INTRODUCTION

Promoting renewable energy such as biofuels occurs not only in developed countries but also in developing countries. Renewable energy has advantages for environmental, social and economic development because of its sustainability and potential contribution to economic development.1-3 The production of biofuels, particularly biodiesel as a renewable energy has increased over the last decade, promoted and implemented by governments worldwide as a means of reducing greenhouse gas (GHG) emissions,4 increasing energy security, promoting technological innovations and providing

Implementing a palm oil-based biodiesel policy: The case of Thailand

Somjai Nupueng1,2 | Peter Oosterveer1 | Arthur P. J. Mol1

1Environmental Policy Group, Wageningen University and Research, Wageningen, The Netherlands
2School of Management, Walailak University, Tha-Sala, Nakhon Si Thammarat, Thailand

Correspondence
Somjai Nupueng, School of Management, Walailak University, Tha-Sala, Nakhon Si Thammarat, Thailand.
Email: somjai.nupueng@gmail.com

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Abstract

Renewable energy promotion is recognized as an important goal in international climate policies in order to reduce CO2-emissions. Biodiesel can potentially be an important contributor in this respect, especially in Thailand with its large biomass production from oil palm cultivation. Palm oil is the main raw feedstock for biodiesel production. However, biodiesel production is also controversial in many respects, in particular considering its sustainability. This paper assesses the collaboration between different actors in the Thai biodiesel and oil palm networks in organizing biodiesel provision. Through qualitative interviews with key political, economic, and societal actors the structure and the dynamic of the biodiesel and oil palm industry, as well as the relevant policy dynamics, were investigated. We found that the implementation of biodiesel policy was dominated by the need to secure the production of palm oil-based cooking oil leading to frequent adjustments. Sustainable improvement and environmental considerations hardly played a role in the interactions between the actors involved in the palm oil and biodiesel industries. Government agencies were dominant and steered the biodiesel and the oil palm industries both directly and indirectly via economic and societal actors. Nevertheless, the promotion of biodiesel continues to be the basis of the national renewable energy master plan with its clear target to balance and stabilize the economic, social and environmental issues. As the renewable energy master plan does not fit with the possible feedstock, the main challenges in achieving these sustainable targets are therefore how to maintain a stable and consistent policy, especially concerning balancing the palm oil used for biodiesel production on the one hand and palm oil-based cooking oil on the other.

KEYWORDS
biodiesel, energy policy, palm oil, sustainability, Thailand
opportunities for employment and regional development.\textsuperscript{5-8} The first generation of (biomass-based) biofuels had a large potential in Southeast Asian countries with its ample availability of feedstock, such as palm oil.\textsuperscript{9} Currently, important biofuel producers in Southeast Asia are Thailand, Philippines, Indonesia and Malaysia.\textsuperscript{10} However, there are many concerns concerning the development of this biofuel production for examples the impacts on food security and land use and the net GHG-impact. Land that is used for bio-energy cropping might replace land previously used for food production.\textsuperscript{11} The food price hikes during 2008-2010 in the United States, European Union, Japan and Brazil were critical reason for reconsidering the expansion of cultivating food crops to produce biofuels. Production of biomass for biofuels may have a negative GHG-balance. Considering this impact is seen as essential in biofuel policies.

The Thai government promotes the production and use of biodiesel.\textsuperscript{12} In December 2015, the Prime minister attended the COP 21 conference in Paris to discuss a new global agreement on climate change. Thailand then submitted its First Biennial Update Report (BUR) within the United Nations Framework Convention on Climate Change (UNFCCC). Simultaneously, the Climate Change Master Plan (2015-2050) was developed to reduce GHG emissions.\textsuperscript{13} Producing biodiesel is one of the mechanisms included to contribute to this aim. Palm oil is the major feedstock to produce biodiesel in Southeast Asia, including in Thailand.\textsuperscript{14,15} Thailand is currently the third largest producer of palm oil in the world. Palm oil is the main raw feedstock for biodiesel production in Thailand, and has the highest potential when compared with other edible and nonedible oils. Palm oil-based biodiesel in Thailand has expanded over the last decade. And the Thai government has been promoting the commercial use of biodiesel production based on palm oil.\textsuperscript{16} Crude Palm Oil (CPO) is produced from Fresh Fruit Bunches (FFBs) which then is transformed into pure biodiesel (B100). The blending rate of biodiesel is called B2, B3, B5, and B7, when blended with fossil diesel at 2\%, 3\%, 5\%, and 7\%, respectively. The production of biodiesel from palm oil feedstock and the blending policy can have both positive and negative socio-economic impacts, on oil palm farmers’ income, the price of cooking oil, the cost of input for food processing industries, and currency savings.\textsuperscript{6}

Availability of sufficient feedstock is a key strength of biodiesel production in Thailand. Promoting oil palm production is positive for smallholder farmers who represent approximately 70\% of all palm growers in Thailand.\textsuperscript{17} However, the critical weakness is that the price and quantity of feedstock always fluctuates and that the average cost of producing biodiesel is high compared with fossil fuels.\textsuperscript{18,19} In fact, the Thai government has utilized the biodiesel industry as a mechanism to buffer the palm oil produced to protect domestic consumers and the oil palm industry. The original policy goal, decreasing GHG emissions and increasing energy security, seems to have become a second priority.

Besides private actors, public actors have key roles in governing the production, distribution and consumption in both the palm oil feedstock and the biodiesel markets. Increasing the blending percentage means increasing biodiesel production and consumption which also affects the growth of palm oil production. Expanding the area of oil palm plantations and improving the efficiency and productivity are a mechanism to support the biodiesel industry.

This paper aims to assess the roles of the public and private actors in the implementation of the Thai biodiesel policy with respect to balancing the use of CPO to produce biodiesel, palm cooking oil, and other usages and to strengthen sustainability by reducing GHG emissions. This analysis includes an overview of the roles of the key actors in the palm oil-based biodiesel industry and biodiesel policy.

The rest of the paper is structured as follows: section 2 gives an overview of the developments in the emergence of the biodiesel industry in Thailand by summarizing the activities and actors in biodiesel production and consumption as well as the biodiesel policy; section 3 presents the research methodology and then in section 4 and 5 we analyze the collaboration between economic, policy and societal actors in the biodiesel and CPO industries, respectively. In section 6, we present the implementation of biodiesel policies and possible strategies for feedstock and biodiesel industry to achieve the policy goal, to end with the conclusion and some suggestions for the actors in the involved network in the final section.

2 OVERVIEW OF DEVELOPMENTS IN THE EMERGENCE OF THE BIODIESEL INDUSTRY IN THAILAND

In this section, we present an overview of biodiesel production and the national biodiesel policy in Thailand. Biodiesel started with a community-based development project that was established through a royal initiative in 1989. Later, biodiesel development was supported by the Thai government for specific targets. The end of 2004 introduced the first commercial use of biodiesel for vehicles. Through a project, B2 was promoted among small local bus drivers in Chiang Mai province with a price reduction of 0.50 Thai baht (US$ 0.0124) per litre (approximately 3.43\%) compared with standard diesel. Later on, B5 was sold in some gas stations, first in Bangkok and later also in other regions by fuel company names Bangchak Petroleum Public Company Limited. And in February 2008, PTT Public Company Limited sold B5 through their 1289 gas stations nationwide.\textsuperscript{20} From the start until today, the Thai government has had a large influence on the biodiesel industry by steering both production and consumption.
2.1 | Biodiesel policies in Thailand

The Thai government controls the biodiesel sector through mandating a blending rate, determining the price, making national strategic plans to encourage the biodiesel production and consumption, providing support through loans and tax incentives, and supporting the production of feedstock. Different Ministries are involved in developing and implementing these policies. The Ministry of Energy developed an integrated national alternative energy master plan with an emphasis on three goals: energy security, a balanced economy to secure economic growth, and a decrease of the negative effects to the environment and the community.21 The Thai government introduced the Renewable Energy Development Plan (REDP: 15 years; 2008-2022) that aimed to develop a low-carbon society by promoting the use of alternative energy through B2 including research on the added value of biodiesel by-products such as glycerine. This plan aimed at achieving B10 nationwide by 2022, which meant a demand about 4.50 million liters/d (see in Table 1).

The REDP Master Plan 2008-2022 was revised and the Alternative Energy Development Plan (AEDP: 10 years; 2012-2021) was established in 2012, which was again revised in 2013. This revised plan increased the target for renewable energy from 25% to 30% of the total consumption and adjusted the timeframe to 22 years (2015-2036). According to the Thai AEDP (2012-2021),21 the Thai Government has set the biodiesel consumption target at 7.2 million liters per day22 while the target of ethanol production has been planned about 6 million liters per day by 2021.23 The plan focuses on both supply and demand of biodiesel. On the supply side, the government has targeted an oil palm acreage of 5.5 million rai (880 000 ha) by 2021. Average yields are expected to reach 3.2 MT/rai (20 MT/hectare) by 2021 while CPO crushing rates should be above 18%. On the demand side, the government anticipates balancing its compulsory production of biodiesel with domestic palm oil supplies. The plan also introduces pilot projects for B10 or B20 blend use in fleet trucks sector and fishing boats.

The Energy Policy and Planning Office (EPPO) within the Ministry of Energy is the pivotal agency in the formulation and administration of the national sustainable energy policies and planning. The timeline of the different national alternative energy plans in Thailand is presented in Figure 1.

2.2 | Biodiesel production and consumption

Biodiesel production and consumption is favored by increases in the FFBs yield and expansions in the plantation area.24 Table 2 shows the details of the rapid growth of biodiesel production from 68 million liters in 2007 to 1210 million litres in 2015 and consumption from 62 million litres in 2007 to 1200 million litres in 2015.

2.2.1 | Feedstock overview

Biodiesel can be produced from many different feedstocks such as animal fats and oils, and also from different vegetable crops such as castor, palm oil, soybean, cotton, etc.25,26

| TABLE 1 | REDP master plan 2008-2022: biodiesel roadmap |
|----------|-----------------------------------------------|
| **Year** | **08** | **09** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** |
| Demand of biodiesel (Ml/day) | 1.35 | 1.35 | 1.35 | 3.02 | 3.64 | 4.50 |
| Government Budget (M THB) | 129.75 | 37.4 | 29.4 | 19.4 | 450 | 330 |
| **Biodiesel Market** | **Mandate B2** | **Mandate B5 (Nationwide)** | **Alternative B5** | **Alternative B10** |
| Biodiesel Production | | | | | | | | | | | | | | | |
| Feedstock | | | | | | | | | | | | | | | |
| Research and Development | | | | | | | | | | | | | | | |
| Source: [http://www.dede.go.th](http://www.dede.go.th). | | | | | | | | | | | | | | | |
However, in Thailand, palm oil is the most used feedstock. Table 3 shows that in 2014 and 2015 about 45% of produced CPO was used for biodiesel production and about 55% for cooking oil production. The cost of feedstock is a major expenditure in biodiesel production, accounting for 50-70% of the total costs. Therefore, key factors for successful biodiesel production in Thailand are price and availability of adequate feedstock both FFBs and CPO and the cost of biodiesel production. The feedstock price fluctuates depending on the palm oil prices and has varied in the period from 2010 to 2016 between 25.24 and 36.59 baht/kg of CPO and between 4.16 and 6.02 baht/kg of FFBs (see Figure 2).

The Ministry of Agriculture and Cooperatives has a key role in planning and supporting the cultivation of feedstock by promoting oil palm cultivation and encouraging farmers to increase the efficiency of FFBs production. The feedstock price fluctuates depending on the palm oil prices and has varied in the period from 2010 to 2016 between 25.24 and 36.59 baht/kg of CPO and between 4.16 and 6.02 baht/kg of FFBs (see Figure 2).

The Ministry of Agriculture and Cooperatives has a key role in planning and supporting the cultivation of feedstock by promoting oil palm cultivation and encouraging farmers to increase the efficiency of FFBs production. The FFBs produced by farmers is processed into CPO, stearin, and Refined Bleached Deodorized (RBD) in crushing and refining mills. In 2015, FFBs yield in Thailand reached 11.016 million tonnes and these were transformed into 2.068 million tons CPO (Table 4). At present, the total production capacity of the crushing mills is at 1.155 million liters of CPO per day. Biodiesel plants buy feedstock from the (about 84) crushing mills and purified palm oil distributors, and they have factories dispersed in the southern, eastern and central regions of Thailand.

The growth in feedstock available for biodiesel production still lags behind the ambition of the Thai government. The feedstock for unblended diesel or CPO is forecasted to grow to 2.2 million metric tons given normal weather conditions and a continued increase in the harvested area. The dry weather conditions throughout Thailand in 2014 and early 2015 were expected to affect oil palm production in 2015. Unfavorable weather hurts not only FFBs output but also overall oil extraction rates, as was shown in the first 4 months of the year 2015.

### Biodiesel market

On the supply side, there are 12 biodiesel plants with a proper license in Thailand, and they have a total production capacity of 4 635 800 L biodiesel/d; see Table 5). In Thailand, standards for palm oil biodiesel are set based on the Guidelines for the Development of Biodiesel Standards in the APEC Region (Thailand Institute of Scientific and Technological Research, 2009). To meet the biodiesel blending policy goals, the Thai government allocates monthly biodiesel quota to individual plants based on the calculated demand. Thailand produced 1170 million liters and beginning stock 32 million
Biodiesel distribution is in the hands of the different fuel companies in the country. Currently, Thailand has ten companies that distribute blended diesel called B5-B7. The government policy ambition is moderate to protect the domestic palm oil sector. As a result, biodiesel consumption is estimated to grow only marginally in 2016 mainly through growth in diesel use. Still, further measures are considered, mainly to secure the production of cooking oil. In response to reduced CPO supplies and skyrocketing prices in the first months of 2015, the government temporarily lowered the mandatory vegetable oil content required in biodiesel from the mandated B7 to B3.5 from 17th February 2014 to 16th April 2015. The mandatory use of B7 was reinstated on April 17, 2015, after an increased production of CPO entered the market following the harvest of more FFBs. Biodiesel producers, especially those who were not integrated with CPO processors and oil refineries were struggling to survive, particularly because of the high production costs. Currently, retail biodiesel price is about 21.49 Bath per litre which is under the production cost price for biodiesel (in Table 6).

**Table 3** The balance of oil palm in Thailand (2014-2015)

| Year   | 2013  | 2014  | 2015  | 2016  |
|--------|-------|-------|-------|-------|
| 1. Planted area (million Rai) | 3.767 | 4.024 | 4.176 | 4.920 |
| 2. FFBs production | 12 370 000 | 12 503 000 | 11 016 000 | 11 683 000 |
| 3. CPO Beginning stock | 364 170 | 203 999 | 167 591 | 344 692 |
| 4. CPO production | 2 135 183 | 2 000 610 | 2 068 475 | 1 804 449 |
| 5. Import (Convert to CPO) |
| 6. Domestic consumption (Cooking Oil) | 1 058 226 | 1 027 561 | 1 053 329 | 987 803 |
| 7. Domestic consumption (Biodiesel) | 775 043 | 842 397 | 837 645 | 815 956 |
| 8. Ending stock | 203 999 | 167 591 | 334 692 | 293 467 |

Source: Department of Internal Trade

**Table 4** The available feedstock of palm oil from 2013 to 2015

| Year | 2013 | 2014 | 2015 |
|------|------|------|------|
| Harvested area (million hectares) | 0.599 | 0.645 | 0.685 |
| FFBs (million tonnes) | 12.374 | 12.473 | 11.016 |
| CPO (million Mt) | 2.135 | 2.000 | 2.068 |
| CPO import (million Mt) | 0 | 0 | 0.053 |

Source: Department of Internal Trade and Office of Agricultural Economics

**FIGURE 2** The average price of FFBs and CPO from 2010-2016

Source: Department of Internal Trade. Remark: The average annual exchange rate (Year: Thai Baht per US$); 2010 = 31.73, 2011 = 30.49, 2012 = 31.48, 2013 = 30.73, 2014 = 32.84, 2015 = 34.25, 2016 = 35.29

**3 | METHODOLOGY**

This section presents the methodology in conducting the study. We analyzed the roles of the different public and private actors involved in economics, policy, and society to assess their roles in the implementation of the Thai biofuel policy. It is important to hereby consider that the Thai biodiesel and palm oil sectors are closely linked because they use the same feedstock. At the same time, the palm oil feedstock and the biodiesel industries differ with respect to the key economic actors, the relevant state institutions and the role of societal actors involved.

We used a qualitative approach. In-depth, semi-structured interviews were held with 30 participants in the biodiesel industry and the palm oil feedstock production in Thailand, in the period between January and March 2016. We interviewed...
respondents from government agencies, producer organizations of crushing mills and biodiesel plants and civil society organizations. The interviews focused on biodiesel production and use and on the role that the palm oil-based biodiesel industry and the government should play in promoting sustainability. The respondents have different roles in the biodiesel production. The actors and their roles in the oil palm-based biodiesel supply chain are summarized in Table 7.

4 | CPO INDUSTRY IN THAILAND

The CPO industry produces the main feedstock for supplying the biodiesel industry and involves different economic, policy and societal actors.

4.1 | Economic actors

The key economic actors in the CPO industry are the oil palm farmers, ramp-owners, crushing millers, palm oil traders or storage companies, biodiesel plants and oil palm cooperatives. These actors produce CPO before it is transferred to refinery mills or biodiesel plants. The supply chain starts with the input suppliers supporting oil palm farmers to produce FFBs, teams harvesting FFBs and collecting them at ramps, sending the FFBs to the CPO industry. About 80% of all FFBs from the ramps was delivered to the crushing millers via the spot market. In 2016, the crushing mills had a total capacity of about 1.8 million ton. This capacity is high compared to the total FFBs production although the production varies according to the season. When FFBs production is low, the farmers have a strong bargaining power, but when the production is high, the crushing millers are the price setters. The crushing millers who are form the middle range of the palm oil chain were controlled by the government through the price of their main input material (FFBs) and the final product (CPO). However, one of the members in the National Palm Oil Policy Committee (NPOPC) was elected by crushing mill owners. They have little power in negotiation about the market of FFBs and CPO.

The main markets for CPO are the refinery mills to produce RBD palm-based cooking oil, RBD palm stearin oil and biodiesel. These industries are mostly connected through direct sale but sometimes via intermediary traders. The large-scale refinery mills have a stronger position compared with the crushing mills also because they use a CPO stock management system to manage their supply for cooking oil processing. The capacity of their CPO storage tanks and their financial mechanism has a direct effect on the demand, supply, and price on the CPO market.
### Table 7
Actors involved in the biodiesel production network

| No. | Actors                        | The scope of activities and roles in biodiesel production network                                                                                                                                                                                                 |
|-----|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.  | Oil palm farmers              | To manage the quality and quantity of produced primary feedstock, Quantity and price of FFBs in response to policy on the biodiesel blending rate                                                                                                                      |
| 2.  | Ramp-owners or collectors     | To collect FFBs and influencing the quality of harvesting which affects the cost price of CPO                                                                                                                                                                |
| 3.  | Crushing millers              | To produce Crude Palm Oil (CPO) efficiently for minimal cost                                                                                                                                                                                                         |
| 4.  | Refinery plants               | To produce Refined, Bleached, and Deodorized (RBD) palm oil efficiently at minimal cost                                                                                                                                                                               |
| 5.  | Biodiesel plants              | To develop efficient biodiesel production with technologies such as FAME and BHD technology                                                                                                                                                                         |
| 6.  | Oil producers                 | To understand the advantage of using biodiesel in liquid fuels in short and the long-term                                                                                                                                                                            |
| 7.  | Auto producer                 | To develop cars that are allowed for biodiesel use                                                                                                                                                                                                                |
| 8.  | Diesel consumers              | Awareness that biodiesel consumption can reduce CO₂ emission                                                                                                                                                                                                       |
| 9.  | Government agencies           | To make plans/policies/regulations that create stability and balanced benefits along the chain                                                                                                                                                            |
| 10. | NGOs and civil societies      | To Promote biodiesel production                                                                                                                                                                                                                                |

#### 4.2 Policy actors

Policy actors are involved in developing and managing institutional arrangements and in interactions with the industries. The key policy actors in the CPO industry are government agencies operating at national level, such as the Ministry of Industry, the Ministry of Commerce, the Ministry of Agriculture and Cooperatives, and the Ministry of Energy.

The Ministry of Commerce is controlling the price of cooking oil, thereby directly influencing the CPO market because this price gets translated into the FFBs market. For example, by the end of April 2015, the price was mandated at 4.00 baht per kg FFBs and 25.00 baht per kg CPO by the Department of Internal Trade, the Ministry of Commerce. And 20 days later, the recommended prices were increased by the NPOPC up to 4.20 baht/kg FFBs under the condition that the oil extraction rate at 17% and 26.20 baht/kg CPO. If the policy is inconsistent, the demand for CPO from refinery plants and biodiesel plants will not be stable either. The other Ministries mentioned above are a member of the NPOPC which is a central organ in controlling the oil palm and palm oil markets. These Ministries have different goals and functions, which is a source of conflicts in policy making and implementation. Whereas the Ministry of Commerce aims to keep the price of cooking oil stable and reasonable for consumers, the Ministry of Agriculture and Cooperatives wants to enhance the price FFBs which would lead to higher CPO price and thus to a higher cooking oil price. In addition, the Ministry of Agriculture and Cooperatives have developed efficiency of oil palm production.

The national CPO stock is a central indicator used in policy considerations. The cooking oil market is central in the allocations for oil palm production thereby making biodiesel production a dependant factor steered through the blending instructions. This situation makes biodiesel blending guided by the Ministry of Energy an activity that requires much flexibility from the industry actors.

#### 4.3 Societal actors

The role of the civil society organizations with respect to the sustainable improvement of the CPO industry is limited. The associations and cooperatives (eg, Crushing Mill Association, Oil palm and palm oil Association and Oil Palm Cooperatives) are primarily seeking support for their business. For instance, the Crushing Mill Association is promoting collaboration between the different crushing mills by promoting sustainable palm oil production, managing the CPO stock to reduce risk, promoting CSR projects such as biomass projects for community electricity and education funds in the area around the mills. These different associations are all member of the NPOPC.

### 5 BIODIESEL INDUSTRY IN THAILAND

The biodiesel industry depends on CPO from the crude palm oil mills as its raw material input, so these sectors are mutually dependent.

#### 5.1 Economic actors

The main economic actors in the biodiesel industry are the crushing mills, biodiesel plants, traders, storage companies, and the Thai government. The biodiesel industry is vertically integrated, dominated by a few processors that rely on many suppliers and distributors. The key economic issue for the industry is the high costs involved in producing biodiesel from vegetable oil feedstock when compared with standard diesel. In 2016, the selling price of B100 was 35.11 baht/L, the CPO price was 31.91 baht/L, while the diesel price was 19.50 baht/L.33,34

In Thailand, the biodiesel sector is organized nationally, so the import of biodiesel was restricted to keep a balance in the oil palm supply.31 Government agencies play a central...
role in the sector and use different political measures to intervene in biodiesel production and use. Their strategy is based on their commitment to implement the policy objectives and the dynamic context of the FFBs and CPO market. All actors in the biodiesel industry are directly affected by changes in their policies. Therefore, if these government policies are unstable, the economic actors have a big problem in managing their business. In their strategies, these businesses have to follow the always changing regulations. The (changing) biodiesel blending rate has direct impacts on the CPO supply and which gets translated in the FFBs price and thereby in farmers’ income. Being smallholders, farmers have little-negotiating power in the market. For instance, in the case of farmers’ cooperative, the Krabi Palm Oil Community Cooperative Ltd., one of the largest cooperatives in Thailand, they provide FFBs to the biodiesel industry for the production of CPO. They attempted to produce biodiesel themselves but without success. The fluctuations in the price of FFBs and CPO that directly affect the refinery plants and the RBD market prevented the cooperative from being successful.

The actors involved in the network seem little concerned about the environmental impact. They agreed that sustainability in the palm oil sector is important but that stable FFBs and CPO prices are more important for them. The chairman of the Biodiesel Producer Association, the main actor involved in promoting sustainable palm oil, supported smallholder farmers to adopt the Roundtable on Sustainable Palm Oil (RSPO) scheme but their certified production was not delivered to the biodiesel industry. Promoting the RSPO is only a CSR project for his company.

5.2 Policy actors

The Thai government is highly involved throughout the biodiesel chain. According to the interviews, direct command and control mechanisms were applied to steer the industry, but the responsibility was dispersed over different Ministries. These Ministries have set policies and regulations with respect to imports, exports, domestic market, production, consumption, and the targets for both the palm oil and the biodiesel industry. The Ministries facilitated financial support, promoted research and technological innovations for the biodiesel industry and also controlled the production standard and increased the feedstock production. Various policies and regulations have been launched to encourage the use and production of biodiesel, to produce the feedstock and keep the national CPO stock secure at 200,000 tonnes. Figure 3 shows the collaboration between several Ministries (Ministry of Agriculture, Ministry of Commerce, and Ministry of Energy), and the NPOPC to secure the national CPO stock by varying the blending percentage of B100. In Thailand, most CPO flows to the food and energy sectors. Therefore, balancing the FFBs price and the demand for food and energy is one of the main reasons for the permanent changes in the biodiesel blending rate. The government uses the blending rate for its direct effect on the demand from the biodiesel industry and its indirect effect on the supply of cooking oil. Biodiesel producers find it difficult to plan and adapt their business because they are confronted with this unstable policy. The biodiesel industry is affected by fluctuations in the government policy and by dynamics in the feedstock market.

Biodiesel policy implementation in Thailand was integrated with the palm oil sector, and both are supported by the government in many ways. At this moment, different Ministries collaborate. The Ministries involved in the palm oil-based biodiesel industry are the Ministry of Energy, the Ministry of Industry, the Ministry of Agriculture and Cooperatives, the Ministry of Commerce, and the Ministry of Finance. They all play an important role in policy implementation following the policies formulated by the NPOPC.

The Ministry of Energy is central in setting the blending percentage of biodiesel, in planning, in collaboration with the Ministry of Industry to manage biodiesel production by the available feedstock on the plantations and considering the demand for palm cooking oil and the price of diesel. They have implemented policies to encourage biodiesel production and consumption to achieve their policy goal. The Ministry of Industry manages the biodiesel plants regarding production, environmental management and safety. The Ministry of Agriculture and Cooperatives is involved in preparing the palm oil feedstock supply by promoting efficiency in oil palm production and by developing policies related to shortages and surplus supply of FFBs and their effects for the blending of biodiesel. The Ministry of Commerce sets and controls the price of FFBs and CPO as feedstock for cooking oil. The Ministry of Finance is supporting and promoting the funding for biodiesel production regarding providing a subsidy for biodiesel producers, managing tax as a policy instrument, and offering a loan for the Special Purpose Vehicle (SPV) committee to promote oil palm and biodiesel production.

The Thai government is promoting, supporting and intervening in the biodiesel industry because it claims it can at this moment assist smallholder farmers in the oil palm sector regarding farm income while protecting the consumers in consuming palm cooking oil. In addition, in normal palm oil and cooking oil markets, biodiesel production is the most efficient domestic resource to reduce fuel imports.

In addition, the Thai prime minister attended the Paris Climate Change Conference (COP 21) in December 2015 and later Thailand in 2016 ratified the Paris Agreement. Thailand’s ratification demonstrates the country’s involvement in the global fight against climate change. Promoting
alternative energy is the main commitment in Thailand’s mission toward a low carbon future. Therefore, the policy agendas on biodiesel promotion and climate change reduction converge.

5.3 | Societal actors

There are only a few social organizations linked to the biodiesel industry. The engaged NGOs and civil society organizations (eg, Thai Center For Development Foundation, Thai Biodiesel Producer Network, Thai Alternative Energy Group) who focus mainly on community-based biodiesel production. They promote the recycling of used oil or animal fats from the household into biodiesel to reduce the local living costs and have a positive impact on society in the long term. They are less involved in the commercial biodiesel sector where the production relies on government regulations.

The actors in the biodiesel and CPO industries interact closely. Both sectors involve public and private actors, material and nonmaterial flows in production, policy making, laws and regulations, production and marketing.

6 | THE IMPLEMENTATION OF THE THAI BIODIESEL POLICY

The implementation of the biodiesel policy in Thailand is affected by different policy considerations in particular with respect to what the appropriate link is between biodiesel production and the palm oil sector’s capacity to produce the necessary feedstock.

6.1 | Policy implementation

In June 2007, the national Department of Energy Business announced a mandatory biodiesel blending rate of B2 and a B5 rate by January 2012. A B7 rate was mandated for short periods between 1st January 2014 and 16th February 2014 and between 14th May 2014 and 21st January 2015. After that B3, B3.5, B5, and B7 were applied from 22nd January 2015 until present as the blending rate was adjusted in accordance with palm oil supply abundance (See Table 8).

In 2016, the blending rates changed several times with direct effects on the demand for CPO. Changing the mandate from B3 to B5 meant that the total biodiesel consumption increased with 37 million liters per month and that about 27 000 ton CPO more was to be supplied to the biodiesel sector. To produce B5 about 68 818 ton CPO is needed and for B3 about 41 818 ton CPO.

The Thai government has established a regulation that enforces diesel blended during 2%-7% biodiesel. Mandating B5 proved a realistic goal by 2011 but mandating B10 requires substantial increases in oil palm yield and planted area, which needs to be achieved without encroaching on forest areas or blocking the development of other oil crops that compete with palm oil. The big challenge is how to integrate this policy goal with policies from different ministries and accommodate the oil palm cultivation and the cooking oil sectors.

The varying implementation of mandatory percentages of blending biodiesel ranging between B3 and B7 during short periods over the years depended on the cooking oil price and the supply of FFBs (interviews with government agencies from the Department of Energy Business and the

FIGURE 3 Collaboration between several public actors in managing the nation-wide CPO stock
Department of Alternative Energy and Efficiency). The main aim of this policy is to keep a balance between the biodiesel and the cooking oil sectors. Changes can occur every day depending on information supplied by institutions such as the Department of Internal Trade, the Department of Energy Business and the Office of Agricultural Economics. The aim of the policy, and therefore of the blending rate, is to secure the price of FFBs during the high season of FFBs yield. From the interview with the Office of Agricultural Economics, we found that the secure price is 4.30 baht which calculated by the following formula:

A: Average total cost of FFBs at plantation (approximately 3.20 Baht or US$ 0.095).
B: Transportation cost (0.25 baht or US$ 0.0075).
C: Farmers’ profit (25%).

Therefore, the secure the price of FFBs is

\[(A + B) + ((A + B) \times 25\%) = (0.095 + 0.0075) + ((0.095 + 0.0075) \times 0.25) = 4.30 \text{ Baht or US$0.128}\]

(Exchange rate 33.56 Baht per US$ 1.00).

According to the Chairman of Thai Biodiesel Producer Association, the reasons that the biodiesel industry cannot achieve its sustainable goal are that the CPO stock management depends on the food consumption sector, the presence of 30%-40% overcapacity in the crushing mill sector and that the master plan was a long-term one. The development of the biodiesel business was affected by fluctuations in the blending percentage leading to problems in producing, financing, managing and marketing such as losses in investments, problems in CPO stock management, inability to honor the contract with suppliers and customers, and failing production planning. He recommended that the government keeps a better balance between all three pillars of sustainability: economic, environmental, and social.

Why does the Department of Energy Business change the biodiesel blending rate? The government changes the blending percentage because it has a specific and pointed policy goal in preventing a shortage in the cooking oil market and in keeping the FFBs price stable. From the interviews with stakeholders in the biodiesel industry, we can conclude that implementing the national biodiesel plan is the second priority because the real target is securing the feedstock market which affects the FFBs market.  

The problems in implementing B10 can be summarized in five barriers:

1. **There are not sufficiently available resources.** The quantity of feedstock (FFBs and CPO) is not sufficient while yield and price also fluctuate over the year, which means that there are not sufficient FFBs to produce enough biodiesel for a B10 blending rate. In, 2016, The average FFBs yield in Thailand was 16.08 tonnes per hectare which is low compared with Malaysia (18.48 tonnes per hectare), resulting in high costs in the palm oil chain. Increasing the oil palm area is not feasible because there are not enough additional resources available.

2. **The lack of clarity and certainty in the regulation in the short, medium and long-term.** Policymakers (may) change the blending regulation during the year due to fluctuations in yield while the biodiesel plants, oil distribution companies and vehicle producers need certainty to guide their business planning.

3. **Different authorities do not collaborate.** Different Ministries have different targets and policies, and they do not collaborate to achieve their goals. Each Ministry involved in biodiesel policy has different responsibilities, the Ministry of Energy sets the policy goals and strategies, while the Ministry of Commerce has the job to secure that the FFBs, CPO, fuel, and cooking oil prices do not have negative effects from the biodiesel industry, and while the Ministry of Agriculture aims at higher incomes for the oil palm farmer.

4. **There are imperfect communication and coordination between private actors to support biodiesel production and...**

| Month/Year          | Biodiesel consumption policy |
|---------------------|-----------------------------|
| June 2007           | B2 mandate, B5 optional     |
| June 2010           | B3 mandate, B5 optional     |
| March 2011          | B2 mandate, B5 optional     |
| May 2011            | B3-B5 mandate              |
| July 2011           | B4 mandate                 |
| 1st Jan 2012        | B5 mandate                 |
| 19th July 2012      | B3.5 mandate               |
| 1st November 2012   | B5 mandate                 |
| 1st January 2014    | B7 mandate                 |
| 17th February 2014  | B3.5 mandate               |
| 14th May 2014       | B7 mandate                 |
| 22nd Jan 2015       | B3.5 mandate               |
| 16 April 2015       | B7 mandate                 |
| 25th July 2016-24th August 2016 | B5 mandate |
| 25th August 2016-24th November 2016 | B3 mandate |
| 25th November 2016-7th May 2017 | B5 mandate |
| 8th May 2017-October 2017 | B7 mandate |

Source: Interview and adapted from Preechajarn and Prasertsri
consumption. Consumers have no option whether choosing for biodiesel or not when they consume diesel. They are hardly conscious of the sustainability reasons for consuming biodiesel. There are only a few campaigns promoting biodiesel and explaining their use for vehicles. At the same time, vehicle producers are not sure whether their vehicles are suitable for B10. Biodiesel producers feel that they are taking serious business risks considering the high uncertainty and lack of clarity about the standard of commercial biodiesel. Therefore, meeting the policy goal of B10 does not seem realistic.

5. The legislation and regulation. Currently, Thailand applies an import-export control policy, so biodiesel blending companies do not have the freedom to import. Domestic producers are protected from biodiesel imports through license control. The biodiesel price on the global market which is dominated by large biodiesel exporters such as Malaysia and Indonesia is lower than in the Thai market.

We calculated the required feedstock for achieving the planned objective on the basis of the diesel consumption data (1990-2015), the predicted fuel diesel consumption by the Ministry of Energy (2016-2025), the planned and expected biodiesel consumption (2008-2015), and the palm oil for biodiesel production system boundary (elaborated in Appendix S1, including the goal of national REDP Master Plan). This resulted in an expected annual fuel diesel consumption of 23,500 million liters in 2025 (See Figure 4). To meet the B10 target, Thailand should increase the FFBs yield for biodiesel production to a total of 9.432 million ton, representing 85.60% of total FFBs yield in 2015. Therefore, the planted area for producing the scheduled biodiesel should increase with about 3.16 million rai (0.506 million hectares) or 73.90% compared with 2015 (Table 9).

6.2 | Responses to the challenges in biodiesel policy implementation toward sustainability

Chanthawong et al.\(^{30}\) suggested that the government should adopt the current policy for controlling the biodiesel price based on price fixing as its main instrument to using the market mechanism because in Thailand there is a positive relationship between the demand of biodiesel and the price.

The biodiesel blending ratio could be fixed for a longer period to allow for efficient management by the companies involved. For this policy, the government should make sure that the feedstock and biodiesel production are sufficiently available for domestic usage. At the same time, the policy of keeping a CPO surplus as a buffer stock should continue. The storage of CPO, the government budget, a target price and supply and demand monitoring system for managing the buffer stock are important elements for consistent policy. Not only the biodiesel market but also the FFBs and diesel markets need to be considered and kept in balance.

From the interviews, we summarized different strategies for the feedstock and biodiesel industry to achieve the policy goal and to increase the production of feedstock for the biodiesel industry in the longer term.

6.3 | The strategies for the feedstock (CPO) industry

Upstream processes and activities relating to oil cultivation were considered to create more efficiency in the production and farm management. It is important to continue knowledge development and research for increasing the efficiency in oil palm cultivation such as lower average cost, higher yield per hectare, higher quality of the yield, developing stability of the oil palm yield, and promoting oil palm farmers cultivate sustainably through the Good Agricultural Practices (GAP) and the Roundtable on Sustainable Palm Oil (RSPO). In light of the expected future demand for CPO, increasing plantations on land that is suitable for oil palm cultivation and using good quality seedlings when replanting are necessary strategies to secure sufficient feedstock. Also, the strength of the stakeholders in the palm oil chain could be promoted, for instance by organizing them as groups of oil palm farmers, crushing millers, and product producers and informing and training them on sustainable production, and by strengthening their bargaining power by creating stable prices, also for input costs.

Regarding linking feedstock strategies with long-term environmental issues and make palm oil production more sustainable, increasing the volume of palm oil that is certified through sustainable certification schemes, such as GAP and RSPO, is a big challenge. This can be achieved by informing and educating oil palm farmers on sustainable cultivation to raise their awareness and engagement and to facilitate their access to sustainability processes in the chain to increase their involvement in these sustainability initiatives.

Furthermore, at the downstream end of the palm oil value chain, added value in the palm oil industry could be promoted through research and development on the value-added products and through collaboration between private and public actors in the chain to upgrade the products produced with the same feedstock.

6.4 | The strategies for the biodiesel industry

The interviews underlined that the government intervened in the Thai biodiesel industry in all phases of production, distribution, and consumption. Achieving the official policy goal should, however, start with facilitating collaboration between the key actors involved. This way the interests of the different industries concerned can be balanced. Biodiesel producers preferred
a stable noninterference policy with a fixed blending rate and an efficient feedstock monitoring system. The feedstock and biodiesel industries need to formulate clear goals to produce sufficient feedstock and manage this adequately to secure from food, energy, and other industries. Furthermore, biodiesel producers should be allowed to import feedstock and export biodiesel when there is a shortage or a surplus on the national market. The implement the biodiesel policy, it is important to involve the different stakeholders, for instance by installing a Thai Palm Oil Board (TPOB) like the Malaysian Palm Oil Board (MPOB), that has a central role in planning, implementing, and evaluating the policy throughout the entire sector.

A key challenge for private actors (lead firms, suppliers) in the biodiesel industry is to increase production efficiency and reduce the average production costs including the development of by-products, such as glycerine. Supporting the biodiesel industry and achieving the policy goal requires a secure CPO feedstock management strategy primarily by developing an efficient feedstock system, improving the production technology throughout the industry, and developing good planning to manage the direct and indirect land use change impacts in oil palm cultivation. An important strategy suggested by the different stakeholders with respect to improve the environmental performance of biodiesel production is the promotion of new technologies, such as reducing CO₂ emissions throughout the production life cycle, promoting efficiency by managing waste and by-products from the biodiesel production system, and determining biodiesel standards and criteria while looking for future new technologies such as FAME and HBD.

Thailand can promote sustainability by encouraging biodiesel use to decrease CO₂ emissions, increase the use of alternative energy and reduce the fossil fuel import expenditures by increasing the production palm oil which is the main feedstock. The Biodiesel Producer Association said that “The key future challenge for the success of the biodiesel

**FIGURE 4** Actual fuel diesel consumption by 1990-2015 and predicted fuel diesel consumption by 2016-2025, and biodiesel consumption by 2008-2015 Source: Data was adapted from Preechajarn and Prasertsri and http://www.doeb.go.th/2016/stat.html

**TABLE 9** Required resources to achieve the 2025 biodiesel goal

|                  | 2016 Situation | Required resources in 2025 with a diesel consumption estimated at 23,500 million liters per year |
|------------------|----------------|-------------------------------------------------------------------------------------------|
|                  |                | Option1: B5 | Option2: B7 | Option3: B10 |
| Biodiesel (ml)   | 1200.00        | 1175.00     | 1645.00     | 2350.00      |
| CPO (ml)         | 837.64         | 977.60      | 1368.64     | 1955.20      |
| FFBs (ml)        | 4041.21        | 4716.45     | 6603.03     | 9432.90      |
| Planted area (m rai) | 1.35          | 1.58        | 2.21        | 3.16         |

6.25 rai = 1 ha.
policy transformation to sustainable production is to keep a successful balance between economic, social, and environmental interests. The three pillars should go together”. However, currently, there are no measures in place to ensure sustainability in biodiesel production such as criteria, standards or certification. The industry is just starting, and therefore only the economic dimension of sustainability is considered in the production network. The main sustainability issues according to the biodiesel plants opinion are the stability of the policies and regulations, as well as achieving a balance in benefit sharing along the chain, while efficiency in feedstock management is important to support the business. Government agencies consider sustainability in biodiesel production the result of a balance between economic, social, and environmental interests. Therefore, a collaboration between all actors in the chain is their main strategy to push the biodiesel industry toward sustainability and equity. The government offers a subsidy to smallholder farmers during the start-up phase of biodiesel production, because there are many more people involved here than in the business sector.

Some NGOs promote green energy and sustainable life such as the Media Centre Foundation for Development, and they consider sustainability in biodiesel production as the balance between benefit, happiness and environmental protection. Their main interest is, however, in promoting community biodiesel production especially by smallholder farmers who can produce biodiesel themselves.

The official Thai policy target included objectives in decreasing GHG-emissions and promoting environmental sustainability but during the implementation of this policy more importance was given to the economic interests of the oil palm and the palm oil sector. Biodiesel blending rates were implemented by the FFBs yield, the national CPO stock and the palm oil market mechanism. Every litre of biodiesel requires 0.832 kg CPO or 4.014 kg FFBs as feedstock (Appendix S1). Hence, the biodiesel and cooking oil industries competed for feedstock. In Thailand, the price difference between palm oil biodiesel and fossil diesel meant that the country could only reach its planned B10 and B20 policy goals only in the future. The present focus of the policy is on protecting the risks of insufficient FFBs and fluctuation in the price of FFBs.

7 | CONCLUSION

This paper presents the results of a study on the roles of the biodiesel and palm oil industries involved in implementing the Thai biodiesel policy with respect to achieving sustainability goals. This study showed the challenges these industries are facing when trying to balance ecological, social and economic issues when implementing this policy. One key challenge is that the biodiesel industry in Thailand is closely linked to the CPO feedstock industry. Both industry sectors need the same feedstock, and it is, therefore, demanding to develop and implement a biodiesel policy that is effective in contributing to more sustainability, balancing the use of CPO for cooking oil, biodiesel production and other purposes, while still being consistent, transparent and trustworthy.

Thailand has gone through a long period of development and promotion of its biodiesel policy in production and consumption, during which the initial aims transformed from “greenhouse gas emission reduction and energy security” to “stability of palm oil sector”. The country has developed several master plans through its Renewable Energy Development Program (REDP) and the Alternative Energy Development Plan (AEDP 2012-2021) which resulted in unclear long-term policy targets. Government considerations dominate all steps in producing and consuming biodiesel. The government is particularly involved in influencing the price of FFBs feedstock and managing the stock of CPO. The government also controls the export and import of CPO. The blending policy is used to balance the quantities of FFBs and CPO and to balance the demand for producing cooking oil, biodiesel and other products. However, as the primary government concern is securing the price of cooking oil, this policy leads to instability for the biodiesel industry. These companies cannot plan their business because their future mainly depends on the government and its unstable policy.

Policy actors dominate the Thai biodiesel industry sector which also involves manufacturing companies and the feedstock industry, who are closely linked with the government institutions through policy goals, regulation and their implementation. The biodiesel industry is highly controlled by the government to create a stable FFBs and fuel market by using biodiesel blending as a buffer mechanism. The biodiesel blending ratio was therefore closely linked to the national CPO stock. The frequent fluctuations in blending percentage affected both the vertical and the horizontal linkages in the biodiesel industry. The industrial actors have little freedom in feedstock management as their business is directly linked with unpredictable government regulation. Encouraging biodiesel production and consumption to promote alternative energy and decrease GHG emissions is the second priority. Although Thailand has ratified the Paris Agreement (COP 21), it has not developed a biodiesel policy conform this objective. The Thai government does not emphasize environmental and social sustainability, although they were mentioned in the policy documents. In practice, their focus is on the FFB price and market and on controlling the supply of FFBs.

Nevertheless, biodiesel production may still be encouraged to promote sustainable palm oil provision by creating stability and achieving a balance between economic, social and environmental targets. Contrary to other palm oil producing countries, such as Indonesia, Thailand does not face the problem of rainforest destruction for palm oil cultivation.
Therefore, FFBs as feedstock for biodiesel is rather uncontroversial but before a stable and sustainable biodiesel policy can be implemented effectively the production of FFBs needs to increase. The policy relies on the price of FFBs as the key feedstock in the biodiesel supply chain. Promoting re-planting to produce more feedstock and encouraging liberalization of the feedstock and biodiesel markets is important. Collaboration between all actors involved may promote efficiency in all stages of the production process, in combination with transparency and consistency in policy making and implement and the development of technological innovations.

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ORCID

Somjai Nupueng http://orcid.org/0000-0001-6027-022X

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SUPPORTING INFORMATION
Additional supporting information may be found online in the Supporting Information section at the end of the article.

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