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The Biofuels Industry in Cambodia: Building a Sustainable Business Environment for Replacing Fossil Fuels

Kenneth Paul Charman *(Corresponding author)*
CamEd Business School
kcharman@cam-ed.com

Socheata Sao
Royal University of Law and Economics
socheata@elbbl.org

Dinesh Elango
American University of Phnom Penh
d.elango@aupp.edu.kh

Nak Srey
Sarana Law Firm
sreynak@saranalaw.com

Leang Sok
Cambodia Center for Mediation
sokleanghrd@gmail.com

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SYNOPSIS

This case study focuses on the biofuels sector from the perspective of policy makers in Cambodia, the Ministry of Mines and Energy (MME) and the Ministry of Agriculture, Forestry and Fishery (MAFF). It examines the role of biofuels in Cambodia's National Energy Plan 2030-50. Biofuels are a source of energy which has gained growing worldwide attention, especially since the 2010s and early 2020s. It is a diverse industry with multiple sources of both supply and demand. Biofuels are derived from food sources, agricultural waste and forestry, algae, and engineered biomass. The case study focuses on the opportunities for development of biofuels in Cambodia, which, like most ASEAN countries, have a large rural population and significant areas under cultivation.

In 2026, Biofuels derived from agricultural waste already contributed a significant amount to Cambodian energy use at the domestic level in rural areas. The case study sets out the diversity of sources and uses of biofuels, and distinguishes between possible scenarios of growth at the local level, and

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large-scale plantations, which would provide employment and potential export revenue. The case study also puts forward the requirements for infrastructure and a policy and regulatory environment to develop a competitive and sustainable environment for growth in the biofuels sector to become a viable alternative to fossil fuels. Inherent in the case are the requirements to develop and integrate a biofuels sector with a fossil fuels sector, and the trade-offs in targeting growth in biofuels, particularly in the context of food security and competition for land-use. The focus is on the how to support the development of the biofuels sector, the contribution that biofuels can make to energy supply, and building a sustainable business environment to integrate fossil fuels into Cambodia's energy plan.

The Evolving Biofuels Industry in Cambodia

The MME was responsible for the Power Development Plan 2050 (PDP) for the Government of Cambodia, which articulated future energy priorities for Cambodia. These included fuel priorities for electricity production, transport and domestic use, the need for fuel imports, and the targets for fossil fuels and sustainable fuels. Each decision for the direction of energy supply had to fit these objectives. The National Institute for Science, Technology and Innovation (NISTI), based in Phnom Penh, provided support for policy making, and researched into projects which tested the application of biofuels in various industry sectors, and in Cambodia's rural and urban areas.

The biofuel industry in Cambodia had reached an important phase in its evolution in the mid-2020s. Following initial interest in the early 2000s, the biofuels industry experienced restored interest with the emergence of new refineries and innovative biofuel projects. Significant challenges remained if the industry were to develop, including the need to establish the most appropriate biofuel products for the Cambodian economy and to develop a comprehensive policy and regulatory framework to ensure standards of quality for biofuels, providing the right incentives and controls for both large-scale and small-scale producers, and dealing with the potential social and environmental impacts of planting biofuel crops. In addition, infrastructure was required to facilitate a competitive biofuel sector, to contribute to the biofuel sector in the ASEAN Region and international markets. This included logistics, storage, processing and refining facilities. With the global focus turning to more sustainable energy consumption, replacing fossil fuels consumption with biofuel production, the sector had gained traction and investment worldwide.

The biofuels sector in Cambodia emerged during the 1990s and early 2000s. Several crops grown in Cambodia were seen as having the potential for biofuel production. Various business models were explored, including small refining projects for biodiesel, but the lack of processing infrastructure and limited national and international interest in biofuels led to a period of quiet during the 2010s, as the early enthusiasm diminished. The boom-and-bust period in the 2000s ended with several biofuel startup companies closing. However, starting in 2018, biofuel companies began to conduct feasibility studies and

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biofuel refineries were started again after a decade-long quiet period.

The key question was how the biofuel sector in Cambodia could be developed into a competitive industry whilst addressing economic and technological challenges. A flourishing biofuels sector at the local level would require cost effective biodigesters for households to turn natural waste into energy. A competitive biofuels sector at the national level, such as targeting biofuels for export, and bioethanol or biodiesel for transport, would require infrastructure for storage, processing and transport and distribution of biofuel.

The environment had changed over the previous two decades in favor of more sustainable fuels, but the question remained as to what the opportunities would be, and where there might be conflicts and trade-offs if significant growth in the biofuels sector was envisaged. Whether biofuels would provide a feasible alternative to fossil fuels, and the achievable goals for sustainability in energy supply had become high profile questions.

ENERGY CONSUMPTION AND SUPPLY IN CAMBODIA

Energy Demand in Cambodia

Cambodia had experienced economic growth since 1998, following the peace and stability regained after its civil war. The economic growth led to a steady increase in energy consumption. From 2000, energy consumption grew rapidly in Cambodia as a result of the country's economic growth. The average rate of GDP growth ranged from 10% in 2000 to 5% in 2023 (World Bank Group, 2025). Total electricity consumption grew more than 20 times compared to its value of 449 gigawatt-hours (GWh) in 2000, to 10,191 GWh in 2019 (MME, 2022a, p. 10). Starting from the early 2000s Cambodia faced the challenge of addressing the high cost of energy, especially fuel and electricity, as it incurred the highest energy prices and experienced the lowest energy consumption in Southeast Asia (Ung et al., 2009, p. 3). Energy was increasingly consumed in households, buildings, transportation, commercial, industry, and services, including tourism. By 2021, the total consumption of energy in Cambodia had reached 66.4 Terawatt-hours (TWh), an increase of almost threefold since 2010 (CEIC, n.d.-a). The share of renewable energy in this total was 54.2% (CEIC, n.d.-b).

Energy Supply in Cambodia

In 2021, biofuels and waste provided 41.9% of Cambodia's total energy supply, followed by oil (39.9%), coal (12%), and hydro power, which supplied 5.5% of total energy (Koons, 2024; also see Figure 1). Biofuels had supplied 92% of Cambodia's renewable energy in 2017, the remaining 8% being hydro/marine energy (Open Development Cambodia [ODC], 2021a; also see Figure 2). However, for electricity supply biofuels were not well represented. The domestic energy supply in Cambodia comprised 44% of electrical energy derived from hydropower, 41% from coal, 8% from fuel oil, and 6% from solar energy, with biofuels contributing 0.6% of total electricity production (Tachev, 2022). The combined total of renewable energies (hydro, solar and biofuel) produced 50.6% of Cambodia's electricity, with hydropower contributing over 90%, solar power 7%, and biofuels 3% of Cambodia's

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renewable electricity capacity in 2021.

Biofuels were mainly used by domestic households and commercial enterprises as a combustible fuel (ODC, 2021a). Although hydro power was significant in the generation of electricity, imported coal and fossil fuels remained the primary sources of electricity generation in Cambodia (Emerging Markets Consulting, 2017). Hydropower provided the potential for Cambodia to help minimize the cost of electricity (Ung et al., 2009, p. 13). However, fuels used for mechanized transport remained entirely imported. Furthermore, the demand for transport fuels was rising at the same time as the awareness of their environmental cost was growing and causing increasing concerns. The blending of biofuel with conventional fuels had the potential to lower both the financial cost of fuel imports and the environmental cost associated with mechanized transport (Ung et al., 2009, p. 13). There were also opportunities to export biofuels, including to the European Union, as demand for sustainable and environmentally favorable fuels continued to grow, or opportunities to export electricity to neighboring countries (Economic Research Institute for ASEAN and East Asia, 2019, p.32).

SOURCES AND USES OF BIOFUELS IN CAMBODIA SOURCES AND USES OF BIOFUELS IN CAMBODIA

Sources of Biofuels

Biofuels are made from biomass, which includes a wide range of crops and agricultural residues (waste), wood, vegetable oils and animal fats, animal manure, sewage, and household garbage (U.S. Energy Information Administration [EIA], n.d.; also see Figure 3). The main distinction is between those biofuels made from dedicated crops specifically to generate energy (such as jatropha) and those biofuels which are produced from agricultural waste such as rice husks and cashew nut cases, or derived from household waste such as garbage and gases from landfill sites. Biofuels include solid biofuels, which are derived primarily from wood, liquid biofuels derived from biodegradable waste, and gaseous biofuels derived from organic materials such as agricultural waste and other forms of biodegradable materials, including landfill waste (Jouzani et al., 2020).

Biofuels are derived from four sources, typically referred to as “Generations”. The first generation is food sources (Coyle, 2007; Stein, 2022; EIA, n.d.; also see Figure 3), comprising agricultural crops including sugar beet, sugarcane, cassava, rapeseed, corn, wheat, potato, and planted crops including palm, sunflower and canola. These edible food crops contain high levels of sugar and starch, which forms a feedstock for ethanol, or oil, which forms a feedstock for diesel oil. Producing biofuels from food crops potentially reduces food supply, which can potentially both limit the availability and increase the price of foods. Production of first-generation crops for biofuel typically also requires significant availability of fertile agricultural land and requires reliable and sufficient supply of water (Loizzo, 2026).

The second generation of biofuels comprises the fibrous parts of inedible, non-

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food sources, such as agricultural waste, trees and grass (Coyle, 2007; Stein, 2022; EIA, n.d.; also Figure 3). This includes wood chips, rice husks, cashew nut skins, wheat straw, corn husks, and other crop residues, perennial grasses. Also included are specific non-food crops such as tung, jatropha and castor bean, which cannot be eaten but which can be grown specifically for biofuels (Let's Talk Science, n.d.). Second generation crops do not compete with food crops, and examples such as burning rice husks to provide heat and electricity, a practice used increasingly in Cambodia industry, shows second generation crops can complement first generation crops by using the whole plant for food and the residue for biofuels. Second generation crops such as jatropha can be grown at large scale or small scale on marginal land where food crops do not thrive. However, deriving biofuels from non-food sources involves allocating land specifically for the purpose of biofuels which could potentially replace food crops directly, and will impact land use, especially arable land and forests.

The third generation of biofuel sources are algae, which comprise non-food biomass, water and CO_2 (Coyle, 2007; Stein 2022). Third generation biofuels are extremely valuable as they grow very quickly and contain a very high oil content, yielding 10-100 times the amount of fuel per unit of land that can be produced from traditional food or non-food crops. Feedstocks include microalgae and macroalgae (seaweed). Producing algae has a limited impact on food security due to the much lower requirement for land, and algae can also be grown in waste water and salt water, so do not require fresh water. Algae can be processed into biodiesel, biobutanol and aviation (jet) fuel, with by-products such as animal feed, fertilizer and nutritional supplements. Cultivating algae for biofuels can involve the development of small or large-scale algae processing facilities (Loizzo, 2026).

The first three generations of production of biofuels are not mutually exclusive. Biofuel feedstocks are the starches and fuels which can be converted into ethanol or biodiesel (Loizzo, 2026). Ethanol is derived from first generation sources, the most directly convertible to biofuels. Secondary sources require some processing and can be derived from wood, bioenergy grasses, and crop residues. Third generation feedstocks are derived from algae and micro-organisms. Production of ethanol results from fermentation, a fourth-generation process. Biodiesel is derived from first generation sources of palm, sunflower, and canola, and specific crops such as tung, jatropha, and castor bean. The production of biodiesel requires oil extraction and purification (Loizzo, 2026; Let's Talk Science, n.d.; ODC, 2021a).

The fourth-generation biofuels are the "engineered" biofuels, derived from synthetic biology and carbon capture using genetically modified organisms (GMOs) to maximize the fuel output. Feedstocks include bioengineered algae, plants, captured CO_2 and industrial exhausts which can be converted directly into biofuel using solar energy. Fourth generation biofuels are designed to be carbon-negative, and most are still in the research and development phase but these are likely to have a high profile in the near future with expected technological process especially in the area of carbon capture. The fourth generation of biofuels involves processing of biomass to create biofuels such as ethanol or biodiesel, and can involve, for example CO_2 released from a

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power plant (Stein, 2022; EIA, n.d.; also Figure 3,).

Uses of Biofuels

Renewable energy can be derived from a wide range of sources, including bioenergy, solar energy, hydrogen fuel cells, wind, hydropower and other water sources such as ocean energy, and geothermal energy, which are primarily used to generate electricity (Das, 2024). Biofuels are used to produce energy for three purposes, to generate electricity, to generate heat, and for power transportation, and all forms of biofuels can be used to provide energy to produce electricity, heat, and transport (EIA, n.d.; also see Figure 3). The conversion of biomass into electricity is common. The combustion of gases drives team turbines which in turn produce the electricity (Khashaba, n.d.; EIA, n.d.).

Biofuels are used for transportation and electricity production. Light vehicles and marine (shipping) can be fueled with bioethanol and biodiesel, whilst heavy vehicles can be fueled with biodiesel. Sustainable aviation fuel can be derived from the same feedstocks, and in particular crops such as jatropha, palm oil, waste oils, and algae (Khan, et al., 2021; also see Figure 4). Engines for transportation running on biofuel for transportation replace engines using gasoline and diesel (Ung et al., 2009, p. 14). Replacing engines with biofuel at scale would represent a huge transition for Cambodia for a more sustainable electricity consumption environment. Moreover, a reduction in imports of oil and other fossil fuels would decrease expenses for the country and its citizens (Ung et al., 2009, p. 1). However, energy use in the production of biofuels and their potential adverse impacts on society and the environment are on-going issues.

Dedicated Biofuel Crops and Agricultural Waste

The studies on energy crops in biofuel production have shown that they are quite an economical and environmentally beneficial way of sustainable energy production. Today, most developed countries use staples such as corn, sugar beet, soybean, rapeseed, and wheat in order to obtain energy. Moreover, bioethanol is mostly produced from sugarcane and corn, and biodiesel from oilseed plants (Kocar & Civas, 2013). Crops like jatropha are considered appropriate for biofuel production as they are not edible and could be grown on less fertile soil and do not need much care in cultivation. Agricultural residues such as rice husks and cashew nut skins can also be converted into biofuel. However, widespread moves to grow these crops, the possibility of competition for land, and decreased land for planting edible crops remained perennial issues for policy on the development of biofuels.

A biofuels sector based on dedicated biofuel crops and on agricultural waste presented many options. Cambodia had biomass available but biofuels were primarily derived from agricultural waste (rice husks, corn cobs, and sugar cane) rather than dedicated crops like palm oil, which could pose potential risks to food security. Jatropha had the potential to become a significant source of biofuel, as it would not affect food security as it was an inedible crop. Similarly, the growth in cashew nut production and the processing of fineries

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could leave behind the shell which is a source of biofuel production.

The growth in cashew nuts is an example of enhanced income from producing crops, as the attraction of processing plants and the harnessing of cashew shell for biofuel shows how an ecosystem for a circular economy could emerge. Agricultural waste initiatives had great potential in Cambodia where there were many smaller-scale farmers and considerable scope for cooperative ventures to gather and process agricultural waste for the purpose of developing critical mass production of biofuels. The biofuels sector had the potential for an industry with great and positive impact on the environment, on incomes, and a social impact on a great number of small-scale farmers and local communities. By the early 2020s the biofuels sector was set to emerge and impact the lives of many. But how the growth in biofuels would benefit the interests of all stakeholders was becoming a major question for policymakers (Mom, 2024; Van, 2024).

Small Scale Versus Large Scale Biofuel Development

Biofuels are important to Cambodia as both a commercial crop and a source of energy at the local level (MME, 2022a). The interests of small farmers would be served by cooperatives to process agricultural waste and small-scale jatropha into biodiesel. Large-scale developments of biofuels in Cambodia require processing plants for agricultural waste, dedicated crops, and connection to the electricity grid.

Potential Oil Crops for Cambodia: Palm Oil and Jatropha

Potential oil crops for biofuel production in Cambodia include palm oil and jatropha, given the characteristics and requirements of oil crops. There was limited land suitable for oil palm trees, which require a tropical forest climate with an annual rainfall of over 3,000 mm. Only three provinces, Sihanoukville Province (2,937 mm), Koh Kong Province (3,512 mm) had rainfall at or near the required level. Jatropha was being grown in Kampong Speu, Battambang, Banteay Meanchey, Prey Veng, Siem Reap, Kampot, and Kep, with the additional likelihood of further small-scale growing in other provinces (ODC, 2021a, ODC, 2021b). The trees were not difficult to grow and their rainfall requirements are 300 mm to 1,500 mm per year whilst the rainfall range in Cambodia was between 1,000 mm and 3,512 mm per year. Since Jatropha cannot be eaten or used for other trade purposes besides biofuel, its production did not directly negatively impact on "food security", but provided a possible scope for economic development (Ung et al., 2009, p. 27).

Commercial Planting of Jatropha: Small Scale Jatropha Oil Plantations

Cambodia had the potential for plentiful and low-cost raw materials to use as resources for biofuels such as jatropha, as a non-edible crop, and agricultural waste. However, widespread substitution of jatropha planting would lessen the dependence on food crops used for energy with possible consequences on food security (Gheewala et al, 2019). Jatropha yields had been found to vary depending on farming techniques. Under optimum growing conditions,

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including proper pruning and irrigation, each shrub can produce as much as 9 kg of seeds per year once it reaches maturity in its fifth year. In Thailand, yields had been found to reach 20 kg per tree, with differences in the yield differences apparent between the species used and farming techniques. Increasing the yield of jatropha in Cambodia would require new species with optimum yield and high adaptability and improved farming techniques (Ung et al., 2009, p. 22-23). However, with the potential existed for the creation of employment for a farm worker with each hectare under jatropha cultivation, and the ability of farmers to generate income from selling jatropha seeds at KR 500/kg to supplement and diversify farm income (Ung et al., 2009, p.27).

If biodiesel refineries were established, low-priced fuel would become available for agriculture, industry, and transport (Ung et al., 2009, p. 27). Thus, a significant benefit of planting jatropha would be the increased income and the improved livelihood it could provide for the rural poor by enabling more land to become productive and by diversifying crops. In addition, the residue that remains when oil is extracted from jatropha seeds is high in carbohydrates, nutrients, and energy and has been used successfully in other countries as a natural fertilizer. Chemical analysis suggests it would be beneficial for a range of crops and conditions, such as mushroom cultivation, and it may also be useful as an ingredient in stock feed (Ung et al., 2009, p. 28).

POTENTIAL BENEFITS AND RISKS OF BIOFUEL DEVELOPMENT

Reduced Reliance on Energy Imports (and export potential)

One of the major factors influencing the decision to support biofuels was the potential impact on energy imports. Increasing biofuel production and replacing fossil fuels derived from oil and natural gas by using biofuels produced within Cambodia would potentially reduce the energy imports into Cambodia. This reflects the benefits of lower expenses for the state and citizens in being able to switch to biofuels. In 2009 with only a nascent biofuel industry, Cambodia imported 100% of its fuel for trade purposes (Ung et al., 2009, p. 10, para. 2). In 2023, Cambodia still totally depended on imports, the total cost of which was USD 2.17 billion (Khmer Times, 2024). Cambodia's total consumption of energy was anticipated to rise from 159 terajoules (TJ) in 2010 to 346 TJ in 2030 (Ung et al., 2009, p. 7). If Cambodia were to produce biofuel in significant quantities, it would decrease import costs and impact expenses for the state, for individual citizens, and would directly impact transportation costs, and as a result, the costs of products and services.

Increased Farm Incomes and Poverty Reduction

The potential impact on farmers' incomes was also a major potential benefit of biofuels. Biofuel production derived from companies' investment in plantations and processing plants would create job opportunities. Where small-scale farms could incorporate biofuels within their range of crops, or where biofuels are derived from utilizing agricultural waste, this could create another potential source of income for farmers. Local farmers could exchange the biomass crops with electricity supplies (Ung et al, 2009, p. 15). This would likely require cooperative establishments to achieve critical mass of biomass,

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and would also require standards developed for biomass quality. However, growing and utilizing locally produced biomass would create the potential for opportunities to find new sources for local incomes.

Reduction of Greenhouse Gases

The impact on climate change was also an important potential benefit of promoting biofuels. Biofuel production in Cambodia would contribute to the reduction of greenhouse gas emission and would potentially contribute to addressing climate change and to lowering temperatures. According to the Initiative for Climate Actions Transparency, the total baseline of emissions of poorly maintained vehicles in 2016 was 0.19 $MtCO_2e$ (million tons of carbon dioxide equivalent), and was expected to rise to 0.6 $MtCO_2e$ in 2030 (Climate SI, 2022, p. 38). This calculation entails diesel cars, gasoline cars, and motor bikes (Climate SI, 2022, p. 38). Buses and trucks that were poorly maintained produced greenhouse emissions of 25 gCO_2/tkm (grams of carbon dioxide per ton-kilometer) in 2016 and this was expected to increase to 43 gCO_2/tkm in 2030 (Climate SI, 2022, p. 37 para. 2). Meanwhile Cambodia's environmental temperatures were between 34 and 37 degrees Celsius in the dry season and between 31 and 35 degrees Celsius in the rainy season (What's The Weather Like, n.d.). Cambodia's temperature in the dry season could also reach 41 degrees Celsius (Nop, 2023). Owing to the generally attributed cause and effect of greenhouse emission and temperature level (United States Environmental Protection Agency [EPA], 2024), the transition to biofuel usage and production in Cambodia would have the potential to contribute to lowering temperatures.

Adverse Impact on Food Supply and Food Security

Despite the potential economic benefits of increasing home-grown energy, the possibilities for exports, raising farm incomes and reducing greenhouse gas emissions were compelling, replacing food crops with crops destined to biofuels could adversely impact on food supplies (Ung et al., 2009, p. 1). Cambodia had sufficient land to grow biofuel crops (e.g. oil palm, sugarcane, cassava, jatropha, soybean, and sweet sorghum), but it could potentially contribute to increased food prices and impact other food and agricultural production (Ung et al., 2009, p. 1). Food security is a very important issue on the international agenda. Many countries try to produce bioenergy without compromising food availability and food security for their population. Solving this challenge requires international agreed frameworks and collaboration among stakeholders. For example, the Food and Agriculture Organization (FAO) of the United Nations is an agency working in this area (FAO, 2014).

Demand for Land, Potential Conflicts and Deforestation

The demand for land growing the biomass crops had the potential to trigger competition for land, which can also take the form of deforestation. However, the huge progress regarding land registration in Cambodia that had occurred since the early 2010s (Hap, 2021) had established land titles and a more robust legal and regulatory framework for land acquisition. The report on biofuels by ADB in 2009 raised the issue that the lack of land titles at that time would lead

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to a situation where companies were using the land 'beyond the zone of one's land' causing conflicts (Ung et al., 2009, p. 15; Equitable Cambodia, 2013, p. 37). Furthermore, when there were to be investment in biofuel, there would be a need for economic land concessions (ELCs) or long-term land leases which may potentially lead to cleared forests (Ung et al., 2009, p. 30; Chan et al., 2020; Hance, 2012), leading competition for land use and increasing the potential for land conflicts (Equitable Cambodia, 2013, p. 37).

THE DEVELOPMENT OF THE BIOFUELS INDUSTRY IN CAMBODIA

Development of the Biofuels Sector in Cambodia

In the 1990's and early 2000's, Cambodia's biofuel sector first emerged and a market for biofuels began to develop. This was driven in part by high global oil prices, making biofuels attractive, but also by the potential rural growth as several companies invested in biofuel crops (Ung et al., 2009). Early experiments in biofuel businesses led to only limited success due primarily to the lack of technological knowhow and facilities, without a comprehensive policy framework to support the industry. The biofuels industry during this period comprised mainly small-scale biodiesel production and pilot refineries.

By 2009 the biofuel industry had started to decline in the face of technical challenges and market volatility (see Additional Notes). By 2010, many of the pilot projects and initial companies to enter the market had ceased their operations. A biofuels sector would need land for plantation of bio crops (jatropha and other crops), water (rain and irrigation), labor supply for the prospective plantation and finance for the necessary infrastructure for collecting, processing and refining biofuels. Many types of businesses are involved in turning biomass into products used by consumers and industry. The supply chain for biofuels starts with biomass farms, with cooperatives for processing into biofuels. This requires storage facilities and transportation to blending facilities to ensure that the biofuels are of a consistent standard (University of Greenwich, n.d.). Activity in the biofuels sector began to increase in the late 2010s, as the components of biofuels, providing combustible fuels derived from agricultural waste, wood, animal manure could become significant contributors to the country's energy requirements and at the same time create a positive environmental aspect and promote development in rural areas. Cambodia possessed significant sources of biomass, derived from agricultural waste including rice husks, corn cobs, sugar cane bagasse, and had the potential to produce up to 10 million tons of biomass per year, which in turn could be used to generate around 2,500 megawatts of electricity. The country's total power capacity installed at the time stood at 2,208 megawatts (Khmer Times, 2023).

By 2018 a new biofuel sector had begun to emerge. Agricultural waste had become an effective raw material, and biofuels derived from cashew nuts shells and rice husks were established as new refineries in Cambodia. Two companies, MH Bio-Energy, from South Korea, and Mong Reththy Group, a Cambodian company, had become the market's key players, having re-entered

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into this market, focusing on both national and international market opportunities for biofuels (Mom, 2024). Despite these advancements, compared to the regional market competitors, including Indonesia and Thailand, Cambodia's biofuel market was still at the early stages of development (see Additional Notes).

Small Scale Biofuels Projects in Cambodia (Biodigester)

A project was started in Battambang Province to install biodigesters in homes in rural areas (Uy & Sok, n.d.). The project has been sponsored by the Ministry for Agriculture, Forestry and Fisheries (MAFF), to facilitate and promote the accessibility of biodigesters, and to encourage research and technology improvements aimed at improving the efficiency and availability of biodigesters to rural homes (MAFF, 2016, as cited in Uy & Sok, n.d.). Biodigesters are typically able to hold around 8 cubic meters of bovine manure and other biodegradable household waste. A total instalment price of USD 690 was supported by a subsidy for a biodigester which typically supports two households, and provides electricity and lighting, and can contribute significantly by providing methane gas for cooking and for the production of electricity. The local authorities provided village livestock officers who undertake training and support in installation. Biodigesters are typified by a relatively high set up cost, and require adherence to a system of collection of waste, after which biowaste can be used as a lifelong source of fuel. Biodigesters can produce fertilizer as a by-product, but this involves some trade-off between using biomass for fuel or for land fertilizer (Uy & Sok, n.d.).

BIOFUELS POLICY & LEGAL FRAMEWORK: INCENTIVES, UNCERTAINTY & CHALLENGES

Economic and ESG Perspectives on Biofuels

The revival of the biofuels industry in Cambodia was reflected in the amount of interest from potential foreign investors. The sector had become established, the demand for biofuels had become mainstream based on both economic and Environmental, Social and Governance (ESG) criteria.

Economic criteria: Demand for biofuels could come from multi-sources, including heating, electricity production, road transport, and aviation fuels. Biofuels were being seen as a potentially productive import replacement for fossil fuels in all forms of transport on the basis of economic criteria alone, and new industries were emerging in all forms of biomass conversion. Sustainable incomes could be foreseen at the local and regional level which could involve conversion to biofuel crops or extra incomes for small-scale farmers.

Environmental Criteria: The opportunity to recycle agricultural waste products by converting into biofuels was beginning to be seen as a mainstream opportunity to switch to energy use which would have less impact on the environment.

Social Impact Criteria: This was also an emerging issue, and the possibility

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of diversifying farming crops to include biofuels had social as well as economic benefits in terms of supporting communities and supplying a greater proportion of energy needs locally, and with the opportunity to sell off surplus. This could have great potential given that the adverse impacts discussed were properly addressed or mitigated (Economic Research Institute for ASEAN and East Asia: (2019, p.56).

Governance Criteria: As a relatively new sector, the governance aspect was less well-established. Cambodia's policy and legal framework would guide the biofuel sector's development and potentially its focus, as policy could incentivize use of biofuels at the local level and as potential export crops. At the firm level, the incentives to switch to biofuels would affect the impact on both local communities and regions. The development of standards for biofuels and clear, systematic, transparent and ethical business practices would impact the sustainability of the biofuels sector (FAO, 2014, p. 7-12).

Setting of Standards for Biofuels

Agricultural produce was straightforward to classify (Cambodia sold 90% of its raw agricultural produce). However, biomass fuels were not straightforward, and this emerging sector was characterized by industry standards, which related to the value of the biomass as a combustible fuel, and a legal and regulatory framework under which biomass could be sold. This was particularly the case in rural areas where the majority of biomass fuels were produced (Khmer Times, 2023). There are also other issues of quality related to biofuel and tax. For example, in order to be effectively used in transportation, the biofuel needs to reach the standards required of motor manufacturers, otherwise it can damage the engines, harming stakeholders involved such as farmers, vehicle holders and business operations (Ung et al., 2009, p. 15 para. 2). There would need to be an accepted and nationwide system for testing the quality of biofuels, along with appropriate incentives and controls effected through tax policies and laws and the national budget generation (Ung et al., 2009, p. 15 para. 3).

ASEAN Biofuel Policy

ASEAN countries demonstrated differing power mix, although each with a significant dependence on fossil fuels (Suryadi, 2020; also see Figure 5). Despite some development on biomass policies and national legal frameworks on "biofuel" or "renewable energy" within the Association of Southeast Asian Nations (ASEAN), they were not yet comprehensive (ASEAN, 2021 p. 9 para. 1).

The ASEAN Plus Three Comprehensive Strategy on Food Security and Bioenergy Development (APTCS-FSBD) Framework set out strategic goals to facilitate biofuel production to ensure consistency with food and overall energy security, to promote innovation in the development of biofuels from agricultural wastes to improve farmers' incomes and rural development, as well as to promote sustainability in both food and energy security. Enhancing research cooperation and national policy development were also encouraged. (ASEAN, 2010, p. 2-3).

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This strategy was created together with the Strategic Plan of Action on Food and Energy Security (SPA-FES) 2010-2013 (ASEAN, 2010), stressing most on programs relevant to biofuel production and how to strike a balance, assessing adverse impacts of biofuel production on the climate and environment, and cooperation, research, law, policies and governance concerned the biofuel production (ASEAN, 2010, p. 8-10).

Acknowledging the need for both the environmental preservation and economic development, the "ASEAN Strategy on Sustainable Biomass Energy for Agriculture Communities and Rural Development In 2020-2030" was adopted, aiming for fostering "reliable", "affordable", and "sustainable" biomass energy (ASEAN, 2021, p. 9, para. 2). This strategy was based on the following missions: innovating biomass energy within the "rural" areas to improve the standard of living of the rural communities through "shared research", "educational training", "public policies", "awareness", "market development", "data sharing", and "technology transfer" (ASEAN, 2021, p. 9 para. 3).

The strategy contained four principles, "thrusts", such as using biomass energy of 10% of the total energy consumption by 2030, increasing "effectiveness" and "efficiency" of biomass production and energy by composing a network for "research development", providing capacity building among ASEAN members, increasing "awareness" and "best practice" among the "policymakers", "private" and the general public, and increasing financial support and access for biomass production, regional and national "biomass market" (ASEAN, 2021, p. 10-12). In rural areas of ASEAN countries, the rate of access to electricity was still low in most countries. The price of electricity also had the tendency to rise, so this is the constraint to rural households. Biomass energy has been used extensively in ASEAN countries, particularly in Indonesia, Malaysia, Philippines, Thailand and Vietnam over the past years. However, there is still a need for the improvement and sharing of technologies relating to biomass energy with other member states in order to make optimum use of the available and appropriate technologies (ASEAN, 2021, p. 2).

Cambodia's Biofuel Policy

Despite the lack of specific laws on biofuel production (ODC, 2021a), there have been governmental policies and governmental structure in this area. Land allocation was based more on market signals than on coordination among farmers. While Thailand placed sugar and cassava as the main raw materials for producing bioethanol, Cambodia did not target any crops for biofuel development (Ung et al., 2009, p. 29).

The objectives set out in the PDP firstly was to target an affordable and reliable supply of electricity, covering all sectors in Cambodia. Secondly, it was to strengthen energy security by reducing the dependence on energy imports and maximizing domestic energy production. Thirdly, it was to promote the use of clean energy, including renewable energy, without compromising the reliability and affordability of energy supply. These objectives were designed to ensure that the PDP was consistent with Cambodia's national

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environmental goals and the country's commitments to global energy targets in terms of reduction in greenhouse gas emissions. (PDP p2)

Cambodia was seen as having great potential regarding biofuels in its energy mix in 2024 (International Renewable Energy Agency [IRENA], 2024). Commercial viability seemed to be the big problem, as the government had not implemented stand-alone biofuels policies but had incorporated biofuels within the Power Development Plan (PDP) 2022-2040, which prioritized expanding renewable energy sources, including abundant solar, wind, biomass, and hydropower (MME, 2022b; MME, 2022c; Asian Development Bank, 2024). The lack of specific biofuel laws created grounds for uncertainty for the investors (ODC, 2021a). It also prevented long-term strategic planning and coordination in the industry and Cambodia (Bun et al., 2006).

Cambodia's Regulatory Framework for Biofuels

Cambodia's Policy and Regulatory Frameworks for developing clear biofuel policies aligned with the Power Development Plan (PDP) 2022–2040. Policies provide incentives for local production, establish quality standards, and encourage private sector involvement. Also, prioritizing Innovation and Technology for adopting advanced technologies, such as those used in cashew shell processing, could improve efficiency and create a competitive edge. Investments in R&D are critical to scaling production and meeting international standards. The structural administration within the General Department of Energy of the MIME has three departments, including the Department of Hydropower, and the Department of Technical Energy having responsibility for "renewable energy" (ADB, 2015, p. 12). Furthermore, the government created a "ministerial bioenergy program committee", composed of the Ministry of Industry, Mines and Energy, Ministry of Environment; and the Ministry of Agriculture, Forestry and Fisheries, and Ministry of Economy and Finance (ADB, 2015, p. 12).

Cooperation with ASEAN Countries

Established producer companies in ASEAN, particularly in Indonesia and Thailand dominated regional markets. Established producers in Southeast Asia dominated regional markets, challenging Cambodia's entry. In 2024, the Cambodian biofuel industry was still at an early stage of development for both domestic level and or to international (export) level development of biofuels. Cambodia needed to prioritize which of these markets it would target. Cambodia, by collaborating with other ASEAN countries and taking notes from Indonesia's mandatory biofuel blending policies could enhance competitiveness. Such a collaboration could provide useful technological and policy lessons to increase the competitiveness of Cambodia (Balanay & Halog, 2023). The application of agricultural residues like cashew nut shells as a source of biofuel feedstock opens up a sustainable path of diversification while minimizing waste (Kyei et al., 2023). Bringing in foreign capital investment and establishing alliances with multinational corporations would open up access to cutting-edge technologies and broaden market penetration.

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Incorporating Potential Conflict and Food Security Issues into Biofuel Crops

Cambodian took into consideration Short-Term Costs vs. Long-Term Gains: Investments in infrastructure and innovation were crucial but would require significant capital upfront. At the same time, expansion of biofuel crop cultivation could lead to conflicts over land usage, causing food crops production to be displaced with biofuel crops while other forms of environmental degradation occur like deforestation, water pollution, and biodiversity loss (Scafidi and Leslie-Bole, 2025). Thus, Cambodia needed to address the question of food security versus biofuel crops; how to balance biofuel production with the need to protect food supplies and other environmental and economic impacts.

PROSPECTS FOR BIOFUELS IN CAMBODIA

Biofuels: An Emerging Sector Replacing Fossil Fuels

The biofuels sector was still an emerging sector which created opportunities and at the same time costs and risks. Biofuels per se were attractive because they can directly replace fossil fuels, leading to both being environmentally attractive and providing a commercial proposition. However, the biofuels industry was diverse, comprising many products, many ways of producing energy from biomass. It can be small-scale, providing opportunities for additional incomes for rural communities, as well as being used as a primary fuel. This could also be a large- scale industry with plantations of dedicated biofuel crops and processing plants. Biofuels could be exported and could be expanded to incorporate waste recycling and agricultural residue processing to provide a huge amount of bioenergy.

Biofuels: Costs and Benefits and Trade-offs

There were costs and risks associated with biofuels development, each of which influenced biofuels development in Cambodia. Firstly, the possibility was that dedicated biofuel crops could replace food crops and thus impact food security. Secondly, there would be significant costs in terms of infrastructure to collect, store, process, blend, and distribute biofuels produced at scale. Thirdly, there would be a need to develop a legal and regulatory framework that facilitates incentives for biofuel production and use, protects against potential adverse effects—such as the food security and deforestation risks—and incorporates a mechanism for ensuring standards for biofuel quality. This would be particularly relevant where biofuels were traded or blended with fossil fuels for use in transport.

The question remained as to the objectives Cambodia aimed to achieve with biofuel development, whether for local use, raising farmers' incomes, import substitution, potential export revenues, or all of these.

There was real potential for Jatropha to be produced at small scale in rural areas, and could lead to diversification of crops and extra income for farmers. Whereas there was less scope for plantation crops such as palm oil due to lack of suitable land, and the Responsible Business Conduct (RBC) aspects of

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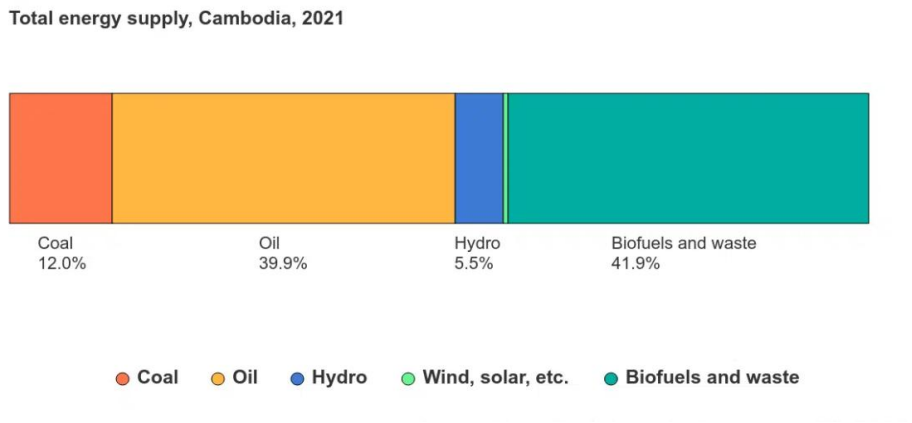
potential land captures to produce palm oil. However, the significant progress made in the 2010s and 2020s to provide hard titles to farmers for the land they own could significantly alleviate the potential RBC risk.

ESG and RBC principles—including environment and social impact, and governance of resources and companies active in the sector—should be applied to sources and uses of biofuels. This reflects the diversity of the sector, its potential to contribute to energy and environmental goals, and its impact of rural incomes.

The future for biofuels in Cambodia in 2026 had undoubted potential with opportunities, costs, and associated risks. The discussion as to whether biofuel projects at a local level were more appropriate for a country like Cambodia than large-scale plantations is an issue for policy. The biofuels industry represented both opportunities and risks, and the trade-off between these would likely be key to the prospects for biofuels development in Cambodia.

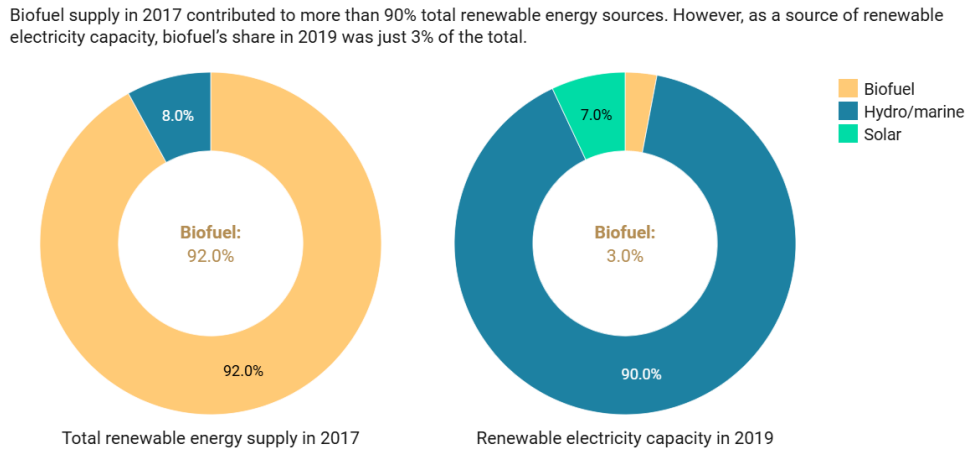
FIGURES

Figure 1: Total Energy Production in Cambodia - Biomass for Heat Production



Source: Koons, 2024
License: CC BY 4.0

Figure 2: Renewable Energy Supply and Capacity in Cambodia



Source: (ODC, 2021a)
License: CC BY-SA 4.0

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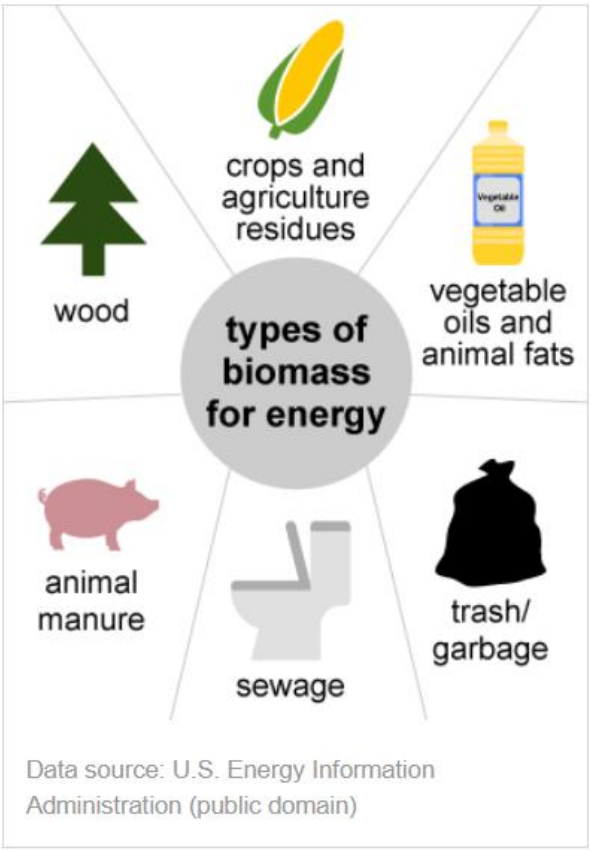
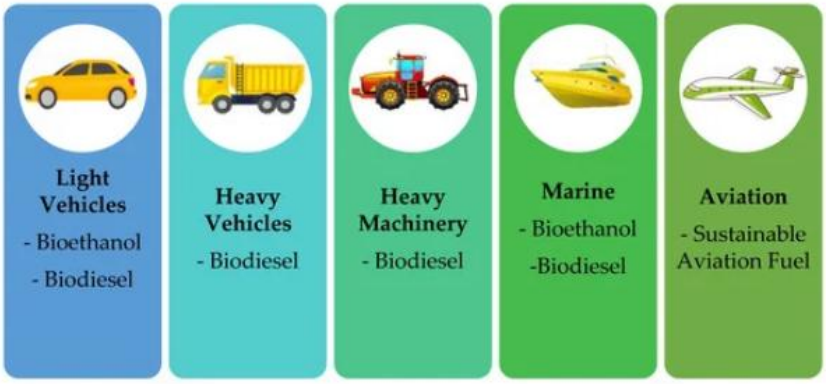
Figure 3: Biomass - Renewable Energy from Plants and Animals



Source: U.S. Energy Information Administration (EIA)
License: Public domain

Figure 4: Biofuels in Transportation Sector



Source: Khan, et al., 2021
License: CC BY 4.0

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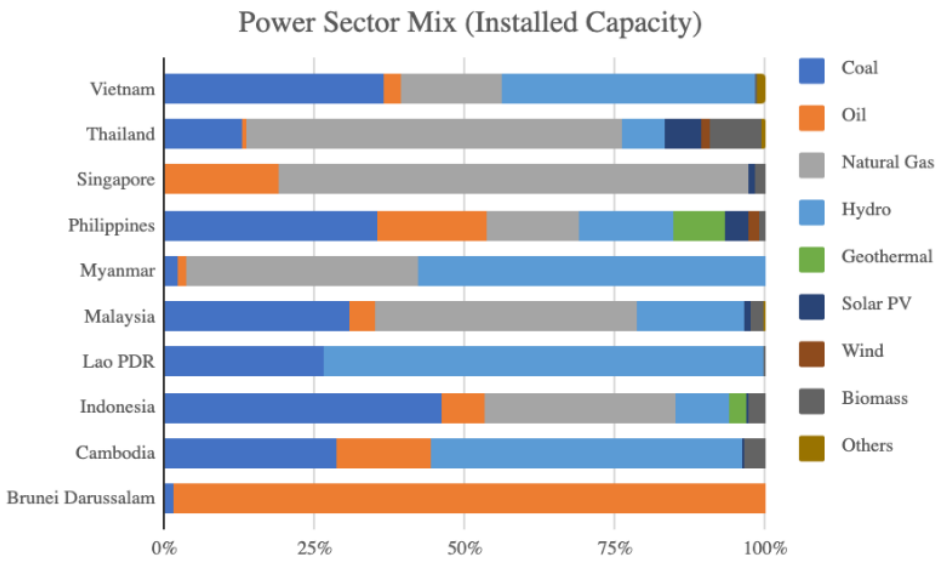
Figure 5: Power Production Capacity in ASEAN Countries and From Different Sources



Source: Suryadi, 2020

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ADDITIONAL NOTES

BIOFUELS PROJECTS IN CAMBODIA (UP TO 2009)

Early Small-Scale Biofuel (Biodiesel) Projects

An example, Mr. Tham Bun Hak, lived in Batrang Commune, Mong Kul Bory District, Banteay Meanchey Province, made biofuel from jatropha and kapok to use in his "diesel engines", supplying electricity to around eighty "households". In 2005, after several tries of jatropha, he succeeded. Nevertheless, the production quality was "low" because of the viscosity (Ung et al., 2009, p. 22).

In order to produce biodiesel, Maharishi Vedic University (presently known as National University of Cheasim Kamchaymear) located in Prey Veng Province completed a biodiesel refinery that could produce 200 liters per day. In 2004, Development and Appropriate Technology (DATe), an NGO in Kampong Chnang District, Cambodia, developed a system to produce biodiesel and seed cake fertilizer from jatropha in rural areas (Williamson, n.d.; Ung et al., 2009, p. 22). DATe provided training to local farmers on how to "plant", "harvest", and "process" jatropha to become biodiesel in their communities (Ung et al., 2009, p. 22).

In 2009, **Biodiesel Cambodia** piloted a project to produce biodiesel in de-mined areas in Banteay Meanchey on a 10-hectare trial plantation of jatropha in cooperation with local NGOs. The NGOs identified participating farmers, trained them, and provided necessary support. Biodiesel Cambodia sourced the capital to run the project for two years until the project became sustainable, and provided a guaranteed market for the farmers' crops. It also had the technology to extract the oil from the seeds and process the oil into biodiesel for use in diesel engines. Biodiesel Cambodia owned a small pilot refinery that could produce 500 per day and a biodiesel machine that was used to convert old cooking oil and jatropha plant oil into international-standard biodiesel (Ung et al., 2009, p. 22).

Early Commercial Biofuel Plantations

The commercial planting of jatropha to produce biodiesel also attracted attention. A number of initiatives focused on the development of jatropha due to its high oil content. Some Cambodian entrepreneurs and businesses invested in small-scale pilot jatropha plantations and successfully extracted crude jatropha oil from seeds. However, initial trials on 100% replacement of diesel fuel with crude jatropha oil in electricity generation were not satisfactory due to engine failures after a short period of operation. The cause of engine failure was not identified or evaluated due to limited knowledge and institutional capacity (Ung et al., 2009, p. 22). Before 2009, several initiatives were started in Cambodia in the biofuels sector, including:

- **Mong Rethythy Group - Vegetable Oil Plantation**: The Mong Reththy Group (MRC) initiated a big project planting oil palms on eleven thousand hectares of land "near Sihanouk" with Borim Universal, its South Korean venture partner. This was the first project

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in Cambodia to commercialize vegetable oil (Ung et al., 2009, p. 22).

- **Biofuel for Rural Electrification in Cambodia Project**: Tests on the use of biofuels were carried out by the Biofuel for Rural Electrification in Cambodia project, partnered with Groupe Energies Renouvelables, Environnement et Solidarités Cambodia, and the Institute of Technology of Cambodia (ITC), using "crude vegetable oil" to power a tiny engine using diesel to assess how it functioned and the time frame that the engine could be used (Ung et al., 2009, p. 22, para. 5).

Emerging Companies Leading the Industry in Cambodia (2025)

In 2024, there were several biofuel companies and projects in Cambodia. These included the following active companies with several assessment studies.

- **MH Bio-Energy Co.**, a South Korean company producing bioethanol from cassava. It has 100 percent share from South Korea, registering with the Ministry of Commerce (MoC) in Cambodia in 2007 (MH Bioenergy Co. Ltd., n.d).
- The **Mong Reththy Group**, which planned to build a crude palm oil refinery in Sihanoukville to replace their smaller capacity refinery.
- **Idemitsu Oil & Gas**, assessing the feasibility of a cassava-fueled plant in Battambang. It has no record of official registration with the MoC in Cambodia (Royal Government of Cambodia, n.d.).
- In 2019, a Japanese company **Top Planning Co LTD (TPJ)** having no record of registration with the MoC in Cambodia, assessing the feasibility of a cashew nut factory, with the facility to process the shells into fuel.
- In early 2024, **6 Chinese companies** were assessing the feasibility of establishing cashew processing plants in Cambodia, each with the facility to process shells into biofuels. This interest and specialty also coincided with **Singapore's new processing plant in Kampong Speu** province in January for cashew nut processing, while the interested Chinese companies required the cashew nuts shells to convert them into biofuel for export to environmentally conscious nations such as Japan, South Korea and EU members (Van, 2024).

Ministerial Responsibility in Cambodia

In Cambodia the biofuels sector is managed by the MME[1], which is responsible for the biofuel energy, including the technical standards, fuel blending and distribution of biofuels to customers, contributing to Cambodia's renewable energy portfolio. Also, the MAFF[2], responsible for the agricultural supply-side, including the allocation of land for bioenergy crops, determining plant nutrient requirements, and conducting agricultural research. The Ministry of the Environment[3] is responsible for regulating carbon emissions, and environmental compliance. The Ministry of Commerce[4] oversees market

[1] https://mme.gov.kh/
[2] https://www.maff.gov.kh/
[3] https://moe.gov.kh/
[4] https://moc.gov.kh/kh

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trading controls and fuel distribution networks.

The mission of the National Institute of Science, Technology and Innovation (NISTI[5]) is to provide technological solution support to enterprises, promote the utilization of NISTI's research in business, strengthen research, training, and dissemination of NISTI's work to enterprises, and transform NISTI into a revenue-generating institution. NISTI provides research and support in all areas of biofuels and recommends to policy makers.

BIOFUELS IN ASEAN COUNTRIES

Thailand Biofuels

According to a 2023 report by USDA, the Thai government promoted the use of gasohol, the name given for gasoline that contains ethanol, through price incentives at the gas stations and an excise tax reduction for cars compatible with E20 and E85 gasohol. In addition, biodiesel consumption, mainly for usage in transportation, was required under the government's mandatory biofuel blending requirements into diesel. However, a mandatory blending requirement for diesel used in industries and agriculture was not enforced. Industry primarily used diesel in power generators (United States Department of Agriculture, Global Agricultural Information Network [USDA GAIN], 2023, p. 4).

Thailand actively promoted second-generation biofuels derived from non-food sources, reducing the risk of food security concerns (World Bank, 2011). The Thai government provided subsidies and tax incentives to biofuel producers, ensuring financial sustainability. For two decades, the Thai government had been promoting ethanol and biodiesel consumption through tax measures and price subsidies (Phomsoda et al, 2021).

Pricing incentives have been in operation to encourage purchase of cars with E20 and E85 blends, and ethanol provided 12.6% of gasoline fuel in 2022. Thailand also uses B10 blends for biodiesel although the program to increase the use of biodiesel was restricted by the high prices for palm oil. However, Thailand planned to increase the use of biodiesel to B20 blend in order to improve security of energy supply and reduce emissions in line with targets for reductions in pollution (Silva et al., 2024).

Vietnam Biofuels

According to the IEA BioEnergy 2024 Report, Vietnam had significant potential for biofuels production (Silva et al., 2024). Wasted grain and crops in the country could meet about 6.6% and 11% of the total gasoline demand respectively. The Vietnamese government had implemented policies to encourage the use of ethanol blends in gasoline, with E5 currently being used nationwide. In addition to the environmental advantages of ethanol, the local government had also created a roadmap for its use, considering the importance of energy supply security (Silva et al., 2024, p. 9). The World Bank's Public-Private Partnership Resource Center website stated that Vietnam encouraged public-private partnerships (PPPs) to advance research

[5] https://www.nisti.gov.kh/

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and development in biofuel technologies (World Bank, n.d.).

Malaysia Biofuels

Malaysia focuses on biofuels development to enable the country to reduce subsidies provided for fossil fuels (Silva et al., 2024). Malaysia does not possess suitable crops for bioethanol production, so the primary focus is on biodiesel produced from palm oil, for which Malaysia produces 24% of the world output. A blended rate of 20% was introduced and has been in operation in some states of Malaysia since 2022. Research into palm oil development is partially financed by a levy on palm oil producers, and this levy also contributes to biodiesel subsidies and environmental protection. As a result of the environmental measures, the area comprising naturally regenerating and planted forests, has been maintained at 58% of total land area for over a decade.

Indonesia Biofuels

Indonesia produces 59% of the total world production of palm oil, and has pursued a policy of biofuel development in order to reduce reliance on oil imports, improving energy security of supply of energy and at the same time contribute to rural development. Biodiesel represents the core of the biofuels development policy, and is financed by levies on exports of palm oil. Domestic demand for palm oil has increased as a result of the biofuel promotion, and a blending mandate of 35% came into operation in 2023. A complementary program to supplement blended biodiesel with indigenously produced hydrotreated vegetable oils was also introduced in 2024. Indonesia also produces a limited amount of sugarcane-derived ethanol and opened two new corn ethanol plants in 2023. Increased corn production was encouraged by subsidizing corn seed, but was limited in effectiveness due to the need for adequate storage and handling plants for corn production and processing (Silva et al., 2024). Indonesia and Malaysia rank among the top producers of biodiesel in the world.

Philippines Biofuels

Like all ASEAN countries, the Philippines continues to develop its biomass and waste-to-energy capacities, and has maintained blending mandates since 2009, comprising E10 for bioethanol blends heavily supported by imports, and 2% blends for biodiesel. Around 50% of bioethanol is imported, almost entirely from the USA as ethanol production is limited to sugarcane processing in the Philippines. However, there is considerable scope for biodiesel, with the possibility of 6.6% of total gasoline demand being supplied from wasted grain and crops (Silva et al, 2024; ERIA, 2026).

Singapore Biofuels

Singapore both uses and supplies biofuels for the maritime and aviation sectors, and Singapore has one of the largest bunkering hubs for biofuels in the world, managing biofuel blends including B20 to B30 biodiesel (with trials of B100 biodiesel) to ocean-going vessels. Sales of biofuels have surged in the early 2020s. Singapore is a major producer and user of Sustainable Aviation Fuel (SAF) and uses significant amounts of blended biofuels for aviation.

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Requirements have been set for local harbor craft to use B100 biofuels or shift to zero-emission fuels (Singapore MPA, 2026; Singapore MOT, 2026; ASEAN Centre for Energy, 2017).

Data Sources

Data sources have primarily been obtained from publicly available sources, with interviews and discussions with relevant experts.

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ISSN: 3008-1017

REFERENCES

ASEAN Centre for Energy (2017): The 6th ASEAN Energy Outlook, https://asean.org/wp-content/uploads/2023/04/6th-asean-energy-outlook-2017-2040.pdf

Asian Development Bank. (2015). Renewable energy developments and potential in the Greater Mekong Subregion. https://www.adb.org/publications/renewable-energy-developments-and-potential-gms

Asian Development Bank. (2024). Cambodia: Support for a Sustainable Power Sector (Public Project No. 52096-001). *Asian Development Bank*. Retrieved from https://www.adb.org/sites/default/files/project-documents/52096/52096-001-tacr-en_0.pdf

Association of Southeast Asian Nations. (2010). ASEAN Plus Three comprehensive strategy on food security and bioenergy development (APTCS-FSBD): Framework and strategic plan of action on food and energy security (SPA-FES) 2010–2013. https://www.asean.org/wp-content/uploads/images/archive/11th%20AMAF%20Plus%203%20APTCS-FSBD%20%20SPA-FES_Draft_23-9-11%20final%20draft.pdf

Association of Southeast Asian Nations. (2021). ASEAN strategy on sustainable biomass energy for agriculture communities and rural development (2020–2030). https://asean.org/wp-content/uploads/2021/12/FAFD-53.-Biomass-Energy-Strategy-ASEAN-2020-2030-Final-Draft-210820.pdf

Balanay, R., & Halog, A. (2023). Bioenergy updates and prospects for decarbonization in the ASEAN region: A review on logistical concerns and potential solutions. *WIREs Energy and Environment*, e499. https://doi.org/10.1002/wene.499

Bun, V., Govindarajalu, C., Haider, W., & Lui, Z. (2006). *Cambodia energy sector review – Issues paper* (World Bank Report No. 43349). World Bank. https://www.researchgate.net/publication/341907201_Cambodia_Energy_Sector_Strategy_Review_-_Issues_Paper

CEIC. (n.d.-a). Cambodia primary energy consumption [Data set]. *CEIC*. Retrieved January 01, 2026, from https://www.ceicdata.com/en/cambodia/environmental-co2-and-greenhouse-gas-emissions-annual/primary-energy-consumption

CEIC. (n.d.-b). Cambodia KH: Renewable energy consumption: % of total final energy consumption [Data set]. *CEIC*. Retrieved January 01, 2026, from https://www.ceicdata.com/en/cambodia/environmental-energy-production-and-consumption/kh-renewable-energy-consumption--of-total-final-energy-consumption

Chan, S. S., Ngorn, C., Hour, T., & Hem, M. (2020). Land conflicts between economic land concessions and smallholder farmers in Bousra commune, Cambodia. *Mekong Region Land Governance*. https://www.mrlg.org/wp-content/uploads/2020/11/Case-Study-Land-conflicts-between-Economic-New-Edition-11NOV2020.pdf

Climate SI. (2022). MRV framework for transport sector in Cambodia. https://climateactiontransparency.org/wp-content/uploads/2022/11/20220518_CMB_MRV_DEL5_MRV_framework_for_Transport_sector_in_Cambodia_Final-3-1-1.pdf

FPF
ISSN: 3008-1017

Coyle, W. T. (2007). The future of biofuels: A global perspective. *USDA Economic Research Service.* https://www.ers.usda.gov/amber-waves/2007/november/the-future-of-biofuels-a-global-perspective/

Das, T. K. (2024). *What are the various types of renewable energy?* Das Energie Private Limited. https://dasenergie.com/blog/types-of-renewable-energy/

Economic Research Institute for ASEAN and East Asia: (2019). *Cambodia Basic Energy Plan* https://www.eria.org/uploads/media/CAMBODIA_BEP_Fullreport_1.pdf

Economic Research Institute for ASEAN and East Asia (2026), https://www.eria.org/publications/biofuel-market-potential-for-regional-cooperation-in-asean

Emerging Markets Consulting. (2017, October 8). Energy efficiency: Cambodia's industrial sector. https://emc-consulting.asia/2017/10/08/cambodia-energy-efficiency/

U.S. Energy Information Administration. (n.d.). *Biomass—Renewable energy from plants and animals.* https://www.eia.gov/kids/energy-sources/biomass/

Energy Tracker Asia. (2022). Renewable energy in Cambodia: Opportunities and challenges. https://energytracker.asia/renewable-energy-in-cambodia-opportunities-and-challenges/

Equitable Cambodia. (2013). A community guide to economic land concessions (Facilitator's ed.). https://equitablecambodia.org/website/data/training-and-education/A-Community-Guide-to-Economic-Land-Concessions-Facilitators-English.pdf

Food and Agriculture Organization of the United Nations. (2014). BEFS bioenergy and food security approach implementation guide. https://www.fao.org/4/i3672e/i3672e.pdf

Gheewala, S. H., Damen, B., & Shi, X. (2013). Biofuels: Economic, environmental and social benefits and costs for developing countries in Asia. *WIREs Climate Change*, 4(6), 497–511. https://doi.org/10.1002/wcc.241

Hance, J. (2012). Mongabay: Cambodia suspends economic land concessions. *Rights and Resources Initiative.* https://rightsandresources.org/blog/mongabay-cambodia-suspends-economic-land-concessions/

Hap, P. (2021). Land registration in Cambodia. *Journal of Accounting, Finance Economics, and Social Sciences*, *6*(1), 33–43. https://doi.org/10.62458/jafess.160224.6(1)33-43

International Renewable Energy Agency. (2024). Energy profile: Cambodia. https://www.irena.org/-/media/Files/IRENA/Agency/Statistics/Statistical_Profiles/Asia/Cambodia_Asia_RE_SP.pdf

Jouzani, G. S., Aghbashlo, M., & Tabatabaei, M. (2020). Biofuels: Types, promises, challenges, and role of fungi. In Fungal biology (pp. 1 – 14). https://link.springer.com/chapter/10.1007/978-3-030-44488-4_1

FPF
ISSN: 3008-1017

Khan, N., Sudhakar, K., & Mamat, R. (2021). Role of biofuels in energy transition, green economy and carbon neutrality. *Sustainability*, 13(22), Article 12374. https://doi.org/10.3390/su132212374

Khashaba, S. O. (n.d.). Bioenergy [Slide presentation]. SlideShare. https://www.slideshare.net/slideshow/bioenergy-40510418/40510418#

Khmer Times. (2023, July 6). Prospects of biomass energy in Cambodia's market. https://www.khmertimeskh.com/501319893/prospects-of-biomass-energy-in-cambodias-market/

Khmer Times. (2024, January 15). Cambodia imports oil products worth $2.17 bln in 2023. https://www.khmertimeskh.com/501423161/cambodia-imports-oil-products-worth-2-17-bln-in-2023/

Kocar, G., & Civas, N. (2013). An overview of biofuels from energy crops: Current status and future prospects. *Renewable and Sustainable Energy Reviews*, 28, 900–916. https://doi.org/10.1016/j.rser.2013.08.022

Koons, E. (2024, March 13). *Renewable energy in Cambodia: Continued growth*. Energy Tracker Asia. https://energytracker.asia/renewable-energy-in-cambodia/

Kyei, S. K., Eke, W. I., Nagre, R. D., Mensah, I., & Akaranta, O. (2023). A comprehensive review of waste valorization of cashew nutshell liquid: Sustainable development and industrial applications. *Cleaner Waste Systems*, 6, Article 100116. https://doi.org/10.1016/j.clwas.2023.100116

Let's Talk Science. (n.d.). Introduction to biofuels. https://letstalkscience.ca/educational-resources/backgrounders/introduction-biofuels

Loizzo, M. (2026). Get to know biofuels. *University of Florida*. https://blogs.ifas.ufl.edu/swsdept/2020/10/08/get-to-know-biofuels/

Maritime and Port Authority of Singapore. (2026); https://www.mpa.gov.sg/port-marine-ops/marine-services/bunkering/biofuel-bunkering

MH Bioenergy Co. Ltd. (n.d.). All jobs of MH Bioenergy Co., Ltd. https://pelprek.com/company/1466/mh-bio-energy-co-ltd.html

Ministry of Agriculture, Forestry and Fisheries (MAFF). (2016). Policy to promote biodigester access, research and develop technology, efficiency and support partnership (As cited in Uy & Sok (n.d.).

Ministry of Mines and Energy. (2022a). Cambodia energy statistics 2000–2019 (ERIA Research Project Report No. 08). *Economic Research Institute for ASEAN and East Asia*. https://www.eria.org/uploads/media/Research-Project-Report/RPR-2022-08/Cambodia-Energy-Statistics-2019-2020.pdf

Ministry of Mines and Energy. (2022b). Power Development Master Plan (2022–2040). *Open Development Cambodia*. Retrieved from: https://data.opendevelopmentcambodia.net/en/library_record/power-development-masterplan-2022-2040

Ministry of Mines and Energy. (2022c). Power Development Master Plan 2022–2040 [Policy document]. *Climate Change Laws of the World*. Retrieved from https://climate-laws.org/documents/power-development-master-plan-2022-2040-6097

Ministry of Transport of Singapore (2026). https://www.mot.gov.sg/what-we-

FPF
ISSN: 3008-1017

do/green-transport/maritime-environment-responsibility/

Mom, K. (2024, December 5). Investors eye cashew nut shells for bioenergy in the Kingdom. *Khmer Times*. https://www.khmertimeskh.com/501603215/investors-eye-cashew-nut-shells-for-bioenergy-in-kingdom/

Nop, S. (2023, December 26). Dry season temperature to hit 41 degrees Celsius. *Khmer Times*. https://www.khmertimeskh.com/501412858/dry-season-temperature-to-hit-41-degree-celsius/

Open Development Cambodia. (2021a). Biofuel crops. https://opendevelopmentcambodia.net/topics/biofuel-crops/

Open Development Cambodia. (2021b). Jatropha. https://opendevelopmentcambodia.net/topics/jatropha/#:~:text=8.%20Sopornetra%20Chap%2C%20%E2%80%9CA%20study,accessed%2000n%2004%20August%202021

Phomsoda, K., Puttanapong, N., & Piantanakulchai, M. (2021). Economic impacts of Thailand's biofuel subsidy reallocation using a dynamic CGE model. *Energies*, 14(8), Article 2272. https://doi.org/10.3390/en14082272

Royal Government of Cambodia. (n.d.). Business registration. https://www.businessregistration.moc.gov.kh

Scafidi, A., & Leslie-Bole, H. (2025, June 10). Increased biofuel production in the US Midwest may harm farmers and the climate. *World Resources Institute*. https://www.wri.org/insights/increased-biofuel-production-impacts-climate-change-farmers

Silva, J. F. L., Cantarella, H., Nogueira, L. A. H., Rossetto, R., Filho, R. M., & Souza, G. M. (2024). Biofuels in emerging markets of Africa and Asia: An overview of costs and greenhouse gas savings (IEA Bioenergy Task 39 Policy Brief). *IEA Bioenergy*. https://www.ieabioenergy.com/wp-content/uploads/2024/10/Emerging-Markets-Policy-Brief-pb2_v06.pdf

Stein, Z. (2022, August 10). What are biofuels? *Carbon Collective*. https://www.carboncollective.co/sustainable-investing/biofuels

Suryadi, B. (2020, February 5). Energy priorities in high-performing ASEAN. Energy for Growth Hub. https://energyforgrowth.org/article/energy-priorities-in-the-asean-region/

Tachev, V. (2022, February 21). *Renewable Energy in Cambodia – Opportunities and Challenges*. Energy Tracker Asia. Renewable Energy in Cambodia - Challenges and Opportunities

Ung, L., Hay, S., Siek, S., & Sar., C. (2009). *Status and potential for the development of biofuels and rural renewable energy in Cambodia*. Asian Development Bank. https://www.adb.org/sites/default/files/publication/30309/biofuels-cambodia.pdf

United States Department of Agriculture, Global Agricultural Information Network. (2023). Biofuels annual: Thailand (Report No. TH2023-0034). https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Biofuels%20Annual_Bangkok_Thailand_TH2023-0034.pdf

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ISSN: 3008-1017

United States Environmental Protection Agency. (2024). Basics of climate change. https://www.epa.gov/climatechange-science/basics-climate-change

University of Greenwich. (n.d.). Understanding biofuel supply chains. https://www.acpnonfood.com/Understanding-Biofuel-Supply-Chains.html

Uy, S., & Sok, L. (n.d.). Environmental governance at sub-national level on greenhouse gas emission mitigation through household biodigester as renewable energy in Banan district, Battambang province [Poster].

Van, S. (2024, January 1). CAC eyes funding for cashew shell biofuel production. *The Phnom Penh Post*. https://www.phnompenhpost.com/national/cac-eyes-funding-for-cashew-shell-biofuel-production

What's The Weather Like. (n.d.). The climate of Cambodia. https://www.whatstheweatherlike.org/cambodia/

Williamson, A. (n.d.). Biofuel: A sustainable solution for Cambodia? *Cambodian Research Center for Development*. https://data.opendevelopmentcambodia.net/library_record/biofuel-a-sustainable-solution-for-cambodia

World Bank. (n.d.). Renewable energy. https://ppp.worldbank.org/sector/energy

World Bank. (2011). Thailand: Clean energy for green low-carbon growth. https://doi.org/10.1596/26741

World Bank Group. (2025). GDP growth (annual %) – Cambodia. https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=KH

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APPENDICES

I. Teaching Note

Topic: The Biofuels Industry in Cambodia: Building a Sustainable Business Environment for Replacing Fossil Fuels

Teaching Note — For Instructor Use*

**The comprehensive Teaching Note for this case study—including the discussion guide and suggested solutions—are restricted to maintain the integrity of classroom instruction. If you are an educator interested in using these materials, please contact the author directly at muhammad@cam-ed.com to request a copy.*

In-Class Questions for Students

Questions relating to the case study content:

- What are Biofuels?
- How much does this class know about biofuels?
- What are characteristics of biofuels compared to other forms of energy (diversity in sources, from agricultural waste to dedicated crops
- Why is it that the biofuels sector started in the 1990s and early 2000s, but did not expand?
- How are biofuels currently used in Cambodia? Where is the potential for biofuel usage?
- What is the potential of biofuels locally?
- What are the positive and negative effects of biofuel development in Cambodia
- Why did the early biofuel projects (prior to 2009) not take off?
- How has the biofuels sector in Cambodia developed since 2018?
- What are the ESG Considerations for biofuels?

ASEAN Policy on Biofuels

- Should Cambodia & ASEAN benefit through cooperation on policy for biofuels development?
- What are the models of Thailand, Indonesia, and Malayia for biofuels development and how could Cambodia develop its model?
- What policy does Cambodia have and what is the future for biofuel development in Cambodia?
- What is the potential for biofuels development in Cambodia, and what would we expect to see in the next 10 years
- What lessons can be learned from this case study for other countries (including both developed and developing countries)?
- How might the governmental support for Biofuels evolve over time if biofuels are shown to provide sustainable worth?

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In-class Questions for MBA / Business Students

Questions relating to the use of strategic frameworks

1. Using Porter's Diamond Model, assess the competitiveness of Cambodia's biofuel sector
2. How can Cambodia's biofuel sector address its policy and infrastructure gaps to enhance competitiveness and RBC consideration?
3. Could we envisage two scenarios for biofuels growth, one based on plantations and one based on use of agricultural waste?
4. What strategies can Cambodian biofuel companies adopt to balance domestic energy needs with export opportunities?
5. How can public-private partnerships support the growth of Cambodia's biofuel sector? Could Cambodia follow the Vietnamese model of PPPs?
6. Could local cooperatives provide the answer for farmers to gather and process agricultural waste, or to pool resources to produce critical mass of biofuels at the local level?
7. Evaluate the potential of a circular economy model for Cambodia's biofuel production, focusing on innovations like cashew shell processing.
8. What lessons can Cambodia learn from regional competitors like Indonesia and Thailand to strengthen its biofuel industry?
9. Using the SWOT analysis, assess the competitive strengths, weakness and opportunities and threats for Cambodia in developing the biofuels sector
10. Using the PESTEL framework, assess how the external environment has changed during the last decade and what implications this has for biofuels development in Cambodia
11. Using any of the sustainability frameworks (e.g. ESG, GRI), assess how companies involved in the biofuels sector will report on their biofuel businesses
12. Does the biofuel sector contribute significantly to the SDGs, and which in particular?

II. Reviewer 1

Topic: The Biofuels Industry in Cambodia: Building a Sustainable Business Environment for Replacing Fossil Fuels

Reviewer's Comments (Please ensure your feedback is constructive.)	**Author's Responses** (Please provide a point-by-point response and highlight any changes in the revision)
1. **Hook & Context: Summary is clear but may lack a compelling hook or precise context.** You've laid a great foundation here! To make this even more engaging for the students, I suggest introducing a specific 'protagonist'	We have included the "protagonist" and the "dilemma" in the Introduction. Rather than a single protagonist, the case is viewed from the perspective of the governmental bodies involved in the development of policy and support for the biofuels sector. Primarily these

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in the first section—perhaps a decision-maker at the Ministry of Energy. Giving the reader a specific role to step into helps them navigate the context and feel the weight of the problem. If you can end the introduction by clearly defining the dilemma they need to solve, it will give the students a very clear 'mission' for their analysis	are the Ministry of Mines and Engineering (MME), and the Ministry of Agriculture, Forestry and Fisheries (MAFF) which are the two Ministries responsible for the biofuels sector. The main decisions of policy support for biofuels are manifested in the Cambodia Power Development Plan 2025-50, and in the implementation of policy for biofuels. The dilemma is how to construct a regulatory framework, including a market structure and incentives, to reflect the diversity of the biofuels industry and the complexities and trade-offs involved in policy development for biofuels. *Reference: Page 1; Paragraph 1*
2. **Narrative Flow: Narrative is logical and uses past tense but headings may be inconsistent.** This provides a fantastic, data-rich foundation for understanding Cambodia's biofuel landscape. To transition this from a report-style overview into a true case study, I suggest shifting the narrative toward 'storytelling. By adopting the perspective of a specific stakeholder—perhaps an official navigating these projects—you can present these facts as a sequence of events leading up to a critical decision. This 'protagonist' approach will help the reader feel the urgency of the dilemma rather than just observing the data.	The number of headings and been reduced to be clearer and to allow the text to flow as more of a story-telling format. To shift it to a more storytelling format some paragraphs have been rephrased to focus on the lead up to the present-day decision-making dilemma. A linking statement has been added to several paragraphs to focus the attention on it contributes to the overall mission of determining how and how much to support the biofuels sector, focusing on the perspective of the MME, the policy decision maker. The text has been shortened, and certain relevant but non-critical material has been moved to the Appendix. *References: Section 4, page 5-6; Section 5, pages 6-7*
3. **Protagonist & Organization: Protagonist or company context is vague or missing.** Building on my earlier point, introducing a central 'protagonist'—either a person or a specific organization—would really bring this case to life. By anchoring the facts to their lived experience, you can transform the data into a compelling narrative. This shift allows the reader to truly walk in their shoes as they navigate the events you've described.	Introducing the protagonist (in terms of the perspective of the MME and MAFF), the text has been revised to highlight that Cambodia has choices in how policy supports the direction that the biofuels sector will take in future. Additionally, an Open-ended question (OEQ) has been included to ask the students to think how support might evolve as biofuels progress from the uncertainties as to how and how much biofuels can add to efficiency, profitability and environmental sustainability, to sustainability, to a mainstream contributor to Cambodia's energy supply.

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	References: Page 1, paragraph 1; *Open-ended Questions (page 11)*
4. The Central Dilemma: The central dilemma or key issues are unclear or not defined. To bring everything together, I suggest focusing the next draft on a single, central dilemma. While you've shared many great insights, anchoring the text around one core challenge will make it even more impactful. A few quick steps to help with this transition: • Select a Protagonist: Choose one person or organization to lead the narrative. • Lead with the Dilemma: Introduce their main challenge early on to set the stage. • Tell the Story: Organize the background info as a sequence of events that builds toward that decision point. This approach might allow you to streamline some of the broader data to keep the reader focused on the 'mission' at hand!	The central dilemma is multi-faceted, envisaging how best the biofuels sector will contribute to the Cambodian economy, whether biofuels represent a real opportunity to develop crops grown for fuel with significant export earning potential, or whether biofuels are better targeted at the local level primarily converting agricultural waste for biofuels, and supporting local initiatives to improve farm efficiency and augment farm-level incomes. The MME, MAFF represent the protagonist insofar as the case views policy development for biofuels as the key dilemma. The text emphasizes the policy challenge of growing the industry, against the trade-offs that other sectors may suffer. Leading with the dilemma of whether and how to support the growth in the biofuels sector. Both the text and the OEQs ask the students to consider what would a competitive biofuels sector actually mean at the large-scale, dedicated plantation crops for fuel, or at the small scale, based on agricultural waste at the local level. Telling the story: the text (and headings) has been shortened and simplified where possible to build the background information to focus on the vision for biofuels in Cambodia, the policy decisions to get it there and the trade-offs required (particularly for food security). For example, we have included the 2010s experience as part of the "story" of development of biofuels. Open-ended questions (OEQs) have been included: what could Cambodia really expect from biofuels? Could biofuels really significantly reduce the use of fossil fuels? What would need to happen for a competitive biofuels sector to develop? *References: Sections 1, 4, 5*
5. Analytical Depth and Technical Quality: Fails to connect findings to theoretical models or frameworks. I noticed the Teaching Notes have some excellent models! To help	Included in the text are now references to frameworks (SWOT, PESTEL, and Sustainability Frameworks, including ESG, and SDGs). Open-ended questions (OEQs) refer to these more specifically, asking the students to use these

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students connect those dots, you might consider weaving in some foundational theories—like sustainability or consumer behavior—directly into the case narrative. Even a subtle mention of these frameworks would provide a great academic 'grounding' for the dilemma. It helps the reader see the broader theoretical context as they work through the specific events you've described.	frameworks to assess the biofuels sector strategically and to assess the extent to which biofuels contribute to sustainability (SDGs). *References: Section 1, Page 2, paragraph 1 (SWOT, PESTEL, SDGs, ESG, GRI, IFRS)* *Included is a reference to sustainability goals in page 2 paragraph 1 (and included the summary of the sustainability frameworks and the strategy frameworks in the Teaching Note (pages 1-17)*
6. **Data Exhibits: Data is included but some exhibits may be poorly labeled or non-essential.** You've gathered a wealth of great information! To help the reader stay focused on the core dilemma, I suggest curating the data to highlight what is most essential for the final decision. For any background details that are helpful but not critical to the 'mission,' moving them to an Appendix is a great way to keep the narrative lean while still providing that valuable context for those who want to dive deeper.	Relevant but non-essential data and associated text have now been moved to the Appendix. I have included in the Appendix 1) Cambodia country development of biofuels 2) ASEAN countries' experience of biofuels *References: Sections now in the Appendix (companies and individuals involved in biofuels).*
7. **Tone & Ethics: Generally professional, though minor tone or formatting issues exist.** As you define the central protagonist or organization, it's also a great opportunity to clarify your data sources. Since much of the current data appears to be secondary, briefly noting your collection process will help make the ethical procedures clear to the reader. Distinguishing between internal organizational data and external sources will add a layer of transparency and professional grounding to the case.	We have now clarified the collection processes in a note in the Appendix. Much of the sources have provided the background and facts of biofuels and this combination of country experience and Cambodia experience can help students reach a judgement as to the future of biofuels for Cambodia. *References: Appendix*
8. **Teaching Notes and Pedagogical Value: Objectives are present but may be too broad or vague.** The activities you've outlined for the students are very clear! To take this a step further, I suggest framing the Learning Objectives around the specific competencies or skills they will develop. Instead of listing what they will do, we can focus on what	The Learning Objectives have been revised to reflect what the students will actually achieve and learn through addressing the issues. *Reference: Teaching Note: Learning Objectives (page 18-19)*

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they will learn—for example, what new analytical or decision-making abilities will they walk away with? This helps show the long-term value of the case study for their professional growth.	
9. **Discussion Questions: Questions are useful but may lead to simple "yes/no" answers.** You've provided a great variety of activities! Once the central dilemma is defined, I suggest streamlining the list of questions to ensure they all point directly back to that core challenge. This alignment helps students stay focused on the key competencies you want them to develop. By narrowing the scope, we can make each question feel even more impactful and relevant to the 'mission' of the case.	All the questions in the Teaching Note have been reviewed and amended where appropriate. The questions have been included in the case study in accordance with the other peer review. The dilemma has, to the best of our abilities, been reflected in the diversity and depth of the questions and answers provided. *References: Discussion questions, pages 11-12 in the Case Study, and pages 4-11 in the Teaching Notes.*
10. **Teaching Plan: Detailed 60-90 minute timeline provided with specific "cold call" questions.** The detailed timeline you've put together is a fantastic resource! Once the central dilemma and learning objectives are finalized, I suggest a quick review of these activities to ensure they all drive toward those specific goals. This will help the timeline feel like a purposeful roadmap, guiding the students directly through the most critical stages of the protagonist's decision.	The Sample Teaching Plan has been revised accordingly. The modules set out in the Teaching Plan are suggestions for teachers of this case study, who are welcome to choose from the sides, materials and discussion questions provided. The Teaching Plan suggests 60-90 minutes, and there is significant material referred to in the Teaching Notes. The final teaching schedule will depend on the class and the teachers' chosen style. Cold call questions have been included in the Teaching Plan. *Reference: Teaching Note: cold call questions (pages 26-37)*
11. **Analysis & Answers: Answers are provided but lack depth or discussion of alternative views.** The Sample Teaching Plan provides a great starting point for instructors. To make it even more impactful, I suggest expanding on the potential student answers. A more thorough discussion of these responses would give teachers a great roadmap for navigating different classroom scenarios.	In the Sample Teaching Plan, student answers have been expanded, especially in the inclusion of cold-call questions. To the best of our abilities, we have given as much information to the potential teachers as we can without repeating. *Reference, Teaching Note (pages 26-37)*
12. **APA style Compliance:** You've gathered a great list of web resources! For the final version, a quick update to the APA format for these references will give the case a very polished, professional finish.	References have been revised (these will be double checked again to ensure APA compliance).

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This ensures the APA style compliance.	
13. **Final Recommendation:** Acceptance with revisions	Thank you greatly to the reviewer for your time and effort in making these suggestions. We have made these amendments to the best of our abilities, and consider that these amendments will significantly add value to this case study. Thanks again

III. Reviewer 2

Topic: The Biofuels Industry in Cambodia: Building a Sustainable Business Environment for Replacing Fossil Fuels

Reviewer's Comments (Please ensure your feedback is constructive.)	**Author's Responses** (Please provide a point-by-point response and highlight any changes in the revision)
1. **Hook & Context: Summary is missing, too brief, or gives away the solution.** Adding a brief summary at the beginning of the case would be a great way to immediately engage your readers. Since the current synopsis in the teaching notes is quite detailed (800+ words), a more concise version for the case itself—perhaps 150-200 words—would provide a perfect 'at-a-glance' overview of the story.	We have added a 200 (+/-) word summary at beginning of the Introduction to provide an overview of the focus and main issues in the case, particularly the choices and trade-offs required to develop and integrate growth in biofuels in Cambodia. The introduction also introduces the protagonist as this could introduce the protagonist as the Ministry of Mine and Energy (MME), and the Ministry of Agriculture, Forestry and Fisheries, which are primarily responsible for the policy on development of the biofuel's sector, and in particular the Power Development Plan (PDP), which sets out policy on biofuels within the overall energy strategy for Cambodia. It also introduces the National Institute of Science Technology and Innovation (NISTI), which is the research institute responsible for recommendations on biofuels standards. *(Reference: Section 1, Page 1, Paragraph 1), and Appendix*
2. **Narrative Flow: Narrative is logical and uses past tense but headings may be inconsistent.** The case provides a thorough history, and a few structural adjustments will make it even more reader-friendly:	The headings and sub-headings have been reduced for consistency and simplicity. Sections 6 and 7 are merged into Section 6 since they both involve biofuels policy and overlap. All policy issues are now covered in Section 6. *(Reference: Section 6, page 7-10)*

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• Streamline Content: Consider merging Sections 6 and 7 since they both cover biofuels policy to avoid overlap. • Refine Section 5: To keep the focus on Cambodia, you might move the insights on Thailand and Vietnam into a comparative sub-section or an appendix. • Order Visuals: Re-numbering the figures sequentially (starting with Figure 1) will help the reader follow your data more naturally. You can also save space by referring to figures by number only (e.g., 'See Figure 1') rather than the full caption. These small shifts will create a much smoother narrative flow!	Section 5 Refined; Thailand and Vietnam have been moved into the Appendix (this has helped keep the narrative leaner). *(Reference: Section 5, page 6-7 (+ Appendix))* Visuals are now ordered in the sequence they are referred to in the text. I have deleted the title and just referred to the number (*Reference: Tables and Figures: Pages 16-23)*
3. Protagonist & Organization: Protagonist or company context is vague or missing. Adding a protagonist to the opening paragraph would be a fantastic way to personalize the story. Introducing a specific character facing the dilemma right away will help readers immediately connect with the case's core challenge.	We have included the MME and the MAFF as the "protagonists" because of their responsibility to develop the Power Development Plan. How could they include biofuels in the PDP. Also added is the National Institute of Science, Technology and Innovation (NISTI), which we visited, which provides a lot of research for the decision making regarding which energies to support). The dilemma is whether and how to promote the biofuels sector, given that neighboring countries are rapidly developing their biofuels sectors, biofuels is a diverse sector with many possible but competing objectives (from export potential to poverty reduction) and is not yet proven technically or commercially. *(Reference: Section 1, Page 1)*
4. The Central Dilemma: The core problem or phenomenon is framed as a critical choice with significant implications. The core problem is framed at the end of the introduction. It is further elaborated with significant implications in Section 8.	The core dilemma was how to support and integrate a diverse and unproven energy source such as biofuels. Should Cambodia go the way of Indonesia and Malaysia with big investments in biofuels for export, or should it take a back seat for biofuels and let it develop organically, or focus on promoting domestic consumption, and lower income farmers? *(Reference: Section 1, Page 1; Section 7, Page 10)*

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5. **Analytical Depth and Technical Quality: Findings are seamlessly related to relevant theories, models, or frameworks (e.g., SWOT).** The Teaching Notes provide a great foundation. To further support instructors, I suggest incorporating a few relevant theories (such as strategic management or sustainability frameworks). This will help students connect the case's practical challenges to broader academic concepts.	Included are now the references to the strategic frameworks, the SWOT analysis for Cambodia, and the PESTEL framework for the biofuels sector in Cambodia, and the contribution to the sustainability framework (SDGs). Also included is an open-ended question OEQ referring to the SWOT, PESTEL frameworks and the SDGs, ESG, and GRI. *(Section 1, Page 2, Paragraph 1; (+ Open-ended questions pages 11-12 of Case Study))* *Teaching Note for SWOT and PESTEL frameworks and for sustainability frameworks including SDGs, ESG, GRI and IFRS*
6. **Data Exhibits: Factual data and exhibits are clearly labeled and essential for student analysis.** Data is rich for students to be able to make analysis.	We have tried to make the narrative flow as well as possible to make it clearer for students to follow. This includes focusing on the story telling, relating every paragraph to its impact on the decision as to whether or how to support and promote the biofuels sector. *(Reference: Throughout Text)*
7. **Tone & Ethics: Professional tone with clear evidence of ethical data collection and consent.** Data has been collected from reliable sources, and citations to sources have been made in an ethical manner.	Noted with thanks
8. **Teaching Notes and Pedagogical Value: Objectives clearly state specific concepts or skills students will master.** Learning objectives are clearly presented in the Teaching Notes.	Noted with thanks
9. **Discussion Questions: Open-ended questions are designed to encourage critical thinking and meet objectives.** Open-ended questions are provided in the Teaching Notes. In my opinion, they could already be provided in the case, at the end of section 8.	The OEQs in the teaching note have now been included in the case text at the end of Section 8 (now 7). OEQs have been added to ensure coverage of all aspects of student learning outcomes *(Reference: Open-ended Questions (page 11-12 -end of Section 7))*
10. **Teaching Plan: Detailed 60-90 minutes timeline provided with specific "cold call" questions.**	The teaching plan has now been amended to 60-90 minutes, on the assumption that the students have read the case beforehand. The estimated

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A detailed timeline is provided for 180 minutes. In my opinion, this is too long. I suggest that the authors replan it for 60-90 minutes.	timing per module is variable depending on teacher, and knowledge of the case by each class. *(Reference: Teaching Note Pages 26-37)*
11. Analysis & Answers: Provides detailed, well-reasoned answers, including alternative/incorrect options. Detailed answers are provided for each question.	Noted
12. APA style Compliance: Overall, citations and references are ok, but there are some mistakes, for example, in the use of italic font when referencing journal articles.	The references have been revised, and will be double checked again to ensure APA compliance (referencing is my weak point)
13. Final Recommendation: Acceptance with revisions	With thanks to the reviewer for the time and effort that they have undertaken in making these suggestions. We have completed all the amendments to the best of our abilities, and consider that these add significantly to the case study. Thanks again