



# Utilisation of renewable energy sources in the water and sewerage sector

## INTRODUCTION

In Oslo, air pollution from dust and atmospheric discharge from public and private transport has increased by approximately 10% since 2000, contributing to more than 50% of total CO<sub>2</sub> emissions in the city. The local government has initiated an urban ecological program that promotes a circuit-based waste system and the utilisation of renewable energy sources.

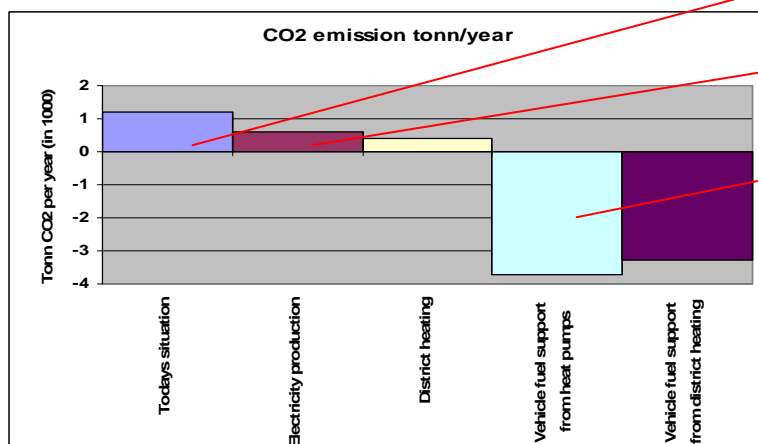
The annual cost to the environment from public transport in Oslo is calculated to be around 0.85 billion €. Vehicle transport accounts for around 85% of the pollution. 100% climate neutral bus transport in Oslo would cut climate gases from public transport by 6%.

## The new Bekkelaget sewage treatment plant

Oslo Water and Sewerage Works investigated five methods for how to best use biogas produced from Bekkelaget sewage treatment plant; the plant treats sewage from 290,000 person equivalents (pe). In 2000, the sludge was digested thermophilically at 55 degrees, dewatered, and dried. The final product contains about 90% dry solids and is used for farming purposes. From the beginning of 2007, the dryer was closed down due to high operational costs and a poor working environment.

## ENVIRONMENTAL CONSEQUENCE ASSESSMENT

In calculating the environmental gains, the amount of carbon dioxide released and the net energy production were key factors. Upgrading biogas to biomethane would be an energy gain sufficient to run 80 buses 100,000 km. This corresponds to 30 % of the bus transport in Oslo. Since biomethane is replacing fossil fuels/diesel the CO<sub>2</sub> emissions are reduced by 3,700 tons/year.



*Present operations. The excess gas is flared off. 1200 metric tons of CO<sub>2</sub> discharged annually*

*Alt. 2: Installation of a gas generator for electricity production. The discharge of CO<sub>2</sub> is reduced to 580 metric tons/yr.*

*Alt.: 4: All gas is upgraded to biomethane for vehicle fuel thus replacing diesel. Heat pumps are used for internal heating requirements. CO<sub>2</sub> discharges are minus 3700 CO<sub>2</sub> per year.*

*The corresponding CO<sub>2</sub> discharge from the use of diesel for bus operations is around 5,050 tons. The difference of 5050 – 3700 = 1350 metric tons of CO<sub>2</sub> per year is CO<sub>2</sub> discharge in association with production of necessary purchased energy.*



Five alternatives were investigated for their potential for utilisation of renewable energy sources. (only alt. 2 & 4 were evaluated for a technical-economic evaluation):

1. Present operations with sludge dryer shut-down. (The gas is used for internal heating).
2. Installation of a gas generator for electricity production.
3. Production of heat for a remote/district heating network.
4. Production of biomethane for bus operations with heat pumps for internal heat requirements.
5. Production of biomethane for bus operations with remote/district heating for internal heat requirements.

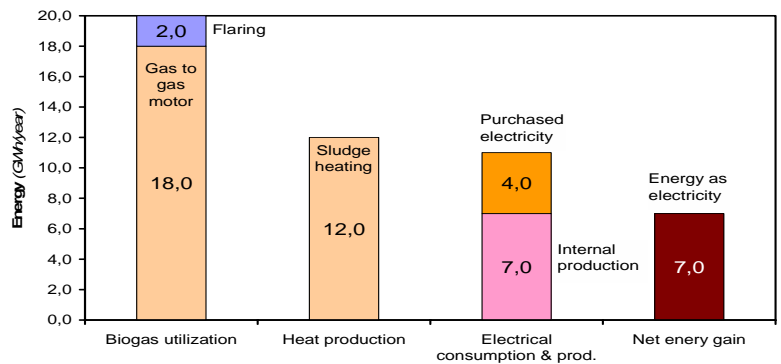
Energy consumption can be optimised with the installation of new heat exchangers and heat pumps. All the produced biogas can be used for new purposes. The production data is as follows:

Biogas production	3,600,000 Nm <sup>3</sup> /year
Energy content	20,000 MWh/year

**ENERGY CONSIDERATIONS**

Figures demonstrate the consumption and production of energy in the alternatives installation of gas motor for electricity production and the alternative upgrading of biogas to vehicle fuel.

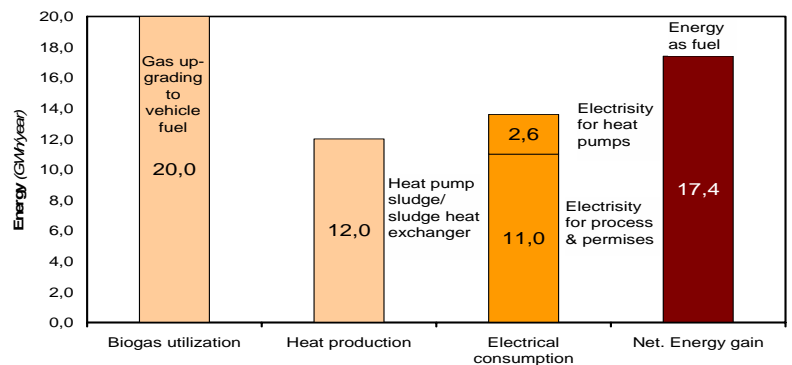
*Production of electricity with gas motor.*



*Installation of a gas motor with an electricity production capacity of 1100 KW will provide an annual electricity of 7 GWh/yr and a heat production from cooling of gas motor of 8 GWh/yr. Compared to present operations this is a reduction of 7 GWh/yr*

*The total quantity of biogas produced is sufficient to run 80 buses in Oslo. An extensive conversion of the biogas to biomethane must be undertaken to secure that nearly all gas can be converted to vehicle fuel. This means that sludge heat exchangers and heat pumps must be installed to heat the sludge into the digesters*

*Compared to present operations, the energy gain is 20 – 2.6 = 17.4 GWh/year. More than twice as much energy can be generated by upgrading the gas to vehicle fuel compared to the electricity production. In addition, the specific energy from vehicle fuel is considered to be of higher value than from electricity. With an electricity price of 0.06 €/kWh and a diesel price of 1.25 €/l are assumed, the sales prices of the energy for the two alternatives are 0.44 and 2.6 mill. € respectively.*



## Upgrading biogas to biomethane

To be able to use the gas as vehicle fuel, CO<sub>2</sub> which contributes to about 40% of the biogas and other undesirable gases, must be removed in a gas upgrading plant. From the upgrading plant the gas is compressed to 200 bar and transported in mobile gas tankers to stations for rapid tankers.

### COSTS

The investment costs for production of biomethane are considerably higher than the alternative for electricity production where the investment costs were 1.4 million €

#### *Investment costs biomethane:*

Upgrading plant	2.9 million €
Modification existing biogas plant	1.2
20% uncertainty	0.7
<b>Total investment</b>	<b>4.8 million €</b>

#### *Annual costs:*

Capital costs	0.5 million €/year
Operation/maintenance	0.1
Electricity heat pumps	0.3
<b>Annual costs</b>	<b>0.9 million €/year</b>

Production costs	$0.9/3.6 = 0.25$ €/m <sup>3</sup> biogas 0.42 €/m <sup>3</sup> biomethane
Distribution costs	0.30 €/m <sup>3</sup> biomethane
Total costs	0.72 €/m <sup>3</sup> biomethane (in diesel equivalent 0.67 €/l diesel)

### CONCLUSIONS

Building of the upgrading plant will start in 2008 and be ready for the distribution of biomethane within a year.

Biogas from Bekkelaget wastewater treatment plant will eliminate the discharge of climate gases from 80 buses in Oslo.