

# Development of Performance Measurement Framework for Biomass Smokeless Charcoal Production

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## Abstract

Charcoal provides basic energy requirement in the process of heating. Many households in Thailand use charcoal as an essential energy requirement. Meanwhile, as a commercial consumption of charcoal, Smokeless charcoal has become more high growth among grill restaurants. There are various types of smokeless charcoal that depend on material residue types to produce. The production process of charcoal involves air pollution and health. For sustainability of production biomass smokeless charcoal, economic aspect, environmental aspect, and social aspect are considered for long term production. This paper aimed to develop a framework for the sustainability of biomass smokeless charcoal production. The outcomes of a framework will evaluate the sustainability performance of smokeless charcoal production.

## Keywords

Smokeless charcoal, Performance measurement, Sustainability.

## 1. Introduction

Biomass is an essential resource of alternative energy. It provides basic energy requirement in the process of heating. Northern of Thailand has a high potential in biomass from agriculture crop, which can be found by six types such as rice straw, rice rusk, sugar cane, leaves and tops bagasse, corn stalk and cob, and stalk, shell, leaf of legume.

Table 1 is shown annual crop production of agricultural residues by showing potential area that North of Thailand are mostly found potential of utilize agricultural residues.

**Table 1** Agricultural Residues (Source by Department of Alternative Energy Development and Efficiency, Ministry of Energy)

Type of Agriculture Crop	Annual Crop Production (Million ton/year)	Generated Waste	Potential Area in Thailand
Sugar cane	100	Top and leaf, Bagasse	Northeast, North
Oil palm	15	Palm shell, Fiber, Empty fruit bunch, Trunk	South
Rice	39	Husk, Straw	North, Northeast
Corn	5	Cob, Stalk	North, Northeast
Cassava	30	Rhizome	Northeast, North
Rubber tree	0.22	Root, Sawdust, Slab	South, East

Type of Agriculture Crop	Annual Crop Production (Million ton/year)	Generated Waste	Potential Area in Thailand
Coconut	1	Shell, Husk, Flower	South, West
Cashew nut	0.09	Shell	East, Northeast
Legume	0.06	Stalk, Shell, Leaf	North, Northeast

Thus, agriculture residues are high potential to convert to energy for three sectors which are the heat sector, electricity sector, and biogas sector. Mostly agriculture residues are well known as primary heat fuel, which are biofuel. Biofuel can be two types, which are biomass wood pallet and biomass charcoal briquettes. Mainly, a household in Thailand use charcoal for essential energy requirement, which is still using charcoal as elemental energy for the heating process. Nowadays, the increasing trend of cooking grilled food is popular which is barbecue. Normally a basic of barbecue is using charcoal for heat fuel but there is a variety of charcoal types which depends on premium level of barbecue cooking.

Biomass smokeless charcoal is commercial name of charcoal which produced from agricultural residue and used as primary heat fuel. The type of charcoal depends on material are produced from. Biomass charcoal briquettes are well known as a high-grade, smokeless fuel, which are popular among grill restaurants.

Biomass charcoals are products that respond to the commercial sector and the non-commercial sector. For the non-commercial sector, many of households using biomass charcoals as fundamental heat processes. In the meantime, for the commercial sector, many grill restaurants using biomass charcoals as a heating process. The commercial sector, biomass charcoals must be high-grade and smokeless. To satisfy a demand for the market and utilize agriculture residues for high effective, then agriculture residues need to convert for the final product in the suitable effective way. The production process of charcoal involves air pollution and health. For sustainability of production biomass smokeless charcoal, economic aspect, environmental aspect, and social aspect are considered for long term production. This paper aimed to develop a framework for the sustainability of biomass smokeless charcoal production. The framework of performance measurement will be considered indicator by literature review. The outcomes of a framework will evaluate the sustainability performance of smokeless charcoal production.

## 2. Literature review

Sustainable development refers to long term vision by considering three aspects of economic aspect environment aspect, and social aspect. There are many ways to improve the process with measurement of the performance. According to Neely et al.'s. (2002, p. xiii) defined performance measurement as “the process of quantifying efficiency and effectiveness of action”. Objectives of performance measurement is included 4 steps

- Step 1 Monitoring system performance by establishment of appropriate metrics to track and report
- Step 2 Controlling system performance
- Step 3 Benchmark with competitor
- Step 4 Improvement of company

### 2.1. Performance measurement framework

From Chan and Qi, 2003, they measure a performance measurement to inform in the supply chain, that can benchmark the performance. Performance measurement is to perform and analyze the effectiveness of strategies in the supply chain which performance measurement identify information on activities in the supply chain that reflects the need for improvement, and identify potential of opportunities to rearrange and analyze in the supply chain. According to Reddy, et al., 2019, Performance measurement is a framework to measure the efficiency of the system which performance measurement has multi of dimensional, in term of sustainable is the concept of 3-dimensional which are social aspect, environmental aspect and economic dimension. From Wichaisri and Sopadang, 2017, They considerate to balance sustainable supply chain for long term development. Companies should be more considerate in sustainable logistics system, that need to reduce cost and improve quality product of their products in order to respond to customer requirements and maximize their profits. Taticchi, et al., 2013 analyzed sustainable performance measurement which composed with three aspects. Sustainable supply chain is the main component to develop sustainable development. Sustainable development is economic, environmental and social aspects, that has been known as Triple bottom lines. According to Sopadang, et al., 2017 describe three aspects as the economic aspects, the social aspects and the environmental aspect. According to Santiteerakul, et al., (2015) Goals of

sustainability are increasing of economic performance, reducing resource depletion, reducing environmental pollution, and reducing negative impacts on humans in terms of health and safety. From these goals will be supporting short term of sustainability. For long term improvement of sustainability, which are the ability to improve in term of non-polluting products and non-polluting technologies by using less material and energy usage to considerate. Thus, sustainability must be considerate in term of the short term and long term.

#### 2.1.1. The Economics Aspect

The economic indicator is evaluating the capability of an organization. Indicator to measure in economic mostly are profitability, costs, flexibility, timeless, productivity, quality and employment. According to Santiteerakul, et al., 2015, they have been categorized economics dimension for two dimensions of the economic aspect, which are non-financial and financial. Huang, and Badurdeen, (2017) proposed that financial as economics aspect are profitability which are profit from operations that can be from sales revenue, material cost, energy cost, employment cost, water cost, transportation cost, warehouse cost, and other expenses. Then Luthra, et al., (2017) proposed that non-financial as economics aspect are quality of product, flexibility, delivery and service of the product, and lead time required.

#### 2.1.2. The Environment Aspect

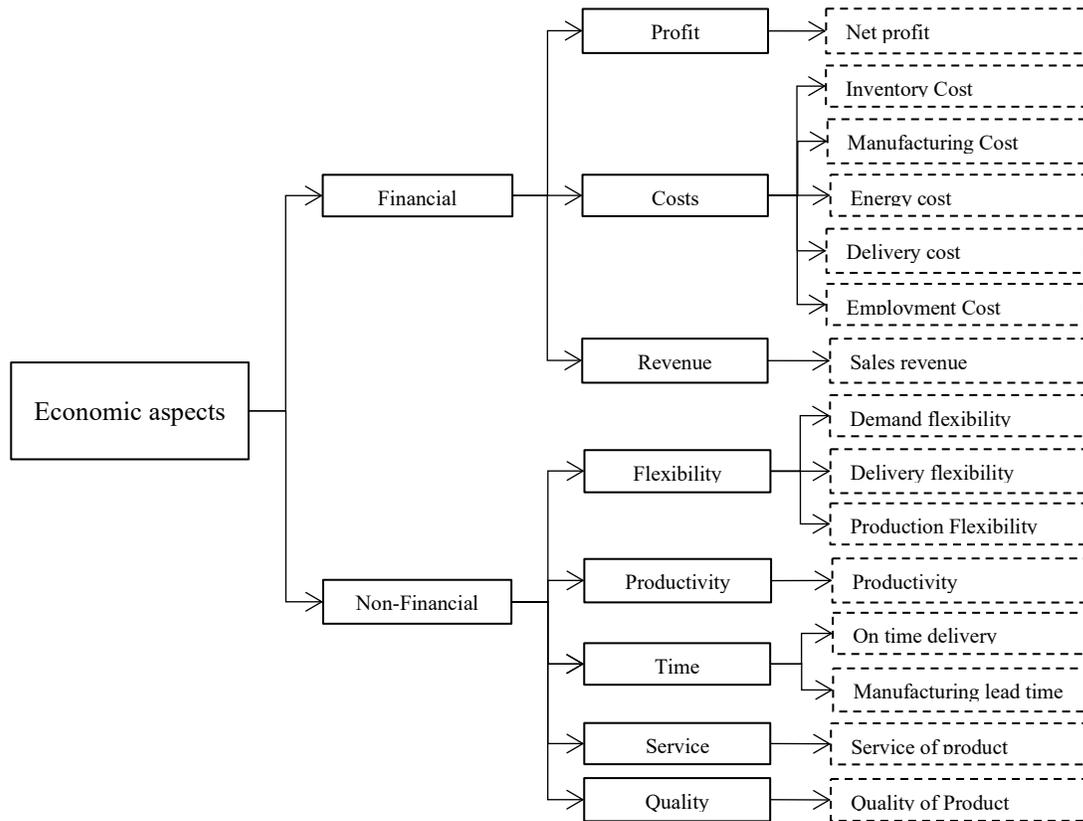
The environment aspect was considerate as energy consumption as a manufacture in the supply chain. Cagno, et al., (2019) They had been creating framework as environment dimension as resource consumption which are water (total water use and recycled water use), material (total material use, recycled material use, and hazardous material use). For energy consumption, they divide for total energy use, renewable energy use, and fossil fuel use. For emission and waste, they divide emission for toxic emissions, and waste which is hazardous solid waste, non-hazardous solid waste, hazardous liquid waste, non-hazardous liquid waste, and waste recycling.

#### 2.1.3. The Social Aspect

According to Allaoui, et al., (2019), they divided the social dimension as employment, and health and security of employment. Sopadang, et al., (2017) they identified the social aspect of the focal company which based on employee satisfaction, customer satisfaction, and health and safety. By following of indicators, performance is measuring as social aspects. According to Santiteerakul, et al., (2015) Goals of sustainability are increasing of economic performance, reducing resource depletion, reducing environmental pollution, and reducing negative impacts on humans in terms of health and safety. From these goals will be supporting short term of sustainability. For long term improvement of sustainability, which are the ability to improve in term of non-polluting products and non-polluting technologies by using less material and energy usage to considerate. Thus, sustainability must be considerate in term of the short term and long term.

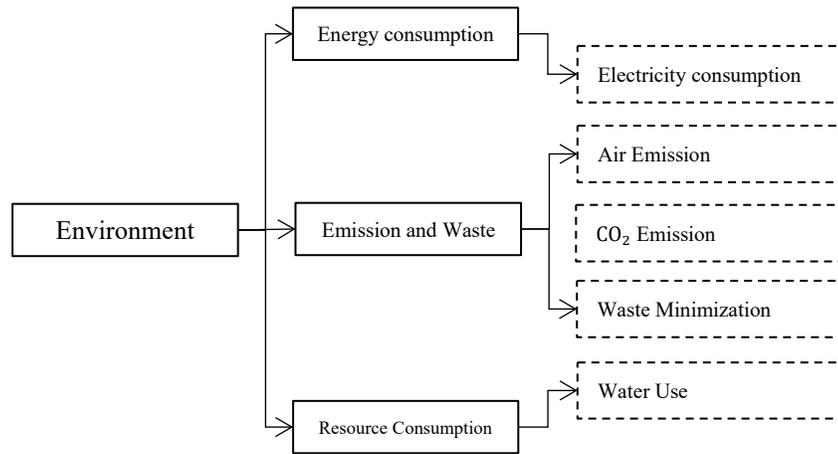
## 2.2. Metrics of sustainable framework

From literature review, there are three aspect framework which are considered to economics aspect environment aspect and social aspect. Economics aspect are 11 quantitative indicators and 4 qualitative indicators. Environment aspect are 5 quantitative indicators. Social aspect are 4 quantitative indicators and 2 qualitative indicators. In the Figure 1 of the economic indicator divides for two groups financial and nonfinancial. Indicator for measure in economic which are mostly are profit, costs, revenue, flexibility, productivity, times, service, and quality.



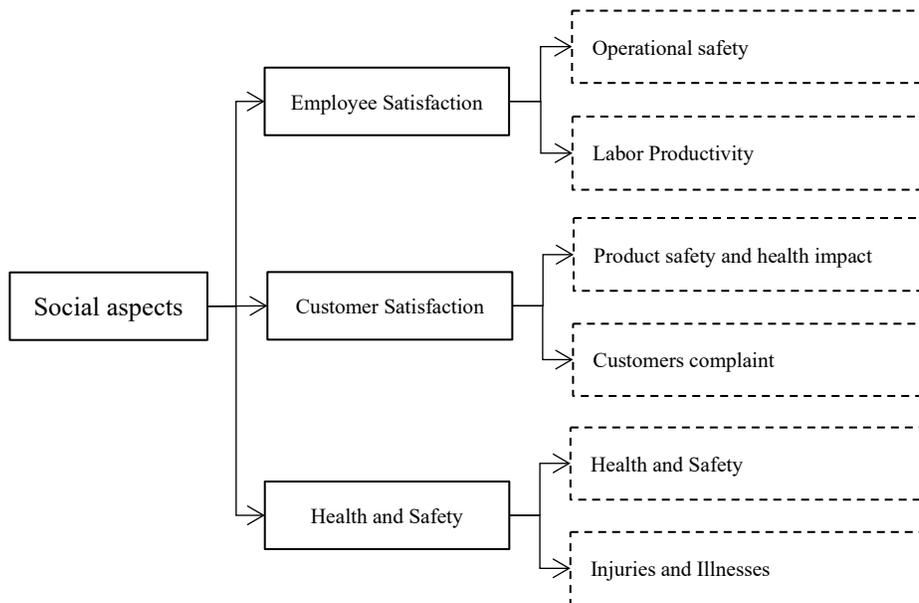
**Figure 1** Metrics of economic aspect framework

In the Figure 2 of the economic indicator divides for 3 criteria which are energy consumption, emission and waste, and resource Consumption.



**Figure 2** Metrics of environment aspect framework

In the Figure 3 of the social indicator divides for 3 criteria which are employee satisfaction, customer satisfaction, health and safety.



**Figure 3** Metrics of social aspect framework

### 3. Methodology

The objective of performance measurement for biomass smokeless charcoal production by monitoring process measuring process and analyze process. This paper is performed framework by developed key performance indicator from literature review of sustainable framework. In the supply chain of biomass smokeless charcoal, framework will be measuring in term of manufacturing since the process of raw material transfer to production of biomass charcoal. From review the previous study, Framework is based on literature review by gaining the conceptual framework.

The conceptual framework is based on literature review which follow by sustainable performance measurement. There are three aspects to considered of economic aspect, environment aspect and social aspect. From reviewing literature review, Indicators of framework will be categorized for three aspect. Indicators of economic aspect are considered for 2 dimension which are financial and non-financial measurement. Indicators of environment aspect are considered for 3 dimension which are energy consumption emission and waste, and resource consumption. Indicators of social aspect are considered for 3 dimension which are employee satisfaction, customer satisfaction, and health and safety. Therefore, conceptual of indicators is proposed in Table 2.

**Table 2** Indicator metrics of reviewing sustainable performance measurement framework.

			Indicator	Reference
Economic	Finalcial	Profit	Net Profit	Huang and Badurdeen, 2017. Cagno, et al, 2019. Sopadang and Wichaisri 2017. Santiteerakul, et al, 2015. Wichaisri and Sopadang, 2014 . Allaoui, et al, 2019. Luthra, et al, 2016.
		Costs	Manufacturing Cost ,Inventory Cost,Delivery cost,Energy cost ,Employment Cost	Huang and Badurdeen, 2017. Cagno, et al, 2019.Sopadang and Wichaisri ,2017. Qorri, et al,2018. Wichaisri and Sopadang, 2014. Resat and Unsal, 2019. Allaoui, et al, 2019. Olugu and Wong, 2010. Santiteerakul, et al, 2015. Ramezankhani, et al, 2018.
		Revenue	Sales revenue	Santiteerakul, et al, 2015.
	Non-Financial	Flexibility	Demand flexibility , Delivery flexibility,Production Flexibility	Sopadang and Wichaisri ,2017. Santiteerakul, et al, 2015. Resat and Unsal, 2019. Olugu and Wong, 2010.
		Productivity	Productivity	Sopadang and Wichaisri ,2017.
		Time	Manufacturing lead time,On time delivery	Cagno et al, 2019. Qorri, et al,2018. Luthra, et al, 2016. Bai and Sarkis, 2014. Olugu and Wong, 2010.
		Service	Service of product	Luthra, et al, 2016. Bai and Sarkis, 2014.
		Quality	Quality of Product	Cagno et al, 2019.Sopadang and Wichaisri 2017. Qorri, et al,2018. Santiteerakul, et al, 2015. Wichaisri and Sopadang, 2014. Resat and Unsal, 2019. Allaoui, et al, 2019. Luthra, et al, 2016.
	Environment	Energy Consumption	Energy use,Electricity consumption	Huang and Badurdeen, 2017.Cagno et al, 2019. Nikolao, et al,2018. Qorri, et al,2018. Santiteerakul, et al, 2015. Bhakar, et al, 2018. Wichaisri and Sopadang, 2014. Allaoui, et al, 2019. Ahi, et al, 2016. Ramezankhani, et al, 2018. Bai and Sarkis, 2014.
		Emission and Waste	Air Emission,CO2 Emission (gCO2/tonne-km) ,Waste Minimization	Huang and Badurdeen, 2017.Cagno et al, 2019. Nikolao, et al,2018. Qorri, et al,2018. Sopadang and Wichaisri ,2017. Santiteerakul, et al, 2015. Wichaisri and Sopadang, 2014. Allaoui, et al, 2019. Ahi, et al, 2016. Rajeev, et al, 2019. Rovere, et al, 2009.

		Indicator	Reference
	Resource Consumption	Electricity Use ,Water Use	Huang and Badurdeen, 2017.Cagno et al, 2019. Qorri, et al,2018. Wichaisri and Sopadang, 2014. Allaoui, et al, 2019. Ramezankhani, et al, 2018. Rovere, et al, 2009.
Social	Employee Satisfaction	Operational safety,Employees exposed to high-risk work environment ,Labor Productivity	Huang and Badurdeen, 2017.Cagno et al, 2019. Qorri, et al,2018. Wichaisri and Sopadang, 2014. Allaoui, et al, 2019.
	Customer Satisfaction	Product safety and health impact,customers complaint	Huang and Badurdeen, 2017.Cagno et al, 2019. Qorri, et al,2018.Nikolaou, et al, 2018. Ramezankhani, et al, 2018. Olugu and Wong, 2010.
	Health and Safety	Health and Safety, Injuries and Illnesses	Huang and Badurdeen, 2017.Cagno et al, 2019. Qorri, et al,2018.Sopadang and Wichaisri ,2017. Nikolaou, et al, 2018. Santiteerakul, et al, 2015. Resat and Unsal, 2019. Allaoui, et al, 2019. Ahi, et al, 2016. Ramezankhani, et al, 2018. Rajeev, et al, 2019. Luthra, et al, 2016.

From reviewing literature indicator, indicators grouping are based on manufacturing process which are economic aspects of manufacturing, environment aspects of manufacturing, and social aspects manufacturing.

#### 4. Results

Biomass charcoal production can produce from different type of materials. From different type of materials will be perform efficiency from evaluation performance. In this paper aimed to develop framework which will be measured in manufacturing activity. The framework indicators are developed by literature review. Key performance indicators proposed the framework for measuring three aspects of performance measurement. From framework is divided for 3 aspects. Each aspect is included of metric and indicator of framework.

##### 4.1 Economic aspects

Following by the metric and indicator is in the Table 3 Economic aspect can divide for 2 groups of economic which are financial and nonfinancial and criteria of financial are profit cost and revenue. Non-Financial criteria are flexibility productivity time and quality.

**Table 3** Framework of economic aspects

Measure		Indicator	
	Profit	Net profit	Total Revenue - Total cost
Financial	Costs		Holding cost
			Inventory Cost
			Shortage cost
		Manufacturing Cost	Manufacturing Cost per Product Unit/ Total Cost per Unit
		Energy cost	Electricity cost
		Delivery cost	Delivery cost
		Employment Cost	Employment cost
	Revenue	Sales revenue	Sale revenue
Non-Financial	Flexibility	Demand flexibility	Demand flexibility
		Delivery flexibility	Delivery flexibility
		Production Flexibility	Production Flexibility

Measure		Indicator	
Productivity	Productivity	Unit of out put / Unit of in put	
	Time	On time delivery	Numbers of On-time Delivery/ Total of Purchase Orders
Quality	Quality of Product	Manufacturing lead time	Manufacturing lead time
	Quality of Product	Product output / Materials input	

## 4.2 Environment aspects

Following by the metric and indicator is in the Table 4 Environment aspects measure for 2 criteria which are energy consumption and emission of pollution.

**Table 4** Framework of environment aspects

Measure	Indicator	
Energy Consumption	Electricity consumption	Electricity consumption
Emission	Air Emission	No x
		TSP,
		PM <sub>2.5</sub> PM <sub>10</sub>
		CO <sub>2</sub> Emission
		CO
		O <sub>3</sub>
		SO <sub>2</sub>

## 4.3 Social aspects

Following by the metric and indicator is in the Table 5 Social aspects measure for 3 criteria which are employee satisfaction customer satisfaction and health and safety.

**Table 5** Framework of social aspects

Measure	Indicator	
Employee Satisfaction	Operational safety	Operational safety in production process
	Labor Productivity	Total Output/ Total In put
Customer Satisfaction	Customers complaint	Number of customers complaints
Health and Safety	Number of injuries	Number of injuries

## 5. Conclusion

Evaluation of performance measurement framework reflect efficiency of production process. To be able to meet the demand of product to a customer, a production might be increasing profit but in terms of producing biomass smokeless charcoal production which involves to environment and society, a sustainable production process must be considered. Frameworks are effect to evaluate three aspects which will be noticed for how different aspect of each performed. The outcome of the framework is clarified efficiency to the manufacturer. Biomass smokeless charcoal is a compound of different raw materials then the decision-maker will be able to evaluate the efficiency of sustainability performance.

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