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Ground source heat pump driven by reciprocating engine firing biomethane from wastewater treatment plant sludge in a cogeneration for district heating and cooling. A case study in Spain

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Abstract-

Wastewater treatment plants are a key facility in municipalities to reach the required water quality before returning to the environment. Their energy consumption constitutes the most critical cost in their operation, although sludge produced in the treatment can be fed into an anaerobic digester to produce biogas. Such biogas is usually burnt into a cogeneration reciprocating engine that produces power injected into the grid and heat to maintain the required temperature in the digester. This energy recovery technique also avoids direct methane emissions from the biogas to the atmosphere. An alternative energy recovery of the sludge is proposed in this paper, seeking to cover both the winter and summer thermal demands of the municipality whose wastewater is treated by the plant.

A district heating and cooling network is assumed to be available in the municipality, whose demand will be met (total or partially) by the proposed system. The biogas production has been assessed from a large number of wastewater treatment plants in Spain. This fuel will be upgraded to biomethane to inject eventual surplus generation into the natural gas grid. The hourly thermal demand is estimated from a self-elaboration expansion of annual expressions given in Spanish regulations. A high insulation level in the dwellings of the municipality is assumed to reach the maximum thermal demand coverage level. Underfloor heating and cooling is used as final air conditioning system. The conversion is carried out by supplying the biomethane to a cogeneration reciprocating engine, whose power output drives a ground source heat pump and its recovered heat is used for the thermal conditioning of the biogas digester as well as for heating in winter.

The results show that for a 50,000 inhabitants treatment plant, the thermal demand coverage percentage ranges from 28 % to 51 % and the levelized cost of heating and cooling from 38 to 65 €/MWhth. Generally, the lowest cost is reached in zones with an intermediate coverage percentage. Even with high insulation dwellings and high-efficiency systems, the thermal demand coverage percentage is low. This suggests that biomethane production from all the entire municipality can be devoted to meet a selected district's complete demand, built with high standards. This district might be focused on social dwellings.

Index Terms- Biomethane; Wastewater treatment plant; Ground source heat pump; Cogeneration reciprocating engine

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