A SWOT analysis of biodiesel production from waste cooking oil

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Abstract. Biodiesel is a renewable and environmentally beneficial energy which has a variety of raw materials. Waste cooking oil (WCO) as one of the feedstocks has advantages not only in the environmental aspect, but also in the economy. With the increasing attention on the use of WCO for biodiesel production, some drawbacks are encountered as well. This paper aims at using SWOT analysis to find out the strengths, weaknesses, opportunities and threats of WCO as a raw material for biodiesel production. Results show strengths including guaranteed food security, energy security, and positive impact on the environment as well as offering direct and indirect jobs. The weaknesses include complex production process, low recovery rate of WCO and high standards demand for WCO as a raw material. Biodiesel produced from WCO is capable of dealing with the increasing concern of environmental protection and the demand for renewable energy. Moreover, governments have been making laws and regulations to support its development. These mentioned above are all the opportunities with the use of biodiesel. Lack of efficient economic incentive, other energy sources competitors and a small market for biodiesel can be threats for its development.

1. Introduction
With increasing population and modernization, the world is being faced with a new challenge of an urgent need for energy as well as environmental improvement. According to statistical data, fossil fuel makes up for more than 80% of the world’s energy consumption [1]. This has eventually led to a dilemma: environmental protection or economic development? Many efforts have been made to solve this dilemma and one of the solutions is to popularize biofuel as an alternative to fossil fuel. Biodiesel is a non-toxic and biodegradable alternative fuel that can be obtained from renewable sources [2]. It has a variety of raw materials. For example, the EU mainly uses colza oil as the raw material. Palm oil is used as raw material in the southeast. Unlike other counties, China and Japan pay more attentions to their arable land safety and so it is reasonable for them to use some other materials such as waste cooking oil (WCO) to produce biodiesel. WCO is the used cooking oil. Many scholars have studied the biofuel production from WCO. Liang et al. (2003) evaluated seven categories of biodiesel feedstocks including WCO, finding out that WCO had a good performance on energy production and net economic benefits [3]. Basheer et al. (2012) estimated that 70% of WCO could be recovered from restaurants and other sources with adequate economic incentives. This results came after an analysis
about the performance of biodiesel produced from WCO in the US, Canada, Japan and Ireland etc. [4].
With the increase in production and consumption of biodiesel, biodiesel production from WCO has
drawn attention all over the world.

2. Methodology
SWOT (strengths, weaknesses, opportunities and threats) analysis is a method for investigating the
internal and external environmental influencing factors in a project. The aim of applying SWOT
analysis is to find out the strengths and weaknesses inherent to a project as well as the opportunities
and threats in the external environment.
The following steps were used in the analysis:
Identification of the internal aspects in biodiesel production using WCO: includes the advantageous
aspects and the disadvantageous aspects. Characterization of the internal aspects and classifying them
into strengths and weaknesses.
Identification of the external aspects: Characterization of the external aspects and sorting out the
opportunities and the threats.

3. SWOT analysis of biodiesel production from waste cooking oil

3.1. Strengths

3.1.1. Food security Biodiesel production has existed over a long period of time. There has been an
expansion in biodiesel production in the last 10 years. Since it is renewable and benefit in
environmental protection, it has gained much support. Meanwhile, with the significant rising prices of
crops, concerns have been raised about biofuel’s impacts on land use and food prices [5]. As for WCO,
which has the potential to release the pressure on food crops for biofuel production, it has a
tremendous output all over the world. EU countries generate 0.7 - 1 million tons of WCO per year.
The UK produces 0.2 million tons of WCO per year and for Canada it is 0.135 million tons per year.
China and Japan on an annual basis generate about 4.5 and 0.6 million tons of WCO respectively [6].
Besides its adequate production, it is also a good way to ensure food safety because it does not
compete with crops on land use and reduces the possibility for the use of reprocessed WCO at the
same time [7].

3.1.2. Energy security The International Energy Outlook 2017 anticipates a 28% growth in world
energy consumption between 2015 and 2040, with more than half of the increase attributed to non-
OECD Asia (including China and India), where strong economic growth drives increasing demand for
energy. As fossil fuel is non-renewable and leads to greenhouse gas emissions, it is time to make
renewable energy as an alternative to fossil fuel. Biodiesel production from WCO has met the growing
need for energy security as it is renewable and it can be produced by any country as long as there is
WCO. The quantity of biodiesel produced from WCO is increasing around the world. In Europe, the
amount of WCO was 800 thousand tons in 2011, and in 2014, it increased to 1800 thousand tons [8].
In 2016, recycled grease was the source of about 13% of the total feedstock used to produce biodiesel
in the US [9].

3.1.3. Environment friendly World energy-related carbon dioxide (CO2) emissions are projected to
grow on an average of 0.6% per year between 2015 and 2040. Studies show that compared to
petroleum-based diesel, biodiesel has micro scale carbon dioxide emission and its burning emits, on
average 48% less CO, 47% less particulate matter, 67% less HCs and lower unburned hydrocarbons
[10]. Therefore, using WCO to produce biodiesel does not only extend its life cycle, but also has a lot
of benefits on our environment with reference to its renewability, non-toxicity and low emissions.
Besides, the use of WCO in producing biodiesel also avoids the pollution of underground water, soil,
and the sewerage system.
3.1.4. Creation of direct and indirect jobs The World Bank reports that biofuel industries require about 100 times more workers per unit of energy produced than the fossil fuel industry [11]. Biofuels employment increased around 3% to an estimated 1.7 million in 2016 [12]. Job positions can be created at every stage in the biodiesel production chain: in the WCO recycling sector through the number of people required for the collection of WCO. In the fuel supply chain, people are required for transport, storage, etc. of the raw material. In the energy sector, jobs are related to the installation, operation and periodic maintenance of equipment.

3.2. Weakness

3.2.1. Complex procedure Trans-esterification is believed to be the most widely used method to obtain biodiesel through all sorts of processes [13]. Trans-esterification can be alkali-catalyzed, acid-catalyzed or enzyme-catalyzed, depending on the undesirable compounds (especially water) and free fatty acids present. Among these, the most popular method is the alkali-catalyzed process. The alkali-catalyst process is a complex process with the greatest number of equipment pieces because of the addition of a pre-treatment unit in order to reduce the content of FFA. If the level of FFA is above 3wt. %, the only reaction products you can get are soap and water [7]. Due to the sensitivity of the alkali-catalyzed reaction to FFA found in waste oil, a pre-treatment is required prior to the trans-esterification unit to reduce the content of free fatty acid [14]. The pre-treatment processes include 4 steps: washing step, centrifugation, flash evaporation and acid esterification. After the pre-treatment steps, solid impurities can be eliminated whereas FFA and water contents can also be reduced [15].

3.2.2. Low recovery rate of WCO The recovery rate of WCO is essential in the production of biodiesel. A low recovery rate of WCO means a shortage of feedbacks. This will not only frustrate the positivity of biodiesel enterprises, but also go against biodiesel mass production. China has a WCO production capacity of about 4-8 million tons annually, half of this quantity has the potential of being collected [16]. 33 pilot projects have already implemented a WCO-to-biodiesel convention carried out by the Chinese government to recover WCO. The recovery rate however is still low in China. In Beijing and Nanjing, the rate is not even up to 50% [17]. Singapore has an even lower recovery rate of WCO. The Agri-food & Veterinary Authority (AVA) of Singapore showed 115,585 tons of oil consumption in 2010, of which only little was recycled into biodiesel, with much of it going back to the food preparation process [18]. In Brazil, only 0.5% of biodiesel was produced from WCO in 2015 [19].

3.2.3. High standards demand for WCO as the biofuel raw material WCO is more sour, darker and smelly after repeated use. The necessity of purifying decreases the economic advantage of WCO [20] as a raw material for biodiesel production. The quality of WCO has a great influence on the biodiesel produced. Different salt content, water content, cooking time and temperature all make a big difference in the physical properties of its biodiesel [21]. Thus, not all WCO can be used to produce biodiesel. A serious analysis of its characteristics is necessary. For example, WCO containing too much water makes the trans-esterification reaction difficult [22].

3.3. Opportunities

3.3.1. Renewable energy requirement and environment requests In recent years, with the increasing social awareness towards environmental pollution, ecological damage, resource shortage and so on, people pay more attention to all kinds of renewable and clean energy, which is also a good chance for biodiesel. Countries all over the world have already taken steps to promote the use of biodiesel. For example, in order to reduce the emission of the Greenhouse Gases, The Renewable Energy Directive (RED) has won full support from EU members since 2009 which stipulate a minimum of 10% renewable energy use in the transportation sector by 2020. With renewable energy, biodiesel makes up the major part. In Malaysia, NGO volunteers have conducted a campaign on the environmental impact
caused by the direct discharge of WCO. The result is that they will collect WCO and send it to the biodiesel factory. The payment for the collected WCO is used as the community fund [15].

3.3.2. Policy encouragement Governments have issued many policies, laws and regulations to promote biodiesel production using WCO. For instance, Japan issued the Food Waste Recycling Law, announcing a harsh punishment for the restaurants that buy WCO. Restaurants that break the law are asked to stop business [23]. In addition, restaurants who sell WCO to illegal processing enterprises are shut down as well [17]. As one of the largest producers of WCO, China has issued many regulations to ensure the proper recycling of WCO, including Regulations on the Waste Cooking Oil Management for the Food Production and Business Operation Entities (2002), Emergency Notification of Preventing Entry of Waste Cooking Oil Entering Food & Beverage Services (2010) and so on [24].

3.4. Threats

3.4.1. Lack of efficient economic incentive. The high cost of biodiesel is thought to be the major drawback to its commercialization compared to petroleum-based diesel. It is 1.5-3 times more expensive than fossil diesel. The cost of raw oil makes up for more than 70% of the total cost [25]. The price of biodiesel mainly depends on the price of raw oil (71-80%) and capital cost (15-16%) [26]. It makes economic incentive more important in promoting biodiesel. Governments usually implement subsidy as one of the economic incentives but the real effect of the incentive remains uncertain. For example, in China, the Chinese government uses the investment subsidies mode which is a one-off event and subsidy given to biodiesel enterprises. However, according to statistics, the investment subsidies reduce the revenue of biodiesel enterprises. This is because after the investment, enterprises have to bear the operational risks themselves especially when there is a serious shortage in the supply of raw materials, which makes it an insufficient incentive [17].

3.4.2. Other energy source competitors With the persistent economic growth in the world, the consumption of energy will witness an enormous growth in the future. According to EIA’s International Energy Outlook 2017, the consumption of energy in the world will increase 28% from 2015 to 2040. Natural gas will be the most popular energy in fossil fuel consumption, and petroleum will remain the largest source of liquid fuels. Therefore, there will be many energy competitors, whether in fossil fuel or in the new-clean energy, for biodiesel in the future [27].

3.4.3. A small market for biodiesel although biodiesel can be used directly or mixed up with other fuels, the market for it is still very small. For instance, as one of the world’s biggest energy consumption countries, China mostly relies on various fossil fuels as its major energy consumption, taking biodiesel as complementary energy in all aspects. The consumption of biodiesel in China mainly is in the transportation industry (about 62%), then power generation (about 6%), industry production (about 12%), and agriculture (about 8%) [29]. However, biodiesel is not sold to the public in the retail network of oil. This means biodiesel industrialization is slow and is harmful for an enlarging biodiesel market.

4. Conclusion

From the discussion above, the advantages and disadvantages in producing biodiesel from WCO are summarized in Table 1.
Table 1. Relevant factors identified in SWOT analysis

| Positive | Internal | External |
|----------|----------|----------|
| Strengths | • Food security | • Opportunities |
|          | • Energy security | • Renewable energy requirement and environment requests |
|          | • Environment friendly | • Policy encouragement |
|          | • Creation of direct and indirect jobs | |
| Negative | Weakness | Threats |
|          | • Complex procedure | • Lack of efficient economic incentive |
|          | • Low recovery rate of WCO | • Other energy source competitors |
|          | • High standards demand for WCO as raw material | • A small market for biodiesel |

The strengths are remarkable, including ensuring food security and energy security. Since biodiesel releases less pollutions and the reuse of WCO prolongs its life circle, it helps protect the environment. Also, the development of the biodiesel industry can create direct and indirect jobs. Weaknesses include the complex procedure of biodiesel production, the low recovery rate of WCO, and the high standards demand for WCO as a raw material. The opportunities include the renewable energy requirement and environment requests, and policy encouragement from the governments also makes for its development. Threats to the industry include lack of efficient incentive, other energy source competitors and a small market for biodiesel.

Acknowledgements
This study was funded by Beijing Natural Science Foundation (9164022), and also supported by the Beijing municipal commission of education social science project (SM201610005011), Beijing outstanding talent young scientists training program (2015000020124G036), Beijing Social Science Fund (16YJC042) and Beijing Natural Science Foundation (9172001).

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