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Bioenergy and the Road to Sustainable Growth

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Bioenergy and the Road to Sustainable Growth

Executive Summary

Bioenergy is expected to grow rapidly around the world including in Thailand. Key supporting factors are government policies on national energy security, rising consumer awareness in environmental issues and climate change, effort to increase value-added for agricultural raw materials as bioenergy feedstock and new technologies to increase product value. This issue of Insight presents new perspectives and identifies business opportunities and challenges for the bioenergy industry in Thailand. In particular, we focus on 3 areas: 1) biofuel, 2) biomass power plants, and 3) bioplastics. EIC estimates that investment in the Thai bioenergy industry will reach THB 180-200 billion between 2016 and 2020.

The biofuel industry has been growing steadily boosted by supportive government measures. Key reasons behind the government's support for biofuel such as gasohol or biodiesel are to curb reliance on fossil fuel imports and strengthen Thailand's energy security. In addition, biofuel production from agricultural raw materials provides an alternative outlet for farmers and adds value to agricultural products. Even though the current low oil prices present a major challenge to the industry along with foreign competition, volatility in volume and prices of agricultural commodities used as feedstock and trend in electric vehicles, the Thai biofuel industry still has a high growth potential. The development of cars that use ethanol and biodiesel will boost future demand for biofuel. Moreover, R&D on high-quality biofuel and the expansion of gas stations that sell E20 and E85 will also help support demand.

Biomass power plants are another promising option for Thailand's energy security. Today, more than 60% of Thailand's energy production relies on natural gas. The government therefore encourages power production from biomass which is more available in the country.

Although, this business is still challenging in terms of managing costs and biomass supply to support long-term production plans, investment opportunities remains as government support for the industry is still strong. Investing in biomass power plants still requires support from the government in specifying locations and available agricultural supply volume to ensure adequate supply of feedstock for power production.

The bioplastics industry has a bright prospect given recent eco-friendly trends, rising awareness on environmental issues, and attempt to seek alternative market outlets and to increase value for agricultural products. In response to the escalating problem of plastic pollution and climate change, consumers around the world are shifting towards more environmentally-friendly products every year. Naturally degradable products like bioplastics are therefore increasingly replacing traditional plastic products. The Thai bioplastics industry must adapt quickly to this changing trend. Thailand has a potential to step up as the ASEAN manufacturing hub as the country is ready with a full supply chain of bioplastics production ranging from upstream to downstream industries. Moreover, bioplastics production will provide an alternative market outlet for cassava and sugarcane, creating higher value products. Yet, many obstacles remain to be overcome such as high production cost, limited applications for bioplastics, and risks in oil and agricultural commodity prices that affect competitiveness of bioplastics. The consumer trends in eco-friendly products and collaborative support from the public and private sectors will be keys to growth in bioplastics as a viable replacement for traditional plastics in the future.

Many challenges remain for the Thai bioenergy industry to achieve sustainability in production. Such challenges includes the overlapping use of agricultural raw materials between food and energy industries, price competition with other types of energy, and skepticism over the environmentally-friendly advantage of biofuel compared to fossil fuels. Investment in R&D is therefore extremely important for the bioenergy industry to grow sustainably.


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Prologue: The Global Bioenergy Industry

Technological advances and the environmental challenges of the recent decades have resulted in the emergence of bio-based industries. A large part of the current bio-based industry is bioenergy. Bioenergy such as biofuel, biomass, and bioplastics[1] hold the promise of being more environmentally-friendly than their fossil fuel counterparts as they are considered renewable and sustainable. On the economic side, bio-technologies offer the prospects of development of value added products, new hi-tech industries, and job creation. However, as much of the bioenergy sources used today are substitutes for fossil fuel, changes in oil prices can impact the industries. Can bioenergy survive if oil prices stay low for an extended period of time?

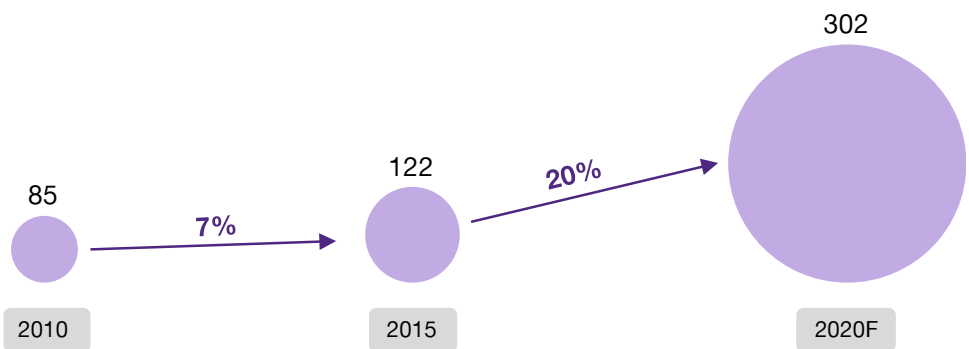
[1] In the context of this publication, bioenergy includes biofuel, biomass power plants, and bioplastics as they can be petroleum fuels subsitutes

In the past 20 years bioenergy has experienced strong growth worldwide due mainly to government support. Governments around the world have mandated the use of biofuel in the transportation sector. For example, renewable fuel Annual Volume Standards that require bio-fuel production and consumption to increase every year and blending mandates that require a certain amount of bio-fuels be mixed with conventional fuels have led to biofuel production and consumption increases every year. These government mandates have supported the growth of biofuel trade over the years, where biofuels have become global commodities. Similarly, government support for biomass power plants have led to increased demand for biomass, which resulted in an increase in global trade in wood pellets. Lastly, the bio-plastics industry has become one of the fastest growing industries, with demand expected to quadruple in less than five years.

1 Biofuel growth is driven by government policies and mandates that requires a certain volume of renewable fuel to replace or reduce the quantity of petroleum-based fuel

Growth projection of global biofuel production and Compound Annual Growth Rate (CAGR)

Unit: billion liters

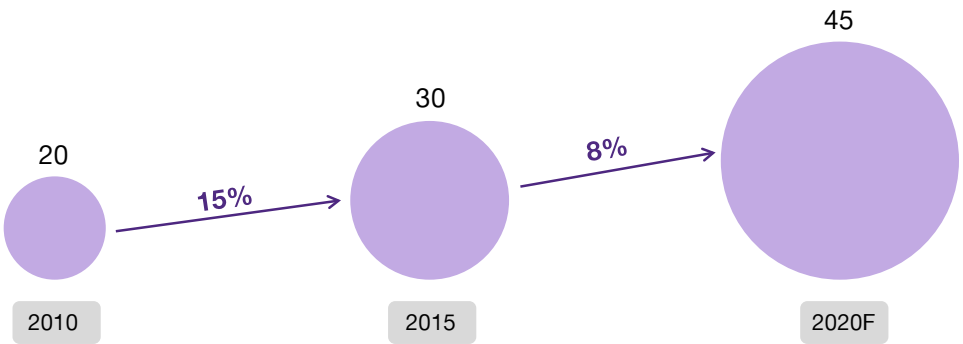


Source: EIC analysis based on data from Bloomberg, Altenergymag, Market Research Media and Jefferies Research

2 The increase in the use of biomass to produce heat and electricity has resulted in wood pellet production growth

Growth projection of global wood pellets production and Compound Annual Growth Rate (CAGR)

Unit: million tons

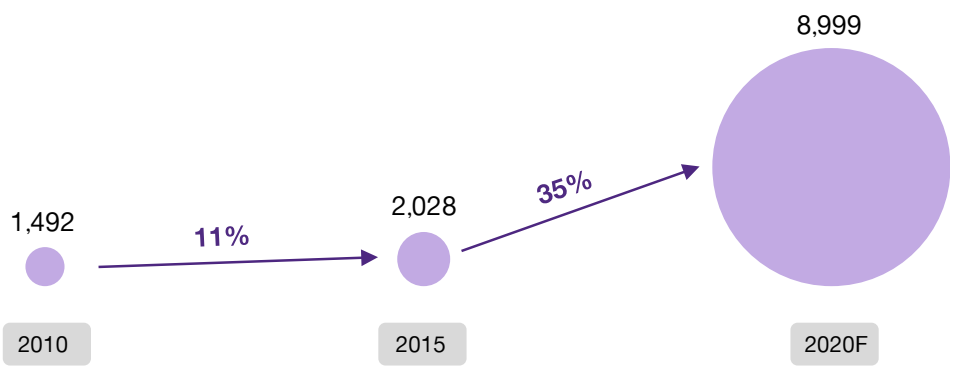


Source: EIC analysis based on data from Food and Agricultural Organization (FAO) and Poyry

3 Growth in the production of bioplastics is driven by value-added and environmental policies

Growth projection of global bioplastics production and Compound Annual Growth Rate (CAGR)

Unit: million tons



Source: ICIS forecast

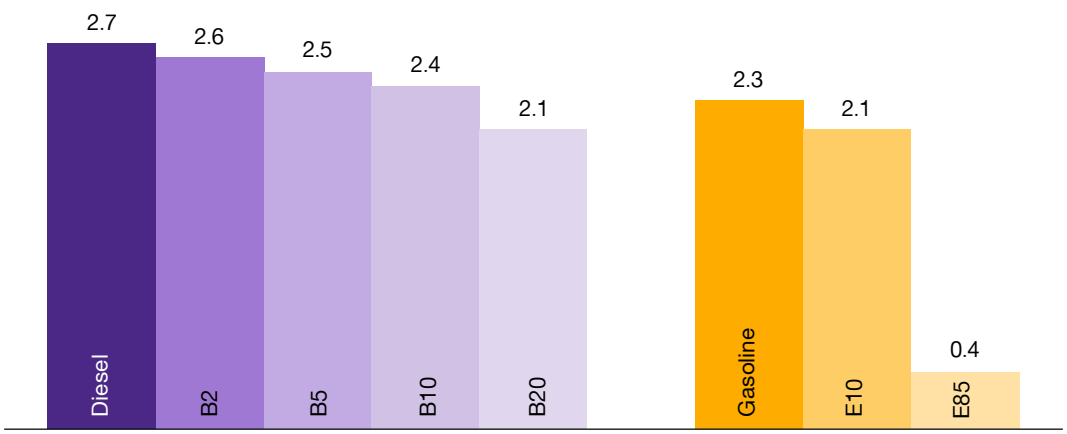
Although the bioenergy industries have experienced rapid growth over the years, future growth will be driven by 1) concerns for the environment, 2) energy securities, and 3) the use of bio-technologies to develop high value products and industries.

1. Environmental concerns, particularly related to greenhouse gas (GHG) emissions and waste are driving investment in bioenergy worldwide. Use of biofuels in the transportation sector helps cut GHG emissions from tailpipes by replacing fossil fuels, while using biomass for power generation results in lower GHG than conventional sources such as coal. Bio-plastics are viewed as being more environmentally friendly than their petroleum-based counterparts due to their ability to decompose and the use of renewable materials. Decomposable plastics are better than non-decomposable plastics because, under the right conditions, they take much less time to breakdown, thus alleviating the problem of plastic waste.

4 Environmental benefits of biofuels are based on carbon dioxide emission factors which are lower than fossil fuels

Carbon dioxide emission factors* for transportation fuels

Unit: kilograms CO_2 per liter

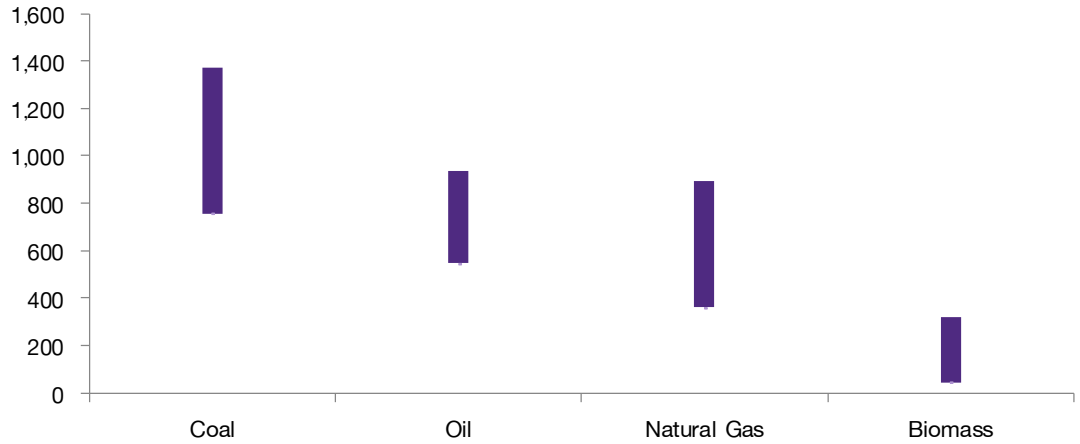


**Greenhouse gas emission factor is used to calculate the volume of GHG emitted from each fuel type*
Source: U.S. Energy Information Administration (US EIA)

5 Biomass power plants emit less greenhouse gases per unit of electricity than fossil fuel power plants

Greenhouse gas emission from different types of thermal power plants

Unit: kg CO_2e per MWh



**Lifecycle greenhouse gas emission exclude land use change from increasing bioenergy production*
Source: EIC analysis based on data from UK Environmental Agency, World Nuclear Association, and US Environmental Protection Agency (US EPA)

6 Biodegradable plastics can be decomposed in a matter of months compared to hundred of years for conventional plastics

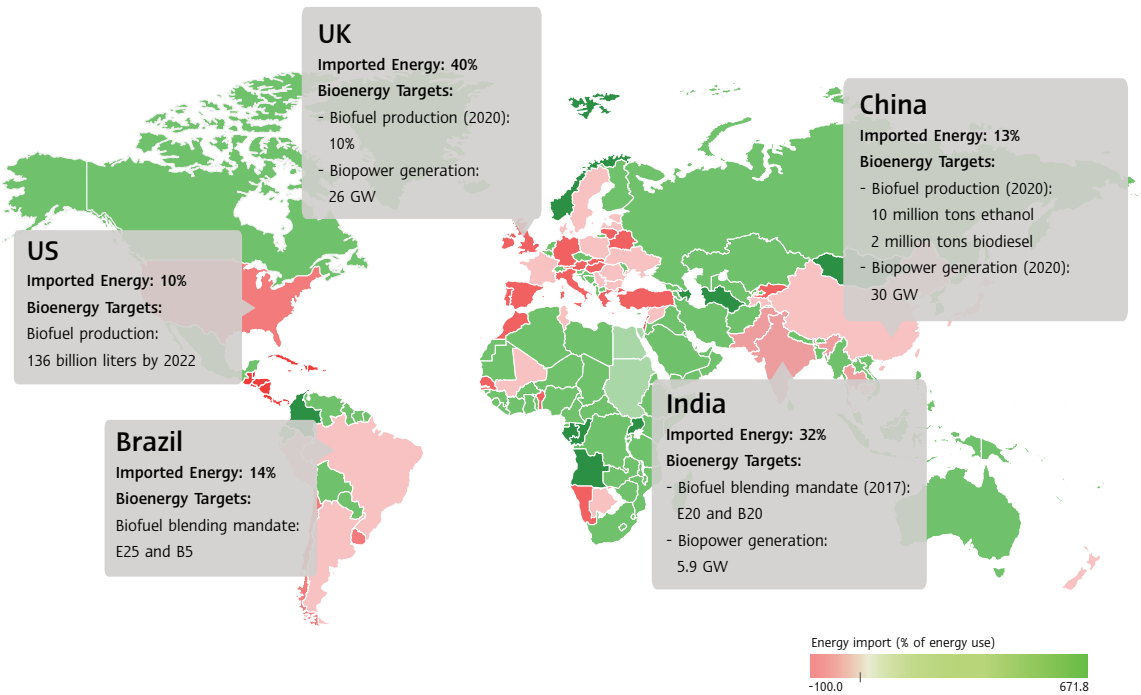
Decomposition time for different types of plastics

Unit: years

**Bioplastics must be under the right set of conditions to decompose*
Source: EIC analysis based on data from New Hampshre Department of Environmental Services, Futurism, ASTM International

2. For net energy importing countries, energy security is an important driver for bioenergy. Agriculture crops are diverted to establish biofuel industry and wastes are being used to produce electricity and heat instead of imported coal, oil, or natural gas. For many of these countries, electricity generation from biomass together with other renewable sources such as solar and wind energy serve as insurance against an energy portfolio that may currently be too heavily reliant on imported energy.

7 Net energy importing countries have set national targets for bioenergy use to increase energy security



Source: World Bank, US EPA and The International Renewable Energy Agency (IRENA)

Local biofuel productions for domestic consumption have helped countries to lower dependency on fuel imports. For example, the Brazilian National Development Bank (BNDES) estimated that between 1975 and 2008 the country's bioethanol program saved Brazil over USD 390 billion in foreign exchange and avoided imports and foreign debt interest. The U.S. Department of Energy estimated that in 2007 U.S. production of 6.5 billion gallons of ethanol helped to reduce the trade deficit by USD 9 billion.

Box: Oil price and bioenergy

Reducing dependency on foreign fuel is a main driver for bioenergy. The United States' ethanol market was effectively created when Congress approved a 40-cent-per-gallon subsidy for corn ethanol. Around the same time, Brazil implemented Próalcool, a national program to develop sustainable and renewable fuels. Ever since, governments around the world continue to provide support to the industry through tax exemptions, subsidies, and blending mandates. Supports for other forms of bioenergy have also been added, including favorable feed-in-tariff for biomass power and public research funds for the bioplastics industry.

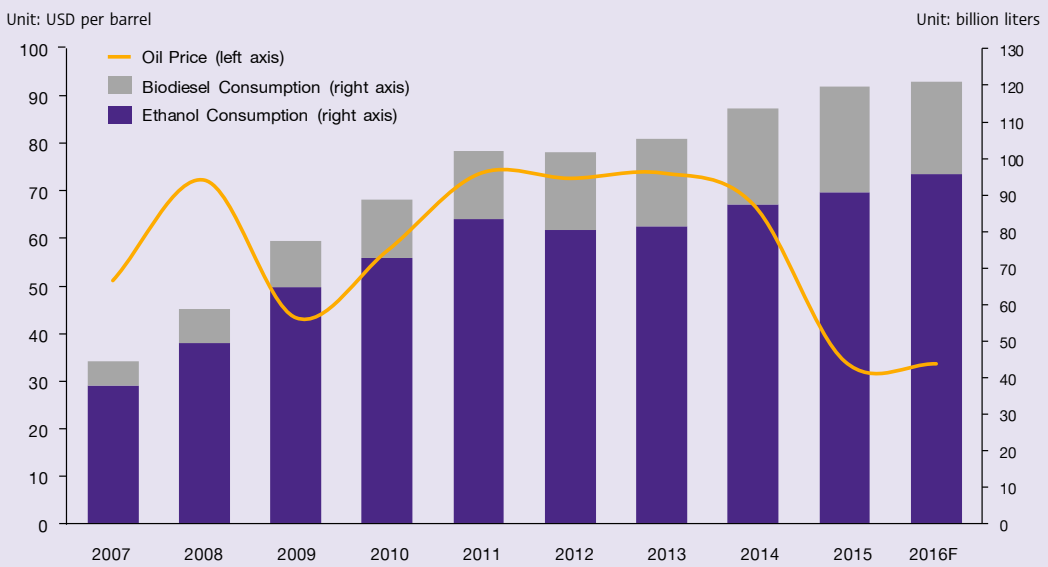
However, the oil industry has changed - new exploration and production technologies such as shale oil and deep water drilling have helped increase oil production. OPEC is now fighting to maintain market share, and energy efficiency measures and a sluggish world economy have dampened the demand for oil. All of this has led to a drop in oil prices. What are the impacts on bioenergy industries in a prolonged low oil price environment?

Changes in global oil prices have limited impacts on biofuels, biomass power plants, and bioplastics industries.

Policy supports remain the biggest driver for biofuel consumption. However, biofuels become less competitive when oil prices are low since it is still generally costlier to produce one liter of ethanol or biodiesel than petroleum fuels. In addition, in countries such as the United States and Thailand where multiple types of fuels are offered, consumers may choose to buy standard gasoline for higher engine performance instead of biofuel when the price of oil is low. However, overall impacts are relatively limited. This is due to the fact that the production and consumption of biofuels are driven by government agenda.

8 Global ethanol consumption continues to climb despite the drop in oil price

Global annual biofuel consumption and oil price



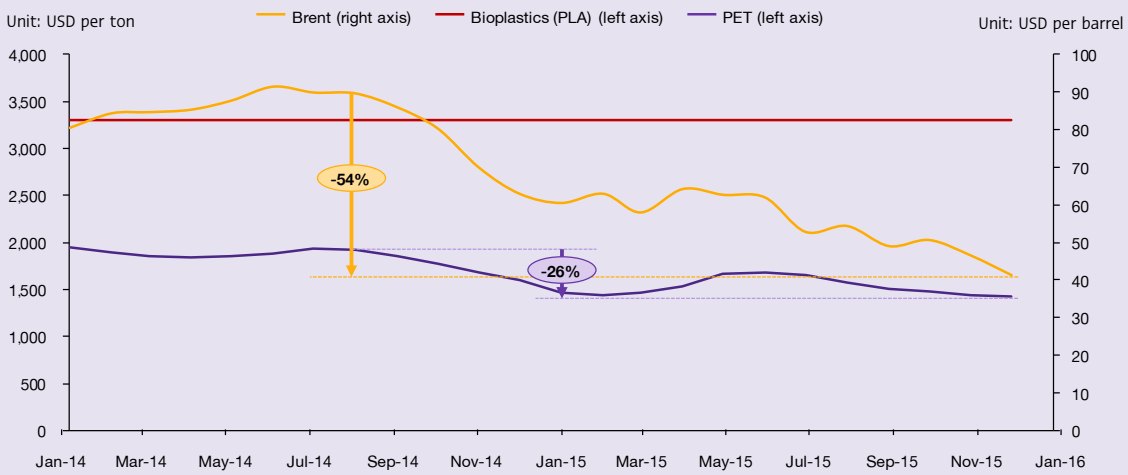
Source: EIC analysis based on data from Bloomberg

Biopower does not act as a substitute only for oil but for other forms of energy such as coal, natural gas, and nuclear power the rise or fall of global oil prices does little to impact the industry. Unlike bioplastics, where material performance is discernible from conventional plastics, electricity is the same whether generated from bio-based sources or other sources. As a result, consumer awareness of electricity usage is not as high as for biofuel or bioplastics due to the fact that electricity from bioenergy performs the same function as electricity from fossil fuels.

The bioplastics industry establishment was predicated more on the environmental benefits of the products rather than a search for a lower cost substitute for petroleum feedstock. Consumers who demand bioplastics are basing their purchasing decisions on green factors rather than price. In addition, as a new industry, the production costs of bioplastics are still much higher than conventional plastics. Since the price of conventional plastics are correlated with oil prices the price gap between bioplastics and conventional plastics becomes even greater in depressed oil market conditions. Given the current considerable cost of research, innovation, and technologies being employed to produce bioplastics, any fluctuation in oil prices does not have a major impact on the industry.

9 The price of conventional plastics track closely with oil price. Bioplastics cannot compete, especially in low oil price environment

Conventional plastic (PET) price, bioplastics price (PLA), and brent price

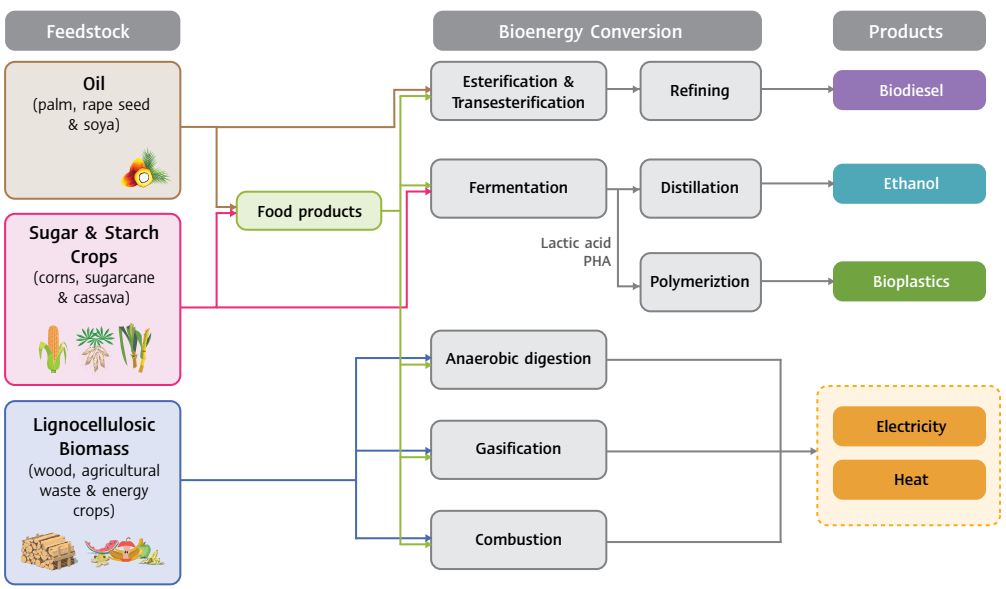


Source: EIC analysis based on data from Bloomberg, Argeni and NatureWork

3. Bioenergy offers economic benefits by enabling the development of new value chains from agricultural commodities. The most readily available economic opportunity of bioenergy lies in turning previously unused by-products such as agriculture waste into energy in the form of heat and electricity. Low value by-products of food production, such as molasses from sugarcane, can be turned into biofuel and bioplastics, thus adding value to the entire production chain.

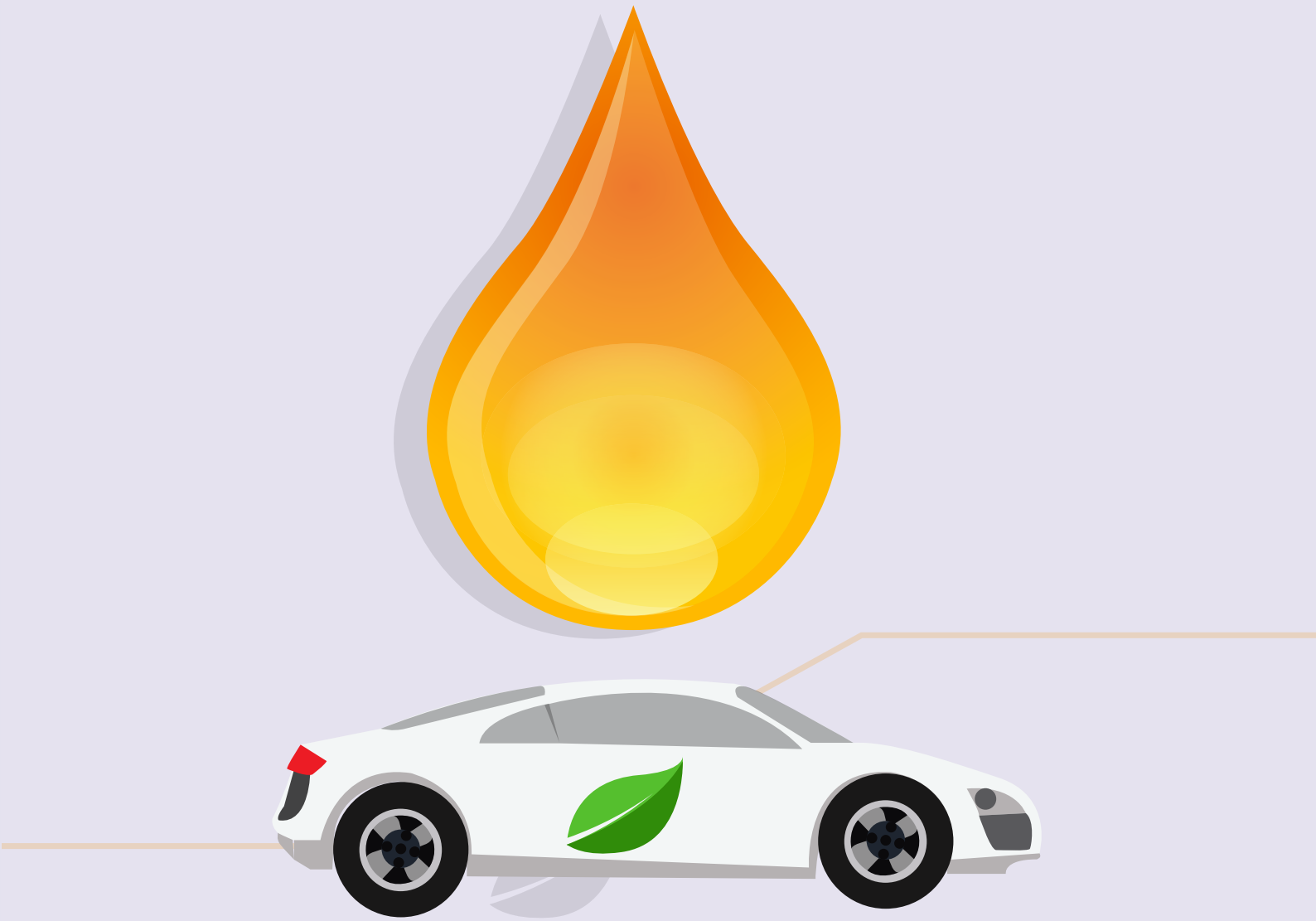
As demands for bioenergy increase governments around the world are encouraging the development of biotechnologies to foster innovations in both the bioenergy and agricultural industries. In 2012, the European Commission adopted a Bioeconomy Strategy to develop the bioenergy industry in order to reduce dependency on fossil fuels, create new consumer products, and create jobs. To this end, the EU has established a EUR 3.7 billion Public-Private Partnership with the Bio-based Industries Consortium to boost research and investment. In Canada, the government has committed 698 million CAD under the AgriInnovation Program to accelerate innovation through research and development opportunities.

10 Conversion process yield multiple bioenergy products



As one of the top exporters of agricultural products, Thailand has abundant resources to build a strong bioenergy industry. Past and current policies aim to capture additional value from agricultural commodities and by-products. In Thailand, the Alternative Energy Development Plan (AEDP) sets biodiesel and ethanol targets for 2036 of 25.3 million liters per day, a four-fold increase from production level in 2014. In addition, the biopower target of 5,570 MW is set for 2036. Lastly, the government's push to create a bioplastics industry has attracted investment from the private sector, where local petrochemical companies now have bioplastics production capacities. EIC estimates that Thailand will see between 180 and THB 200 billion in new investment in the bioenergy industry by 2020.

In the next three chapters we discuss Thailand's biofuel, biopower, and bioplastics industries – what are the drivers, opportunities, strengths, and challenges facing each industry, and the key success factors for companies.



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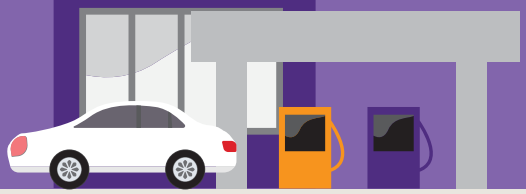
The Biofuel Industry in the Age of Cheap Oil

Imported crude oil accounts for up to 80% of Thailand's transport-related oil demand. As such, biofuel produced domestically from agricultural raw materials serves as an important alternative source that will help decrease crude oil import dependency and strengthen the country's energy security. Thailand holds an advantage in the biofuel industry thanks to the availability of agricultural raw materials, as well as readiness in terms of the production chain. As consumers' concerns about climate change, pollution, and other related environmental issues gain further traction in global debate, several countries are setting target levels for biofuel use around the world. The Thai biofuel industry stands to benefit from these trends. Low oil prices pose a major challenge to the industry, yet the sustained push for biofuel has to continue in order to ensure energy security.

Biofuel

Filling up your car with Biofuel



Biofuel used in Thailand consists of ethanol and pure 100% biodiesel, or B100

Biofuel plays an important role in transport sector to reduce crude oil import dependency and increase value to agricultural products. At present, biofuel including gasohol and biodiesel are sold at the gas station.

Gasoline and Gasohol

Gasoline

Benzene 95 (ULG 95)

Gasohol

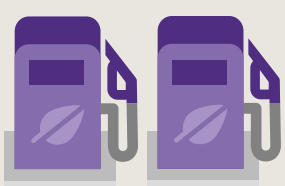
Ethanol combined with standard gasoline (benzene) at various levels results in gasohol, which is available in gas stations today, including E10, E20, and E85 blends (the number indicates the percentage of ethanol in the formula, e.g. E10 contains 10% ethanol).

Benzene 91 90% +ethanol 10% → Gasohol 91 (E10)

Benzene 95 90% +ethanol 10% → Gasohol 95 (E10)

Benzene 95 80% +ethanol 20% → E20

Benzene 95 15% +ethanol 85% → E85



Diesel

Diesel

B100 combined with diesel results in biodiesel oil. As of today (2016) gas stations sell only one type of biodiesel, namely B7 (7% B100)

Diesel 93% +B100 7% → Biodiesel B7

* The government may decrease B100 mandate in biodiesel in case of palm oil supply shortage.

Why does biofuel matter in Thailand?

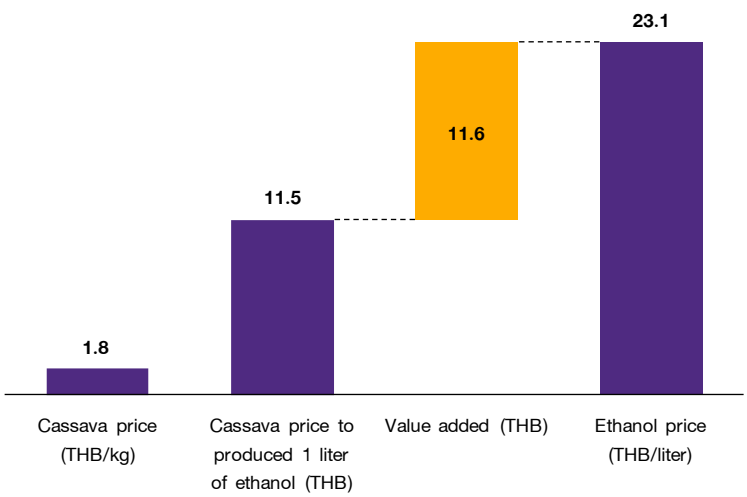
The government has been subsidizing the use of biofuel in transport in order to reduce Thailand's dependence on imported fossil fuel. Up to 80% of Thailand's crude oil demand is imported. Domestically produced biofuel made from agricultural feedstock, such as sugarcane, cassava, and palm oil can help lessen the country's reliance on imported oil and contribute to energy security. In 2015 Thailand consumed 26 million liters of gasoline and 60 million liters of diesel per day. With ethanol and B100 blends Thailand will be able to reduce its use of fossil fuel by 8 million liters per day, saving THB 65 billion per year.[2]

Biofuel made of agricultural raw materials will provide alternative options for farmers to distribute their product and add value to their output. The use of agricultural raw products to produce ethanol (sugarcane and cassava) and B100 (oil palm) will provide alternative channels for farmers to distribute their surplus in the energy market and add value to the agricultural products. For example, the value added from processing cassava to ethanol is two times of selling cassava as the agricultural product.

11 The processing of cassava to ethanol can double the value

The value added from processing cassava to ethanol

Unit: THB



Note: Cassava and ethanol prices are average prices during the first half of 2016
6.5 kg. of cassava can produce 1 liter of ethanol
Source: EIC analysis based on data from CEIC

[2] Estimation is based on demand of E10, E20, E85 and B7 in 2015, with crude oil price at USD 50 per barrel.

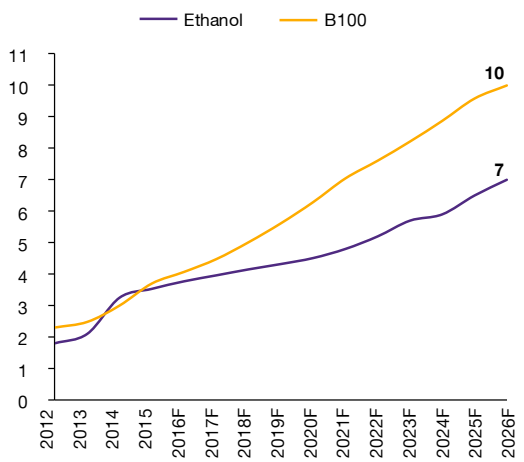
What are the strengths of the biofuel industry? Where are the opportunities?

Thailand has been using biofuel for more than a decade thanks to the government's sustained push for growth in this sector. Although the raw material cost of biofuel is higher than the cost of regular oil production, Thailand needs to support the use of biofuel to reduce the country's dependence on fossil fuel imports in order to foster energy security. In the government's Alternative Energy Development Plan 2015 (AEDP 2015), the target goal of ethanol and B100 production is set at 7 and 10 million liters per day respectively for the first phase by 2026 and 11.3 and 14 million liters per day respectively by 2036 for the second phase. Previous support measures include regulations that gradually increase the use of B100 in biodiesel from 2% (B2) to 7% (B7), and potentially 10% (B10) in 2018, leading to higher demand for B100. Other measures include price mechanisms resulting in lower gasohol prices relative to benzene to induce higher consumption. Exemption of tariffs for machinery will also encourage investment in biofuel production.

12 The use of ethanol and B100 is likely to continue an upward trend as a result of the increasing use of gasohol with a high ethanol percentage, such as E20 and E85, as well as the increase of B100 mandate in biodiesel from B7 to B10.

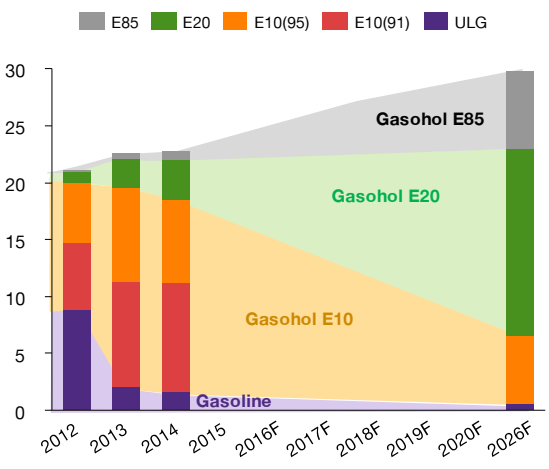
Ethanol and B100 consumption forecast

Unit: million liters per day



Gasohol consumption forecast

Unit: million liters per day



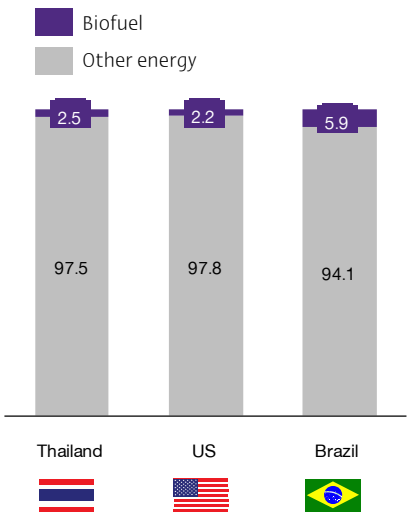
Source: EIC analysis based on data from the Department of Alternative Energy Development and Efficiency (DEDE) and CEIC

Consumption of biofuel in Thailand is growing fast, currently accounting for 2.5% of total final energy consumption. This figure is quite high. Biofuel has been subsidized for more than 30 years in the USA, but its use accounts for only 2.2% of total final energy use. Ethanol and B100 are increasingly popular in Thailand, with consumption growing at approximately 14% per year due to swelling demand for gasohol and 14-16% per year for biodiesel. In the U.S., biofuel has been expanding by only 5.5% per year. However, when compared to Brazil, which also subsidizes ethanol and is a major sugarcane producer, Thailand's biofuel use still has much room to grow. In Brazil, the rate of use is as high as 6% of total final energy consumption. Demand for biofuel in Thailand can still climb with a further push for alternative energy.

13 Thailand's rate of biofuel use is quite high when compared to developed countries such as the U.S. compared to Brazil, however, there is still room to grow.

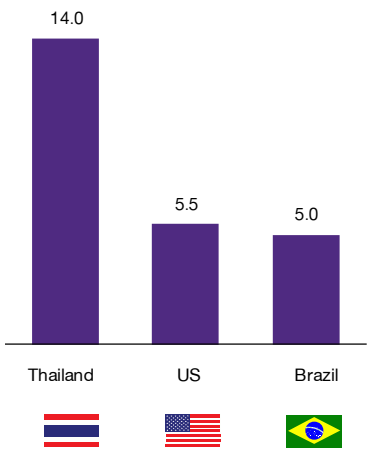
Proportion of biofuel consumption compared to other energy in 2015

Unit: %



Biofuel consumption annual growth during 2009-2015

Unit: % CAGR 2009-2015



Source: EIC analysis based on data from the Energy Policy & Planning Office (EPPO), US Energy Information Administration (EIA) and University of Sao Paulo's College of Agriculture

The development of flexible fuel vehicles (FFV), diesel eco-cars, high-quality biodiesel (H-FAME) production technology, and the growing number of gas stations selling E20 and E85 will raise biofuel demand further. More energy-efficient and environmentally-friendly vehicles are likely to be manufactured in the future. Currently the majority of vehicles running on gasoline in Thailand can already run on E20 gasohol, and newer models will be able to run on E85. In the future FFV, which can run on different types of fuel, including 100% ethanol such as in Brazil, may also be available in Thailand, resulting in higher demand for ethanol.

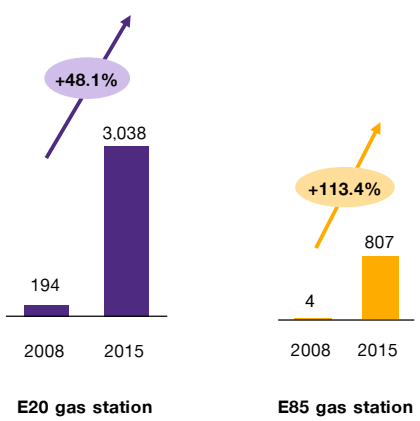
As for vehicles that run on diesel, 2016 will see the introduction of diesel eco-cars to the Thai market. They tend to become as popular as cars with gasoline engines due to the government's favorable tax measures. Newer developments include the production of new high-quality biodiesel or H-FAME (Partially Hydrogenated Fatty Acid Methyl Ester), which can be mixed with diesel at a rate of 20%. H-FAME has been tested on some vehicles without any issues. With car manufacturers' growing acceptance of biodiesel with high levels of B100, such as B10 and higher, we can expect to see increased demand for the fuel. The government's stipulation that biodiesel be provided in gas stations will also contribute to demand.

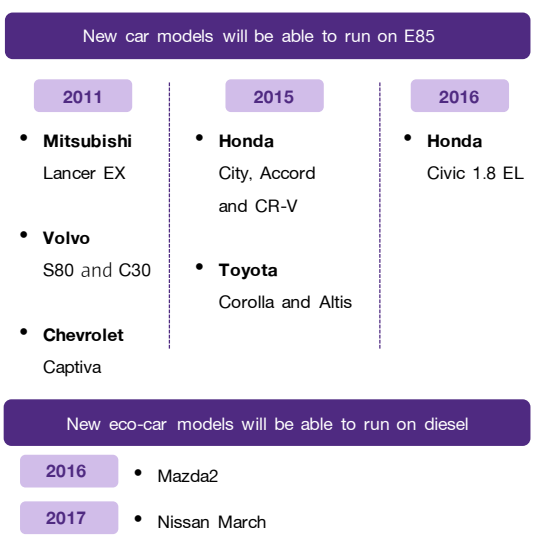
The number of gas stations which provide E20 and E85 gasohol have been steadily climbing at a rate of 48% and 113% per year respectively. Gasohol's wide availability is convenient for drivers, providing another incentive for buyers to consider cars that run on E20 or E85.

14 The number of gas stations with E20 and E85 gasohol, the availability of newer vehicles that can run on E85, as well as the introduction of diesel eco-cars will contribute to the growth of ethanol and biodiesel use.

E20 and E85 gas station and Compound Annual Growth Rate (CAGR)

Unit: station

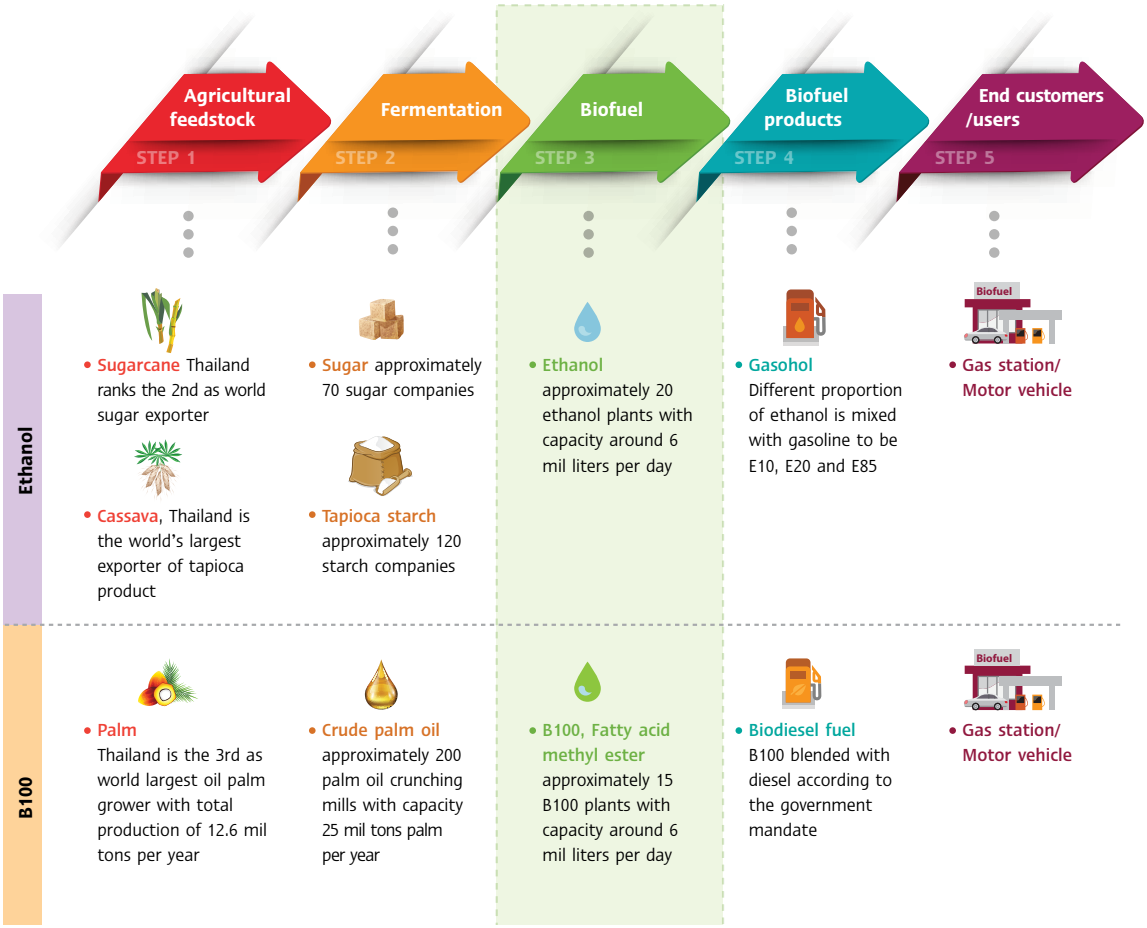




Source: EIC analysis based on data from the Ministry of Energy and the Department of Land Transport

From upstream to downstream, the value supply chain of the Thai biofuel industry is strong, with domestically available feedstocks and markets. The biofuel industry in Thailand is robust throughout the supply value chain, from the sourcing of raw materials to the final stage of processing into gasohol and biodiesel. Upstream, Thailand has the capacity to produce feedstock for ethanol and B100. Thailand is the world's largest exporter of tapioca starch, the second-biggest producer and exporter of sugar after Brazil, and the third-largest producer of oil palm, after Indonesia and Malaysia. Midstream, there are many sugar and tapioca starch factories in Thailand, as well as palm oil crushing mills with quality standard such as GMP[3] and HACCP[4]. Finally, downstream many oil companies in Thailand operate large oil refineries with high refining capacity sufficient to domestic consumption and also export, where ethanol and B100 are blended with gasoline, resulting in biofuel such as gasohol and biodiesel. These are then distributed to gas stations throughout the country.

15 The Thai biofuel industry is strong throughout the supply chain.



Source: The Office of Agricultural Economics and the Ministry of Energy

[3] GMP (Good Manufacturing Practice) is a system for ensuring that products are consistently produced and controlled according to quality standards.
[4] HACCP (Hazard Analysis Critical Point) is an approach to food safety that is systematic and preventive.

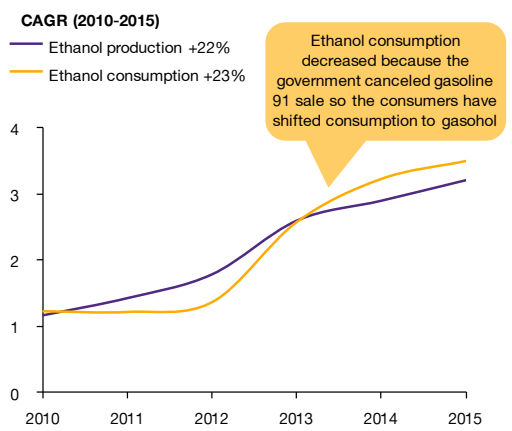
In terms of market situation, there is inadequate supply for the current demand for ethanol and B100. Therefore, the overall biofuel market still has room to grow. In 2015 Thailand consumed 3.5 million liters of ethanol per day, more than the domestic production capacity of 3.21 million liters per day. The high consumption level was a result of increasing demand for gasohol, especially gasohol with a high ethanol level, such as E20 and E85. From 2010 to 2015, consumption of E20 and E85 expanded by 173% and 62% per year respectively. This usage spike was partly attributable to the low, subsidized retail prices of E20 and E85, especially when compared with regular gasoline. Furthermore, the government canceled the sale of benzene 91 gasoline in 2013 in order to bolster gasohol use. As for B100, demand has continually grown, corresponding with the 14% per year rate of growth of biodiesel consumption from the transport and logistics sectors (most trucks run on diesel). The government has also increased the mandatory level of B100 in biodiesel, from 2% (B2) in 2007 to 7% (B7) today.

16 Ethanol and b100 demand exceeds domestic supply.

Biofuel (Ethanol and B100)

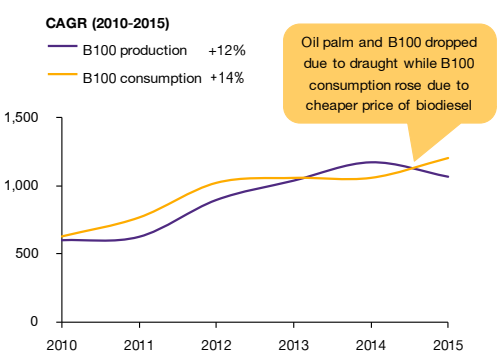
Ethanol production and consumption

Unit: million liters per day



B100 production and consumption

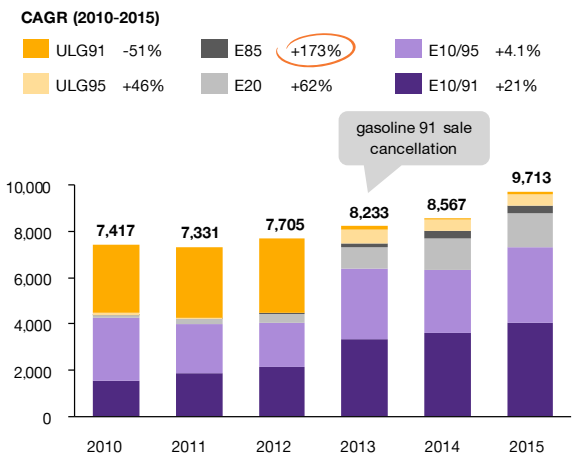
Unit: million liters



Petroleum products (Gasohol and Biodiesel)

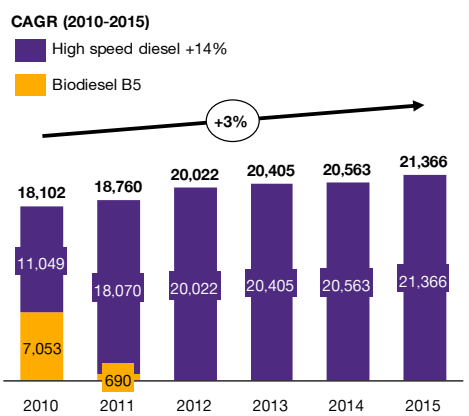
Gasoline and gasohol sales

Unit: million liters



Diesel sale

Unit: million liters



Source: EIC analysis based on data from EPPO and CEIC

What are the challenges facing the biofuel industry?

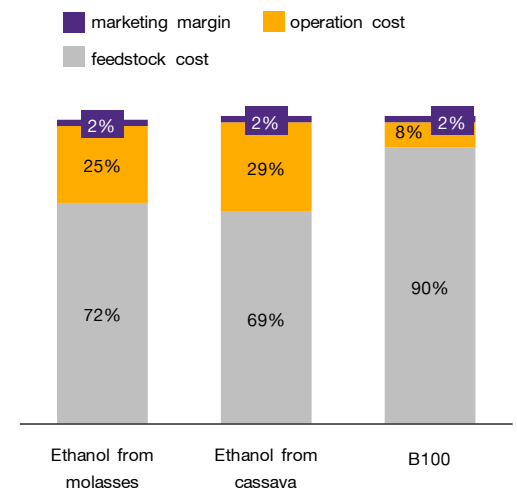
Currently, the slump in oil price poses the biggest challenge. Price-wise, biofuel can compete with fossil fuels only when crude oil prices exceed USD 70-80 per barrel. The cost of biofuel depends largely on the price of raw materials, which account for 70% of total cost in the production of ethanol and 90% in the production of B100. The remaining cost stems from transport, labor, and other expenses. While cheap oil may help decrease transport costs, this has little positive effect overall as the prices of other raw materials such as molasses, cassava chips, and oil palm are not affected by crude oil prices. Rather, their prices are determined by their respective markets. As such, the cost of biofuel remains quite high compared to that of fossil fuel, which, in addition, has also gone down significantly following the drop in global crude oil prices.

Comparing the oil price at USD 100 per barrel during the early 2014 with that at USD 50 per barrel in 2016, it is clear that low crude oil prices had a negative impact on the competitiveness of gasohol and biodiesel. In the case of E85, the cost became 30% higher than that of regular gasoline. Consequently, gasohol requires intervention from the government.

17 Raw materials contribute to the majority of biofuel production cost. When crude oil prices are low, biofuel's competitiveness also falls due to its higher relative cost compared to fossil fuels.

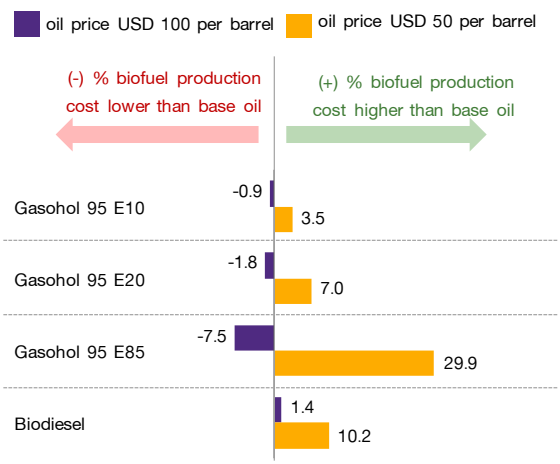
Ethanol and B100 production cost structure

Unit: %



% increase of production cost of biofuel compared to that of fossil fuel during different oil price situations

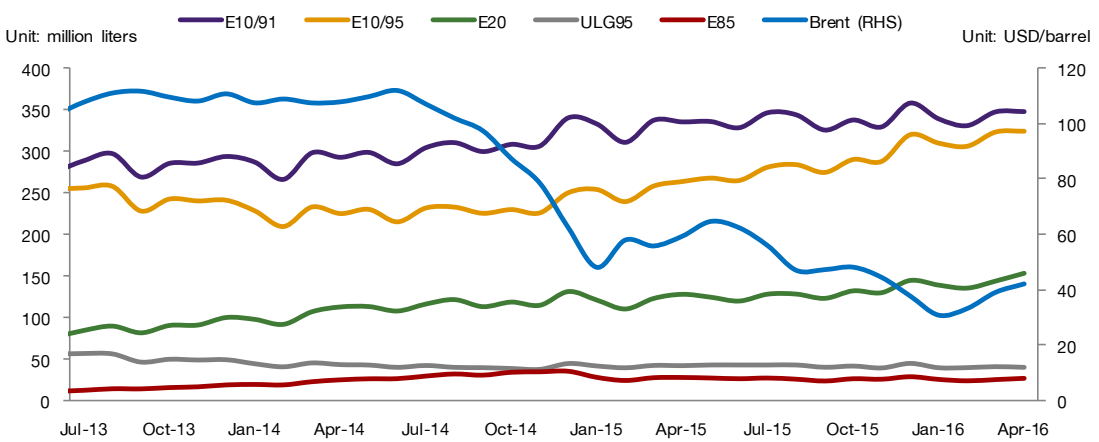
Unit: %



Source: EIC analysis based on data from the Ministry of Energy, Bangchak, and Thai Oil.

On the demand side, the slump in crude oil prices led to a dramatic increase in the use of gasohol and biodiesel due to a fall in overall retail fuel prices. However, when oil prices are low, some consumers switch from E85 and E25 to E10 and benzene 95, potentially leading to lower-than-expected demand for ethanol. Crude oil prices have been continually falling since mid-2014, resulting in a 30% drop in retail fuel prices on average. This contributed to increasing demand for fuel among drivers. In 2015 use of refined fuel grew both in the regular gasoline and diesel categories (26.4 million liters per day, a 13.2% increase, in the former case, and 59.9 million liters per day, a 3.7% increase in the latter). However, since 2014, the government's energy reform policy has tried to adjust the energy price structure in order to reflect actual costs and provide more equitable cost-sharing among consumers. For example, the rates of contribution to the national oil fund taken from benzene 95 and E10 sales have been cut, narrowing the price difference between these types of fuel and E20/E85. In mid 2014 the price gap between benzene 95 and E10 was THB 24.2 per liter, while In mid 2016, the price difference is THB 13.7 per liter. As such, more consumers have turned to benzene 95 and E10, enjoying lower fuel consumption rates and reduced engine deterioration compared to E20 and E85; both of which are high in ethanol.

18 In an era of cheap oil, consumers increasingly switched from E85 and E20 to E10 thanks to a significantly narrower price gap.



	Monthly growth			Price gap compared to E85 (THB per liter)		
Fuel	Jun 13-May 14	Jun 14-May 15	Jun 15-May 16	Jun 14	Jun 15	Jun 16
E10/91	+9.2%	+19.6%	0.5%	13.7	5.5	6.3
E10/95	-10.4%	+27%	1.7%	16.2	6.3	6.7
E20	+53.2%	+16.9%	2.1%	11.2	4.1	4.2
ULG95	-25.2%	+7.8%	-0.6%	24.2	12.1	13.7
E85	+155.8%	+3.2%	0.2%	-	-	-

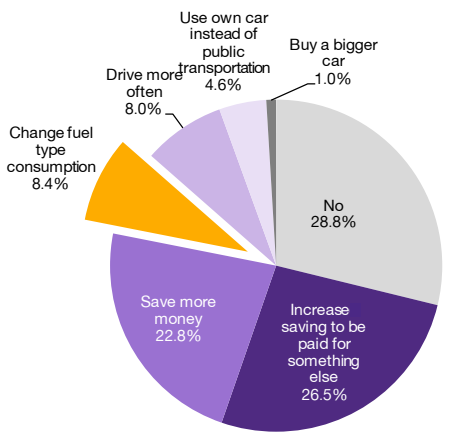
Sources: EIC analysis based on data from the Energy Policy and Planning Office, Bloomberg, and CEIC.

In addition, an EIC survey revealed that consumer behavior did not change much between early 2015, when crude oil prices were high, and 2016, when crude oil prices were low, with 8.4% of respondents indicating that they switched the type of fuel they filled their cars with. The rate of E85 and E20 use fell, while the rate of E10/95 and benzene 95 use climbed.

19 Most respondents did not adjust their consumption behavior after oil prices fell. During the time of cheap oil prices, the shares of E85 and E20 usage decreased; while the share of E10/95 and Benzene 95 usage climbed.

Have you changed the consumption behavior after oil price dropped significantly?

Unit: %



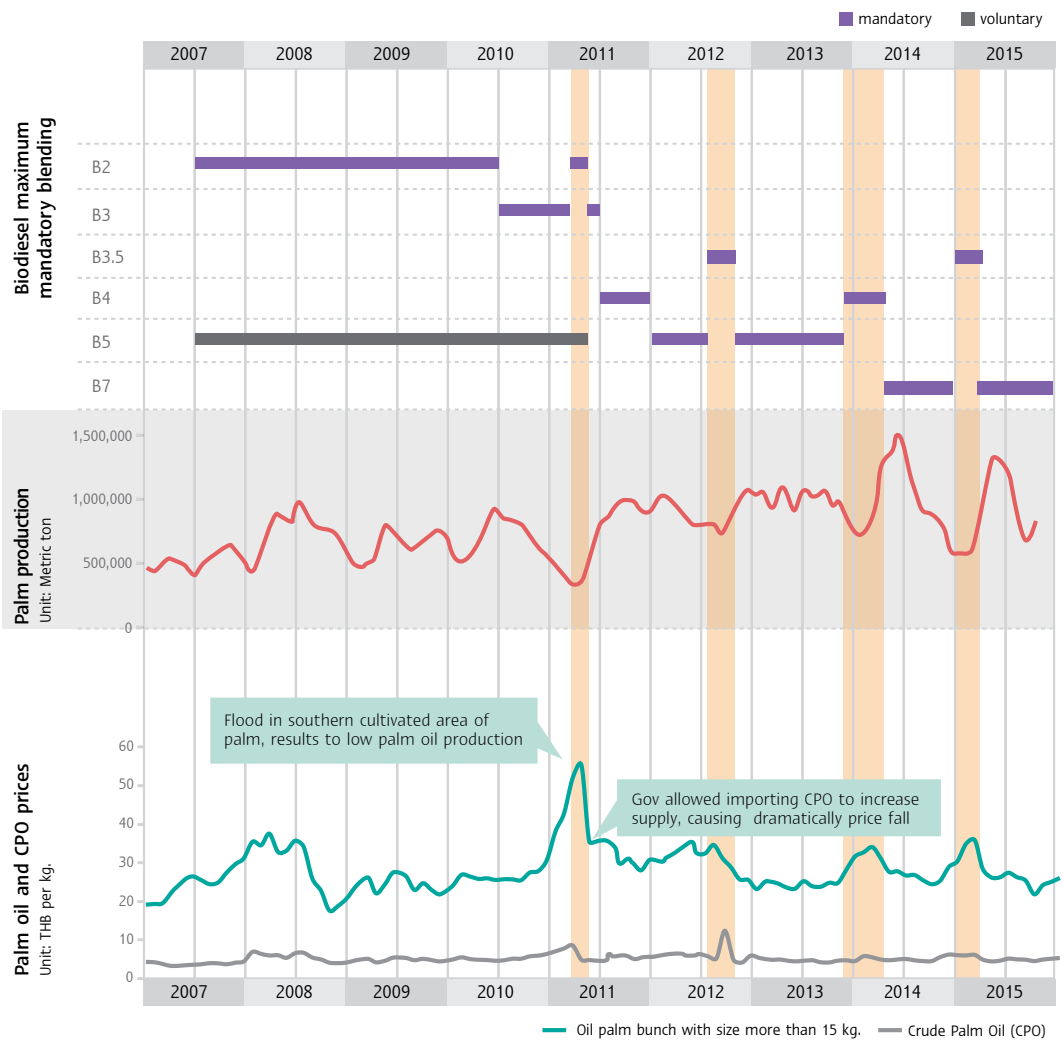
Proportion of oil consumption during different oil price situations

Unit: %

Source: EIC analysis based on a survey conducted in June 2016 with 20,883 respondents.

Another important challenge to the biodiesel industry is the volatility of production and prices of raw agricultural materials. Due to this volatility the government has had to reduce the rate of mandatory blending. Take the case of B100, which is made of oil palm. Due to the seasonal cycle of oil palm cultivation, supply is usually low during the first quarter of each year. In some years, drought further cuts down the supply of oil palm and crude palm oil (CPO), resulting in higher prices for B100 production and necessitating the import of palm oil. During the drought in late 2014, for example, oil palm production fell by more than 30%, as the available stock of palm oil also dropped from the usual level of 200,000 tons to 110,000 tons, which was lower even than the critical level of 135,000 tons. In response to this situation, the government had to cut the rate of mandatory B100 blending in diesel from 7% to 3.5% in early 2015, while also exempting the ban on palm oil imports, allowing 50,000 tons of imported palm oil into the domestic market. As this example demonstrates, volatility in the oil palm market poses a risk to B100 producers, who depend on oil palm supply for their production.

20 The government may decrease B100 mandate in biodiesel in case of oil palm supply shortage. Feedstock price volatility and supply shortage are key risks of B100 producers.

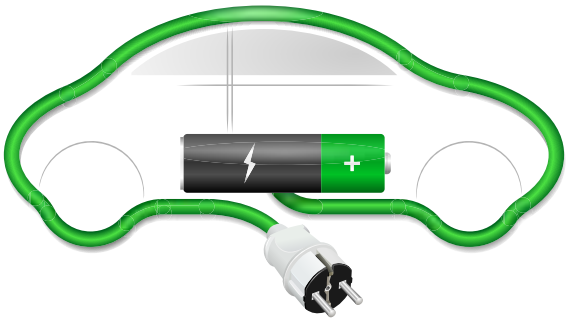


Competition from foreign competitors in oil palm industry is also likely to rise. Producers upstream of the supply chain will need to adjust accordingly. In particular, farmers and B100 producers will have to increase their production efficiency. The government has previously imposed limits on oil palm imports. There have also been tariff barriers in place to protect domestic producers, leading to artificially high oil palm prices in the domestic market. However, in the wake of the AEC, officially coming into effect on 31 December 2015, member states had to reduce trade barriers by scrapping tariffs and non-tariff measures. It is likely that oil palm and crude palm oil (CPO) from Indonesia and Malaysia will soon flood the domestic market. Not only are they less expensive, but are also better graded.

Thailand's main palm oil competitors are Indonesia and Malaysia, the world's two largest oil palm producers whose combined production accounts for 85% of global production. Despite being ranked third, Thailand produces only 3% of total world production and most producers are small-scale farmers. On the contrary, Indonesia and Malaysia grow oil palm on a large-scale basis, resulting in lower costs and higher yields. Malaysia's oil palms on average provide 20% oil content, compared to 17% for Thai oil palms. Indeed, an average of 20% of global palm oil production has been certified by the Roundtable on Sustainable Palm Oil (RSPO)[5]. Among these, 19% and 25% of Indonesian and Malaysian producers have been certified, respectively, but only 1% of Thai producers are certified. If Indonesia and Malaysia join hands to develop their oil palm technological knowledge and successfully produce B100 Thailand will be worse off and trail its competitors even further.

Liberalized imports of raw palm oil and B100 will severely affect sales of domestic farmers and B100 producers whose prices are generally higher. Players in this industry must therefore find ways to increase yields and lower unit costs as much as possible to remain competitive against foreign competitors.

Electric vehicles (EV) pose another challenge to the biofuel industry in the long run. Electric vehicles are set to become an appealing alternative to drivers looking for environmentally-friendly options and those looking to cut down on gasoline costs. The biofuel industry should keep a close watch as these developments will pose a challenge to their business. Currently use of electric vehicles in Thailand remains very limited, accounting for 0.3% of cars using gasoline and natural gas. This is due to several factors: the limited number of charging stations, the long time period required to fully charge an electric car, as well as the lack of consumer confidence in the technology and maintenance service. However, electric vehicles' popularity is likely to rise in the future, as the technology gains more widespread acceptance. Car manufacturers have started using new battery technology, which allows faster charging time, and more charging stations are in the works. The luxury car brand BMW already provides two BMW i pure Wallbox charging stations in Bangkok. They provides free charges to the i series cars. More stations are planned in department stores and five-star hotels in the future. Meanwhile, the electric car brand Tesla is gearing up for the Thai market, with Supercharger stations planned in approximately 120 gas stations nationwide. In addition, the government has set the target goal of 1.2 million electric cars by 2036, with supporting measures such as battery R&D funding, public transport piloting, provisions of more charging stations, and the setting up of specific electrical billing rates for electric vehicles. The growing trend of electric vehicles use will negatively affect oil and biofuel consumption.



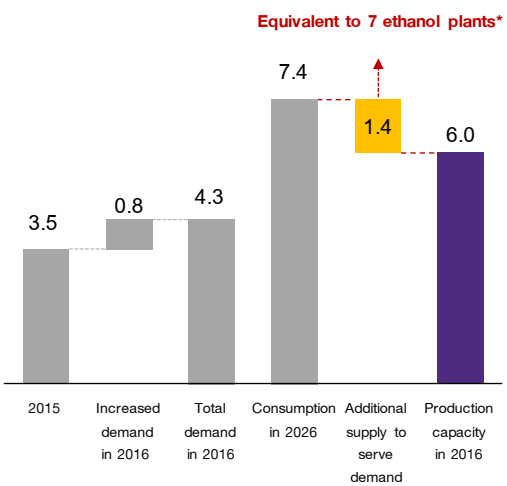
[5]Producers of RSPO-certified palm oil have an advantage in selling to most multi-national corporations such as P&G, Unilever, Walmart, Nestlé, and Johnson & Johnson. Such firms only purchase palm oil from suppliers whose products meet RSPO standards.

EIC assesses that the biofuel industry by 2026 will have an opportunity to expand capacity in producing ethanol by 1.4 million liter per day equivalent to 7 ethanol plants[6], and producing B100 by 3.8 million liter per day equivalent to 8 B100 plants[7]. Domestic demand for ethanol will expand by 6% annually, while for B100 is expected to grow 9% annually. Though depressed oil prices remain a challenge for the future of the biofuel industry, which bears higher costs relative to the production of traditional energy. However, there are many supporting factors for sustainable development of the biofuel industry, such as environmental concerns and advantages from using agricultural products as raw materials. Moreover, there are government support measures such as maintaining a price margin between benzene and gasohol, and reducing gasoline types, especially those with low ethanol content. In particular, there are plans to cease gasohol 91 E10 sale, to increase the proportion of B100 in diesel from 7% to 10%, and to develop FFV cars, etc.

21 Biofuel businesses are presented with opportunities to expand capacity

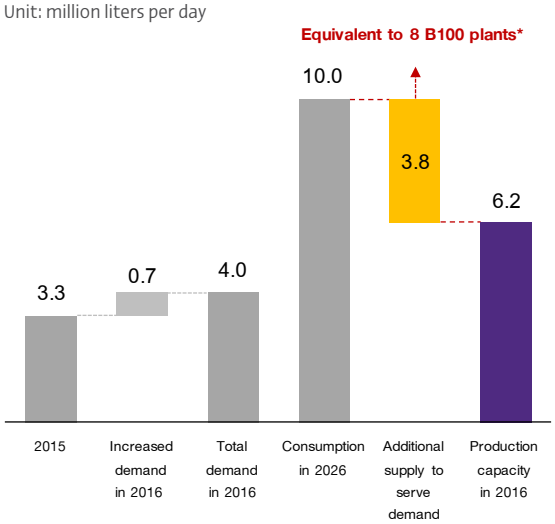
Ethanol demand and supply forecast

Unit: million liters per day



B100 demand and supply forecast

Unit: million liters per day



Source: EIC analysis based on data from Ministry of Energy

[6] Assuming that one ethanol factory has an average production capacity of 0.2 million liters per day at 100% capacity utilization.
[7] Assuming that one B100 factory has an average production capacity of 0.5 million liters per day at 100% capacity utilization.

What are the success factors in the biofuel industry?

Success factors for ethanol and bio-diesel producers are the ability to fully integrate the whole upstream and downstream supply chain, diversify risks on feedstock, produce of economies of scale, and emphasize high value-added products. In the past, the biofuel industry has seen both successful producers and those who did not make it. For example, Mitrpol, a successful ethanol producer and a leading sugar producer and exporter, applies a Sustainable Zero Waste business model. To grow sustainably, the company builds on their core business and runs ethanol factories using molasses, a by-product from the sugar production process, as feedstock for ethanol. This process has reduced risks associated with feedstock sourcing. On the other hand, Ubon-bioethanol, a large and fully integrated cassava producer and processor, can make ethanol from 3 types of raw materials, namely cassava, cassava chip and sugar molasses. Their joint venture with an oil company also assures that they always have a buyer. Moreover, the company also extended their export destinations to China, Indonesia, and South Korea.

Pathum Oil is a successful B100 producer who is now the country's largest palm oil and bio-diesel producer, allowing them to benefit from economies of scale and save on costs. In addition, the company aims to meet the production standards of the Roundtable on Sustainable Palm Oil (RSPO) by supporting RSPO certification for producers along the supply chain, including farmers and oil extraction factories.

However, there have been cases of biofuel producers who failed to compete and left the market. The number of B100 factories in 2015 fell from 14 factories in 2010 to 10 factories, with total production capacity down from 5.9 million liters per day to 4.7 million liters per day. Producers that quit were mostly small-scale with limited production capacity. They faced higher costs due to a lack of economies of scale. Their usage of only one type of feedstock made them subject to risks from agricultural price volatility. These small producers also lacked supply chain integration of upstream and downstream industries.

The biofuel industry will register robust growth due to a number of supporting factors. In particular, government policy has shown great support for production and usage of gasohol and bio-diesel over the past 10 years. For example, active policy measures have been in place to boost demand for biofuel, such as maintaining the price margin of gasohol and benzene and a continued increase of B100 content in diesel. The main goal of such measures aims at energy sustainability and higher added value for agricultural products. However, it would not be sustainable to solely rely on government policy to boost demand for biofuel. Players in the industry and new investors must be able to link upstream to downstream production processes, sustain feedstock supplies, and lower unit costs by achieving economies of scale. As a result, they will raise their competitiveness level as compared to fossil-fuel production as well as foreign competitors.

Box: Ethanol industry in Brazil: a success case for energy sustainability

As we look at policies for energy security in other countries, particularly those using ethanol in transportation, Brazil offers a successful case study. Brazil has the highest utilization rate of biofuel in the world. Interestingly, Brazil transformed itself from a country that relied on oil imports for 80% of total demand to an oil self-sufficient country by 2006 partly due to alternative energy produced from domestic resources. **What lies behind Brazil's successful promotion of ethanol usage?**

The success of Brazil's adoption of biofuel such as ethanol mainly came from government policy. The oil crisis in 1973, when oil prices quadrupled, prompted the Brazilian government to launch the Próalcool Program to support the production and widespread usage of ethanol as an alternative energy source, with the aim of reducing fossil-fuel dependency. The program started out with guaranteed purchases of ethanol by Petrobras (Brazil's national oil company), soft loans for investment by sugarcane farmers and ethanol producers, and fixing the selling price of ethanol at 59% of benzene prices as the government provided subsidies to ethanol producers. This provided an incentive for drivers to fill their tanks with gasoline with ethanol content. Moreover, the government issued legal regulations mandating the blending of ethanol content in benzene that applied to all gasoline sales across the country.

Such policies boosted ethanol production during the past 30 years from 3.8 to 24 billion liters per year to support demand, which grew around 6% annually. The government recently approved higher mandatory blending from 25% to 27.5%. We expect demand for ethanol to increase by 4-5 billion liters per year, equivalent to an increased demand for sugarcane of 7-8 million tons per year.

Brazil has an advantage in an abundant supply of feedstock and continued biofuel R&D. With suitable agricultural land and weather for sugarcane production, Brazil's sugarcane yield is the highest in the world. Therefore, Brazil has large quantities of low priced feedstock for biofuel. It is therefore not surprising to see Brazil as the world's largest sugarcane-based ethanol producer, accounting for 27% of global ethanol production. Brazil can use sugarcane juice or molasses as feedstock for ethanol. This allows them to flexibly produce either ethanol or sugar. In contrast, sugarcane juice in Thailand is not allowed to be used to make ethanol.

Despite its advantage in agricultural areas, Brazil has never overlooked R&D. They have heavily invested in biofuel R&D, making Brazil the most efficient sugarcane grower in the world. They have increased sugarcane yields by 4% annually while Thailand's yields have fallen by 0.19% annually (from 12.19 tons per rai in 2011 to 12.1 tons per rai in 2015). Moreover, Brazil developed sugarcane varieties that yield higher sugar and ethanol content as well as better disease resistance as sugarcane production expanded to other areas of the country. Moreover, the latest cellulosic ethanol production from a sugarcane program is now commercialized in Brazil. This new technology can increase ethanol production by 30% compared to existing methods.

Another success factor stems from the demand for ethanol from FFV users. Brazil's automobile industry worked together and developed flex-fuel vehicles (FFV) during the 2000s. FFVs can operate on many fuel types, such as benzene, benzene with ethanol content (e.g. E20 and E85), and pure 100% ethanol (E100). Vehicle drivers were assured that there would be no harm to their engines by running their vehicles on ethanol. The government also provided tax credits to FFV buyers. Moreover, government policy made ethanol-mixed gasoline cheaper than benzene. As a result, FFVs have consistently gained popularity, as reflected by 52% annual growth in FFV sales over the past 10 years. This has in turn further raised demand for ethanol. To date Brazil has produced more than 160 models in 13 brands of FFVs, making Brazil the country with the most FFVs in the world. There are 21 million FFVs, or 62% of Brazil's total passenger and pick-up vehicles. By 2020, the ratio of FFVs in the country is expected to reach 81%, prompting demand for ethanol in Brazil to double.

However, alternative energy in Brazil has faced challenges from raw material shortages and oil price volatility. When global sugar prices peak, businesses tend to use sugarcane to make sugar rather than ethanol. This results in a shortage of ethanol and increases the need for ethanol imports. The government also has to temporarily lower the mandatory blending of ethanol. Similar to when crude oil prices are low, benzene prices also fall, threatening the competitiveness of ethanol producers. The government has to provide significant subsidies to make ethanol prices lower than benzene prices.

Let us now look at Thailand – a country that shows a great potential in developing biofuel for long term energy security. The Thai government has been actively promoting the production and usage of gasohol for more than 10 years. This is reflected in 24% annual growth in demand for ethanol during 2010-2015. However, the goal of the Alternative Energy Development Plan 2015 (AEDP 2015) suggests a level of ethanol production at 11.3 million liters per day by 2036, tripling the amount of current ethanol consumption. To reach this goal, the government must support R&D in order to increase sugarcane and cassava yields as well as increase the ability to produce more ethanol given the same feedstocks. In addition, the government should be proactive in supporting usage of gasohol with a high ethanol content such as E85 and promoting FFVs, which will in turn boost demand for ethanol.

3

Biomass Power Plants in Thailand Power Industry

Thailand has a great potential for biomass power plants as residues from agricultural activities have not been fully utilized. This reason partly supports why investors are becoming more interested in this industry. Moreover, government policy is another supporting factor for this industry through energy security plans and reduction in agricultural waste. Nonetheless, investors' main concerns are price and supply of feedstock to support power plant operations.

Electricity Production from Biomass Power Plant

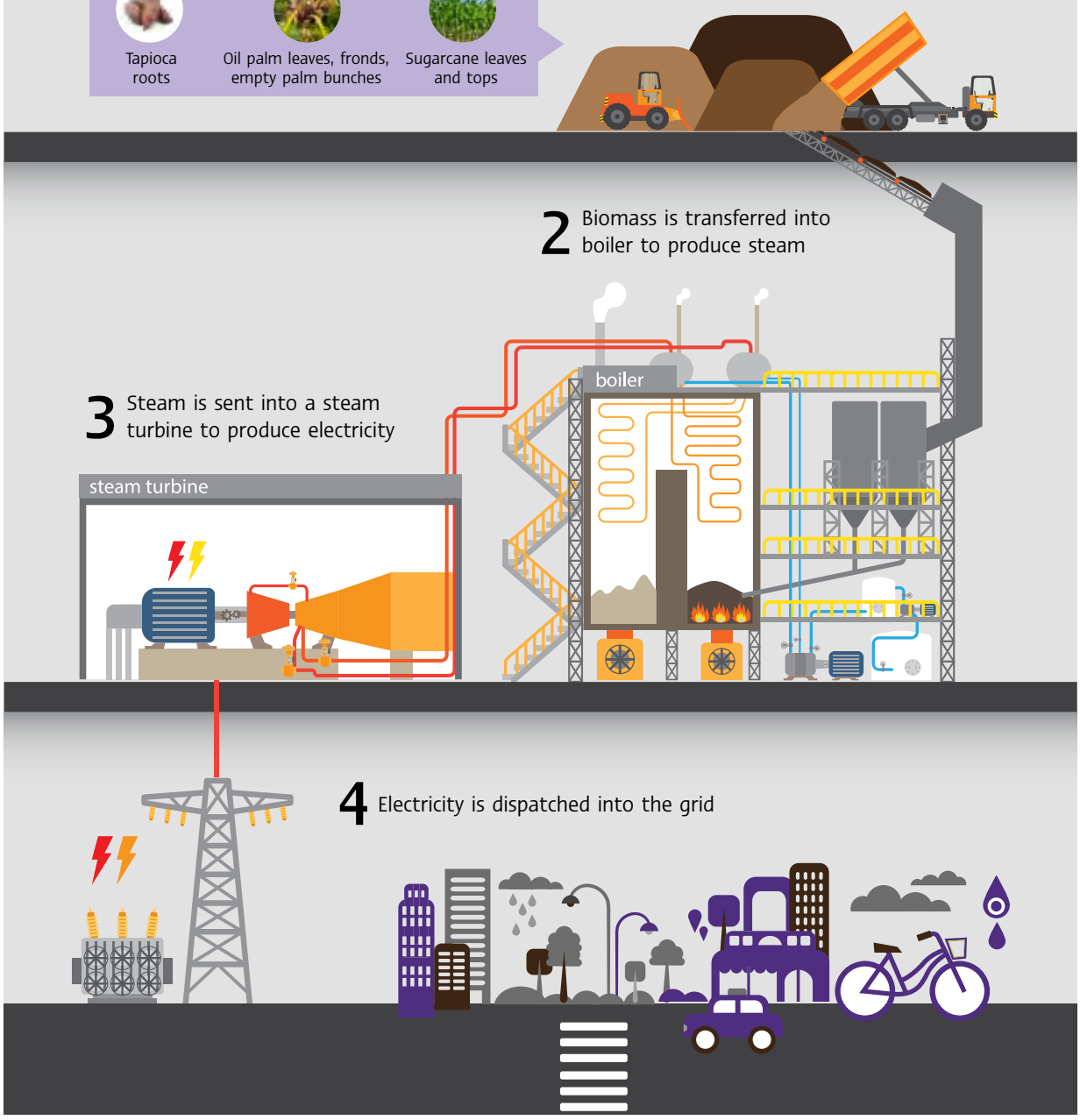
Currently, biomass power plants have played an important role in reducing energy dependency and adding value to agriculture waste

Agricultural waste used in biomass power plants in Thailand

1 Agricultural wastes are collected and used for feedstock in biomass power plants

2 Biomass is transferred into boiler to produce steam

3 Steam is sent into a steam turbine to produce electricity



4 Electricity is dispatched into the grid

Why should Thailand use biomass for electricity generation?

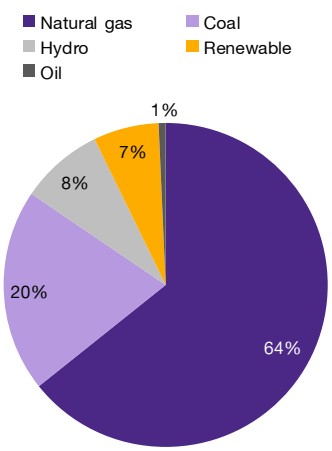
To achieve energy security, the Thai government must increase electricity production that is based on domestically available resources, including biomass. Currently some 64% of Thailand's electricity generation relies on natural gas due to the stable and dispatchable nature of natural gas power plants. Recently, domestic production levels of natural gas have been declining; therefore, power plants have to increasingly rely on imports of natural gas. This has resulted in higher costs and fluctuating prices. In response, the government plans to diversify the country's energy dependency to other sources in order to ensure better energy security. According to Thailand's Power Development Plan for 2015-2036 (PDP 2015), by 2036 20% of total electricity production should come from renewable energy.

One advantage of biomass power plant compared to other types of renewable energy such as wind and solar is control. With stability and controllability regarding production, biomass is one of the most viable renewable energy alternatives to replace natural gas. In Thailand, biomass also has large room for growth as agricultural waste is still under utilized. In comparison to solar energy that is only available during the day time and wind energy whose installation is only possible in limited areas, biomass can be used to generate electricity with greater stability because it can run at all times.

22 Currently Thailand's power generation is heavily reliance on natural gas. The government plans to reduce natural gas reliance through renewable energy

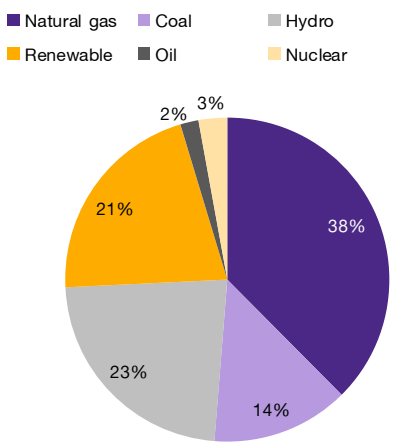
Fuel mix in power generation (2015)

Unit: %



Fuel mix in power generation (2036)

Unit: %



Source: Ministry of Energy

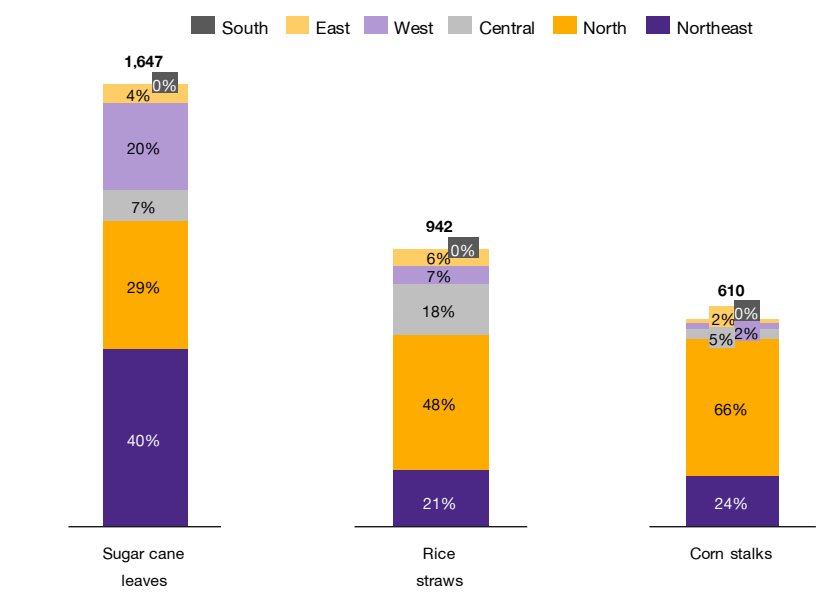
What are the opportunities and strengths of the Thai biomass industry?

There are many areas in Thailand with considerable biomass potential. Agricultural residues in these areas can be used as biomass to generate heat or electricity. According to a survey and assessment of biomass potential by the Department of Alternative Energy Development and Efficiency, Thailand's unutilized biomass potential is higher than 3,940 MW, most of which comes from sugarcane leaves and tops. Concentrated in the Northeastern region, the unused sugarcane leaves and tops can potentially produce 1,647 MW of electricity. Rice straw is the second most unused agricultural residue, with a potential to generate 942 MW of electricity. Over 66% of these materials are in the Northern region. Ranked third are by-products from corn production, including tops, leaves and stalks, which can potentially generate 610 MW of electricity. These again are concentrated in the Northern region. Moreover, other biomass sources such as tapioca roots, oil palm leaves, fronds, and empty palm bunches, can generate electricity equivalent to 226 MW, 201 MW and 112 MW, respectively. This potential electricity generation shows Thailand's spare capacity in biomass electricity.

23 Sugarcane leaves, rice staws, and corn stalks are the most common feedstock for biomass power plants

Installed capacity from top 3 biomass feedstock

Unit: MW

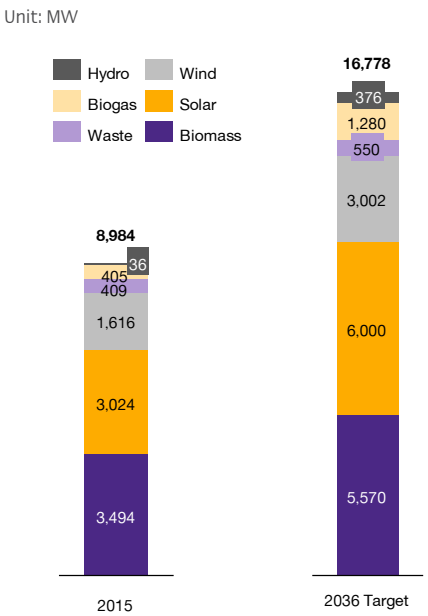


Source: EIC analysis based on data from Ministry of Energy, Department of Alternative Energy Development and Efficiency

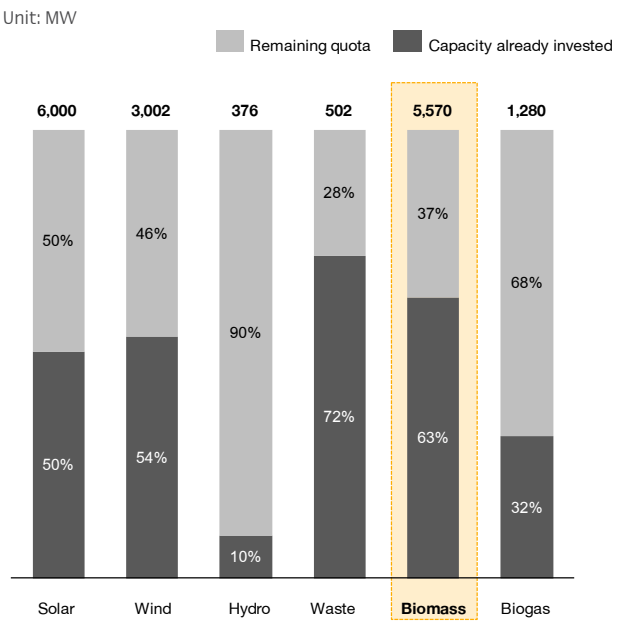
The government has given top priority to the biomass electricity industry, with an investment quota of over 2,000 MW remaining. Electricity production is among the industries under government control, given its impact on the stability of the domestic economy. Hence, the direction of investment and operations in the industry depends on government policy. In 2015 the Ministry of Energy conducted a thorough review of energy production plans, including the ADEP 2015-2036 that emphasizes various forms of alternative energy. The plan emphasizes the roles of different energy sources, according to the potentials of fuels remaining in the country, as well as their social and environmental benefits. Biomass energy received second priority after waste energy, because the problem of household waste is at the top of the government's agenda. As such, an investment quota of 5,570 MW has been provided for biomass power plants between 2015-2036. EIC expects the remaining quota to support continued investment in biomass power plants.

24 Currently biomass power plants represent 39% of total renewable installed capacity; however, over 2,000 MW quota still remains

Renewable energy installed capacity



Remaining quota against target



Source: EIC analysis based on data from Ministry of Energy, Department of Alternative Energy Development and Efficiency

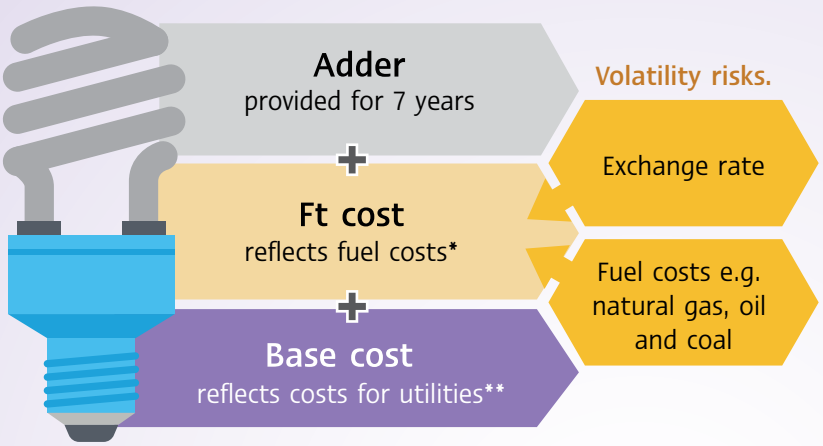
The switch in financial support schemes from the original Adder[9] system to the FiT[8] systems shields biomass power plants from the volatility of oil and natural gas prices. Under the Adder system, revenue that producers receive from electricity prices depends on the Ft[10] cost, which in turn changes with the cost of fuels in the whole electricity production system, most importantly that of natural gas. In the past year, natural gas prices have fallen sharply, biomass producers have been affected by lower revenues per unit, leading in many cases to shutdowns and takeovers. This was particularly the case among plants that have been operating for more than seven years where the Adder contracts have expired. The switch from the Adder system to the FiT system will ensure fixed revenue per unit for investors. Under the new system, electricity prices will depend on the actual cost of fuel relevant to each particular energy type. This means that the cost of other raw materials, including oil and natural gas, would not affect the revenue of biomass electricity producers. Moreover, the variable FiT is indexed to core inflation, providing a buffer against changes in the price of agricultural residues; compared to the Adder system, will help boost confidence among new investors interested in biomass energy.

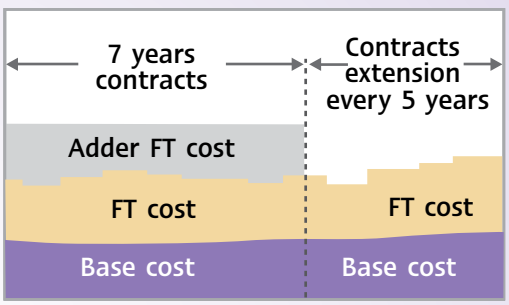
[8] FiT (Feed-in-Tariff) is a scheme that pays a fixed price per unit throughout the length of the program.
[9] Adder is a scheme that buys specific types of electricity by topping up from the base price.
[10] Ft (Fuel Adjustment Change) costs that utilities cannot control such as fuel prices, inflation, and foreign exchange rate.

Comparison of revenue structure for biomass power plants

Adder scheme

Under the old Adder scheme, power plants are exposed to fossil Fuel (eg. oil, natural gas and coal) price

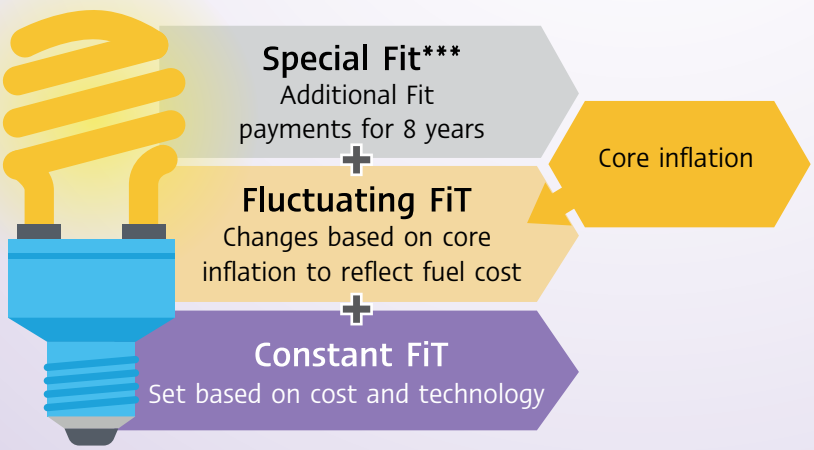


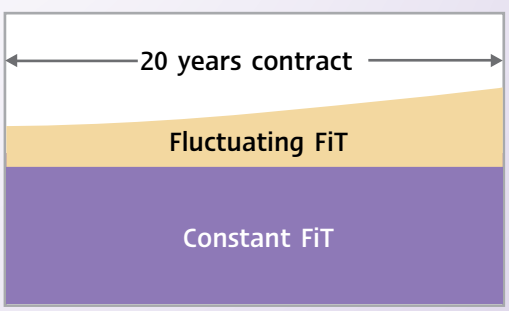


* Costs of electricity based on fuel costs and policy costs. Changes every 4 months
** Capital costs of power plants, transmission and distribution and operating costs

Feed-in-tariff (FiT) scheme

The new FiT scheme eliminates risks associated with fossil fuel price fluctuation





***For Yala, Pattani,Narethiwas and Thepha, Sabayai, and Nawi districts in Songkhla province

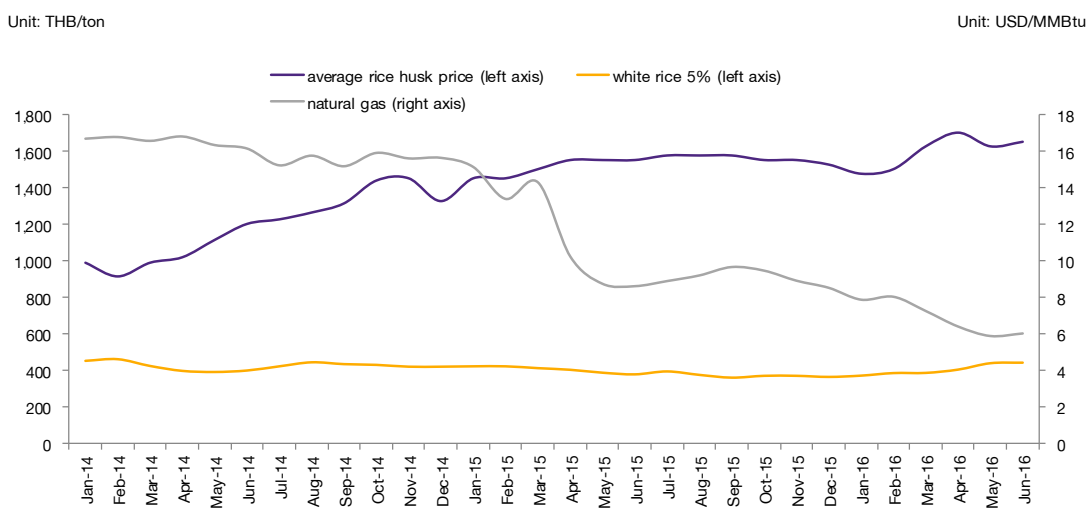
What challenges lie ahead for Bio Power?

The main challenges to the development of bio power plants include the acquisition of feedstock and fluctuations in feedstock prices. Feedstock supply is integral to the operation of biomass power plants. The biomass power plant industry took off in 1997, before any financial support from the government was in place. At the time, most plants relied only on sugarcane and rice husks, which are waste materials from sugar factories and rice mills. As such, facilities were only designed for these types of feedstock. Although nowadays the plants have been adjusted to fit with a greater variety of feedstock, acquiring these materials has proven difficult for power plants without their own agricultural business. In particular, the problem intensifies in areas with high demand or during the off-harvest season. With expensive transportation costs of feedstock compared to the amount of electricity they can generate, purchasing raw materials from a distant source is not commercially viable.

Apart from the acquisition of agricultural residues, the fluctuation in raw material prices is another risk factor that investors should recognize. This could prove particularly challenging for new plants that do not have their own supply of agricultural residues, and thus have to rely on purchases from farmers or other investors. Movements in prices of different materials can vary. For instance, the price of rice husks usually fluctuates between 500 and 1,600 baht per ton, depending on supply and demand. Moreover, it has no relation with the price of rice or natural gas. Factors that contribute to higher feedstock prices include the following: 1) demand surge from an increase in the number of power plants, 2) uncertainties in agricultural supply. The latter could be affected in some years by natural disasters such as droughts, making it difficult to meet demand from bio power plants.

25 Rice husk price does not move in steps with rice price or natural gas price

Rice husk price, natural gas price, and rice price



Source: Energy for environment foundation (EforE) and Bloomberg

New power plants additions are limited by the supporting transmission infrastructure. Due to the success in government policies supporting biomass power plants and other renewable energy, the transmission infrastructure has not been able to keep pace with new additional capacity of power plants. As a result, some new plants were unable to sell the electricity they generate. More recently, however, the government has started to dictate where power plants can be constructed based on the availability of transmission and substations. As a result, such change has limited the location selection of power plant and intensity competition among power plants developers.

EIC believes that investment in biomass electricity can quickly break even if feedstock can be effectively managed. In addition, biomass power plants can provide additional value to agricultural sector. Biomass electricity production can break even within 7-8 years if sufficient amounts of feedstock are acquired beforehand and the timing of purchases is planned so as to ensure low production cost. In addition, the switch to the FiT revenue structure will increase per unit income by as much as 40% for biomass energy producers. Given such high potential and the remaining 2,000 MW government support quota, the biomass energy industry will invest more than THB 120 billion in additional investment if the quota is used up. In the process, it will also support agricultural sector income as well as feedstock suppliers.

What are the key success factors for Bio Power?

Since feedstock cost contributes to around 45-50% of the total revenue of a biomass power plant, management of raw material balance throughout the project's life is critical for success. The three important aspects of raw material management are as follows:

1. An evaluation of the potential of feedstock supply in the area surrounding a biomass power plant. Transporting biomass feedstock is one of the challenges facing the biomass business. Due to low density of the materials, the volume transported is not worth the transportation cost. As a result, plants often source the needed feedstock from surrounding areas. Therefore, when planning a power plant the potential supply of feedstock from nearby areas has to be taken into consideration in order to avoid shortages that will directly affect electricity production and income. Hence, investors, particularly those without their own supply of raw materials, need to examine the potential feedstock in the area in comparison to the amount demanded by the plant of the size being planned.

2. Management of feedstock supply to ensure uninterrupted electricity production throughout the contract period. Biofuel investors who do not own fuel supplies face important challenges in acquiring sufficient agricultural waste materials, and from volatile fuel prices. Supply shortage and high costs of feedstock can directly impact electricity production and immediately impair profits. Feedstock prices also depend largely on supply and demand, both of which are difficult to control. Amidst these risks, effective management of fuel supplies is key to success. A number of strategies can be used to aid in management. 1.) Bulk acquisition of feedstock when prices are low, such as during harvest season when there is excess agricultural waste materials. Regular monitoring of prices is necessary. 2) Storage for feedstock to be used during shortages of agricultural waste materials. On average, supply of feedstock should cover at least 15 days of electricity generation. 3) When feedstock is expensive or in short supply, different types of feedstock can be mixed together to lower costs. However, since different feedstock have different combustion reaction, plants that operate with many types of feedstock will require more frequent maintenance than those that operate only with one main feedstock.

3. Relationship building with feedstock suppliers and farmers. Biomass business owners should emphasize relationships with local farmers to benefit both their business and the farmers. Collaborations can be useful, for instance, in upgrading farming quality and expanding farming areas. These efforts will not only generate higher production and income for the farmers, but also increase the supply of agricultural waste that biomass power plants need. One way to maintain a relationship with feedstock suppliers is to settle long-term trade contracts at fixed prices. Such agreements would help power plants avoid uncertainties associated with price volatility and the acquisition of feedstock which depend on demand and supply conditions. Moreover, it provides price guarantees for feedstock suppliers.

In sum, Thailand still possesses tremendous potential for bio power electricity. The government has also made bio power one of its top priorities, with over 2,000 MW worth of investment quota remaining. However, the risks stemming from acquisition and prices of feedstock may hurt investment returns if careful management is not put in place. Despite such risks, a number of strategies can offer important solutions for success. These include evaluation of potentials, feedstock management, and relationship building with suppliers. In addition, outsourcing machine operations and plant maintenance is another way to eliminate problems concerning feedstock.

Box: Wood pellet exports offer another opportunity for biomass business

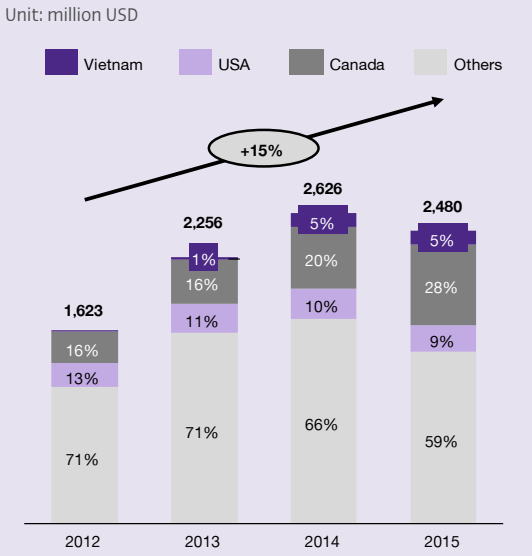
Wood pellets are a type of highly efficient biomass fuel that allows for control of quantities used and heat generated. Wood pellets are made of sawdust and residual materials from lumber production or tree trunks. They are commonly produced in the wood industry because of their low moisture and higher fuel efficiency, around 19 MF/kg[11], compared to 15 MJ/kg for other biomass feedstock. Also, their small and regular cylindrical shapes allow users to easily calculate and control the amount of heat generated. In addition, transporting wood pellets is convenient and cheap, due to their higher density compared to other types of biomass. Lastly, wood pellets produce less ash compared to other biomass feedstock, so the cost of ash disposal is saved while air pollution is reduced.

Vietnam has benefitted from the growing global wood pellets market, having gained a larger market share in South Korea. Global exports of wood pellets have grown by 15.2% on average since 2012, reaching USD 2.48 billion in 2015. The three top exporters are the United States, Latvia, and Canada. In ASEAN, Vietnam has successfully increased its export value over the past years, mainly by taking some market share from U.S. in South Korea, where price competition is high. Vietnam now contributes to 5% of global exports, making it the 7th biggest exporter in the world. In Thailand, the supply of wood pellets account for just 0.11% of global exports. And like Vietnam, Thai producers rely mainly on the South Korean market. In 2015, however, Thai exports to South Korea have fallen significantly. Nevertheless, exports to other markets, such as North Korea, China, Cambodia, Australia, and Saudi Arabia, have picked up, although these markets still constitute a very small share of the country's total exports.

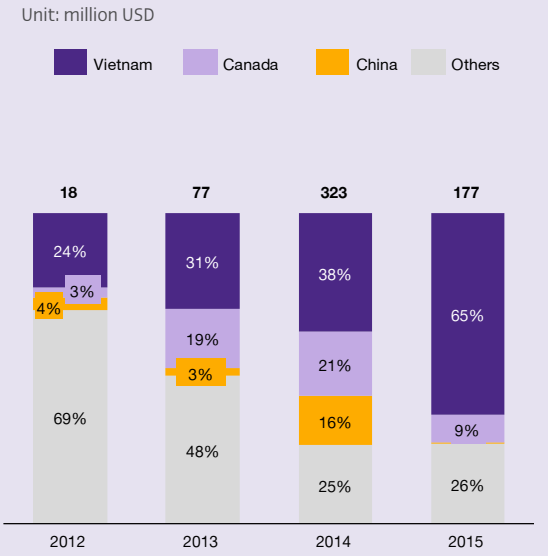
[11] Unit of energy density where 3.6 MJ equals to 1 kwh

26 Wood pellet trading has grown globally; in the past 4 years Vietnam has gained significant market share in Korea

Global wood pellet export value



Korea wood pellet import value



Source: EIC analysis based on data from Trademap

The advantage of Vietnamese wood pellets comes from their cheap price, thanks to the low production costs of a large number of small producers. Export of wood pellets from Vietnam has thrived because it has successfully expanded into South Korea by undercutting other exporters' prices. Vietnam can compete on cost due to the sourcing of wood scraps from the furniture industry. Vietnamese furniture industry is the second largest in Asia, the industry is made up of small and medium-sized wood factories, totaling over 3,000 firms. More than 90% of wood pellet factories, also very small in size, are situated nearby. Middlemen buy the output from each small factory and ship it to South Korea. Freight costs can be saved by using cargo ships that have been used to import electrical appliances. In 2015 Vietnam received as much as USD 120 million from exports of wood pellets.

Production of wood pellets, both for export and domestic consumption, is another attractive opportunity in biomass energy for investors in Thailand. Those with businesses related to the wood industry in Thailand should consider investment in wood pellets. Opportunities abound because in addition to global demand that is projected to grow by more than 15%, domestic demand for wood pellets is also on the rise, thanks to the PDP 2015 plan. As biomass power plants add up to 5,570 MW capacity, demand for fuels will surge. In the near future, therefore, the use of wood pellets, with superior efficiency and ease of transportation, will surely become more widespread.

4

Riding the Green Consumer Wave with Bioplastics

Bioplastic, an alternative plastic made of bio-based materials that decompose naturally and is environmentally friendly. The bioplastic industry is expected to expand rapidly, becoming a new dimension in the plastic industry and playing a crucial role in our society and economy. This is because bioplastics will not only help reduce environment problems, but also creates investment and add value along the value chain. Given its readiness in terms of production chains, Thailand has a strong potential to become the center of the ASEAN bioplastic industry going forward.

Bioplastics overview

Do you really know?

These packaging are produced from Bioplastics which were derived from agricultural feedstocks.

Agricultural feedstocks

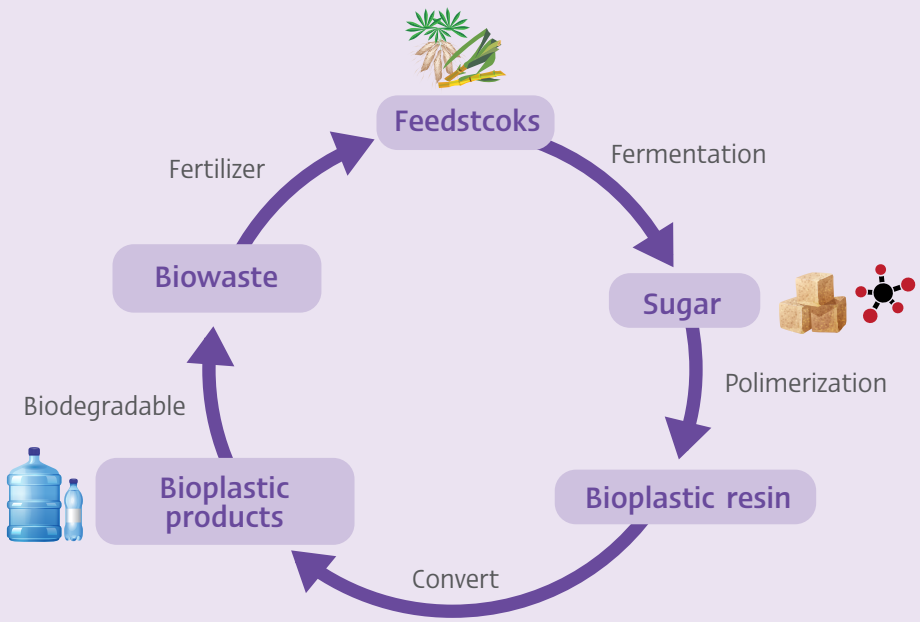
cassava

sugarcane

Go Green Society

Nowadays Bioplastics products is expected to become a new dimension in the plastic industry and play a crucial role in our society and economy. This is due to helps reduce environmental concern and also creates value added to agricultural feedstocks which is an important industry of Thai's economy.

Bioplastics life cycle



Why do we need the bioplastics industry?

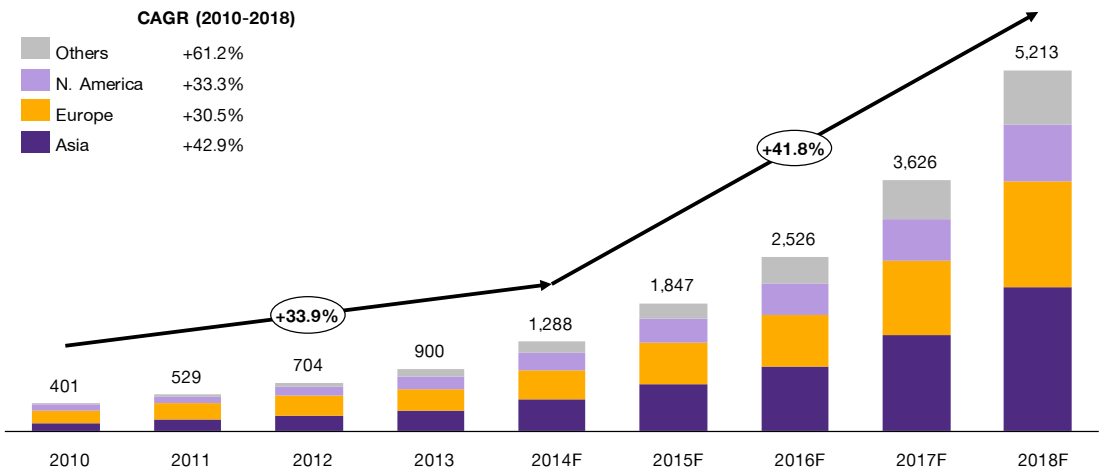
Thailand must adapt to cope with the changing consumption trends of plastic users around the world due to the industry's heavy reliance on exports. Global eco-friendly trends and environmental problems caused by plastic products are driving Thailand's main plastic trading partners like the U.S., Europe, Japan, and China to start erecting trade barriers on standard plastic products and supporting their replacement with more environmentally friendly biodegradable[12] plastic. Some examples are the US setting a target to increase the use of bioplastics in the country from the current rate of 12% to 20% of total plastic use by 2020 and similarly for Japan, which set a goal of raising bioplastic use to 20% by 2020.

Such factors have seen the consumption of bioplastics around the world surge by 30% per year over the past 5 years. The current rate of bio plastic consumption is 1.3 million tons per year, which is equivalent to 0.5% of the world's total plastic consumption. Given such a rate of expansion, bioplastic consumption is expected to triple within 5 – 10 years, reaching a level of 5 million tons per year, or 3% of the world's total plastic consumption. Therefore, as Thailand exports more than 60% of its plastic production, Thailand's plastics industry needs to adapt in order to keep pace with the changing consumption trends. The Thai government has already recognized the importance and potential of the bioplastics industry by categorizing the industry as one of the new wave Industries, or S-curve industries. By doing so the government aims to enhance the efficiency and capacity of the bioplastic industry in Thailand as well as to send signals to the private sector to start adjusting and developing themselves in order to maintain their competitiveness.

27 Demand for bioplastics around the world is rising swiftly

Bioplastic demand by region

Unit: thousand tons



Source: EIC analysis based on data from ICIS

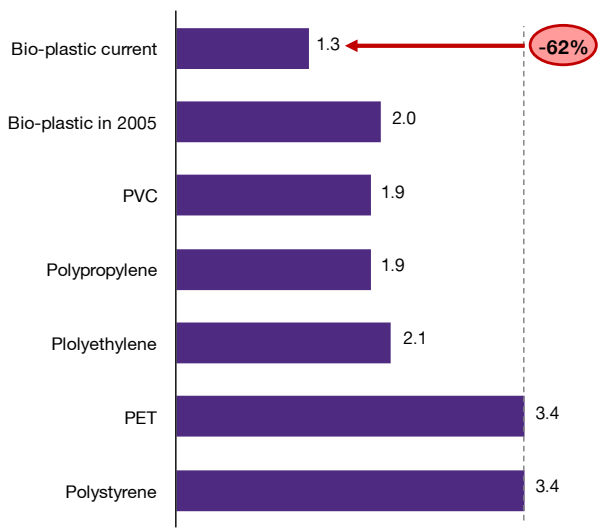
[12] Biodegradability is the ability to naturally and completely decompose through natural microorganisms given the right environment and temperature.

Moreover, bioplastics can also alleviate environmental problems in Thailand that are intensifying and affecting economic growth. According to a report from the Ministry of Natural Resources and Environment, Thailand currently produces more than 2 million tons of plastic waste per year, of which, approximately 1 million tons cannot be recycled and needs to go through a disposal process that takes a long time and creates severe environmental impact. Burning is the most common way to eliminate plastics. However, despite a shorter process, it can also emit a tremendous amount of carbon dioxide into the ecosystem if carried out incorrectly. Carbon dioxide is the main cause of climate change and possibly the reason for the more severe droughts and floods that have an ongoing impact on Thailand's agricultural sector and economy. The amount of plastic waste is predicted to grow by 4% - 5% or 100,000 tons per year corresponding to the growing economy and population. It is likely to reach 30 million tons per year by 2020. Given the aforementioned factors, the use of degradable bioplastics will help alleviate Thailand's plastic waste problem and lessen environmental problems in Thailand.

28 Bioplastics release 2-3 times less carbon dioxide than normal plastic.

GHGs consumption by plastic types

Unit: kg co_2 eq per kg polymer



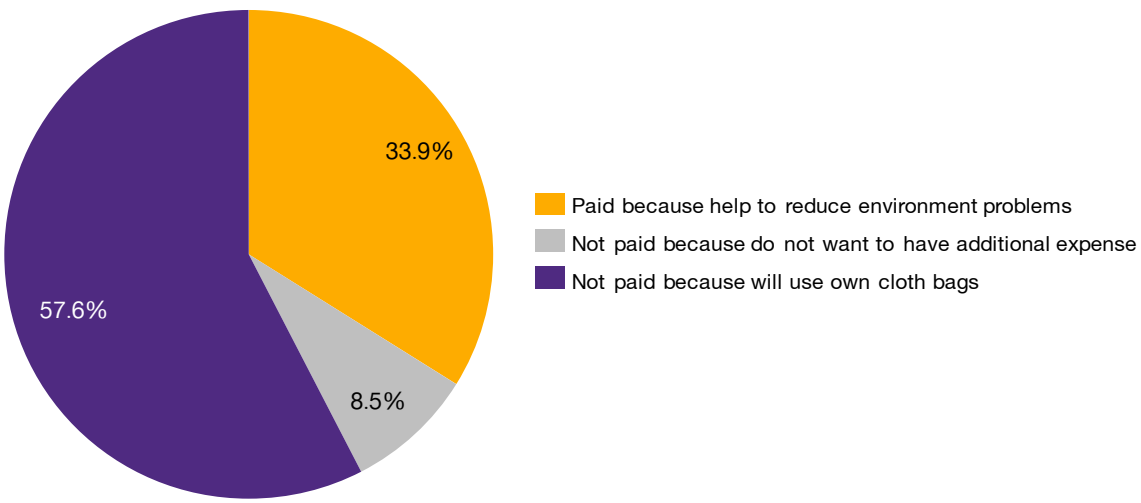
Source: EIC analysis based on data from European BioPlastics

A consumer survey of bioplastics conducted by EIC finds that Thai consumers are more interested in using environmentally friendly products, but are still at an early stage compared to leading countries like the U.S. and Europe. The results of the survey show that approximately 90% of Thai consumers are aware of environmental issues and have taken steps to reduce their use of plastic bags. a majority of 50% use cloth bags instead of plastic bags, while another 34% would pay more money to use degradable bioplastic bags. Meanwhile, in the U.S. and Europe, where the bioplastics industry is more developed, the share of consumers willing to pay a higher price for degradable bioplastic bags is 52% and 62% respectively. Thus, Thailand is still at the beginning stage, providing opportunities for bioplastic usage to grow further and expand the industry in Thailand.

29 A survey on consumer choices between bioplastic bags and regular plastic bags in daily routines

A survey on consumer choices between bioplastic bags and regular plastic bags in daily routines

Unit: %



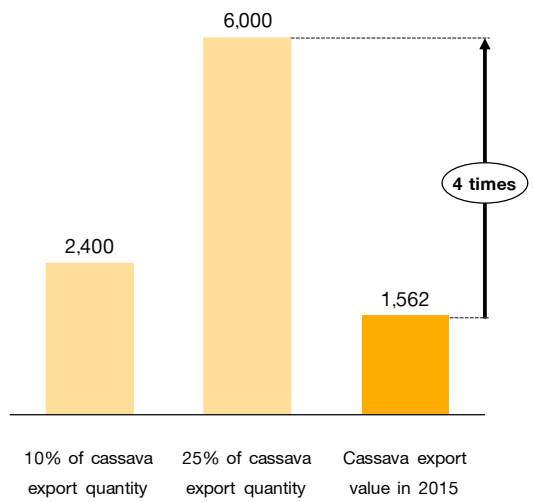
Source: EIC analysis based on a survey conducted in June 2016 with 20,883 respondents.

The construction of bioplastic plants will not only increase investment in Thailand but will also add value to industries related to agriculture and plastic converter that will help boost economic growth in Thailand. The use of cassava and sugarcane as feedstock for bioplastic production can add 3-4 times in value when compared to the production of sugar and cassava. Based on our estimation, the value of cassava will increase by 4 times if the 25% of cassava used in chips/pallet production in 2015 were re-allocated to bioplastic production. Similarly, the value of sugarcane will increase by 3 times, if 25% of the sugarcane used in sugar production were re-allocated to bioplastic production. Additionally, investment in bioplastic plants will also help expand markets to absorb more agricultural products like cassava and sugarcane.

30 Bioplastic production adds 3-4 times more value to agricultural products compared to direct exports

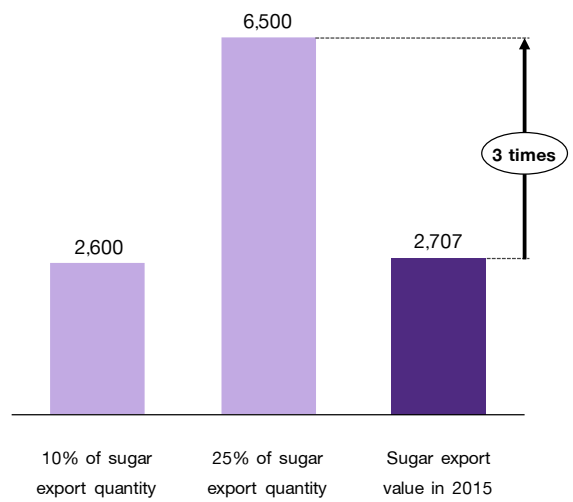
Cassava comparison of bioplastic production value and export value in Thailand

Unit: Mn. USD



Sugar comparison of bioplastic production value and export value in Thailand

Unit: Mn. USD



Source: EIC analysis based on data from the Ministry of Commerce

What are the current and future strengths and growth opportunities for Thailand's bioplastic industry?

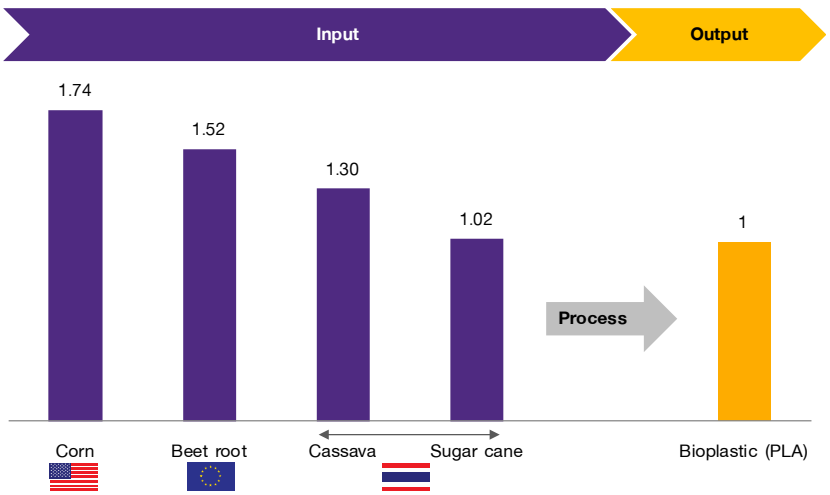
Thailand has the potential to become a leading bioplastic hub due to its readiness in terms of the quantity and quality of agricultural feedstock supply for bioplastics production, being the world's major exporter of cassava and sugar from sugarcane. In the past, the U.S. and Europe were the world's leaders in bioplastic technology and the largest producers of bioplastics. Nevertheless, due to limited supply of raw materials like corn and beets that are mainly consumed as food and high labor costs, bioplastic production has been drawn more towards the Asian region because of its abundance in feedstock like cassava and sugarcane.

Thailand's export of cassava and sugar rank first and second in the world respectively. Up to 70% of the total production of cassava and sugarcane in Thailand is exported. This reflects the fact that Thailand's capacity in producing raw materials far exceeds local demand. Nevertheless, Thailand exports these two agricultural products as raw materials or as basic processed products. Added value is therefore low and does not fully maximize Thailand's advantage in producing such materials. both are highly efficient feedstocks for bioplastic production. Sugar from sugarcane is the most efficient feedstock to be processed into Polylactic Acid (PLA) bioplastics as it can turn into PLA at a ratio of 1.02 kilogram of sugar per 1 kilogram of PLA. Meanwhile, cassava, beets, and corn are less conversion ratio respectively. Moreover, cassava and sugarcane are renewable crops and can harvest in short-term which will help to reduce risk of supply shortage. In addition, government policy supported in AEDP 2015 plan by increasing yield and harvest area of cassava and sugarcane will also help to secure feedstock supply.

31 Sugar and cassava are more efficient than corn and beet in producing bioplastics.

Sugar and cassava are more efficient than corn and beet in producing bioplastics

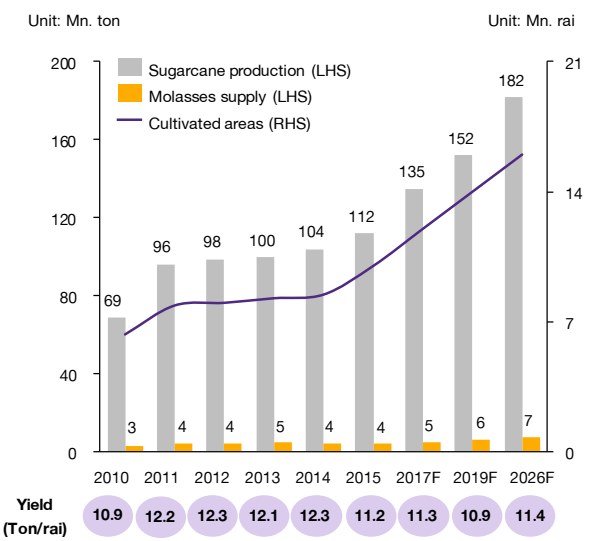
Unit: kilogram



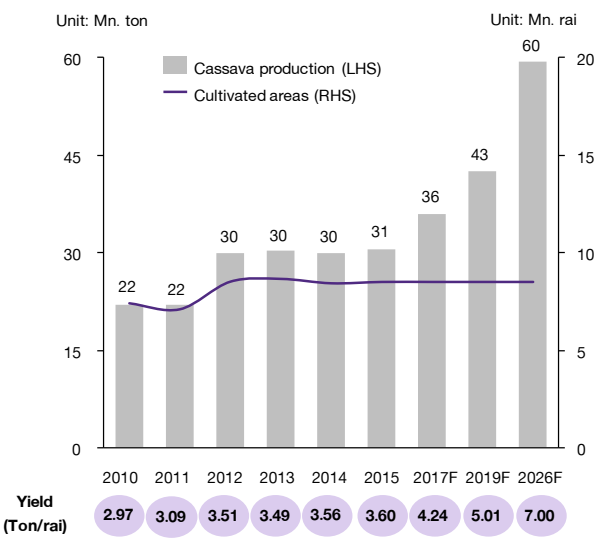
Source: EIC analysis based on data from Corbion, Economy and Environment Program for South East Asia (EEPSEA) and Office of the Cane and Sugar Board (OCSB)

32 Sugarcane and cassava supplies will likely increase due to greater plantation area and more efficient production

Sugarcane production and cultivated area



Cassava production and cultivated area

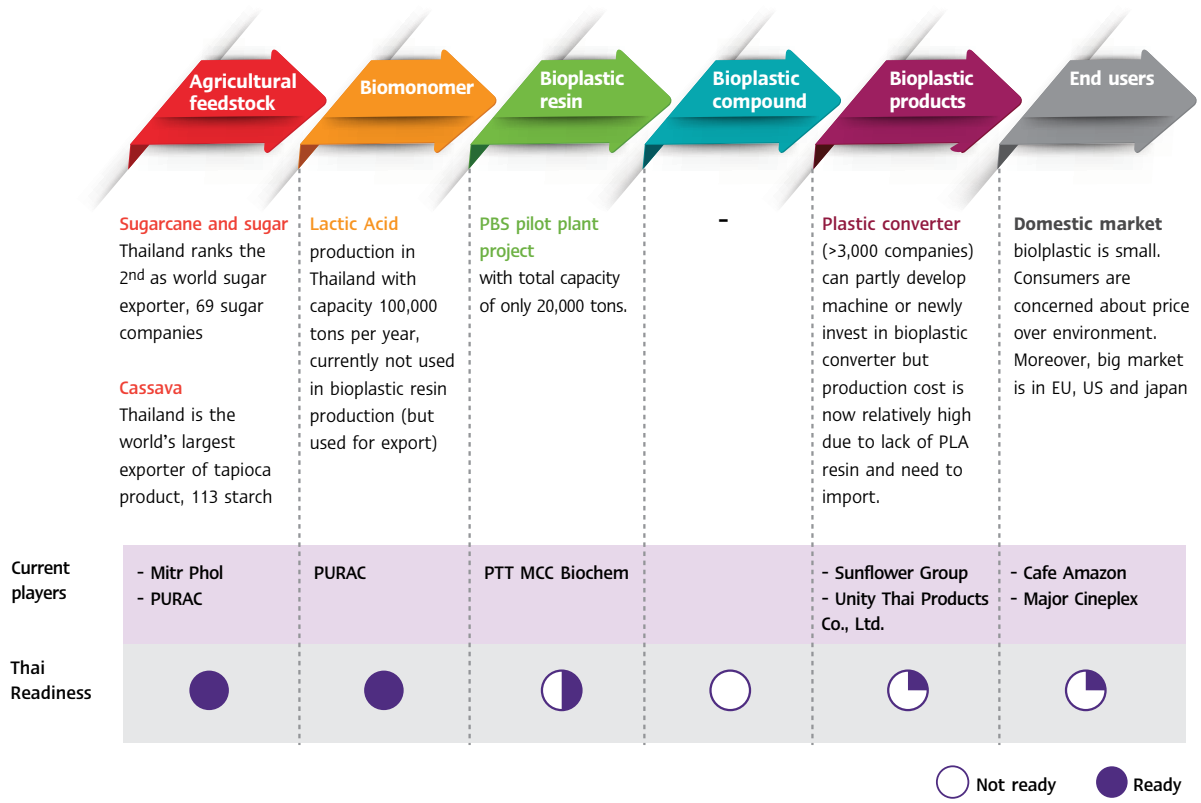


Source: EIC analysis based on data from the Ministry of Energy

The expansion of bioplastic plants will fulfill Thailand's bioplastic production chain from upstream to downstream, allowing better cost control as well as enhancing the competitiveness of the industry. Thailand has a comprehensive petrochemical industry upstream to downstream production chain as it is already a petrochemical production base. The country is also a production base for other related industries, such as the car parts and electronics industries that all use plastic components. Moreover, there are more than 3,000 plastic convertors that can easily modify their production processes to use bioplastics. Nonetheless, Thailand has only one bioplastic plant that is well integrated into the production chain, which is PTT MCC's PBS plant from PTT Groups with a production capacity of only 20,000 tons of bioplastic per year. This is a constraint that makes Thailand unable to increase bioplastic production as well as add value to related industries in the production chain. Furthermore, Thailand has to export almost all the lactic acid produced locally (approximately 100,000 tons per year) because there is no PLA bioplastic plant to absorb the supply, which limits the full maximization of Thailand's bioplastic value chainy. Therefore, it is very important that Thailand pushes forward investments in constructing more bioplastic plants in order to create synergies, help control production costs, increase opportunities for plastic convertors, and expand markets to support agricultural products.

33 Bioplastic plants will fulfill the supply chain requirements of the bioplastics industry

Bioplastic value chain



Source: EIC analysis based on data from Ministry of Energy

The government is promoting investment by issuing measures offering various benefits to both domestic and international investors investing in the bioplastics industry. Such measures will offer benefits to investors in terms of financing, R&D, and tax incentives to attract both domestic and international investment in Thailand. The government's target to promote Thailand as a bioplastic hub in Asia will quickly help develop the industry. Moreover, the government has set up an R&D center in cooperation with several international technology leaders. The goal is to enhance bioplastics' ability to decompose to meet with international standards such as the European Standard EN 13432, which is certified by Germany, and the Green PLA Standard, which is certified by the JBPA in Japan. Additionally, the government also partners with the Thai private sector, academic institutions, and private entities to support over 80 research projects with a budget of over THB 90 million. The area of research will cover all aspects in the supply chain of the bioplastics industry and focus on building new innovations that will help cut production costs and increase the efficiency of bioplastics. This will help increase the competitiveness of the industry and expand the market for bioplastics into industries where plastic is heavily used, like the electronics or car parts industries, which is another way of creating demand for bioplastics.

What are the current and future weaknesses and challenges for Thailand's bioplastic industry?

The main obstacle to the growth of the Thai bioplastic industry is high production costs. In addition, Low oil prices also put bioplastics at a further disadvantage in terms of cost compared to conventional plastics. The bioplastics industry requires large initial investments as the sophisticated production technologies are expensive, causing production costs for bioplastics to be 2-3 times higher than petroleum-based plastics. As a result, higher bioplastic prices will limit growth of bioplastic demand over the medium-term. . Furthermore, the currently low oil price also drives a greater price gap between bioplastics and petroleum-based plastics. The price of conventional plastic granules dropped substantially by roughly 30%, while the price of bioplastics only fell slightly due to a marginal decline in feedstock prices like cassava and sugarcane. Therefore, bioplastics face a cost disadvantage. For bioplastics to compete with petroleum-based plastics, oil prices will have to be higher than 90 – 100 USD per barrel.

Although the overall cost of bioplastics is very high, adaptive uses that take advantage of its biodegradable properties can reduce overall production costs in certain cases. Some examples are: biodegradable agricultural mulch films can help in reducing the cost of removing process, biodegradable garbage bags that can help reduce the cost of waste disposal, and the use of biodegradable medical supplies that eliminate the need for removal surgery. Furthermore, the eco-friendly consumers will essentially concern about environmental impact first. Thus, price is not an important factor that these consumers will account for selecting bioplastic products.

34 Oil prices that have fallen by more than 70% since 2014 drove down prices of HDPE by 32%, while prices of PLA went down by merely 14%. This limited the competitive advantage of bioplastics over petroleum-based plastics.

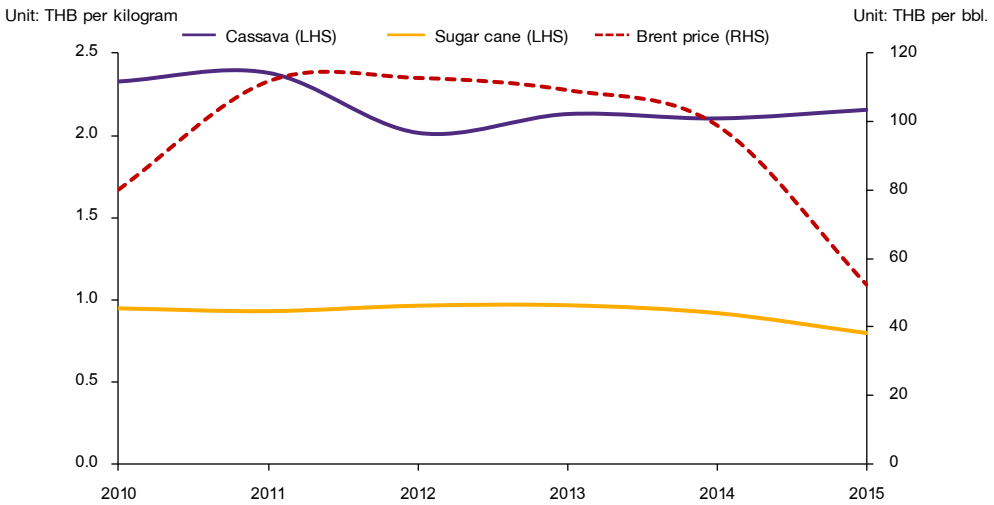
Comparison of conventional plastic and bioplastic

Unit: USD per ton

Source: EIC analysis based on data from Argeni, Bloomberg และ European BioPlastics

35 Prices of agriculture raw materials in Thailand were not affected by low oil prices.

The movement of sugarcane, cassava and oil price



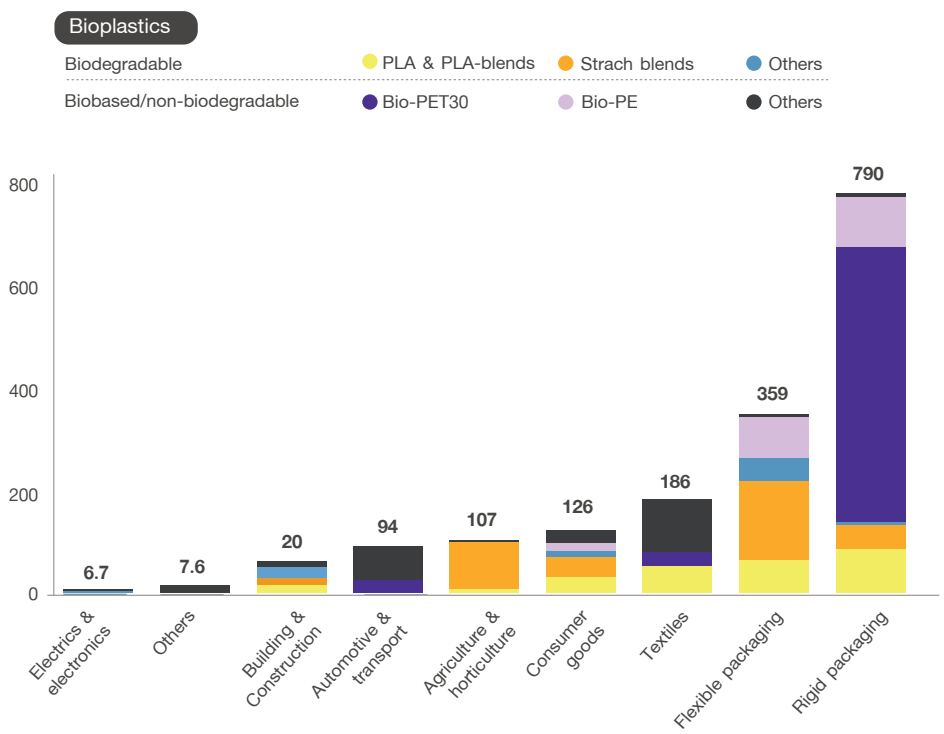
Source: EIC analysis based on data from Bloomberg, OCSB and Office of Agricultural Economic (OAE)

At present, the quality and some properties of bioplastics still limit their ability to replace conventional plastics. The current production level of bioplastics is 1.6 million tons, or only about 0.5% of the total plastics production of over 300 million tons per year. The small share of bioplastics in the plastics market is due to its lack of durability against pressure, friction, and heat. Moreover, bioplastics are not as flexible or as clear as conventional plastics and cannot be used in industries requiring these properties. About 70% of bioplastics produced is used for making bags, bottles, plates, spoons, cups, and films, since these products are generally disposable and do not require much durability. In addition, the costs of producing these products are low, so switching to bioplastics does not significantly increase costs for manufacturers.

36 Current use of bioplastics is limited to making relatively low-value products without advanced properties.

Bioplastic demand by industry in 2014

Unit: thousand tons



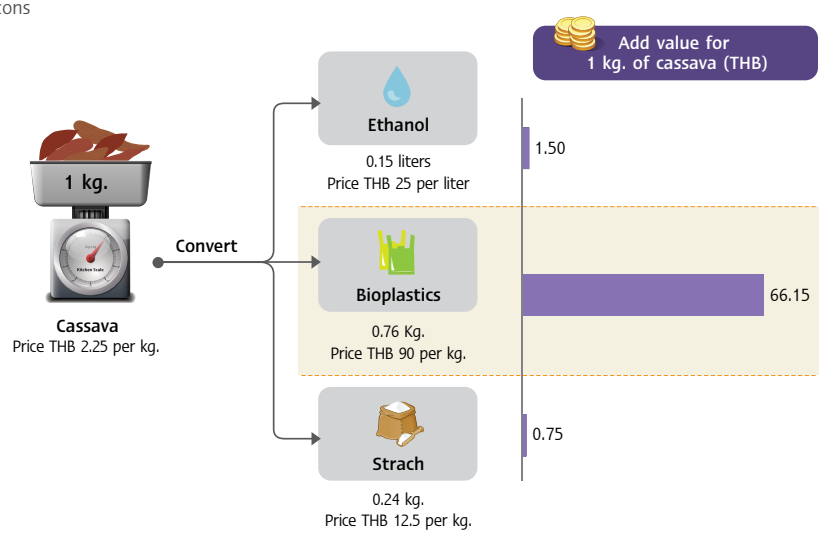
Source: EIC analysis based on data from European BioPlastics

Another challenge is the competing incentive to use agricultural materials in industries with higher demand and higher returns than the bioplastics industry. Agricultural materials like cassava and sugarcane are used mainly in the food and beverage industry to make products such as tapioca starch, sugar, and alcoholic drinks. They can also be used in producing ethanol which is then mixed with benzene to create gasohol, or used as biomass fuel to generate electricity. Although supplying agricultural materials to produce bioplastics will give higher returns per unit, there is not enough demand from the bioplastics industry due to the lack of government support and high production costs. On the other hand, biofuel and biomass energy receive considerable support from the government, leading to higher demand and thus lower unit costs. The policy also ensures market support in the energy sector and reduces risks for agricultural goods providers. Overall, the net returns in supplying to the energy market are higher than providing to the bioplastics industry, making the competition to obtain raw materials another key challenge for bioplastics businesses.

37 Bioplastic production yields the highest added value for cassava, compared to ethanol and starch production.

Cassava conversion rate by product

Unit: thousand tons



Source: EIC analysis based on data from European BioPlastics and Ministry of Energy

EIC sees that Thailand can step up as the bioplastics hub of ASEAN if a few challenges can be properly addressed. The Thai bioplastics industry has the advantage of having abundant feedstock, particularly cassava and sugarcane, for which Thailand is a leading exporter. Moreover, Thailand already has a suitable bioplastics supply chain with strong upstream and downstream industries. This includes the petrochemical industry and plastic products industries with over 3,000 players. The country is also a base for many related industries, including auto parts and electronics parts manufacturers who use plastics as key components in their production processes. Government support in bioplastics R&D as well as government investment incentives will raise around THB 17,000 million and create 47,000 jobs. These factors will help push Thailand to become ASEAN's bioplastics hub in the future. However, challenges remain to be addressed, including limitations in production technology, high production costs, disadvantages of current bioplastics properties, and competition for feedstocks with other industries with higher demand.

What will be the key factors for the success of Thailand's bioplastics industry?

Investment in R&D to improve the production technology, quality, and properties of bioplastics will be the main driver for the bioplastics industry to capture shares in the plastics market. The public and private sectors should join together to establish a bioplastics research center to provide funding for and carry out bioplastics research. The center should focus on both enhancing the quality of bio-based materials to increase output per unit and developing production technology to reduce production costs. Doing so will reduce the effects of bioplastics expansion on the food supply and agricultural areas used to grow food crops. For example, bioplastics producers can use cellulosic and biomass materials instead of agricultural products. Another important aspect is to improve the key properties of bioplastics, including toughness, heat resistance, and friction resistance. Improved bioplastics should solve the problem of high water permeability that prevents it from effectively containing liquid. R&D should also fine-tune the Stereocomplex PLA (or scPLA) technology that allows bioplastics to withstand temperatures up to 220C. When these key properties are improved, bioplastics can be used in a wider variety of applications across industries including those with higher values. For example, car manufacturers can use more bioplastics to make automobile parts and electronics makers can incorporate more bio-based materials in making tablets, mobile phones, and laptops. The above-mentioned factors will help create a sustainable shift from conventional to bioplastics and advance the growth of Thai bioplastics industry.

Another factor in creating sustainable growth for the bioplastics industry is for both the public and private sectors to employ measures to raise domestic bioplastics demand. Increasing domestic demand for bioplastics will not only help reduce the risks from the over-reliance on export markets but will also help raise the overall demand for bioplastics, which means higher quantity and lower unit costs. To increase demand, the government can implement measures such as tax incentives for retail and food businesses to use bioplastic products, such as Café Amazon switching to Bio Cups and Dairy Home using bioplastics for its yogurt cups. Beside government support, companies can help increase demand for bioplastics by replacing some conventional plastics in their products with bioplastics. For example, Tesco, a leading British chain retailer, has increased the proportion of bioplastic packaging to around 37% of its products. Tesco has also arranged a campaign involving bioplastic bags where it charged 0.5 GBP per bag to donate to disaster-affected areas. To increase demand on the consumer side, the government can bring more awareness to environmental issues and campaign for people to use more bioplastics products

Increasing concerns over environmental issues influence consumers to buy more environmentally friendly products and will bring more bioplastics into the plastics market in the near future. With the upcoming shift to bioplastics, the Thai plastics industry, which mainly depends on export markets, should prepare to adjust to this new consumption trend or it will lose the ability to compete with other plastics suppliers both inside and outside of ASEAN. The government should offer investment incentives, increase research funding for bioplastics technology, and collaborate with businesses to increase domestic demand from both businesses and households. Existing bioplastics businesses should expand their investment to cover the whole supply chain for more effective business management and should look for more feedstock sources to reduce the risks of having insufficient and unpredictable supply. They should also invest in production technology R&D and innovative products to decrease costs, increase performance, and diversify their businesses.

Box: A case study on the advancement of the bioplastics industry in Japan

Given the environmental tolls of petroleum-based plastics and the prevalent usage of plastics in key industries such as automobile and electronics, the country has been working on reducing petroleum-based plastics and shifting towards bioplastics. The movement, well supported by many organizations in the country, led to the founding of the Japan BioPlastics Association (JBPA) in 1989 to promote increased usage and bring awareness to the importance of biomass-based plastics and biodegradable plastics.

International cooperation has contributed to the growth of Japan's bioplastics industry. With a target to reduce greenhouse gas emissions by 6% following the ratification of the Kyoto protocol (the only international treaty aiming to lower greenhouse gas emissions), bioplastics were proposed as a new innovation to achieve the goal. Japan's plan to replace around 20% or 3 million tons of petroleum-based plastics with bioplastics by late 2020 has led to continued collaboration between the JBPA and bioplastics organizations in Europe, China, South Korea, and other countries to research and develop bioplastics products.

Partnerships between the Japanese government and the private sector are another key driver for creating bioplastics demand. Japan's leading automotive company, Toyota, is the world's first car manufacturer to replace conventional plastics with bioplastics in producing certain automobile parts. For example, Toyota uses bioplastics produced from sugarcane and cassava to make wheel parts and consoles. The company set up a R&D center for bioplastics with a production capacity of 1,000 tonnes per year. The center is focusing on increasing the durability of bioplastics from heat and friction while driving. If successful, it will increase bioplastics' role in the automotive industry significantly. In addition to the movement in the automotive industry, Unitika, one of the first material manufacturers to start developing biodegradable PLA pellets, has had great success in developing a bioplastic material commercially named "Terramac." Terramac can replace PET and PE in making products such as lamps, mobile phones, and laptops. It is already used in products sold under well-known brands like Toshiba, NEC, and Sony. When more businesses switch to bioplastics and demand for bioplastics grows, we can expect them to replace conventional plastics on a larger scale in the future.

However, challenges remain as Japan has to rely on costly imports of bioplastics pellets. Switching to bioplastics helps reduce greenhouse gas emissions, but feedstock for bioplastics like corn and sugarcane is relatively scarce in Japan and only used for consumption. Japan therefore has to rely mostly on bioplastic pellet imports, which leads to higher and more unpredictable costs of bioplastics production. Because of this, some bioplastic manufacturers have begun to set up bioplastics factories in foreign countries near

where the raw materials are harvested. For example, Hitachi, Zosen, and CRP Corp have plans to invest in tapioca-based bioplastics factories in Vietnam. Moreover, as consumption trends change in Japan's aging society, demand for environmentally friendly goods will rise. This will incentivize major businesses to switch to bioplastics products to meet the changing demand, making bioplastics more important as substitutes for conventional plastics in the future.

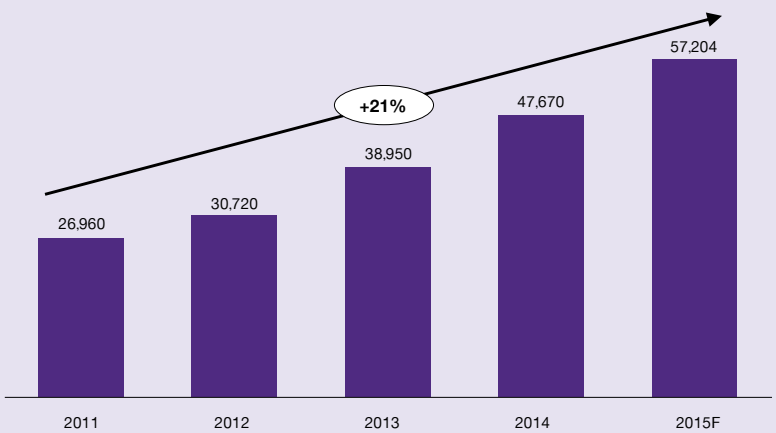
Japan's bioplastics industry grew significantly because of a serious and continuous commitment from both the public and private sectors to support R&D to improve bioplastics quality. In the beginning, the Japanese bioplastics industry faced many challenges, including high production costs, low quality, and inadequate raw materials. The industry took as long as 20 years to fully develop. Yet, in the last five years bioplastics demand in Japan grew rapidly to around 50,000 tons per year, an average growth rate of 20% per year. The surge was partly driven by companies' increasing involvement of bioplastics in producing their products after realizing the change in consumer behaviors. Coca Cola and Santory, the beverage producers; now produce 100% bioplastic bottles. Country-wide supermarkets like Aeon and Fuji have also switched to bioplastic bags. These shifts raised the use of bioplastics in everyday products significantly, marking the success of the Japanese bioplastics industry after a long period of development.

As for Thailand, the bioplastics industry is well supported by an abundant supply of feedstock and a comprehensive supply chain. Although it currently relies on foreign markets and foreign technologies, in the long run the Thai bioplastics industry has the potential to follow the footsteps of its Japanese counterpart by learning from the experience. This will require collaboration between the public and private sectors to fully commit to the development of bioplastics products. With a boost from today's much more advanced technologies, Thailand will be able to successfully build its own bioplastics industry as Japan did.

38 The use of bioplastics in Japan grew rapidly at an average rate of 20% per year over the past five years, as a result of collaboration between the public and private sectors.

Bioplastic demand in Japan

Unit: tons



Source: Yano Research

Epilogue

Bioenergy may contribute significantly to the sustainable and efficient use of resources by providing a variety of products to replace fossil fuels in different markets and sectors. However, in order to sustain growth, the bioenergy industry must overcome three hurdles. First, it must ensure that the industry does not divert resources away from food production. Second, bioenergy must be price competitive with conventional or other sources of renewable energy. And third, bioenergy products must live up to their sustainability and environmental claims.

1. Energy security vs. food security: The linkage between the food and energy sectors has been a major criticism of the bioenergy industry. Currently, the majority of biofuels are derived from food crops (corn in the United States, sugarcane in Brazil, soybean in Argentina, and cassava in Thailand), which raises the question of food security.

Sustainability of feedstock will be integral to industry expansion. Research and development focusing on using non-food feedstock have been on-going. Genetic modification and plantation techniques of non-food energy crops such as willow, eucalyptus, miscanthus, and switchgrass have been studied and conducted to improve productivity and decrease land use.

Advanced biofuel conversion technologies such as cellulosic ethanol, hydrotreated vegetable oil, biomass-to-liquids, and algae cultivation are attracting investment from both the public and private sectors. As a result, technological breakthroughs are allowing companies to consider even greater opportunities for fuel switching using non-food sources, and governments in turn are increasing their targets for the use of these fuels derived from non-food sources. Lastly, more efficient use of wastes and residues that are currently discarded will provide a considerable amount of bioenergy at a relatively lower cost than new technologies being developed today.

2. Price competitiveness: The economic viability of bioenergy depends on the variety of feedstock, technologies employed, and scale of operation or production. In the last decade bioenergy, especially biofuel production, has been driven by governmental policies. While bioenergy's contribution to energy security has been considerable, reliance on government subsidies in perpetuity is no recipe for success. The industry must demonstrate that it can survive on its own as government subsidies wind down. There are various possibilities for cost reductions, such as increasing land productivity and raising yields to reduce feedstock production cost. This involves collaboration with the agricultural sector, both large scale and small-scale farmers. Another possibility is achieving lower manufacturing costs through scale and technology, such as increasing power generation efficiency.

One major impediment to cost reduction through scaling is acquiring sufficient feedstock necessary to bring down production costs. Therefore, management of resources both in terms of storage and logistics is critical, as biobased energy sources are generally seasonal and have lower energy content than fossil fuels. Transportation of feedstock is costly and difficult. Lastly, adding value along the bioenergy value chain and creating high-value products help to shift the competition away from a cost to value base. For bioplastics in particular, economic competitiveness must be built upon the production of high-value products and energy through bio-refining.

3. Sustainability: The environmental advantages of bioenergy over fossil fuels must be defensible and clear. Currently, bioenergy production is seen as land and resource-intensive, which not only raises the question of food security but also the environmental and economic value of bioenergy production is seen as land and resource-intensive which not only raises the question of food security but also the environmental and economic value of bioenergy. Among the major criticisms of bioenergy are land use and greenhouse gas emissions.

The growth of the bioenergy industry has raised concerns over the sustainability of feedstock cultivation. In addition to competing for the same land as food production, deforestation is also a concern. Expansion of farm land for bioenergy crops could lead to deforestation, loss of biodiversity, and land conflicts with local communities. As demand for feedstock increases, farmers may clear forested land to grow more crops. In case of biomass from wood, deforestation may occur as trees are cut down for fuel.

In response to these concerns, various sustainability certification schemes have been developed. For example, the Roundtable on Sustainable Palm Oil (RSPO) has developed a network of stakeholders along the palm oil industry supply chain and established a set of environmental and social criteria that aims to minimize the impacts of palm oil production. Companies who can satisfy the RSPO criteria can use the Certified Sustainable Palm Oil (CSPO) label on their products to demonstrate their sustainability virtues. Certification bodies for forest products also exist worldwide. For example, the Sustainable Forestry initiative (SFI) in North America, the Programme for the Endorsement of Forest Certification (PEFC) in Europe, and the Thailand Forest Certification Council (TFCC) in Thailand.

When it comes to the complex topic of bioenergy in general and its environmental benefits in particular, consumers must consider each product on a case-by-case basis. Bioenergy may be considered "green", but the various intermediary steps in the production processes require resources and produce waste. Indirect effects of bioenergy production and use such as higher food prices, resources used for plant cultivation, and emissions from biomass power plants all contribute to the total environmental impacts and greenhouse gas emissions of bioenergy The environmental benefits of bioplastic products are also more complicated than some claim. For example, certain bioplastics will only biodegrade if disposed of by composting, but consumers may be misled into believing that these products can biodegrade in waterways or soil. Moreover, bioplastics complicate things for current recycling facilities which do not accommodate bioplastics, therefore requiring resources to sort and separate them from recycling streams. Lastly, the decomposition of bioplastics can give off methane, a greenhouse gas. Consequently, debates on the environmental merits of bioenergy remain contentious.

The rise of bioenergy will result in a merger of agricultural, forestry, and energy value chains. As a result, collaboration of businesses in the agriculture and bioenergy space will be integral to the success of both industries. Companies involved in the production of feedstock must master sustainability and logistical challenges, while companies in the downstream segment must find ways to bring down costs and address the shortcomings of bioenergy products. In addition, investment in research and development will be needed along the entire value chain, from increasing yields through genetically modified feedstock to the development of renewable chemicals and biochemicals. Companies looking to enter the bioenergy space should expect to play the long game as these challenges require stakeholder engagement, high capital costs, and long development cycles.

List of Abbreviations

AEC	ASEAN Economic Community
AEDP	Alternative Energy Development Plan
B10	Biodiesel 10%
B100	Biodiesel 100%
B20	Biodiesel 20%
B7	Biodiesel 7%
Brent price	Brent Crude Price
CAGR	Compound Annual Growth Rate
CPKO	Crude Palm Kernel Oil
CPO	Crude Palm Oil
E10	Ethanol 10%
E20	Ethanol 20%
E85	Ethanol 85%
Ethylene	Ethylene
EV	Electric Vehicle
FFB	Fresh Fruit Bunches
FFV	Flexible Fuel Vehicle
FiT	Feed-in-Tariff
Ft	Fuel Adjustment Charge (at a given time)
HDPE	High Density Polyethylene
H-FAME	Partially Hydrogenated Fatty Acid Methyl Ester
HSD	High Speed Diesel
LDPE	Low Density Polyethylene
MEG	Mono Ethylene Glycol
PDP	Power Development Plan
PE	Polyethylene
PET	Polyethylene Terepthalate
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl Chloride
R&D	Research and Development
RBD	Refined Bleached and Deodorized
RPO	Refined Palm Oil
RSPO	Roundtable on Sustainable Palm Oil
ULG	Unleaded Gasoline

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