Chapter 4

Energy production processes

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Introduction

Renewable energy sources are those that have a continuous existence and availability. Examples of these sources are solar/photovoltaic, wind, geothermal, tidal and biomass energy. For example, it is possible to have this energy in the form of electric energy, or in the form of biofuels.

Wind energy is obtained by the use of wind turbines, while photovoltaic energy is obtained by the use of materials that convert photon energy into electricity; and the conversion of biomass to energy takes place through the use of industrial processes, in which several operations are linked, from the conditioning of the raw material to the final products.

In this chapter, several processes developed by Embrapa for the conversion of biomass, cultivated or from waste, into energy will be presented, as well as photovoltaic and wind energy applications implemented by Embrapa, considered as contributions to reach target 7.1 of SDG 7: By 2030, ensure universal access to affordable, reliable and modern energy services.

Biogas energy

Biogas originates from the anaerobic digestion of organic matter present in biomass. It is a product obtained from the biodigestion of agro-industrial waste, usable in the generation of heat, electric energy or even as vehicular fuel.

Among the constituents of biogas, there is methane: a combustible gas that can be used for thermal recovery, electric power generation or even as fuel for motor vehicles. In thermal use, biogas is the main substitute for liquefied petroleum gas, coal and firewood, especially in rural areas and small communities. In these places, small-scale biodigesters, which use animal waste as raw material, enable the use of biogas in the preparation of food, in the heating of water for sanitation, in addition to allowing the processing of food from family farming and avoiding health problems caused by the aspiration of smoke/soot derived from the burning of charcoal or firewood. In industrial scale, the use of waste allows the use of biogas in steam generators, reducing production costs (waste treatment and substitution by other higher value fuels), which is reflected in the mitigation of the cost of preparing the final product.

Besides its thermal use, the generation of electric energy from biogas is already a reality in Brazil. With the creation of Aneel Normative Resolutions 414/2010, 482/2012 and 687/2015 (Agência Nacional de Energia Elétrica, 2012, 2015, 2016), it became possible to access microgeneration and distributed minigeneration to the distribution electricity systems and the energy compensation system. This allows the conversion of biogas into electricity by a generator set connected to the distribution network. This possibility strengthens energy security in rural areas, allowing greater availability of energy to distant regions, as well as increasing the competitiveness of agro-industrial processes by reducing energy costs.

An important alternative is the possibility of using biomethane (purified biogas) instead of natural gas. The recent Resolution 08/2015 (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2015) regulated the use of biomethane for injection in the natural gas network and also its use as a vehicular fuel. Industries ranging from metallurgy, ceramics, textiles, fertilizers to food processing utilize natural gas, which comes from outside sources, causing direct dependence on other countries. The possibility of using biomethane, despite its higher costs, allows an increase in the energy autonomy of these industry sectors.

As a source of raw material (biomass) for the generation of biogas, the sugar-alcohol sector (vinasse) and the agricultural sector (animal waste) stand out as huge carbon source suppliers. Embrapa has collaborated directly in the production of knowledge and implementation of biomass to biogas transformation technologies (Cestonaro et al., 2016; Steinmetz et al., 2016). The challenges are to know the availability of biomass in Brazil, to adapt the digestion process to the regional and socio-environmental conditions, as well as to search for logistic and digestion destination (e.g., water reuse, soil fertilization) solutions (Miele et al., 2015; Bilotta et al., 2017). We highlight the Rede BiogásFert, created in partnership with Itaipu Binacional, to offer to society technological solutions for the integrated production and use of biogas and organic and organomineral biofertilizers from animal waste in the different agricultural production systems. Rede BiogásFert has a partnership with several universities, rural extension agencies and innovation centers such as CIBiogás (Centro Internacional de Energias Renováveis – Biogás).

Other small-scale investigations are also underway at Embrapa, involving several types of biomass/waste (such as banana pseudostem, glycerol, green coconut bark, palm oil) (Leitão et al., 2009, 2011, 2012a, 2012b, 2013; Viana et al., 2012a, 2012b; Costa et al., 2014a, 2014b), different types of bioreactors, various biomass pretreatment methods for increasing conversion efficiency in biogas (Costa et al., 2013, 2014a, 2014b; Silva et al., 2014), etc. There are some researches in biodigestion with a focus on obtaining hydrogen (another fuel gas) (Viana et al., 2014; Vasconcelos et al., 2016) and compounds such as butanol and organic acids (Guilherme et al., 2016), or even from the conversion of methane itself into other products, such as hydrogen (steam reforming).

Biodiesel energy

Biofuels have played a very important role in the country's energy matrix. The energy supply from biomass is almost double the energy from oil products (8.0% from the first one against 4.8% from the second) (Balanço..., 2016). In the case of biodiesel, in 2016, 3.8 million cubic meters of biofuels were produced in the country (Agência Nacional do Petróleo, Gás Natural e Biocombustíveis, 2017).

Since the addition of biodiesel to the national energy matrix in 2005, several types of research have been carried out, either about the availability of raw materials, the efficiency of the production process, also seeking catalysts that allow a lower generation of effluents, or about product quality, which extends from the storage to the end consumer.

Embrapa Agroenergy conducted investigation on improving the quality control of the product and its production process, e.g. the process of refining oil from macaúba pulp and in the process of obtaining high quality crude oil from macaúba pulp, either by a chemical or enzymatic route, from raw materials of high acidity, such as palm oil. Following the chemical route, the hydrodeoxygenation processes have been investigated in addition to the transesterification to create hydrocarbons with chain similar to biodiesel.

Working in partnership with other research centers and regulatory agencies in developing methods to guarantee the quality of biodiesel, Embrapa is contributing to provide reliable energy access. In turn, the research related to process improvement seeks to reduce the negative impacts on production, in favor of sustainability, in addition to increasing efficiency, thus contributing to the achievement of target 7.3.

First- and second-generation ethanol

Bioethanol is proven to be a renewable substitute for gasoline from petroleum. Its world production in 2016 was 97 billion liters, with 57% being produced from corn and 27% from sugarcane, the two main raw materials for this commodity (Renewable Fuels Association, 2017). This bioethanol is commonly known as first-generation ethanol. In Brazil, the production of bioethanol occurs mainly from sugarcane, the main raw material in the manufacture of sugar (sucrose). However, contrary to what is reported regarding energy versus food competition, much of the ethanol produced from sugarcane uses a byproduct as a carbon source: non-crystallizable molasses, from which it is not possible to produce crystal sugar and therefore cannot be traded at competitive prices.

In addition to bioethanol produced from simple sugars such as sucrose, the world today is looking for technologies to produce this fuel from lignocellulosic materials, the so-called second-generation ethanol. It should be noted that there are some industrial plants in operation in the world, such as the DuPont plants, the Spanish Abengoa, and Poet-DSM, located in the United States. However, the economic competitiveness of this type of ethanol still leaves a lot to be desired. Embrapa has been developing research on the production of first-generation ethanol from rice, sorghum and sugarcane juice (Pacheco et al., 2014; Almeida et al., 2017), and has also been active in research on the production of second-generation ethanol, mainly from sugarcane bagasse. Research aimed at the development of new enzymes, such as the following: catalyzed cellulose hydrolysis process by immobilized cellulases; filamentous fungi producing efficient enzymatic complexes for the hydrolysis of sugarcane bagasse pretreated by vapor blast; filamentous fungus genetically improved for the production of cellulases and hemicellulases; genetically modified filamentous fungus for increased production of polysaccharide degrading enzymes; lineage of Komagataella phaffii (*Pichia pastoris*) producing xylonic acid; new fermenting microorganisms; as well as improvements in the pretreatment process efficiency of lignocellulosic materials such as: organosolv process applied to lignocellulosic biomass; lignocellulosic biomass pretreatment process by autohydrolysis (hydrothermal treatment). The higher the production of biofuels at fair prices and in larger quantities, the less and less dependent on oil Brazil becomes. Thus, Brazil may have access to more clean, renewable and safe energy sources since the production and use of bioethanol is a cyclical chain.

Solar and wind energy

The exploitation of soil and water has given economic support to the Brazilian rural environment. Other resources, such as labor that is being replaced by mechanization, have made our country a powerhouse in agricultural production. The greater demand for energy increases production costs, which may determine the need to exploit other unused resources for its feasibility.

Normative Resolution 482 of Aneel (Agência Nacional de Energia Elétrica, 2012), enabled the possibility of electricity consumers connected to the grid being energy generators, and that generated energy can be commercialized in the form of credits with the distributor. Therefore, other rural energy sources, such as hydric, biomass, wind, and solar radiation, may be better and more easily harnessed as power generation on the property.

Solar energy, which is the main source of energy in the rural environment, is both capable of generating thermal energy as well as electricity directly. Depending on the equipment, this inexhaustible source can supplement the income of the rural property, which has the necessary conditions for it, because the space and availability for solar radiation are abundant. Photovoltaic panels, which are the main equipment for transforming solar energy into electrical energy, have semiconductor cells that, when illuminated, generate a potential difference by releasing available electrons as electric energy. Panels that take advantage of solar thermal energy are devices that, by heating liquids, like water, serve as an energy source for various utilities.

Wind energy, which is the kinetic energy of displaced air masses, is dependent on the pressure differences created basically by the difference in the radiation balance and is influenced by the movement of the earth and the friction with the earth's surface. It is an inexhaustible source of energy, proportional to square the wind speed. It has long been used for electricity generation and water movement.

With the evolution of technologies and legislative norms, Embrapa sees the possibility of increasing the income of the property with the use of these resources there. Historically, agricultural research monitors agrometeorological variables for its own use. For this reason, Embrapa has a collection of meteorological data capable of evaluating the conditions of electricity generation in rural areas. Besides this collection, it has a large number of researchers and laboratories specialized in agrometeorology, as well as a network of partnerships in all the states of the country.

With the necessary conditions to evaluate the energy potential in the rural environment, the Embrapa is able to evaluate the performance of equipment inserted inside the property, in order to verify the technical and economic feasibility of the existing technology and to recommend the correct use.

To serve as an instrument capable of informing public policies and a guide for the use of viable techniques to generate income in a rural property, Embrapa has approved projects to teach the producers about a new form of production. Results have shown the feasibility of using electric generation techniques. Despite restrictions on the quantity generated, changes may favor the producer to make these solutions more important, especially to the family producer (Figure 1). It has also been shown that in properties with areas smaller than 50 ha, it is possible to generate, with small facilities, twice as much as the largest thermoelectric plant in the state of Rio Grande do Sul.

Through partnerships with research and teaching institutions, Embrapa has conducted research that can improve the living conditions of the rural producer, such as an automatic solar irrigator made with used bottles or a solar collector to disinfect substrates and produce healthy seedlings, making electricity generation a source of income and, this generation, the new Brazilian agricultural product.

Photo: Paulo Lanzetta

Figure 1. Photovoltaic power generation unit (Embrapa Temperate Agriculture).

Final considerations

Embrapa is seeking new processes to implement energy generation technologies that can be used by the Brazilian rural environment, in the case of photovoltaic and wind energy and biogas production. Another facet is the development of the biogas and first- and second-generation biodiesel and ethanol attainment processes.

The great challenge remaining is how to adapt these technologies and processes to the reality of our country, where often these processes cannot be transferred due to the investment capacity and understanding of its limits. This obviously creates opportunities for Embrapa to help come up with mechanisms to transduce these concepts in different situations.

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