Renewable and Sustainable Energy Reviews 52 (2015) 227–239

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Historical, technical and economic aspects of biogas development: Case of Poland and Ukraine

O. Chasnyk [a,*], G. Sołowski [b], O. Shkarupa [a]

[a] Department of Economics and Business Administration, Sumy State University, 2, Rimsky-Korsakov Street, UA-4007 Sumy, Ukraine
[b] Department of Chemical and Process Engineering, Gdansk University of Technology, 11/12, Narutowicza Street, 80-233 Gdańsk, Poland

ARTICLE INFO

Article history:
Received 24 December 2014
Received in revised form
27 May 2015
Accepted 27 July 2015
Available online 12 August 2015

Keywords:
History of biogas
Biogas manufacture
Green economy
Green tariff
Poland and Ukraine

ABSTRACT

The paper describes 3700 years of biogas manufacture with more details of last 120 years. Due to V. Omelianskij's researches 120 years ago, Ukrainians achieved a share in biogas manufacture in the overall biogas development. Poland started to take part in biogas development 96 years ago by finishing biogas plant in Posen 1928. History and current status of biogas plants achievements are collected and analyzed. Faults and achievements of the two countries are exactly described in the background of global history to draw conclusion for future that helps not to repeat the old errors. The development of green economy based on biogas is discussed. The paper brings back ideas that were previously extinguished due to low technological level and those could be used more successfully nowadays.

Contents

* Corresponding author.
E-mail address: olena.chasn@gmail.com (O. Chasnyk).

http://dx.doi.org/10.1016/j.rser.2015.07.122
1364-0321/

1. Introduction

1.1. General short history of biogas

When people stopped migrating and they began spending a residential life as farmers. Breeding of animals and cultivation of plants are connected with the necessary utilization of wastes like manure or plant shoot which is called as biomass. People tried to make the wastes more useful as substrates for improving the life conditions. One of ways to utilize waste is biogas fermentation in which biomass is transformed into hydrogen and methane. Produced in such way methane or hydrogen could be used as a heating or power source.

This paper describes development of biogas and biogas plant (place designed for processing fermentation) from the beginning of mankind up to today by paying attention to their development in Poland and Ukraine.

History of biogas plants development can be described into three stages: unconscious, transient and conscious stage. Unconscious stage is the first stage of biogas. It was present from XVII B. C. up to 1808 year. At this stage people used fermentation to process like heating source of bath at Assyria in XXX B. C. and at Persia in XVII B. C. The biogas fermentation was also used in ancient China in X B. C. At that time people knew just that if they leave the cattle manure in a tank after some time the explosive heat would release from it and it would be useful. Such “biogas plants” survived in Marco Polo times in the XIII century and due to him the idea transmitted to Europe. However, Alemans near Elba River in V AD used swamp gas, prepared in leather vessels, for cooking. In 1630, J. B. van Helmont discovered that from the flammable manure gas escapes. The observation of B. van Helmont was confirmed by T. Shirley in 1667. R. Boyle with D. Papin announced, in 1682, that there is a possibility to obtain gas from vegetable and animal wastes. Next relevant remark was made almost one hundred year by B. Franklin in 1764 after T. Shirley's works. In 1764, B. Franklin mentioned in a letter to J. Priestly the enlightening of surface of muddy lake near New Jersey. In 1776 A. Volta after observations provided at Vorbio, lake near Como in Italy discovered that factor responsible for such enlightening of surface of lake is gas called as swamp gas [1]. In 1801 J. Cruikshank determined that swamp gas does not contain oxygen. In 1804, J. Dalton formulated the formula of methane as CH_4, confirmed by A. Avogardo in 1821. In 1808, analyzing gas from fermentation of straw earlier called asmarsh gas, was recognized by H. Davy as methane. Discovery of Davy in 1808 was a “milestone” of the biogas development because the people then discovered the relevant element of the process. This was the end of the unconscious stage and new stage of biogas development started named as the transient stage. Another important issue to biogas in XVIII century was replacement of alchemy by chemistry by A. Lavoisier and rejecting phlogiston theory by A. Lavoisier and M. Lomonosov [2].

The In the transient stage people investigated and discovered conditions in which methane could be obtained from the biomass. The transient stage lasted up to 1921. During this stage basic principles of the process were discovered and first biogas plants were built. In1840, first digester was built at Otago in New Zealand.

The research of H. Davy was continued by M. Faraday and then by W. Henry. William Henry in 1860 approved discoveries of J. Reiset from 1856 that methane is formed by decomposition of manure. Due to J. Reiset proposal W. Henry in 1860 compared gases from marshes and gas from cow manure in laboratory. Laboratory research of W. Henry proved that methane was the flammable gas in both cases. Meanwhile the first digestion vessel was built. Critical review of the pre-1970 and 1980 [3] showed that in 1859 a unit digestor was built to heat leper colony Mantunga Homeless Leper Asylum in Bombay. In 1860, J-L. Mourait designed and built an airtight chamber using anaerobic digestion at sewage treatment plant in Vesoul. In 1868, A. Béchamp found that decomposition of biomass at fermentation is done by microbiological process. In 1875, L. Propoff determined range of temperature where biogas fermentation is performed. Additionally L. Propoff discovered that biogas composition and gas composition are independent of temperature. Also in 1875, W. Sluis started to illuminate his farm by biogas in Beemster.

In 1881, L. Mouras with A. Moigno was awarded by a patent constructed first septic tank which was an improved version of an airtight chamber from 1860.

In 1882–1884 L. Pasteur and U. Gayon were experimenting on fermentation of horse manure with different temperature and mixtures. When the manure was mixed with water and the temperature was 35 °C they obtained 100 l of methane from 1 m^3 of manure. The volume of obtained methane was high enough high for L. Pasteur to make it a source of heating and illuminating cities. In 1884, B. Pastnier published work about biogas produced from wastes. In 1886, M. Herter with F. Hoppe-Seyler observed that in waste water acetate is transformed to methane and carbon dioxide. In 1888 biogas plant that produced methane for illuminating street lamps was build in Birmingham. In 1890, D. Cameron designed septic tank used as biogas plant for producing electricity in 1895–1895 in Exeter. Septic tank of D. Cameron differs from chamber of L. Mouras and A. Moigno due to better treatment efficiency. In 1897, biogas sewage treatment at Mantunga Homless Leper Asylum was stopped in Bombay. In 1895–1897, V. Omeljanskij investigated bacterias that provide biogas fermentation and discovered that they are anaerobic and classified them according to their optimum temperatures. In 1901, N. Schongon characterized methanobacterias. In 1904, G. Travis combined methane production with the sewage treatment system. In 1906 and 1910, N. Söhngen confirmed V. Omeljanskij's results and explained the whole fermentation process to the oxidation–reduction reaction in four steps as hydrolysis, acidogenesis, octanogenesis, and methanogenesis [4].

In 1906, first anaerobic treatment plant was built in Germany.

In 1908, Agricultural college of Pogliano constructed a 3 hp motor working on biogas plant.

In 1911, a biogas plant was used for sewage treatment in Birmingham.

In 1913–1921, K. Imhoff and H. von Blunk designed process of treating sludge in Essen-Ruhr and patented it. The design was in part developed by Prussian sewage treatment plants.

K. Oeschsner, in 1916, obtained fermentation of cellulose to butyric acids and then this material was decomposed to methane according to V. Omelianskij's method. In 1916, V. Omeljanskij investigated isolated methanobacterias. In 1920, L. Gourui found Biogas Lamp Company in Shanghai that built biogas plants to illuminate part of the city (patented in 1929).

Also in 1920 gas produced from anaerobic treatment plant was connected with city's gas supply in Germany.

After these discoveries biogas fermentation and biogas plants were a common subject of analysis and solution at waste water