A Business Model for Producing Clean Energy in Developing Countries

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Abstract: - Similar to other business projects, clean energy projects also has orientation for profit maximization in developing countries. Environmental problems caused by industrial wastes have been becoming serious issues in developing countries. Hence, recycling industrial wastes, in order to create more renewable and clean energy, has been recognized as one of ways to reduce adverse impact of global warming and negative effect of greenhouse gases. According to statistics, Viet Nam discharges about 400,000 tons of waste tires annually and this number in the US is estimated about 4,200,000 tons per year (source: vnu.edu.vn). This creates many environmental issues. Hence, this paper aims to propose a business model to solve problems mentioned below in the paper. Building a tire shredding plant in California, USA (for example) to cut the whole tires into small shredded tires then export to developing countries like Vietnam is one method to convert wastes into clean energy and protecting our environment. This is one main objective of this research paper. Another purpose of this study is to find out a financial model to evaluate socio-economic values of renewable energy projects that help to protect our environment, as well as a modern viewpoint of not including or adding (+) new debt issuances to increase net cash flow when estimating FCFE cash flow. Using pyrolysis technology to crack carbon linkage into smaller linkages, and then convert waste tires into renewable energy (FO-R oil, carbon black and steel). This is an application of chemical engineering. Through the economic and technical analysis of this model, we can see the practical benefits of the energy project in terms of economic efficiency, profitability, which bring surplus value for investors, effective solutions for customers and a quality energy product for the society. And it also suggest the relevant government of developing countries to consider proper policies to encourage environment protection and businesses in the field of converting industrial wastes such as tires into clean energy.

Key-Words: - Pyrolysis technology, shredder, clean renewable energy, business model, developing countries

1 Introduction

Industrial wastes such as waste tires, plastic,…have created many environmental problems, which need to be solved by pyrolysis technology to create a cleaner renewable energy source in developing countries. The global issue of waste tires in particular and industrial solid waste has been becoming an environmental problem in developing countries such as Vietnam and moreover, it is a global problem needed to be thoroughly resolved. Annually, Vietnam and other countries around the world release about 14 million tons of waste tires, which presents one of the global serious issues of solid waste.

Table 1 - Waste tires in various countries

Country	The number of waste tires annually (tons)
US	4,200,000
Europe	3,400,000
Japan	1,000,000
Viet Nam	400,000
Others	5,200,000

(source: vnu.edu.vn)

Several environmental impacts of used tires are: Huge quantities of scrap tires are the living source of flies, mosquitoes, cockroaches, disease-causing parasites, and fever viruses. Besides, Potential fire hazard from waste tires will cause acid smoke that is harmful to the environment and human health. Scrap tires also take up much landfill space and are dirty while the precious natural resource has been becoming scarce. Disposal of waste tires is one of global serious environmental problems, Therefore, recycling and converting waste tires into clean energy such as fuel oil-renewable (FO-R), by pyrolysis system, is becoming a crucial method to reduce bad effects of global warming and greenhouse gases.

Continuous waste tyre pyrolysis plant is for processing waste tyres into fuel oil and carbon black for recycle use. Due to continuous feeding and discharge system, the continuous waste tyre pyrolysis plant can keep working without stop, thus to save energy and time.

2 Problem Formulation

This paper will find out:

Research issue 1: what is the business model to convert industrial wastes such as waste tires,… into clean energy in developing countries? What we can do for profit maximization?

Research issue 2: what are solutions that developed countries can help and provide developing countries in this field?

2.1 Research Method and Data

In this research, analytical method is used with data from a Vietnam case in waste tire pyrolysis industry. This is an experimental model, and we also test the products by Vietnam clients in cement industry. All the business results are real examples in Vietnam.

2.2 Conceptual Theories

Pyrolysis reaction will break carbon linkage in the condition without oxygen at high temperature of 300-500°C to produce renewable energy products such as FO-R (oil), carbon black and scrap steel.

2.3 Literature Review

Waste tires pyrolysis is well known method for their thermal recycling by heating at near 500°C with purpose of liquid oil and carbon black by-production as near 50% and 35% yield correspondingly, including about 10% combustible off-gas residual after oil condensing and 5% wire steel cord in rest (all relatively to tire mass [5]. Results showed that: (1) the composition of the liquid hydrocarbon obtained is affected significantly by the air factor; (2) the higher operating temperature caused a higher yield of gasoline and diesel; (3) the yield of gasoline increased due to the catalyst zeolite added, and the yield of diesel increased due to the addition of the catalyst calcium carbonate; (4) the principal constituents of gasoline included dipentene and diprene [10].

Then, Research results also indicated recycling of scrap tyre pyrolysis gives comparable efficiency to diesel oil in medium to high load but it has been question on the desulfurization process. More improvement in fuel quality in term of desulfurization, reduction in viscosity is required for tyre oil as an alternate fuel for diesel engine [14]. Next, Approximately 1.5 billion tires are produced globally each year with 300 million in the USA, which will all eventually become waste tires. Waste tires are excellent candidates for recovery of energy, as well as solid, liquid, and gaseous by-products, via pyrolysis: made predominantly from the petroleum product rubber, they have a high heating value, as well as high volatile content and medium sulfur content [1]. Then, pyrolysis experiments were carried out in a fixed-bed-reactor with cyclone separator at various temperatures (300 °C, 400 °C, 500 °C, 600 °C and 700 °C) and nitrogen, employed

as agent gas, was given batch and continuously during the process. In the study, the calorific values of the liquid and solid pyrolysis products were determined as 9117 kcal m-3 and 8710 kcal kg-1 respectively. When the results of the experimental studies were evaluated, synthesis gas rich in CH4 and H2 with a high calorific value of 4180 kcal m-3 was achieved [6]. Researches provided a lot of data about the pyrolysis of waste tires with respect to the type of reactors used associated with the experimental conditions (temperature, heating rate, type of catalyst) and its effects on the products of pyrolysis [2]. Finally, according to MS and thermogravimetric (TG) curves, tyre pyrolysis could be divided into four stages. The first stage was due to water vaporization and plasticizer decomposition at the temperature below 320 °C. The secondary stage was attributed to natural rubber decomposition at 320–400 °C, and the third stage was related to the decomposition of synthetic rubber, which took place at 400–520 °C. The fourth stage was occurred above 520 °C [3].

3 Problem Solution

3.1 Finding on a business model in developing countries

(Input) Raw materials: Industrial wastes: plastic or waste tires

According to statistics, Viet Nam discharges about 400,000 tons of waste tires annually and this number in the US is estimated about 4,200,000 tons per year (source: vnu.edu.vn). Global car sales continue to rise in the first half of 2018, data provided by JATO, an auto market research firm, show in 57 countries worldwide, total revenue of car industry in the world in the first half of 2018 reached 44 million cars, increase 3.6% compared to the same period in 2017

According to statistics, in 2018 global vehicle sales increased 3.6% compared to 2017 (44.03 million units compared to 42.49 million units). This number still very promising, although according to CNN, The global auto industry plunged deeper into recession in 2019, with sales dropping more than 4% in 2019. The number of vehicles sold across major global markets dipped to 90.3 million in last year. Viet Nam's vehicle consumption growth forecasted will reach 22.6% per annum during 2018-2025 and reach 18.5% per annum during the period 2025-2035. It is forecasted that by 2020, the demand for the domestic automobile market will be about 500,000-600,000 cars and the automobile market will be driven by the GDP per capita surpassing 3,000 USD and the average ownership will be about more than 50 vehicles / 1,000 people. The trend will also take place in Viet Nam during the period 2020-2030. Thus, the automotive market is expected to reach 750,000-800,000 cars by 2025 and reach 1,7 – 1,85 million cars by 2035. Source: (https://bnews.vn/thi-truong-o-to-viet-nam-co-the-dat-800-000-xe-trong-giai-doan-dan-so-vang/86935.html)

With the number of cars currently in reality and the growth forecasted as above, the number of waste automobile tires are very large, ensuring the input materials for the plant.
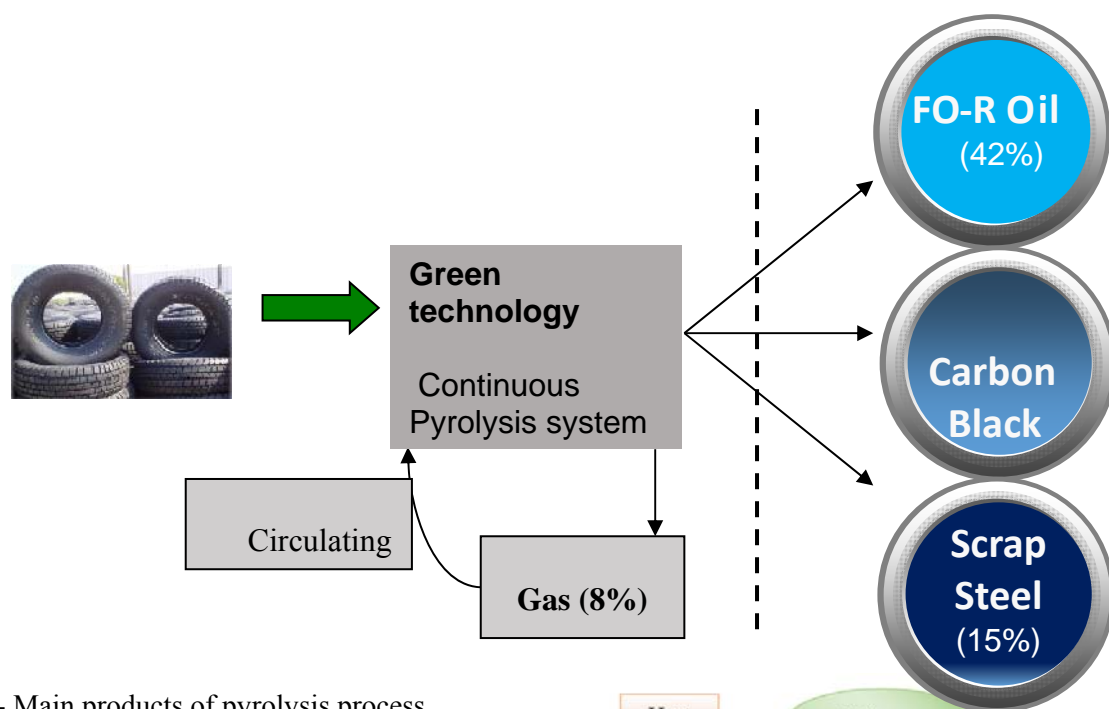
Process (pyrolysis) system:

Figure 1 - Main products of pyrolysis process

Advantages

The advantage of the continuous pyrolysis line is that it separates steel from the beginning by cutting and filtering rubber to increase the quality and price of scrap steel compared to the current line system. The second advantage is that the new line system uses automatic coal packing system to reduce the environmental pollution caused by coal dust compared to the current method. A third advantage is the cost savings made by the continuous pyrolysis line which is automatically controlled and does not process water during pyrolysis. Shredder suppliers in the US such as Ecogreen can provide energy companies with shredding system which help to cut the whole tires into small pieces (with diamers less than 25 mm). Then, they can be put into pyrolyssis system and be converted into finished products with roper pyrolysis yield. Therefore, we can build a shredding tire plant in California to cut the whole tires into shreded tires then we export to developing countries like Vietnam to convert into clean energy through pyrolysis system. Steps of pyrolysis are described in the below figure (source: M. N. Islam and M. R. Nahian, 2016)
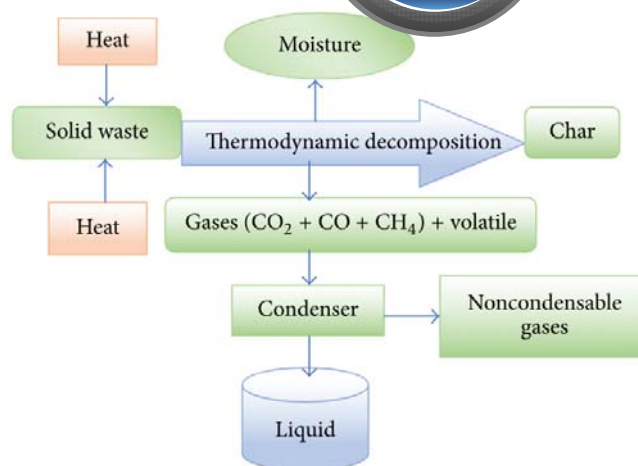

Figure 2 - Steps of pyrolysis process

(Output) Finished products: FO-R oil, carbon black, scrap steel

The product mix of the project is applied in the following areas:

Table 2 - Product Catalog and Application

Product name	Application
FO-R oil from rubber, waste tire (42%)	Fuel oil for steam boiler and dry kiln, production of glass, steel and ceramic tile, replacing FO oil. If additional distillation is used, we can obtain products (petrol, diesel, asphalt).
Carbon black (35%)	Used as a solid fuel, replacing activated carbon as a filler in the processing of rubber products, paint pigments, cement, wire casing, ...
Gas (Hydrocacbon) (8%)	Circulated, fully utilized for heating at the pyrolysis equipment, saving energy for the

	project;
Scrap steel (15%)	High quality steel components, used as raw materials for making steel billet.

As we see from the below statistics results (see figure 3), presents the results of an analysis to identify statistically significant variables, based on the oil yields. With a confidence level of 95%, the results indicate that all the variables are significant, as are the interactions between temperature and pressure (13) and heating rate and pressure (23). The effect of pressure shows negative figures, for the lower the pressure the higher the oil yield. As for the other variables with positive results, the higher their values the higher the oil yields.Statistical treatment of oil yield from pyrolysis (source: Carla, Antonio, Manoel, Aparecido 2008)

3.2. Financial model and analysis

We can propose a financial model for implementing a renewable energy manufacturing factory as follows:

	Effect	Std. error	Confidence interval	
			−95%	+95%
Principal factor				
1 (Temperature)	8.23	1.04	5.84	1.62
2 (Heating Rate)	4.34	1.04	1.95	6.72
3 (Pressure)	−7.70	1.04	−10.08	−5.31
Interaction of two factors				
12	−1.52	1.04	−3.91	0.87
13	3.34	1.04	0.95	5.73
23	−2.50	1.04	0.11	4.88
Interaction of three factors				
123	−1.37	1.04	−1.02	3.76

Figure 3 - Statistics results for pyrolysis

Table 3: Pyrolysis Efficiency

	ITEM		Capacity	Wasted tires	Shredded tires
1	**Waste tire (tons/line)**		**17.65**	100%	
2	Shreds tires (tons cutting wasste tire/line)		**15.00**	85%	100%
3	FO-R Oil			38.25%	45%
4	Carbon black			34.85%	41%
5	Scrap steel			15%	
6	Gas			11.9%	14%

No	Estimate Change in Net working capital	Day	Unit
1	Days in Inventory (Oil)	32.9	days
2	Days in Inventory (Waste tire)		days
3	Days in A/R	30	days
4	Inventory turnover (Oil)	11.1	circle/year
5	Inventory turnover (Waste tire)		circle/year
6	A/R turnover	12	circle/year
7	Days of A/P	0	immediate payment

Table 4: NPV, IRR and FCFE projection

Year	2019	2020	2021	2022	2023
Depreciation		1,374,722	1,883,115	3,190,410	2,337,162
Net profit	(29,700)	2,931,858	14,459,847	18,557,652	20,200,062
(Increase) Decrease in net working capital		(1,162,123)	(2,389,489)	(827,761)	(39,146)
Loan payback	-	(1,142,909)	(2,848,716)	(2,848,716)	(2,848,716)
Corporate tax				(1,855,765)	(2,020,006)
Net Cash flow	(29,700)	**2,001,548**	**11,104,756**	**16,215,820**	**17,629,356**
Capital expenditures	**(7,226,402)**	**(18,951,250)**	**(7,822,348)**		
Free cash flow	**(7,256,102)**	**(16,949,702)**	**3,282,408**	**16,215,820**	**17,629,356**

.	2024	2025	2026	2027	2028
Depreciation	2,337,162	2,337,162	2,337,162	2,337,162	2,337,162
Net profit	20,467,081	20,708,853	20,859,683	20,900,784	20,932,325
(Increase) Decrease in net working capital	-	-	-	-	-
Loan payback	(2,848,716)	(2,153,003)	(447,196)	(286,732)	(286,732)
Corporate tax					

	(2,046,708)	(2,070,885)	(2,085,968)	(2,090,078)	(2,093,232)
Net Cash flow	17,908,819	18,822,127	20,663,681	20,861,136	20,889,522
Capital expenditures					
Free cash flow	17,908,819	18,822,127	20,663,681	20,861,136	20,889,522
Minimum expected rate of return :	15%				
Payback Period	51	months			
NPV	33,735,539				
IRR	45.2%				

There are several points we discuss from the above tables:

First, because we are estimating FCFE (for equity), we choose discount rate as return on equity (expected); therefore, it might be 15% to 30% dependent on investors or shareholders. In international formulas, economists can use WACC instead of expected ROE. But WACC is only used for FCFF (free cash flow for firm). Second, this project will bring socio-economic values such as: create more employment for society, solve environmental problems, contribute to national budget through taxes. Furthermore, NPV > 0 and IRR 45% is good signals for investors to invest. (see above Table 4). A better control of raw materials and technology might bring good cash flow for firms. As shown in Table 3, the pyrolysis yield is much depending on modern technology.

4 Limitation of the Model

Firstly, some countries do not widely notice their supporting policies in the field of pyrolysis of industrial wastes into clean energy. Secondly, finding a good source of capital for businesses in this field is still limited and difficult. Finally, we need to find a proper mechanism for developed countries to transfer their resources to developing countries.

5 Discussion for further Research

The increasing demand for energy production and dealing with larger amounts of waste pushes renewable energy companies to solve the produced pollutant waste, emit lesser amounts of CO2, and generate more energy. Recycling of scrap tires become one of perfect solutions for the recent requirements of the 21st century. In the context of the depletion of natural resources, the quality of the environment seriously affected by the pace of development of industries and urbanization, the reuse and recycling of industrial wastes into production is necessary, because two (2) reasons: in addition to reducing the burden of environmental pollution and protecting the resources of future generations, it also helps businesses save a large amount of money in production and lower production cost(the cost of buying FO-R oil from used rubber is much lower than that of other natural fuels).

6 Conclusion and Policy Suggestion

A global issue: 14 million tons of end-of-life tires are accumulated annuallly in the world and are today one

of the worst global solid waste problems.This paper recommends a business model to recycle industrial wastes into clean energy for a better environment. This model also opens new research directions for renewable energy industry, new materials research, increases the value for society and developing countries in general, and for the company and investors in particular. This study also suggested a financial model to see socio-economic values of renewable energy projects despite of certain risks coming from oil price fluctuations. And it highlights some discussion points which might be different from traditional formula approach when calculating FCFE. This is one of scientific contribution of this paper. And there are more scientific points in FCFE method can be included in further researches.

To promote energy saving and efficient energy using, to the demand of higher energy use of the national economy, and to protect the environment, rationally exploit of resources toward sustainable socio-economic development, the government need to adopt policies to encourage organizations and individuals to seek new renewable energy sources.
The government and authorities in Viet Nam and developing countries as well as developed countries can issue policies which can support renewable energy firms to protect environment. Channels of capital are also needed to encourage these companies to produce clean energy.
Last but not least, this paper opens a future research direction, for example, we can continue to set up qualified factors and upgrade technology in pyrolysis process and technology for more safety and better environment protection. Another hint for future research is for profit maximization, we need to control and reduce cost to achieve the efficiency of the business system. A combination of using laborers effectively, building proper manufacturing and business processes and better management of supply chain might help this project success. Some relevant studies can be found in [14] and [15].

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