



# A review on industrial scale anaerobic digestion systems deployment in Malaysia: Opportunities and challenges



Palanisamy Kumaran\*, David Hephzibah, Ranganathan Sivasankari, Normanbay Saifuddin, Abd. Halim Shamsuddin

Centre for Renewable Energy, Universiti Tenaga Nasional, Malaysia

## ARTICLE INFO

### Article history:

Received 17 December 2014

Received in revised form

30 July 2015

Accepted 27 November 2015

### Keywords:

Anaerobic digestion

Biogas

Clean development mechanism (CDM)

Renewable energy

Methane (CH<sub>4</sub>)

Waste to energy

Feed in Tariff (FIT)

## ABSTRACT

Depletion of fossil fuels and environment deterioration has led to extensive research and development activities to explore renewable energy such as biogas generation from anaerobic digestion of waste for power generation. Anaerobic digestion of waste to generate methane (CH<sub>4</sub>) has been proven to be a very promising alternative to waste disposal and a valuable technology for renewable energy recovery. Although anaerobic digestion is proven to be a feasible and economically viable technology for renewable energy generation of wastes in many developed countries like Germany, there are challenges in implementing this technology in Malaysia. This paper reviews the potential for biogas production from various waste water treatment and waste management industries in Malaysia and current state of anaerobic digester deployment in Malaysia. It also discusses on the benefits and barriers for anaerobic digestion technology deployment to harness the biogas energy potential to support the renewable energy target in Malaysia. The analysis has shown that anaerobic digestion technology deployment has the potential of 1694 MW of electricity generation in 2014 and projected 22.35 TW.h of energy substitution potential by the year 2020. Hence, the analysis has shown that an active promotion and pursuant to anaerobic digestion deployment in Malaysia, a potential electricity generation capacity of 2135 MW and emission avoidance potential of 11.35 Mt of CO<sub>2</sub> equivalent can be accomplished by the year 2020.

© 2015 Elsevier Ltd. All rights reserved.

## Contents

1. Introduction.....	930
2. Anaerobic digestion.....	930
3. Justification of anaerobic digestion development in Malaysia.....	931
4. Potential of biogas production in Malaysia.....	931
4.1. Palm Oil Mill Effluent (POME).....	931
4.2. Sewage sludge(SS).....	932
4.3. Chicken manure.....	932
4.4. Swine manure.....	933
4.5. Dairy manure.....	935
4.6. Food waste.....	935

**Abbreviations:** AAIBE, Akaun Amanah Industri Bekalan Elektrik; AIF, Asian Institute of Finance; CDM, clean development mechanism; COD, Chemical oxygen demand; CPO, crude palm oil; DL, Distribution Licence; DVS, Department of Veterinary Services; EFB, empty fruit bunches; ETP, Economic Transformation Programme; FFB, fresh fruit bunch; FIAH, Feed-in Approval Holders; FiT, Feed in Tariff; GTFS, Green Technology Financing Scheme; HRT, hydraulic retention time; IWK, Indah Water Konsortium; KeTTHA, Ministry of Energy, Green Technology and Water; MESITA, Malaysian Electricity Supply Industries Trust Account; MPF, modern pig farming; MSW, municipal solid waste; OPF, oil palm fronds; OPT, oil palm trunks; PFA, pig farming area; PGU, Peninsular Gas Utilization; POME, Palm Oil Mill Effluent; REBF, Renewable Energy Business Fund; SEDA, Sustainable Energy Development Authority; SS, sewage sludge; TSS, total suspended solids; STP, sewage treatment plants; TS, total solids; VFA, volatile fatty acid.

\* Corresponding author.

E-mail addresses: [kumaran@uniten.edu.my](mailto:kumaran@uniten.edu.my) (P. Kumaran), [hephzibahdavid89@gmail.com](mailto:hephzibahdavid89@gmail.com) (D. Hephzibah), [sivasankari@uniten.edu.my](mailto:sivasankari@uniten.edu.my) (R. Sivasankari), [saiduddin@uniten.edu.my](mailto:saiduddin@uniten.edu.my) (N. Saifuddin), [abdhalim@uniten.edu.my](mailto:abdhalim@uniten.edu.my) (A.H. Shamsuddin).

<http://dx.doi.org/10.1016/j.rser.2015.11.069>

1364-0321/© 2015 Elsevier Ltd. All rights reserved.

5. Industries employing anaerobic digesters in Malaysia. ....	936
6. Benefits of biogas recovery. ....	936
7. Current barriers for anaerobic digestion deployment in Malaysia. ....	937
8. Conclusion. ....	938
Acknowledgement. ....	938
References. ....	939

## 1. Introduction

Anaerobic digestion has been a global focus of research since the 1970s, in the pursuit of alternative fuel due to the issue of fossil fuel depletion. The technology has the potential of converting organic material into usable energy in the form of biogas which is renewable and environmentally friendly. Although it has been mainly used for waste water sludge stabilization, the technology has been actively developed for other waste management sectors [1,2]. In 2012, 56 billion m<sup>3</sup> of biogas was produced in the world that has an energy potential of approximately 1212 PJ. Europe is currently the largest biogas producer in the world, trailed by Asia, Americas, Oceania and Africa. Moreover, Germany is the leader in the installation of anaerobic digesters and production of biogas whereby about 10,000 biogas plants are in operation. Furthermore, United Kingdom, Netherlands, Korea and Brazil are among the top 5 countries in biogas production [3,4]. However, the number of plants for treatment of organic waste in Malaysia, although limited as compared to European nations, is slowly increasing, although incineration of waste is still the major choice [5]. Despite the many benefits of anaerobic digestion, it still remains under-utilized in Malaysia, although most of the wastes produced in Malaysia are compatible for anaerobic digestion. At present there is only 6.30 MW installed capacity of anaerobic digestion plants in Malaysia. Malaysian landfills accommodate nearly 7 million tons of waste annually [6]. Indeed, the deployment of anaerobic digestion has potential energy benefit of Malaysia and also for carbon dioxide (CO<sub>2</sub>) emission mitigation. The Five Fuel policy introduced by the Malaysian government, present energy conservation policies, and the Feed in Tariff (FiT) mechanism are the driving forces to further promote the anaerobic digestion deployment for harnessing renewable energy into electricity or other primary energy substitute.

The objective of this paper is to outline the current status of anaerobic digestion deployment, opportunities and challenges in Malaysia. Benefits of biogas recovery system, the issues faced in setting up a biogas plant and the available potentials for anaerobic digesters in Malaysia will be briefly discussed.

## 2. Anaerobic digestion

In anaerobic digestion, organic biodegradable material is degraded by microorganisms under conditions devoid of oxygen (O<sub>2</sub>) where biogas is produced naturally [7]. The process takes place in 4 stages, namely hydrolysis, acidogenesis, acetogenesis and finally methanogenesis [8]. Biogas is comprised of generally 60–70% CH<sub>4</sub>, 30–40% CO<sub>2</sub> and low amounts of other trace gases [9].

Hydrolysis is a critical rate limiting process which degrades insoluble organic materials such as lipids, polysaccharides, proteins and cellulose into its backbone constituents (e.g. fatty acids and amino acids) [10]. The components formed during the hydrolysis process are further broken down into hydrogen (H<sub>2</sub>), CO<sub>2</sub>, acetates and volatile fatty acid (VFA) by acidogenic bacteria which are converted into consumables for the methanogens.

In the third stage, VFAs are digested to produce acetate and H<sub>2</sub> by obligate H<sub>2</sub> producing bacteria/acetogens. This conversion is however highly influenced by the partial pressure of H<sub>2</sub> in the substrate. The methanogenesis stage where the CH<sub>4</sub> is generated by a variety of methanogenic bacteria can be divided into two groups namely acetate consumers and H<sub>2</sub>/CO<sub>2</sub> consumers. The first group splits acetate into CH<sub>4</sub> and CO<sub>2</sub> and approximately 70% of CH<sub>4</sub> is formed through this pathway [11]. The remaining 30% CH<sub>4</sub> is produced using H<sub>2</sub> as electron donor and CO<sub>2</sub> as the acceptor.

The various groups of bacteria participating in the anaerobic digestion have different optimum pH ranges to collectively ensure efficient digestion and gas production. The process of acidogenesis and methanogenesis require different pH for optimal process control. Acidogenic bacteria are less sensitive and only require pH above 5, while methanogenic bacteria are extremely sensitive and only work well in a pH range of 6.5–7.2 [11,12]. Therefore, the optimal pH range is 6.8–7.4 where both the bacteria group can coexist [13]. The VFAs generated during the anaerobic digestion leads to a reduction in the pH. However, it can be countered by the production of alkalinity in the form of carbon dioxide, ammonia and bicarbonate by the methanogenesis bacteria [12].

Temperature is another environmental factor affecting the substrate in the digester. The metabolism and growth rate of the microorganisms also heavily depend on this parameter [12,13]. Mainly, there are two temperature ranges which are optimized for

**Table 1**  
Type of anaerobic digester systems.Sources: [15–17]

Digester type	Description
<b>Wet</b>	Feedstock is made into slurry by addition of water in order to provide dilute slurry of 10–15% solid content. Has to be continuously stirred for optimum gas production.
<b>Dry</b>	Feedstock's often have solid content around 20–40%. Dry anaerobic digestion is cheaper as the organic loading rate (OLR) is higher and thus more gas production per unit of the feedstock.
<b>Batch</b>	Reactors are loaded with organic raw feedstock and inoculums from other digesters. Once all the organic material has been degraded the reactor is emptied, cleaned and new batch for digestion is added.
<b>Continuous</b>	Most digesters for waste products are operated as continuous flow as restarting the system every few weeks once is economically unfavorable. This system gives higher amounts of biogas per unit of feedstock and the operating cost is also lower due to the reduction in startup time.
<b>Single stage</b>	Easy to operate, cheaper to construct compared to a multistage system. Limitations do exist since optimum condition for all participating microorganisms cannot be achieved in a single system but methanogenic population in the system can be managed efficiently by controlling the feeding rate and ensuring thorough mixing, buffering and addition of nutrients.
<b>Multi stage</b>	The digestion occurs in separated stages allowing provision of optimum environmental conditions for each microbe group. Usually two digesters are employed and separation of acetogenesis stage from methanogenesis stage often results in increased process efficiency.

Download English Version:

<https://daneshyari.com/en/article/8114901>

Download Persian Version:

<https://daneshyari.com/article/8114901>

[Daneshyari.com](https://daneshyari.com)