Can Bioplastics Help Reduce Our Dependency on Petrochemicals? A Study from Thailand

Strengthening local capacity in the economic analysis of environmental issues

The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support training and research in environmental and resource economics across its 10 member countries (i.e., Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, Papua New Guinea, the Philippines, Thailand, and Vietnam.) It aims to strengthen local capacity for the economic analysis of environmental issues so that researchers can provide sound advice to policy makers.

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Like many developing countries, Thailand is working to stimulate its economy in ways that mitigate key environmental problems such as climate change. One potential 'new wave' industry that is being investigated for this reason is the production of biodegradable plastics (bioplastics) from renewable agricultural materials. An EEPSEA study looked at the costs and benefits of producing bioplastics from one of Thailand's leading crops, cassava. The study is the work of a research team led by Siriluk Chiarakorn from King Mongkut's University of Technology Thonburi.

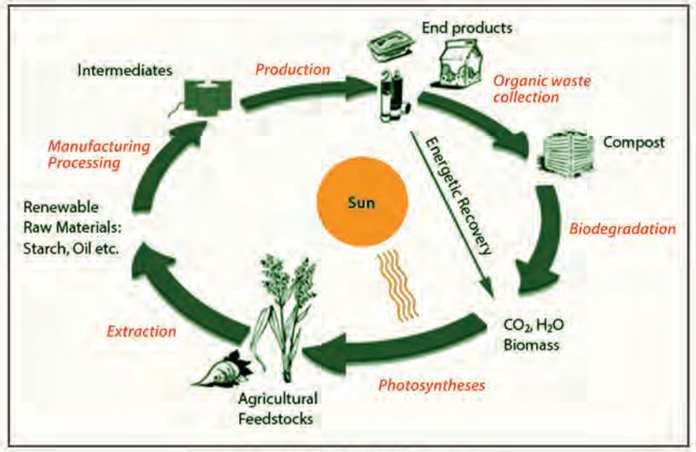
The study compares the production of polylactic acid (PLA), a bioplastic made from cassava, with the production of high-density polyethylene (HDPE), a petroleum-based plastic. It finds that the production of PLA has a net positive benefit for society as a whole. However, it also finds that the efficiency and management of the PLA production process must be significantly improved if bioplastics are to be a cost-competitive and environmentally preferable alternative to petroleum-based plastics. In light of this, the study makes a number of recommendations as to how PLA production could be supported and improved, so that the end product can be both sustainable and cost-competitive.

A summary of EEPSEA Research Report No. 2014-RR7: 'Financial and Economic Viability of Bioplastic Production in Thailand' by Siriluk Chiarakorn, Chompoonuh K. Permpoonwiwat and Papondhanai Nanthachatchavankul. Comments should be sent to Siriluk Chiarakorn, King Mongkut's University of Technology Thonburi, 126 Pracha-Utid Road, Bangmod, Thungkru, Bangkok 10150, Thailand. Email: siriluk.chi@kmutt.ac.th.

The bioplastic challenge

The search for alternatives to petroleum-based plastics is a key part of the global response to the challenge of climate change. Not only does the production of petroleum-based plastics use significant amounts of oil, it also generates carbon dioxide, the most important greenhouse gas (GHG). In addition, petroleum-based plastics are the cause of vast amounts of rubbish, which takes many hundreds of years to decompose.

In contrast, bioplastics are derived from natural and renewable feedstocks (see figure on the right). They are considered to be a potential solution to many of the problems posed by petroleum-based plastics. The majority of bioplastics are currently starch-based. At present, there are only two major commercial bioplastics in the market that are biodegradable and that can be produced from renewable sources such as sugar cane, cassava and rice. These are PLA and polyhydroxyalkanoates (PHA). Key manufacturers of PLA are NatureWorks and Purac and partners, which, between them, have a total capacity of 750 kt.



Life cycle of bioplastics
Source: european-bioplactics.org

Bioplastics in Thailand

For Thailand, one of the most promising of the commercially available bioplastics is PLA. It is produced via the polymerization of lactic acid, which is derived from agricultural products such as starch and sugar. These, in turn, are derived from crops such as cassava. This is a key factor in PLA's favor in Thailand, as the nation is the largest exporter of dried cassava in the world; it has an annual production capacity of 30 million tonnes.

The cost of cassava production in Thailand is lower than in many other countries. In addition, its price is low in comparison to potato, wheat and corn. These factors mean that Thailand is well placed to be a supplier of the raw materials needed for PLA production – or even to be a PLA production base itself. This could be good news for Thai farmers, as it would enhance the value of the cassava they grow. However, it is recognized that PLA production from cassava could have negative consequences for Thai agriculture and for the country's petrochemical industry, if it is poorly managed.

More information and research needed

Despite the opportunities that PLA offers, the development of bioplastic production in Thailand is still at an embryonic stage. To kick start its development, the Thai government established the National Innovation Agency (NIA) as a focal point for the development of the bioplastic industry. It also launched a five-year National Roadmap for bioplastic production. This was designed to prepare and strengthen the nation's bioplastic industry and its production chain.

Although there has been some financial analysis carried out on bioplastic production in the country, little research has been carried out on its costs and benefits. To help fill this information gap, this EEPSEA study analyzed the net social benefits that would come from substituting petroleum-based plastic production with bioplastic production. To do this it used the cost-benefit analysis (CBA) approach.

To establish a baseline for this assessment, a status quo scenario was first analyzed in which the production of HDPE would continue and in which no bioplastics would be produced. This situation was then compared with a new scenario in which 100,000 t of PLA would be produced every year (replacing the equivalent amount of HDPE). The research calculated the costs and benefits of HDPE production and of two types of PLA production: 1) PLA production using cassava root as raw material (Scenario 1); and 2) PLA production using cassava starch as raw material (Scenario 2).

The costs and benefits of PLA and HDPE production

The PLA production costs that the study assessed included the value of the necessary raw materials, capital and labor along with operational and waste treatment costs. Currently, no information on the production costs of PLA from cassava root is publicly available. The study therefore used the estimated cost of PLA produced from US corn to make the required calculations (adjusted to take into account all relevant differences and variables).

Cost-benefit analysis of PLA production (Scenario 2) compared to HDPE production

Scenario 2		PLA production (USD/kg PLA)	HDPE production (USD/kg HDPE)
Direct cost	Production cost	2.46	0.77
	Investment cost	0.16	0.05
Indirect cost	GHG emissions	0.20	0.143
Direct benefits	Sale of product	3.00	1.43
Net benefit		**0.18**	**0.47**

The study also assessed the benefits of PLA production. These come from the sale of the end product (PLA resin) and the value of its by-products, which include cassava meal when cassava root is the raw material. Other potential benefits that were assessed included the value of any pollution reductions that PLA production might bring (in particular, the value of any carbon emission reductions, which could be sold as carbon credits).

In Thailand, HDPE is produced from naphtha- and ethane-based feedstocks. The research evaluated the production costs of the naphtha-based production process (which uses the Ziegler Slurry process licensed by Mitsui Chemicals). An assessment was made of the direct production costs of this process and the value of its pollution emissions. An assessment was also made of the main benefits of HDPE production. This was done using the average domestic price of HDPE sourced from the Thai Plastic Industries Association.

Which type of plastic produces the most benefits?

As said, the benefits of PLA production include the sale of the by-products from starch production and the value of the carbon embedded in cassava. The study found that the overall net benefit of PLA production using cassava root as the raw material was USD 3.23/kg of PLA. This was 6.8 times larger than the benefits of HDPE production. However, the net benefits of PLA production using cassava starch as the raw material was only USD 0.18/kg of PLA (see table above). This was 2.5 times lower than the benefits from HDPE production.

Of these two options, the manufacture of PLA from cassava starch better represents the benefits that an investor in PLA production would receive. This is because proceeds from the sale of the cassava meal by-product (produced when cassava root is the starting point of the production chain) do not go directly to the PLA producers but go to the cassava starch supplier.

Because it best reflects the benefits that would accrue to an investor in PLA production, the manufacture of PLA from cassava starch was selected as the status quo for the calculation of net present values (NPV). The NPVs were calculated for three potential future circumstances: 1) if there are changes in benefits due to PLA price developments; 2) if there are changes in costs due to technological developments; and 3) a combination of 1 and 2. Only the first of these potential circumstances gave a negative NPV, while the rest gave positive NPVs. A sensitivity analysis was conducted based on the variation of real discount rates. This showed that all results were insensitive to an increase in these rates.

Which is best for the environment?

The overall environmental cost of PLA production was twice that of HDPE production. This was due to the larger GHG emissions that resulted from the electricity, fuel oil and wastewater treatment technology used in the PLA production process. For example, one major source of GHG emissions from the PLA production process was the aerated lagoon treatment technology it employs. This produces significant quantities of methane. In contrast, HDPE production caused less of an environmental burden due to its better energy efficiency, better air pollution treatment, and the fact that its wastewater has less organic content.

This finding is explained by the fact that HDPE production is more technologically mature than PLA production. This indicates the significant potential for the environmental impact of PLA production to be reduced through technological innovation.

Overall, it shows that, if PLA is to compete with HDPE from a sustainability point of view, then its production process must be improved. The study therefore

recommends policies that focus on the PLA production process and that champion energy efficiency improvements, the implementation of clean technology, and the utilization of the biomass waste and biogas produced from the wastewater treatment process as an energy source.

Cleaning up PLA production

For example, the study recommends that tax exemptions or reductions (and/or soft loans) should be provided as incentives to starch and sugar producers who implement clean technology and biogas recovery systems. Tax exemptions for new imported equipment could also be made available to all bioplastic producers and suppliers who enroll in an energy efficiency improvement program. In addition, a carbon credit enrollment program should be established for the bioplastics industry to reduce GHG emissions. Supplementary payments should also be introduced for electricity produced from the methane recovered during wastewater treatment. Finally, pollution control measures (coupled with the above supportive policies) should be effectively implemented to reduce the environmental impact of PLA production.

In October 2010, Thailand launched the law of Fiscal Measures for the Environment. This law includes measures such as environmental taxes, product taxes, pollution treatment fees, and emission permits. These measures could be applied to relevant stakeholders in the PLA production chain in order to encourage plant owners to use more environment-friendly technology. Even though this is only a first step for advanced environmental protection in Thailand, it shows that Thai society has begun to pay more attention to the environment.

Making PLA more cost-competitive

The study also highlights another challenge facing the PLA industry in Thailand. Currently, the price of bioplastics is approximately twice that of petroleum-based plastics. Bulk production should help reduce bioplastic production costs by bringing in economies of scale; however, any increase in production capacity depends on there being sufficient demand.

Because of this, the study highlights various things that can be done to encourage PLA production in Thailand. In particular, it recommends that the government should provide incentives to bioplastic investors, which should include a subsidy program.

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