (1996) provides a method for identify waste treatment cost based on activities. Scuring(2003) examined some cost management techniques in the textile chain, both materials and information flows are managed to reduce environmental impacts and costs for green products.

Based on these findings, the authors carried out the case study in a solid waste incineration power plant located in Jinjiang, PRC. The paper is structured as follows. Firstly, an introduction to strategic cost management and its application is given. Secondly, the authors frame the case in terms of the Chinese electricity industry within which the case plant operates. The design of the case study and the methodology used are also discussed. Thirdly, a dissemination of the case is given, with a description of the internal and industry value chain, sources of profitability are discussed, and ways for developing competitive advantages are suggested. Finally, the authors conclude with some recommendations on policies of encouraging adoption of garbage incineration technology.

2. Design of the case

2.1 The Electricity Industry and the Case Company

The electricity industry is centrally controlled by the Chinese government. Power is generated by power plants, sold to the State Grid, and finally to different consumers. Price to the State Grid is set up in a dual system, a planned one and a bidding one. Differential rates are used for electricity sold to consumers, on a cost plus system. As coal is the major power for electricity generation in China, the industry is the major emitter of greenhouse gas. To protect the

environment, the government encourages use of renewable energy for power generation. Price for renewable energy generated electricity enjoys a higher rate than electricity generated from coal （NDRC,2006）.

The company studied is Jinjiang solid waste incineration power generation plant, which was set up by CUGU Environmental Protection International Limited, in July, 2005 under a Build-Operate-Transfer (BOT) investment scheme, the first power plant using garbage incineration technology in Fujian province. The set up of the plant not only meets the demand for electricity in the local city, but also helps to treat solid waste that is on the rise with the industrialization of the city. There are over 2,300 shoe manufacturers that dispose solid waste including waste rubber and leather of 2,000 tons daily. With proper treatment, solid waste incinerator now remove 99.9999 percent of all toxins from their emissions and as such are no more harmful to the environment than landfills, which come with their own inherent hazards, such as leakage and methane-gas emissions(Philip,2000). So this biomass generated power is encouraged by the government. The Ministry of Construction of PRC China granted the plant with "Award for the Best Residential Environmental Model"; whereas Fujian Provincial Government awarded it with "A Model Enterprise of Renewable Economy" and "A model program of Fujian Province Urban Waste Disposal"[1] .The plant is launched in two projects. Project I has the capability to treat 333,000 tons (1,000 tons daily) of waste and generate 12 million Kwh of electricity per year. Project II, which has a similar capacity was under construction when the study was carried out. The study focused on Project I.

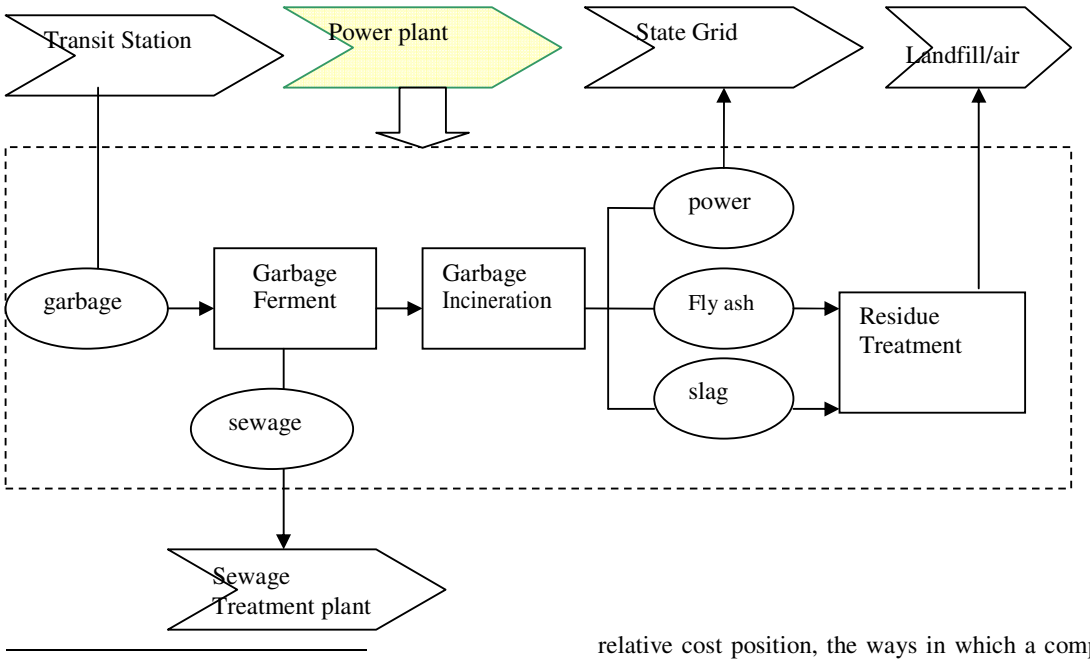
Fig 1 value chain of the solid waste incinerator

The suppliers of raw materials to the power plant are garbage transit stations which are invested and operated by the local government. The buyer of the power generated from incineration of garbage, the electricity, is the Jinjiang branch of Fujian electricity Power Company, a subsidiary company of the State Grid, a monopoly state owned company. Basic flow of process is as such: Delivered to the site of the incineration power plant and weighed, the garbage is discharged into the refuse pit to be fermented. Sewage is collected and then sent to sewage processing station. Then the fermented waste is burnt in the incinerator and the resulting steam is used as power for the steam turbines and dynamos, and electricity is generated. After proper treatment, fly ash is emitted in the air, and the slag is sent to landfill or brickyard (see Figure 1 for details).

2.2 Research Methods

In general terms, a case study is a research strategy that "investigates a contemporary phenomenon within its real life context". It is preferred when "How" or "Why" questions are being imposed, and contributes "uniquely to our knowledge of individual, organizational, social and political phenomena". The aim of the case study in this paper is to understand the reasons for the loss that the plant suffered in 2006, and to find out possible ways of making it profitable.

Waste incineration technology seems to be expensive. So how can a company using such technology sustain its competitive advantage is the core of the study. To understand the sources of competitiveness of this plant, an analysis using strategic cost management techniques will be necessary. Pioneers in strategic management accounting place emphasis on the relative cost position, the ways in which a company may secure a sustainable cost advantage, and costs of differentiation (Inman, 1999).To understand the long



[1] Taken from the company's homepage,http: www.cugu-ep.com

term profitability of industries, Porter's Five Forces Model will be used. Secondly, competitive strategy of the case company is analyzed. And the next approach is the value chain. Using the technique of value chain analysis suggested by Shank (1993), industry and the company value chain will be analyzed, with cost and revenues allocated to different activities, to see the sources of value.

3. Analysis of the Case

3.1 Porter's Five Forces Model and competitive strategy

Porter (1985) sees five competitive forces that will contribute to a strategic equation, ie., the threat of new entrants into the market, the threat of substitute products or services, Rivalry amongst existing organizations within the industry, the bargaining power of suppliers and the bargaining power of consumers.

Suppliers: 23 garbage transit stations with a capacity of garbage processing of 1000 tons per day, invested and operated by the local municipal government. The role is to collect pre process and transport garbage. Initial investment is RMB2.5M yuan (US$1 ≈ RMB 7 yuan), annual operating cost RMB0.4M yuan.

Buyer: The jinjiang branch of State Grid, a state owned company. The price to the buyer is guided by the National Development and Reform Committee. Renewable energy enjoys a favorable rate, which is negotiated between the power plant and the local government.

New entrants: none. As the project requires huge amount of investment and need cooperation and approval of the local government, the threat of new entrants is very small.

Rivalry: For the same reason, there is no rivalry using the same technology in Jinjiang City. There is also another solid waste incineration power plant in the nearby city of Shishi, but as the sell of electricity depends largely on the Grid, the market is segmented, and product of Shishi plant has little effect on the sell of the case company. Most of the electricity sold to the State Grid comes from coal, crude oil, natural gas, hydropower, or nuclear power. Coal fire power plant is the major competitor. But with the BOT scheme, the government has the obligation to buy all the electricity the case company produce, and shortage of energy in most part of China makes this threat to be insignificant.

Subsititue products: Fossil fuels, gas, petroleum, all are non renewable energy and the price is on the rise. They can not replace electricity in the near future.

From the model above, it can be inferred that major forces influencing the long-term profitability of the power plant are suppliers and buyer; both are closed related with the local government. So the government plays an important role in the determination of the profitability of the company.

Sustainable competitive advantage can be achieved by two basic strategies, low cost and Differentiation. Environmental protection companies can gain advantage from either source (Guo, 2007). Incinerators offer several safety and environmental friendly features: renewable energy, pollution-control devices, dry scrubbers, and catalytic reducers (Prveille, 2000).Though the cost of power generation with such technology is high, it earns a premium for sell of its products. So the company is adopting a differentiation strategy.

3.2 Industry value chain analysis

By estimation, the unit cost of garbage preprocessing in the transit station is RMB 30.6 yuan/ ton. Price to the power plant is zero. In the year of 2006, the first year of operation, the case company processed 0.2557 M tons of garbage, produced 57.71M kwh of electricity, sold 46.48M kwh(80%) and the remaining 20% was for self use. So approximately, for each ton of garbage processed, 225kwh of electricity is produced and 181.8 kwh is sold. the favorable rate of power sold negotiated is RMB 0.85 yuan /kwh(155/t of garbage).Total operating cost (excluding interest, to eliminate the effect of capital structure) of the power plant amounted to RMB39.821M yuan, so the unit operating cost of garbage incineration is RMB155.7 yuan /t of garbage. The electricity company then sells the power to consumers in different rates, which is governed by the local government. In 2006,rates to consumers varied from RMB0.40 to 0.73 yuan/kwh(RMB 72 to 133yuan /t of garbage processed).With this information, the value chain analysis of the power plant industry is illustrated as in table 1.

Table 1 Value chain analysis of power industry

	SW incineration power		thermo power
	RMB/t of garbage processed	RMB/kwh Equivalent	RMB/kwh
Price to Cousumer*1			
household	72.47002926	0.39863248	0.4663
commercial	132.9912051	0.73153846	0.8558
Price to State Grid*2	155.3	0.85	0.435
State Grid			
margin(exld. adm cost)			
household	**-70.346**	**-0.3895**	**0.0945**
to commercial	**0.463**	**0.0059**	**0.484**
Power Plant			
processing	155.74		
price to power plant	0		
profit	**-0.44**		
Transit Station			
Freight	15.3		
preprocess	15.3		
profit	**-30.6**		
total industry profit before Adm cost of seller			
household	-101.386		
commercial	-100.923		

*1 rates varies, unit adjusted to ton of garbage processed, based on actual ratio of power sold to garbage processed in 2006. Value added tax excluded .Sources: Sales price of Power electricity in

Fujian province, as approved by Fujiang administration of commodity prices document no. [2006]27. a subcharge of RMB0.001/kwh on renewable energy has been added
*2:excluding value added tax. Source: Reply on the price to State Grid of Jinjaing Thermo Power plant, as approved by Fujiang administration of commodity prices document no.[2006]291.

From table 1, it can be seen that the profit of this industry in negative if the operating cost of the State Grid is considered [2]. The transit stations pay RMB30.6 yuan for each ton of garbage processed, a price close to the landfill cost of RMB35 yuan /ton. The power plant earns about zero, while the Jinjiang electricity branch suffered a lost on biomass energy. Normal price of electricity sold to the State grid is RMB 0.3718yuan/kwh (RMB 0.4782 yuan/kwh lower), so it is the State Grid who transfers its profit to the power plant. Since the State Grid is state owned, and the favorable rate of RMB 0.85 yuan/kwh is the result of negotiation between the government and the power plant, which is subject to change with the cost of the power plant. The transfer can be seen as a form of subsidy given by the government (Sacrifice of the possible profit and dividend that can be enjoy by the local government as the only shareholder). But to the power plant, a private company, zero profit means that required return is not earn on the capital invested. So there must be some other sources of value. The company, as a model of renewable economy, enjoys favor in taxation. For each yuan of revenue it earn, a 17% value added tax credit is charged. As the input of the company is free, it has no value added tax debit, so this 17% tax becomes its value added tax payable. But a refund of the value added tax paid is given by the local government. So for each ton of garbage processed, it will have a refund of value added tax of RMB 26.35 yuan (0.85*17%/kwh), a good margin of sale .In addition to that, as a foreign inverted company, its income tax is subject to the "exemption for the first two years and half for the next three years" policy. The plant has not earned a profit, so this benefit was not evident in 2006. But in the long run, this policy will bring return to its shareholder .So competitiveness of this company in the industry lies the favorable policy it enjoys , which is the result of its green feature, the adoption of differentiation strategy.

3.3Internal value chain analysis

As shown in figure 1, major activities of the power plant include garbage ferment, garbage incineration and residues treatment, with four major outputs, sewage, electricity, fly ash and slag.

The current costing system in the power plant recognizes one product: electricity as the only cost object. Costs are classified as production costs and period costs. All the production costs are attributed to electricity sold. Product costing is simple. The total of accumulated direct labor and manufactory overheads makes the product costs. While the other costs go to period costs accounts. All the operating costs will be born by the only product, electricity. Such accounting system rarely provides environmental cost or stimulates better environmental performance. Yet providing environmental cost information (cost of waste production, treatment and disposal) will give management insights about the negative effects on their operation brought about by pollution, as well as putting them under better control. Insight of environmental cost of business will inform the management about ways of cost management and value creation. So a reclassification the cost and expense accounts was carried out, using costing techniques such as ABC(Guo,2008)

Table 2 cost of different outputs

input of Garbage		Electricity		Sewage	Fly ash	slag
0.2557MT	output units	46.4854Mkwh	1.0327MKw	2.5t	0.8138t	9.93t
	in % of input	46.40%	11.60%		3.20%	38.80%
Traceable resourc	(RMB)					
seweage treatment	1151678			1151678		
depreciation of equipmen	274500			274500		
repair	1690000					1690000
bag filter replacement fee	1612600				1612600	
depreciation of equipmen	45183.83	45183.83				
sub-total	*4773961.83*	*45183.83*	*0*	*1426178*	*1612600*	*1690000*
Chemicals used	*3971902.51*				*302621.51*	*3669281*
resources for incineration						
repair	462992					
environmental monitor	103800					
depreciation of equipmen	18947254.2					
salary	4370387.5					
water	605971.74					
maintenance	844630					
additive	2796255.95					
insurance	264460.15					
amortization of opening e	1520842.92					
others	1158523.3					
sub-total	*31075117.8*	*14418855*	*3604714*		*994403.77*	*12057146*
2nd allocation		2090733.923	-3604713.7		115350.8371	1398628.9
total	**39820982.1**	**16554772**	**0**	**1426178**	**3024976.1**	**18815056**
Unit cost/output		0.356131492		57.04712	371.7100166	189.47689

Cost model: a multistage ABC model was adopted (See figure2).Sewage is discharged in the process of garbage ferment, treated outside the plant, with processing fee paid. So the cost of this activity is easily identified and measured. Number amount of sewage discharge is the cost driver. Treatment fee and depreciation on collection of sewage are traced to this activity.

Three outputs come from the process of garbage incineration, ie. electricity, fly dust and slag. The latter two goes to further process of wasted treatment on site before discharged. Traceable resources (Bag filter replacement fee Maintenance cost of equipment) used for waste treatment is recognized, while common costs (chemicals used) for waste treatment activity are

[2] The operating cost has to be allocated between different sources of power, coal, solid waste and others. Coal power bought has a margin, which make up the majority of the suppliers of power to the State Grid. So on the whole, the Jinjiang State Grid still makes a profit.

allocated based on the amount of waste of fly dust and slag.

Electricity: cost excluding directly traceable cost and cost attributable to fly dust and slag treatment are allocated, based on the percentage of amount of input in tons.80% was sold, the cost of the remaining 20% was added up to the other three cost objects to reflect the true cost of waste treatment .See result of Costing in table 2.

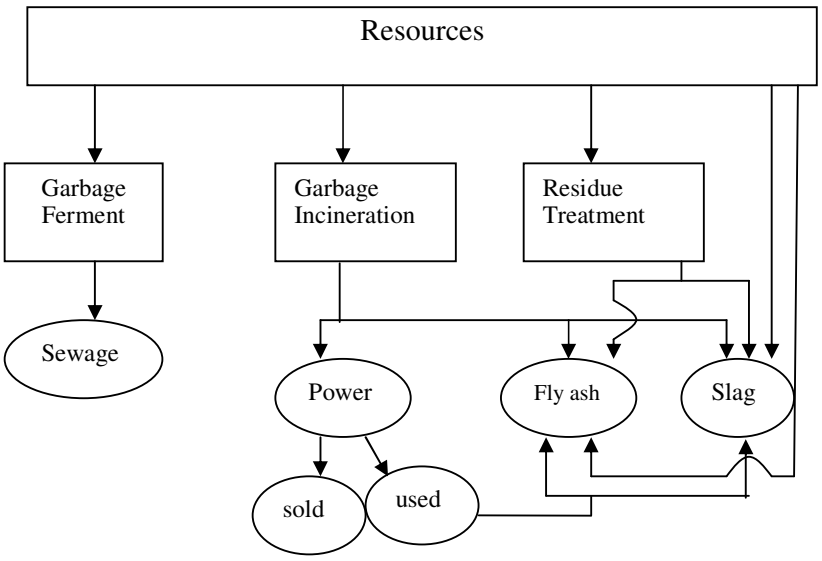


Fig 2 costing model

If not considering the cost of waste treatment, actual cost of electricity is RMB 0.3561 yuan/kwh or RMB 138.21 yuan /t of garbage processed, as compared to the unit operating cost of electricity of RMB 155.7 yaun/t of garbage processed). The difference is the cost of treatment of fly ash,slag and sewage. Without this treatment cost, the plant could have had made a margin. However, such environmental costs are not avoidable, because of the tight environmental standards. The additional cost is the cost of differentiation strategy. For this strategy to be effective the premium should be larger then the additional cost. But currently, the operating cost of the plant equals to revenue, meaning zero profit. To make the strategy sustainable, some efforts should be made.

3.4 Insights from the case study-How to manage cost and sustain competitive advantage.

Basically, there are two ways to develop a sustainable competitive advantage, either cutting down cost or increase value. So suggestions for sustain competitive advantage are aimed at either/both way.

Increase utilization:To cut down cost, analysis of cost should be made. Most of the operating costs are fixed (depreciation and amortization), accounting for 52% of total costs. Such costs are drive by the capacity utilization. The capacity of the power plant is to treat garbage of 333 000 tons annually. But in 2006, only 255 700 tons of garbage was incinerated, the utilization rate being 77%. If the capacity is fully used, unit cost can be reduced by RMB36 Yuan/ton of garbage, a reduction of 31%. A margin can be earned simply by this effort. But the use of utilization is mainly dependent on the supplier, the garbage transit station. There is never a shortage of garbage, but the amount transport to the power plant is not stable. The garbage transit stations were built in 2003. In 2006, only a part of the stations were put into operation, which cause a bottleneck of supply in2006.But to the end of 2007, the daily preprocess capacity of the stations has exceed 1000 tons per day. So this problem can be solved.

Assurance of the calorific value of garbage supplied

From the result of costing above, it can be seen that environmental cost accounts for 59% of the total operating cost. The amount of sewage, fly ash and slag disposed is the cost diver of the environmental cost of the power plant. So to cut down cost, the power plant should try to reduce the amount of waste dispose in production. The garbage incineration technology can reduce solid waste to only 10-25% of input (Keller, 1996). In European countries, about 30% will remain as residues after incineration(Anderola etal.2001) , However, in the power plant, solid waste in production accounts for 40% of input. The major reason for this gap lies in the quality of garbage supplied. For incineration to be feasible, a certain calorific value of the garbage is required. The garbage of Jinjiang city is made of industrial and household garbage. The formal one has a high calorific value, yet the latter one has a relatively high percentage of moisture and a low calorific value. Both types of garbage are combined together in incineration. However, if the portion of household garbage is too high, production efficiency will be affected and cost will increase, as more additives will be needed. In the clause of BOT with the municipal government, the

government has the obligation to excluding medical garbage (special treatments will be required) and construction garbage (little calorific value) from the supplies. But there is no assurance about the proportions of industrial garbage supplied. So the plant should try to cooperate with the transit station to ensure the quality of garbage supplied. On the other hand, the government can try to impose variable fee system on garbage disposed, an explicit fee for waste disposal that varies with the quantity of waste discards, instead of a flat fee system.

Energy conservation in the power plant: The input output ratio of garbage incineration is 225kwh/ton of garbage. Considering the instability of calorific value of supplies, the ratio is quite good. But of the total electricity generated, 20% is used in the production, the cost of which is RMB 3.6M (if market price is used, it is RMB 7.9M). If the company can reduce the amount of energy used in production, electricity sold will increase and value will increase too.

Recycle of solid residues from incineration:It is technologically feasible to use solid residues of incineration such as slag and fly ash with a porcelain stoneware body to produce tiles. However, market for such supplies has not emerged, so at present solid residues are disposed to the landfill with the transportation cost on the power plant. If the power plant can make some efforts with market development, there is a possibility of increasing value in the future.

5. Conclusions

Advances in garbage incineration technology have made it possible to turn garbage into renewable energy while keeping the environmental impact to the minimum. However, as a new technology, it is tow expensive. The authors explored the value chain of a garbage incineration power generation plant, with the finding that such power plants adopt differentiation competitive strategy, the premium comes from favorable rate of power sold and tax policies applied. If the power plant can make full use of its capacity, ensure the calorific value of the supplies, conserve energy for self use, and develop market for its residues, then cost can be cut down and value can be increased, helped the company to sustain its competitive advantage. Closer partnership with the government and policy support from the government will help.Follow this template as an example for second and following pages.

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