INTERNATIONAL NETWORK FOR BAMBOO AND RATTAN
(INBAR)

TRANSFER OF TECHNOLOGY MODEL
(TOTEM)

BAMBOO CHARCOAL UNIT

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TRANSFER OF TECHNOLOGY MODELS (TOTEMS)

Transfer of Technology Models (TOTEMs) are focussed educational tools providing relevant information and distance training on one specific area of bamboo/rattan management, processing or utilization. They are a means of technology transfer between similar regions throughout the world, with the emphasis on South-South transfer for livelihood development. They enable those involved in the management and use of bamboo and rattan resources to more efficiently and effectively develop and use skills relating to these resources.

TOTEMs are primarily intended as practical information resources and teaching aids for those at the local extension level in their communities, who can utilize them to assist local community development. Each TOTEM consists of a detailed written report of the technology, a PowerPoint presentation, a film, and, where relevant, a set of technical photographs. They also include information on target users, financial analyses of sample set-ups from the partner country preparing the report and information on where to source particular technologies (such as equipment). The TOTEM thus provides all the information required for establishing similar technologies within interested countries and regions.

- The **report** contains all the technical details of the particular processes involved, as well as other relevant information for establishing the technology such as costs of business establishment, running costs and cash flows.

- The **PowerPoint** presentation contains details of the relevant technologies and their applications, and is intended to provide an overview of the potential of the technology for development.

- The **film** provides a visual guide to the processes involved and helps to bring them alive in the minds of the learners.

The different parts of the TOTEM are targeted at slightly different audiences, via the local extension workers. The report and film are intended to be the main means of extension to the individuals and communities who will implement the technology and who will directly benefit from it. The PowerPoint presentation is primarily intended as a tool for the extension worker to sell the technology and its role in development to those who provide the infrastructural, policy and financial support for its implementation, such as government departments, donors and NGOs. There is considerable flexibility, however. Local extension workers will be able to incorporate the TOTEMs in their own work as they wish and adapt and develop the TOTEM to suit their particular requirements and conditions.

This TOTEM on the **bamboo charcoal unit** has been produced by Nanjing Forestry University, Nanjing, China. The report part of this TOTEM describes the technology for producing and establishing bamboo splitting and slivering facilities for rural development in regions where bamboo is available as a raw material. It is intended to be used in conjunction with the illustrative film included in this TOTEM package

The first part of the report introduces the technology, discusses its history, its development attributes, its benefits and it's applicability. The second part of the report provides information on

the technical aspects of producing bamboo charcoal. Note that the detailed processes have often been developed by individual companies and are not available to the general public.

This TOTEM is one of the first to be produced by INBAR/Nanjing Forestry University and your feedback is most welcome - kindly contact INBAR or IPIRTI with your comments or suggestions.

Note 1: This TOTEM has been edited at INBAR and may differ slightly from the form in which it was received from the authors.

Note 2: All financial calculations are in Chinese Renmimbi Yuan. At the time of writing 1 USD = 8.25 RMB.

BAMBOO CHARCOAL AT-A-GLANCE

What is Bamboo Charcoal?

Bamboo charcoal has much higher adsorbtivity than wood charcoal can be used for a wide range of different purification and absorption applications, such as purifying drinking water, in air filters, gas masks, matresses and pillows, as a deodoriser, and for certain industrial purification uses. A by-product of the manufacturing process, bamboo vinegar, is used as an ingredient in health products.

How is it produced?

Pieces of bamboo are heated under a specific controlled temperature regieme until they become "carbonised", ie they turn into charcoal. Traditionally this is done in wood-fired brick kilns, but modern automated kilns are now available and allow more rapid throughput. Drying the bamboo before placing it in the kiln and carefully controlling the rise and fall in temperature in the kiln are the main secrets to success.

What is the market for bamboo charcoal?

The export markets of Japan and South Korea are lucrative – in 2001 over seven thousand tonnes of Charcoal was exproted there from China. Opportunities in national markets are also significant. The market In China is growing primarily as a result of innovative product development and marketing, and it is likely that markets in other countries would require similar investments. If used for heating or cooking local markets should be easy to tap into via existing channels.

What is the role of a bamboo charcoal unit in rural development?

Using bamboo charcoal permits substitution of wood timber charcoal and hence reduces the pressure on timber forests. Bamboo cultivation and harvesting offers income generatingg opportunities to farmers and processing and marketing provides work for other community members. The proceedures involved in producing charcoal are relatively simple and can easily be adopted by a wide range of individuals.

How do I establish a bamboo charcoal unit?

On a very small scale a unit can be establised for the cost of a single brick kiln (approximately $500). However, ensuring the charcoal can find a market is the most important factor affecting success, and the entrepreneur should have access to suitable marketing systems. Having a sustainable local source of bamboo is also beneficial.

PART ONE

INTRODUCTION

DEVELOPMENT ATTRIBUTES, TARGET GROUPS and BENEFITS of a

BAMBOO CHARCOAL UNIT

1. Bamboo charcoal

Bamboo charcoal is a porous, adsorptive material that can be used for a range of purification applications such as preserving the freshness of fruit and vegetables, in healthcare products, as air filters and in industrial processes such as sugar processing. A large amount of activated bamboo charcoal is used to dispose of water and waste gas in developed countries. Seventy thousand tons of bamboo charcoal is used every year in America and over fifty thousand tons in Japan.

Bamboo charcoal can also be used as a catalyst and has much potential in hi-tech applications. It has a very high adsorptive capacity – 1g of bamboo charcoal has an absorbing area of over 350 m^2. It is believed that 100 kg bamboo charcoal can absorb 4 kg moisture from the air and purify 5000 L space in a room. By the inclusion of an "activation" process during production the charcoal can be made more adsorptive. It is presently produced mainly in China, Japan and Thailand but there are also a few production units in Northeast India.

Bamboo vinegar, a by-product of the production process, is a potentially useful product though its component chemicals have not yet been clarified. In Japan, it is used in health care, as a medicine (it is said that bamboo vinegar can be use to cure dermatophytosis and to play assistant role in curing diabetes), beverage, and for eliminating offensive odours on farms. It also has some potential for producing high efficiency, low-toxicity agricultural chemicals.

2. General development attributes and advantages

The main development attributes of the charcoal technology are as follows:

- Greater use of bamboo reduces dependence on wood-timber resources and hence increases environmental protection and conservation.
- Promotes rehabilitation of degraded forests and other waste lands through increased areas of bamboo plantations.
- Increased employment opportunities in bamboo growing for supply of raw materials, in running the unit, and in sales and marketing.
- Processing is simple and can be done on a very small scale by individuals with minimal investment and training.
- Creates gender insensitive employment opportunities.
- Permits the establishment of local secondary processing facilities with the associated benefit of extra value addition.

3. Suitable agro-ecological regions

Any area in which bamboo can grow is suitable for local charcoal production. In China charcoal production is primarily located in mountainous regions with prolific bamboo resources, but note that this has more to do with the limited capital investment required for charcoal production and the relative poverty of these regions than their agroecological suitability. Charcoal can be produced from all bamboos, so charcoal production can be located in all tropical, subtropical or temperate zones in which bamboo can grow.

4. Target groups

Due to the relatively simple processes involved in producing charcoal it is eminently suitable for a wide range of local people living in conjunction with bamboo. It can be produced on a cottage industry scale in villages, providing employment to factory workers, bamboo growers and primary processors and to those involved in marketing and transportation of the final product. The production of charcoal is very suitable for mountain farmers who have a certain economic capability to run a private workshop on a small scale. However, marketing and product development are vital for the success of the business, and can be achieved by providing these services at a community level.

Additionally a charcoal unit can be established in conjunction with other local processing units that utilise the charcoal produced in a wide range of products for greater impact and poverty reduction.

5. Benefits

The environmental benefits are considerable. The only raw material required is bamboo, and fuel for the kilns, which can also be bamboo. Bamboos are fast growing giant grasses that can be harvested annually. They are a versatile and renewable resource. Cultivation of bamboo is also beneficial for soil conservation and afforestation activities and plantations are encouraged as part of social forestry programmes. Therefore bamboo and its products are considered as eco-friendly .The splitting and slivering unit consumes only a small quantity of water for the boiler and electrical energy requirements are not high.

The economic benefots are also considerable. A charcoal unit will create more economic activities in the region and help improve the social and cultural conditions of the communities involved.

6. Scope for small enterprise development

Bamboo charcoal production is highly suitable for small scale individual producers. On the other hand, marketing and sales are often more effective if done on a larger scale, as

they require more inputs. In China the following system works well – farmers produce bamboo charcoal in their spare time, and a marketing company purchases the charcoal for onward sale and further product development. Such a company could be established as a community owned enterprise to maximise the spread of involvement and benefits.

7. Requirement for success

The essential requirements for a successful bamboo charcoal unit are:

- Small amount of start-up capital.
- Small area of land for kilns.
- Regular supply of raw bamboos.
- Training staff in the techniques involved.
- Local infrastructures for transporting raw materials and finished product.
- Effective marketing and product development system.

Concluding remarks

Producing bamboo charcoal is relatively simple process and can be done by individual farmers as a sideline business, at the cottage industry scale or on larger local business scales. The real challenge for the entrepreneur or development practitioner comes in finding suitable, sustainable markets for the product. As an example most of the charcoal produced in China is exported to other Asian countries.

PART TWO

THE BAMBOO CHARCOAL UNIT

1. Introduction

Bamboo charcoal is produced by the following basic steps:

- Bamboo culms are cut into segments
- Segments are heated under controlled conditions to carbonise them (ie to turn them into charcoal).
- Charcoal pieces are checked and packed.

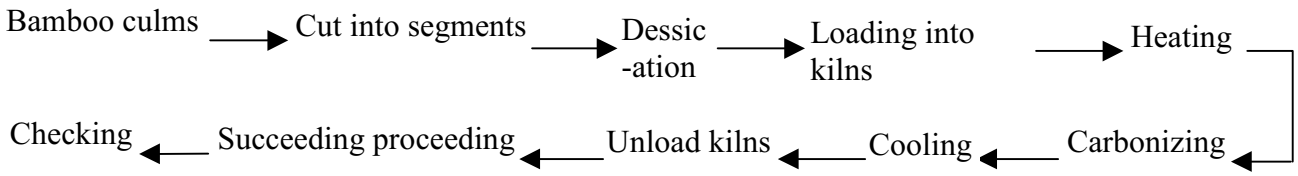
In some instances, waste bamboo is pressed together to form sticks that can be charcoalised. This is referred to as "stick charcoal".

2. Production of bamboo charcoal

Production process

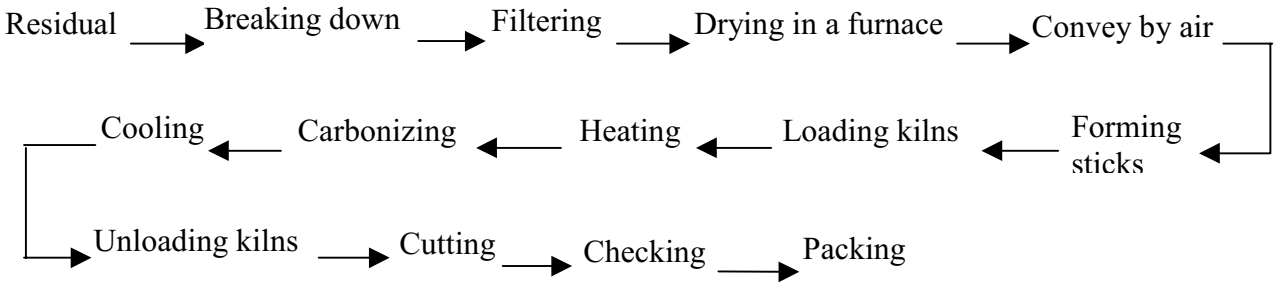
As noted above, there are two main kinds of bamboo charcoal: culm charcoal and stick charcoal. Their production process is different.

a. The production process of culm charcoal in brick kilns is as follows:



Note that the temperature in the kiln during the heating phase can be divided into three periods: smoking (60°Cto 100°C), drying (100°C to 150°C), and pre-carbonizing (150°C to 300°C), and during the carbonizing phase can be separated two periods: carbonizing (300°C to450°C) and refining (450°C to 1000°C) with actual temperature depending upon the required final products.

b. The production process of bamboo stick charcoal is as follows:



The formation of bamboo powder is implemented with an extruding machine with a screw in it at a temperature between 120°C to 140°C. Usually the mechanical kilns are used to carbonize the bamboo stick charcoal due to the its shorter cycle they require compared to brick kilns.

Technical specifications for charcoal

Table 1 Quality requirements for bamboo charcoal

	Unit	Bamboo charcoal	
		1st grade	2nd grade
Moisture content	%	≤7.0	≤9.0
Dash content	%	≤2.5	≤3.5
Solid carbon value	%	≥90.0	≥85.0
Volatile ratio	%	≤7.5	≥9.0
Heating value of solid carbon	J/g	≥33400	≥32300

3. Financial evaluation of the unit (based on one unit operating in China)

3. 1. Products and Plant Capacity

In terms of the local economic conditions and bamboo resources, the scenario is to produce 360 ton bamboo charcoal per year, at the same time get the by-product (72 ton bamboo vinegar per year) . For this target, it is planned to build 30 charcoal brick kilns, each will produce 1 ton bamboo charcoal plus 200 kilogram bamboo vinegar a cycle (25 days/ a cycle and 300 working days per year).

3.2. Total Investment of the Project

Total investment of the project is about 1120 thousands Yuan RMB as follows:

- Initial fixed investment cost of 240, 000 Yuan RMB ($29, 090). See table 1.
- Net Working Capital of 880,000 Yuan RMB ($106, 667). See table 2.

Table 1 Estimate of Fixed Investment Cost

Item	Quantity	Unit Price	Financial cost (in RMB)	Remarks
Kiln Construction	30 Units	0.5	150, 000	Equipment and cost of civil workers and materials
Auxiliary	30 Units	0.3	90, 000	Auxiliary installations etc.
Total		0.8	240, 000	

Table 2 Calculation Of Working Capital (in ten thousands Yuan RMB)

Item	Minimum days for coverage	Coefficient of turnover	Full capacity
Current assets			**105.3**
Accounts receivable	60	6	56.4
Inventory			48.3
Material			
Raw Moso bamboo	45	8	13.5
Packaging	30	12	0.6
Firewood	20	18	1.0
Work-in-progress	20	18	10.3
Finished products	35	10	18.0
Others			4.9
Cash in hand	30	12	0.6
Current liabilities			**17.2**
Accounts payable	35	10	17.2
Net Working Capital 1-2			**88.0**

3.3. Sources of finance

3.3.1 Initial fixed investment cost (240, 000 Yuan RMB) to be funded by direct investment.

3.3.2 Net working capital (880, 000 Yuan RMB) to be funded by bank loan.

4 Production cost and revenue

4.1 Direct production Cost of main product (bamboo charcoal)

Direct production Cost of bamboo charcoal is estimated to 4724.5 Yuan RMB per ton, referring to table 4: Estimate Of direct production cost (bamboo charcoal)

Table 4 Estimate of direct production cost (in Yuan RMB/ tonne finished product)

Direct Cost Item	Cost	Remark
Moso bamboo	3000.00	Bamboo price: 500 Yuan/tonne; Bamboo consumed: 6 tonnes / tonne finished product
Firewood	500.00	Firewood value: 500 Yuan/kiln/cycle
Electricity For productive use	124.50	150 kwh / tonne of finished product (at 0.83 Yuan / kwh)
Labour	500.00	
Carriage	100.00	
Packaging	500.00	Including packaging material and wages
Sum	4724.50	

4.2 Annual Production -Cost And Income Estimate

4.2.1 Parameters

- Product price (bamboo charcoal): 8000yuan /tonne (at present market price ranges from 8000 Yuan /tonne to 10000 Yuan/tonne)
- Product price (bamboo vinegar): 7000 Yuan/tonne (at present market price ranges from 7000 Yuan /tonne to 8000 Yuan/ton).
- Fixed investment is depreciated according to the method of straight line (depreciation period 5 years), no remaining value.
- Sales taxes of 23% (including:VAT of 17% and local taxes of 6%)
- Rate of income tax: 33%.

4.2.2 Annual profit and loss of the unit

It is forecasted that annual net income would be approximately 778, 200 Yuan RMB ($94, 327) See table 5.

Table 5 Net Income Statement (in ten thousands Yuan RMB)

Ref	Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Sum
1	Sales	Under Construction	Product period					
1.1	**Main product** Bamboo charcoal		288.00	288.00	288.00	288.00	288.00	1440.00
1.2	**By-product** Bamboo vinegar		50.40	50.40	50.40	50.40	50.40	252.00
	Sub – total		338.40	338.40	338.40	338.40	338.40	1692.00
2	Direct Production Cost		**177.28**	**177.28**	**177.28**	**177.28**	**177.28**	**886.41**
2.1	Moso bamboo		108.00	108.00	108.00	108.00	108.00	540.00

2.2	Firewood		18.00	18.00	18.00	18.00	18.00	90.00
2.3	Power		4.48	4.48	4.48	4.48	4.48	22.41
2.4	Labour		18.00	18.00	18.00	18.00	18.00	90.00
2.5	Carriage		3.60	3.60	3.60	3.60	3.60	18.00
2.6	Packaging (bamboo charcoal)		18.00	18.00	18.00	18.00	18.00	90.00
2.7	Carriage &. Packaging (bamboo vinegar)		7.20	7.20	7.20	7.20	7.20	36.00
3	Others		**7.50**	**7.50**	**7.50**	**7.50**	**7.50**	**37.50**
3.1	Depreciation		4.80	4.80	4.80	4.80	4.80	24.00
3.2	Repair		1.20	1.20	1.20	1.20	1.20	6.00
3.3	Sundry Charges		1.50	1.50	1.50	1.50	1.50	7.50
4	Operation Profit (1-2-3)		**153.62**	**153.62**	**153.62**	**153.62**	**153.62**	**768.09**
5	Interest on loan of Working Capital		5.14	5.14	5.14	5.14	5.14	25.71
6	Tax on sales		32.33	32.33	32.33	32.33	32.33	161.64
7	Gross profit (4-5-6)		**116.15**	**116.15**	**116.15**	**116.15**	**116.15**	**580.74**
8	Tax on income (33%)		38.33	38.33	38.33	38.33	38.33	191.64
9	**Net profit (7-8)**		**77.82**	**77.82**	**77.82**	**77.82**	**77.82**	**389.09**

5 Calculation Of Cash-Flow Of The Unit

According to post tax cash-flow of the unit, the Net Present Value (discount rate = 10%) is 2.16 million Yuan RMB and the Internal Rate Of Return is 68.3% (Minimum Attractive Rate of Return, MARR=10%). See table 6

Table 6 Cash-Flow Table For Financial Planning (in ten thousands Yuan RMB)

	Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
1	Cash-Flow In		338.4	338.4	338.4	338.4	426.4
1.1	Sales						
1.1.1	Bamboo charcoal		288.0	288.0	288.0	288.0	288.0
1.2.2	Bamboo vinegar		50.4	50.4	50.4	50.4	50.4
1.2	Recover of Working Capital						88.0

2	Cash-Flow Out	112.0	260.6	260.6	260.6	260.6	260.6
2.1	Fixed investment cost	24.0					
2.2	Working Capital	88.0					
2.3	Direct Production Cost		177.3	177.3	177.3	177.3	177.3
2.4	Others		7.5	7.5	7.5	7.5	7.5
2.5	Interest on loan of Working Capital		5.1	5.1	5.1	5.1	5.1
2.6	Sales Taxes		32.3	32.3	32.3	32.3	32.3
2.7	Income Tax		38.3	38.3	38.3	38.3	38.3
3	Net Cash Flow (1-2)	-112.0	77.8	77.8	77.8	77.8	165.9
4	Present value (at 10%)	-101.86	64.313	58.466	53.151	48.319	93.628
5	**Accumulative total**	-101.86	-37.55	20.916	74.067	122.39	216.01

6. Sensitivity analysis

In general the economic index of project is sensitive to many elements. The following factors; investment, production cost and product price, have been selected for the analysis. Within the expected range of fluctuations of these indeces the NPV remains positive and the IRR of each exceeds the MARR, which indicates economic viability of the project and relatively low risk. Furthermore the profitability of the project is relatively sensitive to product price; The key of the project is to develop markets. See table 7.

Table 7 Summary Of Sensitivity Analysis

Indictors	NPV (at 10 %)		IRR	
	Value (in 10, 000 Yuan RMB)	% Change	Value (%)	% Change
Set values	216	—	68.3	—
Total investment increase				
10%	208.3	-3.6	61.2	-10.2
20%	200.0	-7.4	55.3	-19.0
30%	192.8	-10.7	50.3	-26.4
Production Cost increase				
5%	199.3	-7.7	63.9	-6.4

10%	182.6	-15.5	59.4	-13.0
15%	165.9	-23.2	55.0	-19.5
Product Price decrease				
5%	182.9	-15.3	59.5	-12.9
10%	149.9	-30.6	50.7	-25.8
15%	116.8	-45.9	41.9	-38.7

7 Conclusions of Financial Evaluation

7.1 On the basis of the analysis this unit has a high added value and profitability with a lower minimum fixed investment, which is of benefit to the local economy, farmers and sponsors. See table 8.

7.2 At present , the products of the project depend on the export market (mainly Japan), and price fluctuations are one of the important risks for this unit.

Table 8 Summary Of Main Economic Indictors of The Project

Indicators	Unit	Value	Remarks
Products and Capacity			
Bamboo charcoal	Tonne	360	
Bamboo vinegar	Tonne	72	By-product
Sales	10 thousands Yuan RMB	338.4	Including sales from by-product
Sales taxes	10 thousands Yuan RMB	32.3	
Income Tax	10 thousands Yuan RMB	38.3	33%
Net profit	10 thousands Yuan RMB	77.82	
Net present value of the project	10 thousands Yuan RMB	216	Discount rate=10%
IRR	%	68.3	MARR=10%
Net profit-to-investment ratio	%	69.4	Net profit : total investment
Net profit-to-sales ratio	%	27	Net Profit : Sales
Return on Equity	%	324.2	Net Profit : Equity