Biogas – Key Success Factors for Promotion in Thailand

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Abstract: ASEAN countries have high potential for developing biomass energy from wastes and wastewater. Biogas is one of the renewable energy sources that can be used as both heat and electricity. The aim of this paper is to present the current status of biogas technology, biogas purification technology and biogas utilization in Thailand. Biogas utilization at the domestic level has met with varying success, both in Thailand and other nations. Key to success in Thailand has been the focus on treating agricultural and agro-industrial waste streams, with biogas being a useful byproduct of this approach. The data was collected from primary and secondary sources from interviews with technology vendors, technology users and policy makers in Thailand. This paper gives an overview of the development of biogas technology and measures and strategies in promoting biogas production and utilization, as well as providing a successful model to increase biogas utilization in cassava starch industries due to a high success output. Since 1984, anaerobic wastewater treatment has been developed to produce biogas in cassava starch factories. At the beginning, most factories were not interested to invest in biogas production due to the high investment cost. However, this changed radically with the introduction of new measures and strategies such as financial support, tax incentives, small power purchase tariff (SPP) and environmental law enforcement. The key success factors to promote biogas utilization are the result of four important approaches, policy, technology, incentives and maintenance.

Keywords: cassava starch, food industry, industrial waste, policy, incentives, ASEAN.

1. Introduction

World energy consumption has increased significantly as population increases. In 2012, overall energy consumption was 8,677 Mtoe (almost double from 1973). 84% of this consumption was from fossil fuels such as oil, gas and coal [1]. ASEAN, which includes Brunei**,** Cambodia, Malaysia, Myanmar, Indonesia, Laos**,** the Philippines**,** Vietnam**,** Singapore and Thailand, has high potential for producing biomass energy, due to the predominance of agriculture in these economies. Biogas is one form of renewable energy that can be used for several options such as heating, electricity and combustion.

In Thailand, the use of renewable energy has continuously increased, albeit at a slow pace. The Royal Thai Government's Alternative Energy Development plan for 2012-2021 (AEDP: 2012-2021) aims to increase renewable energy use from 11 to 25% by 2021. The target for biogas production and utilization rises to 600 MW by the year 2021. As Thailand has shown success in the promotion of biogas technology, especially in the cassava starch industry and swine farms, this paper explores the current status of biogas technology in Thailand and key factors contributing to this success. In addition, SWOT analysis was conducted using data collected from Thai experts in both the public and private sectors to assess the opportunity for biogas promotion in ASEAN.

2. Development of Biogas Technology in Thailand

Thailand began to utilize biogas from anaerobic waste treatment system in the early 1960s.

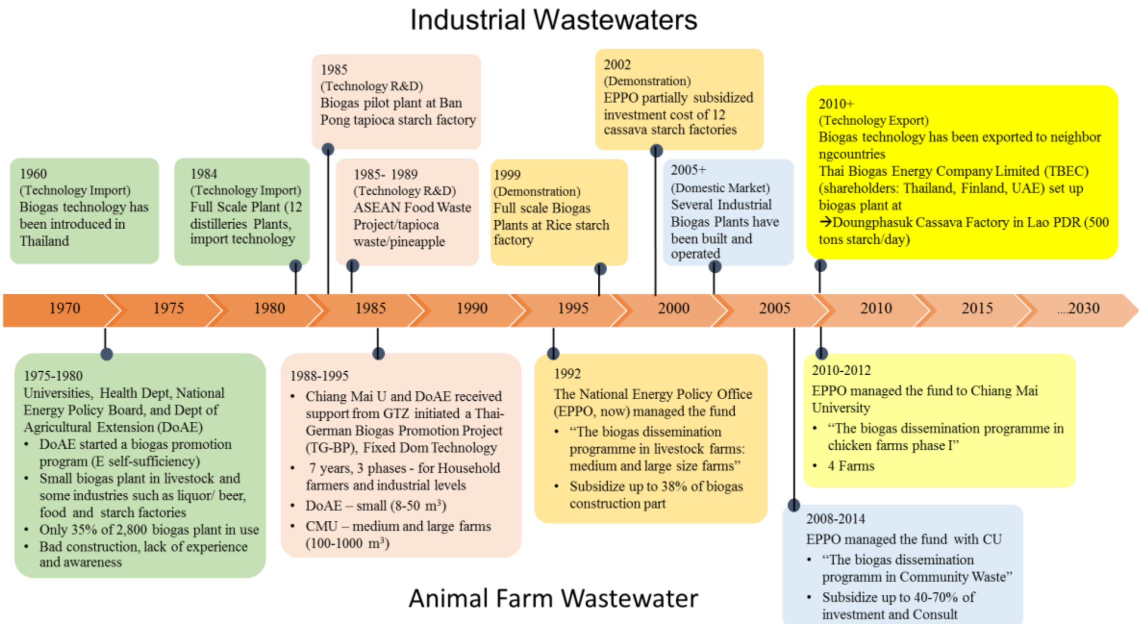

Figure 1. Timeline of Biogas Development in Thailand.

Before 1988, small size biogas plants were built for the purpose of solving sanitation problems at the community level. For example, a conventional biogas system with a floating drum digester or a fixed dome digester was used to treat wastes and wastewater from animal husbandry at the small-scale farm level. Due to the oil price hike in 1975-1980, the Royal Thai government initiated the promotion of biogas plants to produce renewable energy; however, most systems at that time did not perform as expected due to the lack of construction experience as well as knowledge of system control and management [2]. In 1988, the Department of Agriculture Extension (DoAE) under the Ministry of Agriculture and Cooperatives, the Biogas Advisory Unit of Chiang Mai University (BAU) and the Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ) GmbH on behalf of the German Government collaborated to initiate the Thai-German Biogas Project that encouraged the use of biogas plants with the fixed dome digestion technology in small-size livestock farms to build biogas systems with a volume less than 50 m^3. At the end of 1992, more than 150 biogas plants were built as a result of this project. Once the project was concluded in 1995**,** DoAE and BAU requested the subsidization from the National Energy Policy Office (NEPO) to extend their project to comprehensively include the livestock farm sector. This was the first systematic approach to promotion that initiated the current development of biogas technology in Thailand [3-4].

Commencing in 1984, a non-conventional or high-rate system to produce biogas from food industrial waste was adopted. Twelve liquor factories built the closed-wastewater treatment systems using Upflow Anaerobic Sludge Blanket (UASB) technology. However, the systems had their flaws due to the wastewater generated from the liquor factories containing high organic loading as well as high potassium, causing a sludge bulking problem. This problem, in combination with the lack of available expertise, tarnished the image of anaerobic treatment systems for biogas production in the food industrial sector [4].

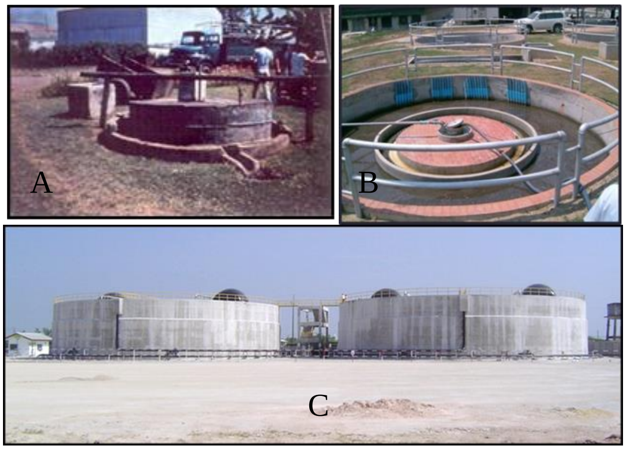

Figure 2. (A) Fixed Dome System [Source: DoAE], (B) Biogas System in Swine Farm and (C) Biogas Plant in Tapioca Starch Factory.

Also in 1984, the National Center for Genetic Engineering and Biotechnology (BIOTEC) provided a research grant to King Mongkut's University of Technology Thonburi (KMUTT) to conduct research and development on utilization of wastewater from cassava starch factories for biogas production. With high levels of suspended solids (SS) as one major characteristic of the wastewater from the cassava starch process, the UASB technology had been perceived as unsuitable. A high level of SS causes the inhibition of sludge granulation and the methanogenic activity of the sludge [5-6]. Further, a high wastewater feeding flow-rate may cause a sudden washout of the sludge bed [5]. As a result, a pilot plant of an Anaerobic Fixed Film Reactor (AFFR), a high efficiency anaerobic system, was developed to treat wastewater and produce biogas from the cassava starch plant. The main component of AFFR is the packed media, which allows the biomass to adhere and grow on as biofilm. Consequently, once the reactor retains more biomass, especially the methanogenic bacteria, resulting in an increase in the efficiency and stability of the system [7]. In addition to research and technology development, training courses were also conducted, along with technical advice and consultancy to industrial partners through BIOTEC and KMUTT. The success of the project can be seen from the production of the renewable energy, biogas, generating increased income to the factory. Figure 2 illustrates the fixed dome system, UASB system in swine farm and AFFR system in cassava starch factories.

3. Measures and Strategies to Promote Biogas Production

Although the biogas project demonstrated a highly successful outcome, most cassava starch factories were not interested due to the high investment cost and low fuel oil cost (~3.50 Baht or 0.1 US$ per litre in 1992-1995[1]), which did not help the promotion. Hence, only a small number of biogas systems for the cassava starch factories were constructed at that time.

To overcome these problems, supporting programs to educate and promote the biogas production to the public and private sectors have been provided continuously by the relevant agencies, such as Ministry of Energy, BIOTEC, KMUTT and BAU. These agencies were instrumental in developing incentives to inspire the starch factories to develop biogas production projects. The government proposed several schemes to support the construction of biogas systems for energy production in the starch and food industries.

3.1 Financial Support

In early 2002, the Thai government initiated a pro-active approach to enhance investment in the construction of industrial plants for biogas production. The Energy Policy and Planning Office (EPPO) under the Ministry of Energy provided a 30% subsidy for the design and construction costs. In all, nine cassava starch factories received were subsidized.

In 2003, the Ministry of Energy adjusted the subsidy measure to provide financial support in the form of soft loans under the revolving fund for energy conservation (Energy Conservation Fund: ENCON fund). The soft loan scheme provides up to 20 million Baht (0.6 million US$) with a 4% interest rate per year.

In addition, since 2002, the Ministry of Science and Technology (MOST) has supported the promotion of biogas technology through a similar soft loan scheme. The Company Directed Technology Development Program (CD), Technology Management Center (TMC) under the National Science and Technology Development Agency (NSTDA) is the responsible entity. The soft loan program provides up to 75% of investment, not exceeding 30 million Baht (0.9 million US$). However, this scheme was considered unattractive as it does not cover the total investment cost. In 2006, TMC provided a soft loan program to support the anaerobic fixed film technology for wastewater treatment and biogas production in the cassava starch industry. With the cooperation from six commercial banks, the program was able to provide soft loans with a low interest rate of 3-4% per year for 4 to 6 years with no capital paid in the first year. This approach is the main driving force for the Ministry of Energy to re-instate their previous strategy of 20% subsidiary for the investment in biogas production systems, starting in 2007.

In addition to the financial support for investment, other measures included:

3.2 Tax Incentive

Starting in 2005, the Board of Investment (BOI) under

[1] Average price of Fuel oil in 1992-1995, Source: EPPO

the Ministry of Industry has offered the highest incentive to the business enterprise related to biogas production from waste. The incentives include an exemption of import duty of machinery or energy efficient equipment and an exemption of corporate income tax for 8 years without limited financial amount [8]. As of January 2009, BOI has already supported 59 biogas project initiatives.

3.3 Promotion for Energy Service Company (ESCO)

To reduce the problem from the high initial investment in the system construction, the government promoted the business enterprise called Energy Service Company or ESCO. ESCO provides a one-stop service for searching financial sources, designing and constructing systems, to sharing benefits among stakeholders. In addition, there is a guarantee for the energy efficient result. If the energy efficiency is not agreed, ESCO is responsible for compensation [9].

3.4 Small Power Purchase Tariff

In addition to promoting the construction of biogas production systems, the government launched a program to increase the proportion of electricity generation from biogas. The measure added 0.30 Baht/kWh (0.01US$/kWh) to the price of electricity produced from biogas for 7 years from the date of purchasing electricity. The VSPP scheme allowed producers to sell direct to the grid [10].

3.5 Clean Development Mechanism (CDM)

According to the Clean Development Mechanism (CDM), projects incorporating biogas production as a renewable energy source are entitled to privilege. The factory has an opportunity to receive money from credit for the quantity of greenhouse gases reduced. This project has inspired several factories to operate biogas production plants. At present, 26 projects generating electricity from biogas have been approved by the government [11].

3.6 Environmental Law Enforcement

The environmental law enforcement is another factor that forced factories to give serious consideration to biogas production investment. At present, the industrial factories have to follow the standards for wastewater treatment systems. In 2006, the Department of Industrial Works declared that factories which have wastewater of more than 3,000 m^3 per day and organic loading more than 4,000 kg^3 per day must have a BOD (Biochemical Oxygen Demand) online system [12]. A taxation law for individual companies producing pollution is being implemented. This regulation supports the utilization of biogas production systems.

Measures and strategies to promote investment and technology development in both public and private sectors have led to the higher investment in biogas production.

Since the initiation of the project of ENCON fund in 2003, the amount of biogas production and utilization has increased. At present, more than 90% of the cassava-starch factories are producing biogas. The maximum potential of wastewater biogas production from the organic industrial wastewater is approximately 2,400 million m^3 but as of now only 900 million m^3 or 37% of biogas is produced annually. While the utilization of biogas in animal farm and municipal solid waste is 17% and 4% of the total potential, respectively [13].

At present, there are many kinds of technology applications available for wastewater treatment and biogas production. Each biogas production system has different efficiency depending on characteristics and quantity of wastewater/waste product such as Anaerobic Covered Lagoon (ACL), Modified Covered Lagoon (MCL), UASB and AFFR. Currently, there is also an Anaerobic Hybrid Reactor (AHR) system developed by integrating the advantages of UASB and AFFR wastewater treatment systems. The advantages of this hybrid system include the ability to withstand the high load of organic concentration with no clogging problems. The attractiveness of these technologies will help cassava starch industries and other industries consider investing in biogas production systems.

4. Biogas Technology

Biogas technology can be divided into 4 major stages: (i) pretreatment (if needed), (ii) biogas conversion technolgy, (iii) biogas cleaning technology and (iv), biogas utilization technology. Figure 3 illustrates the current status of the technology in Thailand. The levels of technology maturity are fully commercial in Thailand, partially commercial in Thailand and under R&D in Thailand.

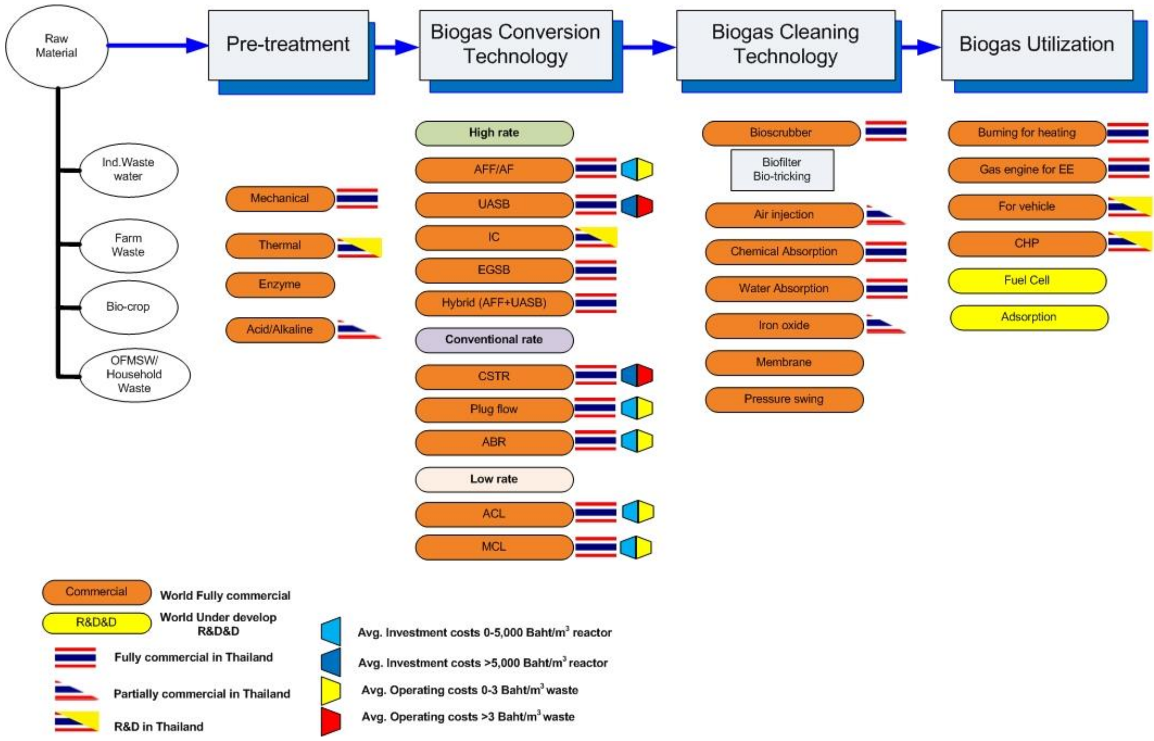

Figure 3. Current Status of Biogas Technology in Thailand (adapted from [14]).

Pre-treatment technology consists of mechanical, thermal, enzymatic and chemical treatments. Whether the technology is needed depends on the type of substrate used in the biogas system. Pre-treatment naturally adds costs to the overall system. Biogas conversion technology, where organic substrate is converted to CH_4 and CO_2, can be catagorized based upon the system efficiency. High-rate technologies means that the system's organic loading rate (OLR) is greater than 4 kg COD/m^3 reactor/day, while the OLR of a low-rate system is lower than 2 kg COD/m^3 reactor/day and that of a conventional-rate system is in between. Figure 3 also provides the average investment cost and operating cost of each biogas conversion technology existing in Thailand. Biogas cleaning technology, aiming to increase the purity of CH_4, consists of water removal, H_2S stripping and CO_2 separation. The current utilization alternatives of biogas are direct burning for heat, for electricity generation, for combined heat and power (CHP) system, or for transportation in the form of compressed bio-methane gas (CBG). Figure 4 shows the current status of existing biogas technology in ASEAN. There exists different biogas technologies and different levels of maturity of technology depending on the variety of resources and expertise of each country.

5. Policy Lessons

The success of biogas energy implementation in Thailand was achieved from the combination of four important approaches – policy, technology, incentives and maintenance.

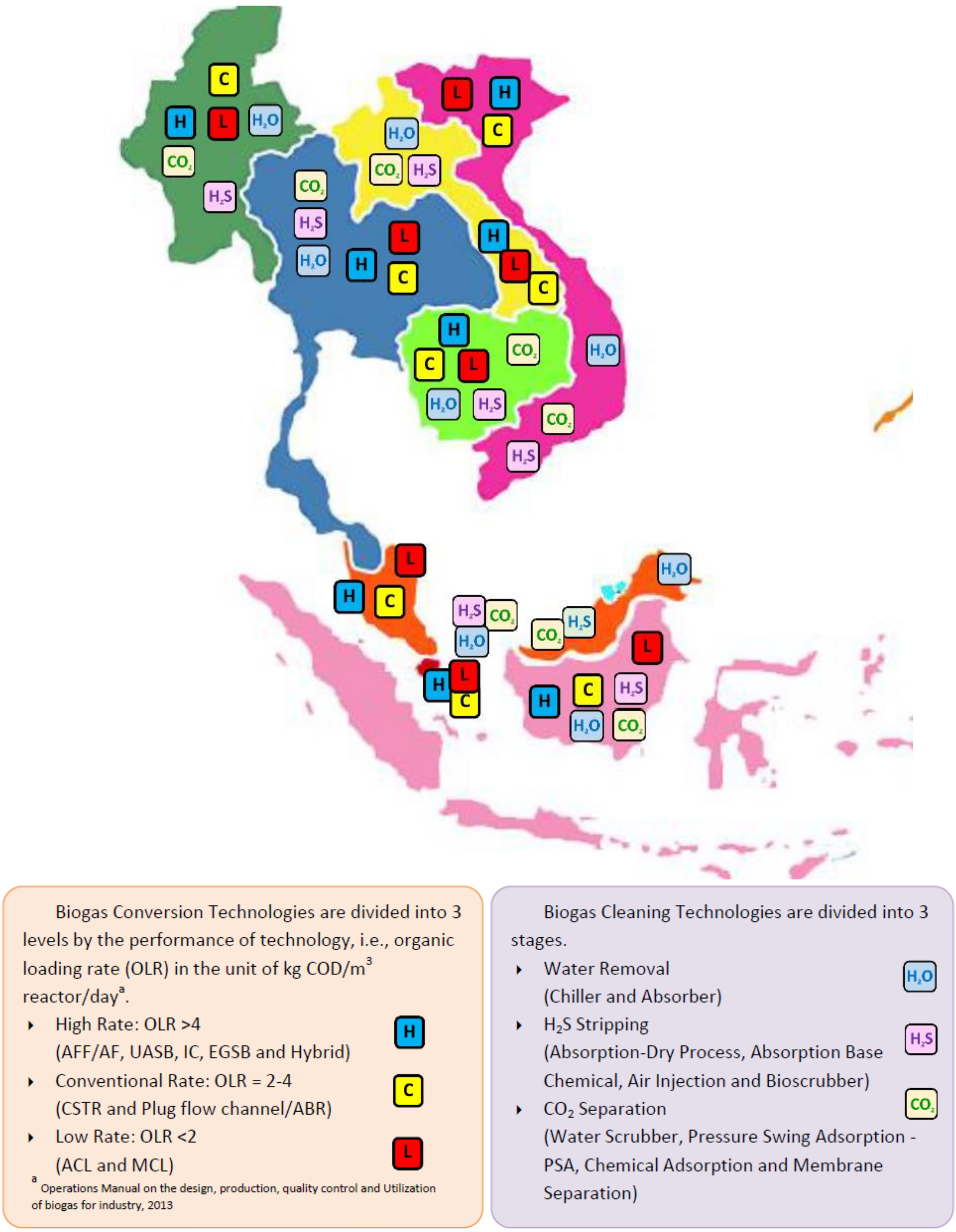

Figure 4. Current Status of Existing Biogas Technology in ASEAN. (indicators in Indonesian Borneo are for all of Indonesia).

5.1 Policy

Government policy in support of specific energy strategies is critical to their success, particularly when these policies are translated into meaningful incentives and active promotion of the energy strategy. The Ministry of Energy was the key agency to promote policy and turn it into practical action. This led to a network of cooperation with relevant agencies such as MOST for research and development of biogas technology and BOI for specifying tax incentive measures.

5.2 Technology

A strong research, development and demonstration network involving both the public and private sectors has helped to increase the wide dissemination and application of biogas technology, particularly the willingness of the research sector to develop various technologies to the pilot plant stage. Presently, home-grown biogas technology has higher efficiency and is less expensive than imported technology. The factory owners are assured of the soundness of the technology and will often select to utilize technology developed in the country. The AFFR technology developed in Thailand has been selected as the technology of choice for the Project of Cows to Kilowatts in Nigeria to treat water and produce energy from slaughterhouses [15]. This project also received the Seed Awards 2005 from the United Nations Organization.

5.3 Incentives

The success in promoting biogas production in the starch and palm oil industries in Thailand are a direct result of government policy and promotion concurrent with the development of biogas technology. The measures for providing financial support and various privileges, combined with environmental legislation, are also important factors encouraging factories to make investment decisions in biogas production systems. Financial incentives have helped to reduce the initial construction costs of biogas systems by 20-30%. Providing the means for small electricity producers to sell direct to the grid has also been instrumental for success.

5.4 Maintenance

Concurrent with technology development has been the close collaboration between the research and private sectors in developing systems appropriate to specific needs. This has included extensive training programs in set up and maintenance of installed systems, as well as trouble shooting. This provides the private sector with confidence to maintain their systems and they are able to consult with researchers (as well as private sector consultants) to overcome any problems they may encounter. This is one major benefit of using locally grown technology.

6. Keys to Success

The achievement of successful biogas energy implementation in the starch and other industries, can be summarized by the "BIOGAS Theory".

B: Business Need

Business need is a primary factor to promote biogas production. The understanding of the industrial needs helps the government sector formulate the measures that meet the need. The incentives to reduce the limitation of capital investment lead to the increase of the research and development of biogas technology which is accepted and assured by the investors.

I: Incentive

The construction of biogas production requires high investment. Good incentives especially grants, soft loans and tax privileges encourage the decision making process. However, these measures should be monitored and adjusted periodically in order to attract the investment and to increase the number of biogas production facilities.

O: Organization and Opportunity

Organization

Cooperation among public and private organizations helps in the continuous development of the biogas production technology. Currently, the cost of home-grown technology is cheaper than imported technology. This cooperation helps to initiate R&D activities, tax incentives from the Board of Investment (BOI) and other measures.

Opportunity

The energy crisis provided the opportunity for investors to find alternative sources of energy. Biogas is one source for industry consideration. In addition, with the service of the Energy Service Companies (ESCO), there is an incentive for cassava-starch and other industries to increase investment in biogas production.

G: Government Support

Government support is a must if the biogas production is to be successfully launched. The policy setting helps direct the goal of the nation and facilitate the coordination among organizations in the area of R&D and incentive privileges.

A: Applicable Technology

Because of the technology readiness, the industrial factories are reassured and the decision to invest in biogas production system is more certain. Currently there is a variety of biogas production technologies that are efficient and cost effective. Investors can choose the ones that best suit their industries.

S: Solution and Success Study

Biogas production is a product of wastewater treatment. The technology helps to not only decrease the environmental problem, but also reduce energy usage in factories. The success of the cassava starch factories is a good example to encourage more investment in biogas technology and reaffirm adaptation of similar technology in other industries.

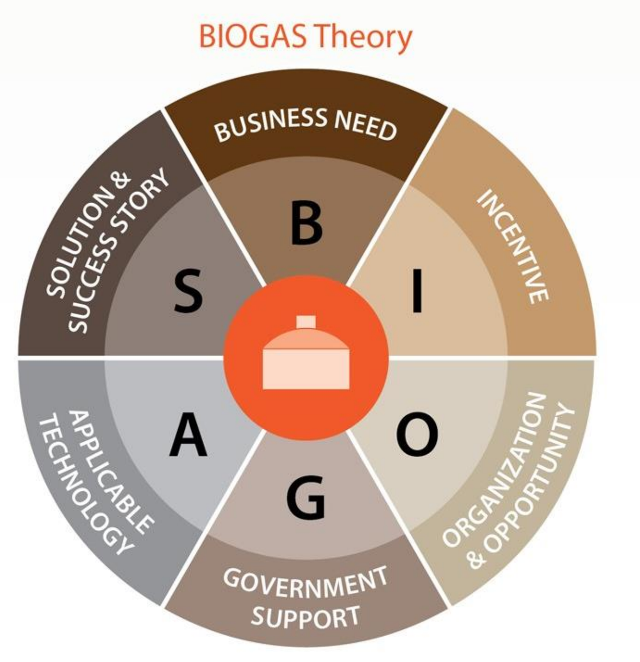

Figure 5. Diagram of "BIOGAS Theory".

In summary, Thailand and ASEAN are well-equipped with abundant feedstock and proven biogas technologies to treat these. Knowledge and technology transfer are encouraged to promote biogas production and utilization in the region through each country's national energy policy plan. If the factors leading to successful promotion in Thailand can be adapted in other ASEAN member countries, there is high potential for environmental benefit and renewable energy generation. Potential exists to explore other waste streams such as rubber (latex), sugar, coconut, municipal solid waste and slaughterhouse waste. Further basic and applied research is necessary to explore the particular requirements of recalcitrant or cellulosic feedstock. Further, the availability of a qualified workforce, along with home-grown technology and the development of safety standards for biogas systems ensure that the region is ready to expand the use of this technology. Lessons acquired from the Thai experience can go a long way to adaptation and adoption of this technology for waste streams in ASEAN.

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