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Vision for utilization of livestock residue as bioenergy resource in Japan ☆

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Abstract

Utilization of livestock residue is important not only for energy recovery and material recycling but also for preventing environmental pollution. This paper focuses on the following options from the viewpoint of the Law on Promoting Proper Management and Use of Livestock Excreta and the Kyoto protocol: energy use from livestock residue, reductions in CO_2 emissions resulting from substitution of fossil fuels, and reduction of other greenhouse gas emissions through appropriate treatment of livestock residue. Bioenergy potential of livestock residue in Japan was estimated to be 167 PJ in the year 2000. This is equivalent to about 0.7% of total primary energy supply. Biogas production with methane fermentation and burning poultry residue at power plants can produce 4.1 TWh of electricity and 46 PJ of heat. The amount of CO_2 substitution for fossil fuels is 6.9 Mt-CO_2. This corresponds to about 0.6% of total CO_2 emissions in 1990. This also has an additional effect of reducing other greenhouse gas (CH_4 and N_2O) emissions from conventional treatment of livestock residue. Development of biogas plants, promotion of biogas utilization, and effective use of fertilizer components extracted from livestock residue are expected to gain importance in the future.

Keywords: Livestock residue; Bioenergy; Biogas; Energy potential; Utilization; Kyoto protocol; Greenhouse gas; Material recycle; Japan

1. Introduction

Utilization of livestock residue is important not only for energy and material recycling but also for preventing environmental pollution. The amount

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of livestock residue in 2000 was about 90.5 Mt, equivalent to 22% of industrial waste discharged (406 Mt) in Japan.

It is important to utilize livestock residue as a source of energy. Appropriate use of livestock residue prevents serious environmental pollution like malodor, soil contamination, underground water contamination, and river pollution resulting from excess fertilizer application [1,2]. However, as Japan imports 75% of the feed for domestic livestock sector, the NPK and the organic components in the soil would increase [3]. This would impose additional load on the local ecosystem and contribute to underwater pollution.

This paper focuses on the following options from the viewpoint of the Law on Promoting Proper Management and Use of Livestock Excreta and the Kyoto protocol: energy use from livestock residue, reductions in CO_2 emissions resulting from substitution of fossil fuels, reduction of other greenhouse gas emissions through appropriate treatment of livestock residue, and mechanism to deal with excess fertilizer constituents due to imported feed.

2. Amount of livestock residue and its energy potential

2.1. Background

Livestock residue contains fertilizer elements such as nitrogen, phosphorus, and potassium. Approximately 90% of livestock residue is now available for farmlands as fertilizer. However, because of excess application of fertilizer, environmental problems have occurred and hence the Law on Promoting Proper Management and Use of Livestock Excreta has been enforced since 1999 [4]. In addition, all components of this law came into force from November 2004.

With an increase in the number of livestock per farmer (resulting from livestock population remaining constant and the number of farmers declining) and with farmers predominantly belonging to older age groups, recently easier options to reduce livestock residue have become more popular. Thus energy from biomass fermentation and direct combustion has lately received considerable attention. In fact, biogas plants have recently been constructed in several parts of Japan.

2.2. Energy potential of livestock residue

Livestock residue contains organic compounds, an energy source. The total amount of generated livestock residue of the year 2000 has been estimated using the livestock population for the same year and discharge rate for livestock given in Table 1. As a result, it was approximately 64 Mt (about 93 Mt including urine). It includes cattle residue of about 42 Mt, swine residue of 8 Mt, and poultry residue of about 14 Mt.

Furthermore the energy potential of the livestock residue in Fig. 1 was estimated using percentage of moisture content and calorific value of residue given in Table 1. There are some higher potential areas in Japan, such as Kyushu, Hokkaido, Kanto, and Tohoku. Classified by livestock, each one, such as dairy cattle, beef cattle, swine, and poultry, has an energy potential of about 40 PJ. In Japan, the potential of bioenergy of livestock residue was estimated to be 167 PJ in the year 2000 (Fig. 2). This is equivalent to about 0.7% of total primary energy supply. However, estimates of other organizations (NEF (New Energy Foundation), Japan: 348 PJ, for year 2010; Bio-oriented Waste Recycle Society: 210 PJ (1995–96); and Investigation of Livestock Residue Discharge and Processing Situation: 289 PJ, year 1997 [8]) are considerably higher. One of the reasons is that other organizations assume larger calorific value for livestock residue. Feed supply for livestock in 1990 was estimated to be 510 PJ and it is forecasted that the number of livestock will not change by much [9]. It is essential that reliable data be available for livestock residue.

3. Energy conversion processes of livestock residue

There are some conversion processes from livestock residue to energy, for example direct combustion, pyrolysis gas, oil obtained from residue, heat recovery from fermentation, and