**Translated version of CPA report.pdf**

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Report Substrate Materials for intersectoral biogas strategy

**Foreword**

In Climate Report (Meld. St. 21 (2011-2012)), the Government decided that it should develop a national, cross-sectoral strategy to increase the production and use of biogas in Norway. In November 2012 was Climate and Pollution Agency (CPA) in the Ministry of the Environment to prepare a support material to this strategy.

Biogas is a renewable source of energy that can be produced from resources that are seen as by-products or waste. This report briefly describes how biogas can be produced and applied to various purpose and how the residual product of biogas production - organic fertilizer - can be utilized. Furthermore, we provide a overview of the status of biogas production and use in Norway, before we look at the possibilities of increase production beyond current levels. Because it's remaining potential in the short term is utilization of organic waste and manure, it is these two raw materials we have looked at.

We compile cost and benefit effects for the production and use of biogas, focusing on use of biogas as fuel and feed into an existing natural gas network. Finally, we describe existing measures and barriers, before pointing to possible new instruments to trigger the various parts of the potential.

The report was prepared for the period November 2012-April 2013 by CPA with professional input from a reference group consisting of Transnova, Enova, the Norwegian Public Roads Administration (VD), Norwegian Agricultural Authority (SLF), Customs and Excise (TAD) and the Norwegian Water Resources and Energy Directorate (NVE). In addition conducted a survey to identify barriers and measures and to update cost figures, as well as a proposal meeting with about 50 participants from industry and individual meetings with several actors. Bioforsk v / Senior Tormod Briseid, Institute of Transport Economics (TOI) v / researcher RolfHagman and Waste Norway v / Henrik Lystad and Roy Ulvang has also provided technical input.

We thank everyone involved for valuable discussions and suggestions!

Oslo, April 2013

Audun Rosland

Deputy

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**Summary**

Biogas is a renewable energy source that can be produced by various organic materials and may

used for many different purposes such as electricity generation, heating and transport.

Production and use of biogas has many beneficial effects, such as reduction of

greenhouse gases and ammonia, recycling of nutrients, reduction of local air pollution and

production of biofuels without seizing arable land.

***Potential***

**We estimate the realistic potential for biogas production in Norway to 2020 to be around 2.3**

**TWh.** **Only a small part of the potential has already triggered; currently produce around 0.5 TWh of**

**biogas.** **The remaining realistic potential for biogas production in the short term is dominated by**

**organic waste (less than 1 TWh) and manure (approximately 0.7 TWh).** **In the longer term,**

**other material such as forest waste, algae and sludge from aquaculture be appropriate for**

**biogas production and can increase the potential significantly.** **Improvements in the production process will increase**

**potential further.**

The theoretical potential for biogas production in Norway is in earlier studies estimated to be

about 6 TWh. Not all the raw materials are available for biogas production, since some already applied for example, feed production or are very difficult to exploit for biogas production. We estimate the realistic potential for biogas production in the short term (to 2020) to be around 2.3 TWh. Only a small part of the potential is already triggered, currently produced around 0.5 TWh of biogas, see Figure 1 About half of the current production is collected landfill gas, of which an estimated half utilized for energy purposes and the remainder is flared. Production of biogas is now very common in treatment of sewage sludge where the majority of the potential is already exploited. This substrate is therefore not be discussed further in this report.

The remaining realistic potential for biogas production in the short term is therefore dominated by

organic waste (less than 1 TWh or 880 000 t of waste) and manure (approximately 0.7 TWh), see

Figure 2 Organic waste includes both food waste from households, large households and commerce,

as well as waste from commercial activities, such as waste from fish harvesting, bakeries, butchers etc.

assessment of the realistic potential is taken into account that part of the wet organic waste

already utilized for such feed production. As shown in Figure 2, the potential for

energy output divided almost equally between manure and waste, given that the potential is triggered

(880 000 tonnes of organic waste and 3.9 million tons of manure).

The potential for biogas production as we have assumed in this report are for biowaste

waste based on that 50% of food waste from households and 80% of food waste from

large households and commerce are separated and collected. Today's rejection rate for food waste from

households around 30%, which means that it requires a significant increase in sorting at source of

food waste to release *all* the realistic potential. The potential for manure implies that

30% of manure to be treated in biogas plants, cf. Report. 39 This is an ambitious

objective and it will require strong measures to trigger the supply of raw material to

biogas production by 2020. In the longer term, other feedstock such as forest waste, algae

and sludge from aquaculture be relevant for biogas production and thus increase the potential considerably.

Improvements in the manufacturing process could increase potential further.

*Figure 1: Potential for biogas production in Norway 2020*

*Figure 2: Potential for biogas production in energy units based on manure and organic waste*

Treatment of the entire realistic potential can be achieved by for example the following

combination of fixed size and number of plants:

• 38 industrial facilities for manure at 110 000 tonnes / plant

• 55 major public facilities for manure at 55 000 tonnes / plant

• 16 plants for wet organic waste processing 55 000 tonnes / plant

We have used this as the basis for the calculations. However, also other combinations

be possible.

**43%**

**57%**

**Energy potential of biogas production.**

**Total energy production = 1.7 TWh.**

Fertilizer

Wet organic waste

**35%**

**65%**

**20%**

**15%**

**65%**

The portion of the theoretical potential

that is unrealistic and / or

impractical to utilize in

2020

The portion of the theoretical potential

is realistic to utilize in

2020

Most of the realistic potential

which is not induced even

Most of the realistic potential

that there are concrete plans for

Most of the realistic potential

previously allocated

**Theoretical potential**

**A total of 5.8 TWh**

**Realistic potential**

**A total of 2.3 TWh**

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If all the realistic potential for organic waste and manure used (1.7 TWh), the

for example, could operate approximately 7000 gas buses or similar heavy vehicles, thereby

could reduce the use of diesel buses in Norwegian cities.

Today used an estimated 60% of the amount of energy produced from biogas plants within the plant. They

remaining 40% used externally supplied in the form of electricity, heat and gas upgraded to

gas mains or fuel. Around 50% of the collected landfill gas is used to heat and

electricity production, while the remaining amount flared.

By the end of 2012, there are about 400 gas-powered buses in operation in Norway, in addition, there are several heavy

vehicles and fleet vehicles that use biogas today. However, there are relatively few cars with

gas engine in Norway at present. Gas-powered cars are more expensive to buy than the equivalent diesel and

gasoline vehicles, both because of the higher price for the car itself, but also due to higher one-time

the gas car.

***Environmental impact of biogas production and use***

**There are positive environmental impacts of the production and use of biogas.** **The**

**production of biogas from manure avoids emissions of greenhouse gases (methane and**

**laughing gas) and ammonia.** **Production of organic waste causes no direct**

**emission reductions, it is only when biogas replaces fossil fuels that this type of**

**biogas leads to emission reductions.** **Biogas can be used for multiple purposes such as**

**heating, electricity and transport.** **Residues from biogas production,**

**organic fertilizer contains nutrients such as nitrogen and phosphorus, and can substitute the use of**

**fertilizers in agriculture.**

There are positive environmental impacts of the production and use of biogas.

Environmental impacts of the production of biogas

The production of biogas from manure avoids greenhouse gas emissions (methane and

nitrous oxide) which have arisen if the manure had been stored in manure storage is common in

days. Production of biogas from manure can reduce emissions of ammonia and

thus helping to meet Norway's current obligation under the Gothenburg Protocol, which currently

exceeded by 13%.

Production of biogas from organic waste causes no direct emissions reductions. When

biogas produced from organic waste that would otherwise have gone along with other waste to

Energy production in incineration plants, it should be replaced by the combustion of waste or with

other energy carriers, which results in an increase in greenhouse gas emissions. *production* of biogas from

organic waste will thus prompting a slight increase in greenhouse gas emissions. This will offset the

application of biogas (see also Figure 8).

Residues from biogas production (organic fertilizer) contains nutrients such as nitrogen and phosphorus,

and can substitute the use of fertilizers in agriculture. If organic fertilizer replacing artificial fertilizers,

reduced consumption of energy and material resources and pollution associated

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| **Page 14** |

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**Economic**

**production**

Production biogas

based on manure:

**1.25 NOK / kWh**

Production biogas

based on organic waste: **0.54**

**NOK / kWh**

the production of mineral fertilizers, extraction of phosphorus and various micronutrients. Additionally,

bio fertilizer constitute a carbon sink to help reduce greenhouse gas emissions. In some cases,

bio fertilizer could be used as fertilizer because of the content of the environmental and

harmful substances such as heavy metals and persistent organic pollutants. Whether bio fertilizer

can be used as fertilizer product therefore depends on the purity of the substrates used in

process. Source separated food waste, for example, provide a better bio fertilizer, than production that is

based on the central sorted waste.

Environmental effects of the use of biogas

Biogas can be used for multiple purposes such as heating, electricity generation and

transport sector. When biogas replaces fossil fuels such as diesel and natural gas, reduced

greenhouse gas emissions. The use of vehicles that run primarily in urban areas are particularly

many positive effects, in terms of reduced greenhouse gas emissions, reduced noise levels and

improved local air quality. In addition, there are few other options to reduce greenhouse gas emissions from

transport sector.

Norway has through the Renewable Energy Directive (2009/28/EC) including pledged to increase the share of renewables in

transport to 10% by 2020. If 0.7 TWh of biogas used in the transport sector,

may target in the Renewable Energy Directive (10% renewable energy in transport) is achieved without

wagering requirement for biodiesel and bioethanol increased above the current 3.5%.

***Production costs for biogas***

**Organic waste and manure are chosen as substrates because these raw materials have the largest**

**remaining potential in the short term.** **Biogas production based on animal manure has a**

**significantly higher economic cost, than biogas production based on**

**organic waste.** **The two main reasons for this is that alternative treatment cost for**

**organic waste is high compared with costs for managing manure, while**

**as gas yield from organic waste is almost 6 times higher than from manure.**

**The costs presented here are average costs.** **Pieces of potential, both for waste**

**and manure, will naturally have a lower cost, while other parts of the potential will have a**

**higher cost.**

Economic production costs

Production of biogas with different social cost

depending on the substrate used in biogas production. In

economic calculations are the costs that are

relevant, ie higher costs compared to a reference scenario.

As shown in Figure 3, the biogas production based on

manures, a significantly higher socioeconomic

cost, than biogas production based on biowaste

waste. There are two main reasons for this:

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1 Reference scenario (option expense) related to the treatment of manure is that

this *spread on the fields.* One does today that is not to build and operate a plant, or

transporting manure far. However, this will contribute to increased economic

costs. For organic waste, the reference however to *burn or compost the waste,*

which will always provide the costs of transporting waste and operation of an incineration or

composting facility etc. Therefore, biogas treatment of waste is not as great

additional costs in the economic calculations compared with manure. It

ongoing revision of fertilizers care regulations may affect this by changing

requirements for manure management. Alternative disposal methods that may be necessary

if the requirements become more stringent, can be so expensive that it would be better for the economy

biogas production from manure significantly.

2 The most decisive reason is that gas yield from organic waste is almost 6

times higher than animal manure. This means that it requires more and / or larger

Biogas plant for the processing of animal manure than that needed for organic waste to

produce the same amount of energy.

In the study, we have assumed management of manure and organic waste in separate facilities.

Another possibility is to sambehandle substrates in mixed systems. Sambehandling of manure

and organic waste can provide benefits to stabilize the biogas process, and by increasing the total

gas yield. At the same time, the investment cost of the plant to be higher than an average of the two

plant types: plant would have to equal a fertilizer plant in size but need a

pre-treatment for disinfection of waste as well. It is possible that some of this will be offset

economies of scale when you can build fewer, larger facilities. Since neither benefit or cost side

for sambehandling are quantified, we can not conclude whether sambehandling will be more

or less cost-effective than separate treatment.

*Figure 3: Comparison of economic costs of production of biogas for manure and*

*organic waste, in dollars per kWh.*

Production

Reduced emissions of NH

3

Reduced fertilizer use

0.0

0.2

0.4

0.6

0.8

1.0

1.2

1.4

Cost

Income

Net

Cost

Income

Net

**NOK / kWh**

**Economic net production cost in NOK / kWh -**

**based on manure and organic waste**

Work

Maintenance

Electricity

Upgrade

Transport

Annual capital costs

**Costs:**

**Income:**

**Net:**

**Fertilizer**

**Organic waste**

**1.25**

**0.54**

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| **Page 16** |

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**Business Economics**

**production**

Business Financial loss

for biogas production based on

manure:

**1.27 NOK / kWh**

Business Financial loss

for biogas production based on

organic waste:

**0.002 NOK / kWh**

Business Economic production costs

**According to our calculations, the biogas produced from organic waste almost commercially**

**profitable.** **Biogas production from manure is not economically profitable today.**

**There are two main reasons for this: Firstly, the gas yield from manure very low.** **For the**

**others can not plant says revenue from gate-fee for manure, so one receives for biowaste**

**waste.**

According to our calculations, the biogas produced by wet organic

waste almost economically profitable, with a deficit

0.002 NOK / kWh. The reason for the measure is virtually

economically profitable, while

social cost is relatively high, a

distribution effect. In the business economic analysis calculated

costs and revenues for biogas plants. In our calculations

we have assumed that plants take a street-fee

1

700 U.S. $ / tonne of waste

which is as high as the average gate fee for

waste incinerators. This income receiving units in

addition to revenues from the sale of biogas. In the

economic analysis, the costs and

income for the community (Norway). Gate fee'en is an income for biogas plant (700 NOK / tonne) but

an equally large cost for waste game (-700 kr / ton), so the social income is equal to

zero (700 kr / ton -700kr/tonn = 0). Similarly, the sale of biogas in the socio-economic

analysis only a removal of money from the buyer to the seller, which does not involve a real income for

society.

Biogas production from manure is not economically profitable today, with a

deficit of 1.27 NOK / kWh. There are two main reasons for this: Firstly, the gas yield from

fertilizer low, making the cost per unit of energy increases. Second, it can not be fixed taking a victory

gate-fee for manure, so he receives for organic waste.

Due to an immature market we have in the business economic analysis assuming bio fertilizer

can not be sold at a positive price currently. This can be both over-and underestimate the value. A

overestimation may result from any "unclean" fractions may lead to bio fertilizer is

quality that makes it difficult and therefore expensive to handle it. An underestimation is possible because

It is possible that organic fertilizer may be recognized as a high-grade fertilizer formulation, which could

give it a positive value.

1

Gate fee: The price of waste owner pay on delivery to the disposal facility, in dollars / ton waste

|  |
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| **Page 17** |

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**Value Chain city bus**

Total emission reductions:

**500 000 tonnes of CO**

**2**

**-Eq**

Contributions manure:

**305 000 tonnes of CO**

**2**

**-Eq,**

cost of measures:

**2300 NOK / ton CO**

**2**

**-Eq**

Contributions organic waste:

**196 000 tonnes of CO**

**2**

**-Eq,**

cost of measures:

**1100 kr / ton CO**

**2**

**-Eq**

***Value chains for biogas***

**In addition to use in the transport sector (specifically buses) we see on a value chain where**

**biogas is fed into an existing natural gas network.** **Of the two applications is the use of**

**biogas in buses that have the lowest costs of action, mainly because of the value of**

**improved local air quality, the reductions in nitrogen oxides and particulate matter.** **The costs of measures for**

**chain with the use of buses is intended to 2300 kr / ton CO**

**2**

**Equivalents at**

**production from manure and 1100 kr / ton CO**

**2**

**Equivalents when organic waste**

**used as raw material.** **Organic waste as substrate has higher gas yield and lower**

**production costs than manure, which are the main reasons that the costs of measures being**

**lower.**

We have in this report focused on comparing costs

and new effects associated with the production of biogas from

manure and organic waste, with consequent

use in the transport sector. Organic waste and

manure is chosen as substrates because it is these

raw materials that we believe have the greatest remaining

potential in the short term. In addition to use in

transport sector, we look at a value chain where biogas is fed into

in an existing natural gas network. These value chains are selected

because in the short term probably has the lowest abatement cost and

greatest potential. In both value chains is seen

production of biogas in relatively large central biogas plant,

so that the costs presented here do not reflect

costs for small farmsteads or other solutions.

Value Chain "city bus"

The value chain with the use of biogas as a fuel is chosen because it is here especially many

positive effects in terms of reduced greenhouse gas emissions and improve local air quality. In

Additionally, there are few other options to reduce greenhouse gas emissions from the transport sector, especially for

heavy vehicles. The value chain is exemplified by looking at the use of buses or similar vehicles fleet,

running in the cities. The reason we look at the heavy vehicle fleet is that there are few other substitutes for

fossil fuels for heavy vehicles, while requiring less infrastructure for fleet vehicles

compared with private vehicle (one filling station can accommodate many vehicles that have the same

daily route).

If the full potential of organic waste and manure triggered (880 000 tonnes of biowaste

waste and 3.9 million tonnes of manure), can be about 1.7 TWh biogas produced and as shown in Figure 2,

potential for energy generation distributed approximately equally between the manure and waste. Given that biogas

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| **Page 18** |

18

used as fuel, this could result in an annual emission reduction of 500 000 tonnes of CO

2

-Eq

2

. About 60%

this reduction in emissions comes from biogas produced from manure, while the remaining

40% comes from production based on organic waste.

As mentioned above, the biogas emissions reductions both in production and in application. Figure 4

shows how **emissions reductions** are distributed throughout the value chain. For manure

occurs around half the emissions reduction in the production of biogas (reduction of

methane and nitrous oxide), but the remaining emission reductions are mainly due to the replacement of fossil

diesel. Organic waste program leads to a small increase of greenhouse gas emissions in the production stage.

This is because the organic waste had been burned, leading to an energy production if

not produced biogas. When waste is used for biogas production rather, it should be replaced

Combustion of such waste, which produces increased emissions. When biogas as substitutes

fossil fuel and provides a reduction in emissions, so that the entire value chain gives a net reduction in emissions.

Emission reduction for biogas produced from organic waste arises therefore first in the application.

**The cost** of reducing greenhouse gas emissions in the supply chain "city bus" is composed of

economic costs associated with the production of biogas upgrading and compression of

gas and procurement of gas buses, filling stations and associated infrastructure and operation thereof. It is

also including new effects such as reduced use of fertilizers, reduced emissions of ammonia,

reduced air pollution and reduced use of fossil diesel. How to measure cost is affected by

These various factors are shown in figure 5.

As shown in Figure 5, measures the cost of the value chain with the use of buses 2300 kr / ton CO

2

-

equiv of production based on manure and 1100 kr / ton CO

2

-Eq when organic waste is used

as feedstock. Organic waste as substrate has lower production costs and higher gas yield

than manure, which are the main reasons why the costs are also lower.

Cost of the measures presented here are average costs. Pieces of potential, both for

waste and manure, will naturally have a lower cost than the costs presented here

while other areas of potential will have a higher cost. It will for example be some areas

which measures the cost of production from manure will be lower because the affected

including the transport distance between the farm and the biogas plant, so that high

livestock density will have lower-cost option than average.

2

CO2-eq: To compare measures across greenhouse gases, it is common to convert all emissions of CO

2

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equivalents. This factor describes the effect discharge of a particular gas has on global warming relative to

CO

2

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19

*Figure 4: Reduction of greenhouse gas emissions throughout the value chain of biogas production from manure*

*(Top) and organic waste (bottom), used in city buses.*

-20

0

20

40

60

80

100

Production

Reduced

fertilizer use

Net

emission reduction

the production

Methane emissions from

engine

Replacement of diesel

Total

emission reduction

**%**

**Emission reduction in production of biogas from manure and**

**use in city buses.** **Total emissions: 305 000 tonnes of CO**

**2**

**-ekv/år.**

**Production**

**Application**

-20

0

20

40

60

80

100

Production

Reduced

fertilizer use

Net

emission reduction

the production

Methane emissions from

engine

Replacement of diesel

Total

emission reduction

**%**

**Emission reduction in the production of biogas from organic waste and**

**use in city buses.** **Total emissions: 196 000 tonnes of CO**

**2**

**-ekv/år.**

**Production**

**Application**

|  |
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| **Page 20** |

20

*Figure 5: Economic costs and savings throughout the supply chain, the biogas production based on*

*manure (top) or organic waste (bottom), used in city buses.* *Costs and savings are shared*

*the total emission reductions to show the development of abatement costs.*

**Value chain - production and use of biogas from manure in city buses**

Upgrade

Maintenance

Electricity

Work

Transport

Annual cost of capital

**Biogas production from manure**

**Application in city buses**

**Biogas production from manure**

**Application in city buses**

Production

Reduced fertilizer use

Compression

Annual capital cost bus

Annual capital cost terminals and

backup

Annual capital cost flakes

Operating tank and backup

Reduced fuel use

Reduction of NOx and PM10

Cost of measures

0.00

0.10

0.20

0.30

0.40

0.50

0.60

0.70

0.80

0.90

1.00

0

500

1000

1500

2000

2500

3000

3500

4000

4500

5000

Costs

Revenue

Net

Costs

Revenue

Net

**NOK / kWh**

**£ / tonne CO**

**2**

**-Eq**

**Value chain - production and use of biogas from organic waste in city buses**

Work

Transport

Annual cost of capital

**Biogas production from organic waste**

**Application in city buses**

**Application in city buses**

|  |
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| **Page 21** |

21

**Business Economics**

**user fees**

**biogas and bio fertilizer**

Business Financial loss

using biogas bus:

**0.04 NOK / kWh**

**Value Chain Rogaland**

Total emission reductions:

**206 000 tonnes of CO**

**2**

**-Eq**

Measures Cost of production

based on manure:

**2400 NOK / ton CO**

**2**

**-Eq**

Measures Cost of production

based on a mixture of

manure and biowaste

waste (volume ratio 1:18

between fertilizer and equipment):

**2200 NOK / ton CO**

**2**

**-Eq**

Commercial profitability using biogas buses

The investment costs for bus operators will consist of

incremental cost of purchasing gas buses, filling stations, flakes and

backup systems. On the operational side, the purchase and compaction

biogas be operating, while bus companies will save

To reduce the purchase of diesel. This means that by choosing

gas buses bus operators will incur additional costs (in

compared to diesel buses) at 4 cents per kWh biogas they use.

The low cost can largely be explained by the fact that diesel price

is high, while the fees for diesel is significantly higher than for gas. The reduced purchasing of

diesel will therefore almost offset the increased investment costs.

Value Chain "Rogaland"

In this chain, we look at feeding biogas in a

existing natural gas network, for example in Rogaland. We have here

focused on biogas produced from animal manure because of

the high livestock density in Rogaland. The cost when

Biogas produced from pure manure and fed into the gas network

Situated at around 2,400 kr / ton CO

2

-Eq. If any wet organic

waste used in the plant as well (volume ratio 1:18 between

manure and waste), reduced cost of measures which (in 2200 U.S. $ / ton

CO

2

-Eq). At higher content of organic waste will

the costs are further reduced.

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***Potential sources of error***

**We conducted a sensitivity analysis to determine which of the input factors**

**3**

**that**

**used in the calculations that yield the greatest impact on the final cost (production and**

**abatement cost).** **Input factors that have the greatest impact on the cost of the measure are:**

• **Fuel for gas buses**

• **Gas yield from the two raw materials**

• **The investment costs for biogas plants**

• **Diesel Price**

**The results of the sensitivity analysis provides a range of measures the cost of bus supply chain of 1500**

**to 2800 U.S. $ / ton CO**

**2**

**-Eq when manure is used in production, and -353 to 3344 U.S. $ / ton CO**

**2**

**-Eq**

**the production from organic waste.** **That is, the numbers are relatively sensitive to**

**changes in the input factors.**

The calculation of the social cost is based on several assumptions. We have therefore made

a sensitivity analysis in which we varied the different input factors by ± 50%, to identify

the parameters that had the greatest impact in the costs. The most sensitive factors will then

be important to have good accuracy. In addition, this gives an indication of the measures will be

have the greatest effect.

For supply chain based on manure is gas buses' fuel consumption, gas yield

biogas plant and the investment costs for the biogas plant the most crucial factors for

measures the cost. For value chain of organic waste as substrate diesel price will make a major

impact on the cost of measures, in addition to the same factors mentioned for manure.

The results of the sensitivity analysis provides a range of measures the cost of bus supply chain in 1500 to

2800 NOK / ton CO

2

-Eq when manure is used in production, and -353 to 3344 U.S. $ / ton CO

2

-Eq by

production from organic waste. That is, the numbers are relatively sensitive to changes in

some of the input factor. Since part of the parameters are relatively unsafe, this entails a certain

uncertainty in the cost figures.

3

Input factor is the underlying figures are based on estimates. For example

investment cost, gas dividends, interest, etc.

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***Biogas in the long term***

**Future costs of measures for the production and use of biogas will be affected by how**

**Parameters such as fuel gas to the bus change over time.** **It is expected**

**reduction of fuel consumption of gas buses, while diesel prices are expected to increase.** **New substrates**

**could increase the total potential and new technology could increase gas yield per ton of feedstock.**

**These changes are expected to reduce the costs.** **In connection with the expected increase in**

**waste up to 2020 may be used, with an increase in processing capacity in Norway.**

**If a biogas plant is built instead of expanding the existing incinerators will reduce**

**the social cost of production of biogas significantly.**

The costs for biogas production fraction is based on the assumption that the total

capacity for waste treatment is sufficient and that new biogas plant in addition to

existing treatment capacity. The amount of waste will however increase significantly up to 2020 -

According to SSB household waste will increase by 36% between 2012 and 2020, while the total amount of waste will

increase by 22% over the same period. If the increase of processing capacity occurs in Norway (and not in

abroad) occurs a choice between expanding combustion capacity or to build biogas plants.

If treatment capacity in Norway matter to be developed, the economic cost

of biogas production based on organic waste will be significantly lower. If a biogas plant

in place of the expansion of an existing incinerator reduces the

social cost for the production of biogas from 0.54 NOK / kWh to 0.15 U.S. $ / kWh.

Future measures costs for biogas production will be affected by how the parameters for

as fuel for gas buses change over time. Because fuel consumption for gas buses

likely to be reduced more by technology than fuel for diesel buses,

while diesel prices are expected to increase, one can expect that measures the cost will decrease over time.

Gas yield in biogas plant can also be increased if the focus on research and development in

area. This will also reduce the cost of measures in the future.

Figure 6 shows the relationship between sensitive ethylene and estimated uncertainties

4

in 2020 for the various

parameters of the value chain where biogas is used in city buses and production based on biowaste

waste. It is also indicated in which direction (decrease or increase) the costs are expected to

move in. Overall, Figure 6 shows that the parameters that affect the cost of measures to the greatest extent

(Far up in the figure) are largely expected to lead to a reduction of cost of measures to 2020 (green

labeled in the figure). We also see that the uncertainty in the parameters is high.

4

The uncertainty is meant essentially variability in the sense that the internal uncertainty in number in addition to the expected

future development are included.

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| **Page 24** |

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*Figure 6: Preparation of impact on the abatement cost and uncertainty in parameter values ​​in 2020.* *Color coding indicates*

*direction measures the cost is expected to change as a result of development of each parameter until 2020.*

IEA points out the need for drastic cuts in emissions in the transport sector, and that biofuels will be important

the long term to reduce emissions from heavy goods. Development of infrastructure for further

use of biogas must be viewed in a much longer perspective than 2020. In the EU, the focus of

waste policy shift from a focus on waste without adverse environmental effects to a focus on

utilization of scarce resources. In the long term potential for the amount of produced biogas increase, both

utilizing larger proportion of the raw materials we have studied in this report, increase gas yield per ton

raw material, and to utilize other resources, such as forestry waste and algae. Biogas can in this way be a

important contribution to an overall increased use of biofuels in a low carbon society. The dynamics of the types and

amounts of raw materials indicates that the remedies introduced, should be reconsidered in a few years.

Investment

biogas plants

Calorific value

biowaste

Gas Yield

Diesel price

Fuel stations,

flakes, back-up

Fuel

gas bus

NOx emissions

Additional cost

gas bus

Calorific value

MSW

Emission factor

combustion waste

Transport

costs

2020 - reduced cost of measures

2020 - unchanged abatement cost

2020 - increased cost of measures

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**Increasing uncertainty in the parameters**

**Cost of measures for supply chain with production of biogas**

**based on organic waste and use in buses**

|  |
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***Measures to increase the production and use of biogas***

**Production of biogas from organic waste is virtually economically profitable according to our**

**calculations.** **This suggests that barriers as lack of longevity and predictability, both**

**regard.** **raw materials and the demand for biogas and bio fertilizer is more crucial for**

**potentials are triggered, than actual profitability.** **To reduce these barriers will increase**

**predictability in regulatory, tax levels and support is important.** **If you wish to**

**triggering potential, the means that will allow more organic waste delivered to the biogas plant and**

**the creation of a larger market for biogas, be relevant.** **Improved sorting of food waste from**

**MSW can be a means to increase the availability of organic waste.** **It is not**

**economically profitable today to produce biogas from manure.**

**The sensitivity analysis shows that the investment cost and the gas yield are the two conditions that**

**affect the profitability of the greatest degree of biogas production from manure.** **Any**

**investment support systems must be very high to achieve profitability in plants.** **A**

**alternative to a financial aid is an interference requirements for manure in biogas plants**

**treat organic waste.** **Business administration is the use of biogas as a fuel for**

**buses almost profitable.** **The main factor for this is the high price of diesel.** **This suggests**

**that a small amount of support as the gas buses will be able to trigger the transition to gas buses during**

**a few years.** **The main barrier will be to create predictability, since a change in fees, which changes**

**cost difference between diesel and gas, change the profitability significantly.** **To increase the use**

**of organic fertilizer, increased focus on the purity of the substrate and thus high quality of organic fertilizer, increased**

**charge of nitrogen and phosphorus in fertilizers and transportation support for bio fertilizer considered.**

Means may be aimed at different parts of the value chain (see also Figure 7):

• Measures to *increase access to raw materials* for biogas plants, such as the requirement

separation and biological treatment of organic waste, delivery support for manure to

biogas plants and stringent requirements for storage and distribution of manure

• Measures to *increase the production* of biogas, such as investment or

production support in NOK / MWh or £ / tonne treated

• Means for *increasing the use* of biogas and organic fertilizer, such as

investment to gas-powered vehicles, reduced one-on gas vehicles,

wagering requirements for biogas as a percentage of natural gas, feed-in-tariff

5

for biogas, as well as tax

on fertilizer and support for transportation of bio fertilizer

Furthermore, measures designed to ensure that they reinforce the demand in the supply chain. This will increase

profitability "backwards" in the value chain (often called "pull"), triggering parts of the potential.

Examples include reduced time fee of gas vehicles and reduced fuel tax on biogas,

and increased tax on mineral fertilizers. Alternatively, means "push" or push the raw materials for

biogas production through the supply chain, for example by means of requirements for separation of food waste, one

delivery support for manure into biogas plant or production support for biogas plants. Since

production from organic waste is significantly more profitable in a commercial

5

Guaranteed price when the manufacturer sells biogas

|  |
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| **Page 26** |

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perspective, measures that enhance demand mainly trigger biogas plants based on

organic waste. To trigger the production of biogas manure, required "push" measures in

addition.

*Figure 7: Schematic representation of the possible chains of production and use of biogas and bio fertilizer*

*6*

*.*

As mentioned above, the production of biogas from organic waste almost economically profitable

according to our calculations. This suggests that the barrier to get triggered production based on

organic waste is not principally a lack of profitability, but rather the lack of predictability

with regard to legislation, tax levels and funding. The sensitivity analysis shows that the size

the gate-fee

7

and investment costs are factors that affect the profitability of the highest degree.

Measures that increase the cost of alternative therapies or reduce

investment costs for biogas plants will be of great importance for profitability. In addition

in the commercial calculation provided that there is availability of organic waste and that it is

buyers of biogas. If one wishes to release the potential, the means that allow more

organic waste delivered to the biogas plant and the creation of a larger market for biogas, be

appropriate. Requirements for separation of food waste and biological treatment could lead to an increase in the number of

biogas plants in Norway. Predictability in the municipal food waste, will provide plant owner

long term perspective of access to raw materials required for construction of facilities. If plants

dimensioned so that it is possible to treat the waste beyond household waste, this can also lead

an increase of biogas processing of industrial waste.

6

CHP = combined heat and power (heat & power plant)

7

Gate fee: The price of waste owner pay on delivery to the disposal facility, in dollars / ton waste

**Access to**

**feedstock**

**Production**

**Application**

Fertilizer

Household

waste

Sewage sludge

Industrial waste

Large-scale

biogas plants

Small-scale

biogas plants

Bio fertilizer

Biogas

Up

grading

Transport

sector

CHP

Fertilizer

SURFACE-

plant

Combustion

Flaring

Gas Supply

Heating

NOT EXCLUSIVE

|  |
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27

It is not economically profitable today to produce biogas from manure.

The loss is estimated at U.S. $ 1.27 per kWh. To release the full potential of manure on

around 0.7 TWh, equivalent to an annual funding requirement of approximately NOK 950 million. The sensitivity analysis

shows that the investment cost and the gas yield are the two factors affecting the profitability of

greatest extent. The gas yield can be improved by providing support for research and development, but this is not a

measure with short-term effect. Any investment aid facilities must be very high

to achieve profitability in plants. An alternative to a financial aid is an interference requirements

manure in biogas plants treating organic waste. The amount of raw materials for the potential

is around 880 000 tonnes of organic waste and around 3.9 million tons of manure, that is,

It is almost five times as much fertilizer as waste. To triggered the potential need words

sambehandlingsanlegg treating waste and fertilizers in a quantity ratio of 1:5

Business administration is the use of biogas as a fuel for buses almost profitable, if

procurement of gas bus happens instead a purchase of diesel buses (ie not replacing

existing fleet before it would normally have been replaced). The most important factor for

this is the high price of diesel, or more accurately price difference between diesel and gas (the

assumed that biogas and natural gas sold at the same price). With the difference as it is today, a little

amount of support as the gas buses could trigger the transition to gas buses within a year.

The main barrier is here predictability. If, for example, biogas and / or natural gas are required

veibruksavgift, the commercial deficit increased from 4 cents to 42 cents per kWh. A

guaranteed exemption veibruksavgift combined with an investment of gas-powered fleet vehicles,

could lead to a large increase in the use of biogas in the transport sector. This will, in addition to

reductions in greenhouse gas emissions could result in noise reduction and positive effects on local

air quality.

To increase the use of organic fertilizer, it is important to have a strong focus on the purity of the substrate and thus high

quality of organic fertilizer. For certain types of fertilizer is skepticism about its purity and quality

determining that they are not used. But also other measures such as developing standards for

bio fertilizer, increased tax on nitrogen and phosphorus in fertilizers and transportation support for bio fertilizer can

considered. Changes in fertilizer products Regulations (currently under revision spring 2013) will be better

possibility of using organic fertilizer and lead to higher demand for biogas processing

manure.

Funding in other countries: Sweden, Denmark and Germany has built up a significant

biogas production during the last few years. Sweden has invested heavily in biogas used in

transport and therefore have many tools aimed at this sector, such as grants

the purchase of gassbil for individuals and required "environment-standard" of public procurement and

prizes for biogas use in heavy vehicles. In Denmark biogassatsingen both contribute to less

dependency on electricity from coal and reduce the challenge of large quantities of manure.

Here it is, among other things introduced investment and guaranteed loans to municipal facilities that will be

treat manure. In Germany, biogas contribute to a transition to renewable

electricity production and support system is therefore arranged such that there is a guaranteed feed-in tariff

for electricity produced by biogas. Feed-in tariff is guaranteed for 20 years from the plant

startup, and partly depends on its initial year, the size of the plant and raw materials that

used and the surplus heat from electricity production utilized. Biogas Production in

Germany is largely based on energy crops as sambehandles with manure.

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***Short summary / conclusion:***

• There is considerable potential for increased biogas production in Norway

• The realistic potential up to 2020 is estimated at 2.3 TWh

• The largest remaining potential for biogas production to 2020 is in biowaste

waste and manure

• If all the realistic potential for biogas production from organic waste (about 1

TWh) and manure (about 0.7 TWh) triggered and biogas replaces fossil diesel in heavy

vehicles, will reduce the Norwegian greenhouse gas emissions by 500 000 tonnes of CO

2

-Eq

• The cost of biogas produced by manure and used in city buses

is estimated to 2300 £ / tonne CO

2

-Eq

• The cost of biogas produced by wet organic waste and used in

buses is estimated at 1100 kr / ton CO

2

-Eq

• Measures introduced to potential unleashed, can "push" raw materials into value chain

(Eg. Required separation and biological treatment of waste), or create "pull" (increased

demand) in the value chain (eg. funding for investment in gas vehicle)

• The introduction of measures that primarily increases demand for biogas and / or

bio fertilizer, the most profitable plants being triggered, ie plants that use

organic waste in production

• If you want to encourage biogas production from manure, it is important to

introduce regulatory measures or "push" factors.

• predictable regulatory framework is particularly important for the players to focus on building

a value chain for biogas.

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**Chapter 1 - General biogas**

**How to produce biogas**

Biogas is produced when microorganisms break down organic material without access to oxygen

(Anaerobic conditions). Biogas consists mainly of methane (CH

4

) And carbon dioxide (CO

2

), Plus

small amounts of some other gases. Combustion of biogas will release energy and heat and transform

methane to carbon dioxide.

Biogas is used as a term for both the gas collected from landfills and gas being

produced in a reactor. Accumulation of methane occurs at landfills is important to prevent

emissions of the potent greenhouse gas methane, but in this report we look mainly at how

active production of biogas in a reactor can be increased in Norway. In a biogas reactor, different raw materials

used, for example, organic waste food waste, sewage sludge and manure, see Figure 1.1. The

is also possible to cultivate different plants as utilized in biogas reactor, for example maize and cereals,

but also trees and algae. Since there is relatively little agricultural land in Norway we have in this report

disregarded the possibility of cultivation of energy crops for biogas production.

*Figure 1.1: Schematic representation of biogas production.*

The composition of the raw material is essential for gas yield, see Table 1.1 and 1.2 for typical values.

Food waste and other organic waste with a high content of proteins and fats provide the highest

gas yield, while manure provides a lower gas yield. Sambehandling of waste and manure

In the same reactor gives a higher and more stable gas yield than treatment of substrates individually

(Sørheim *et al.,* 2010). A mixture of manure and organic waste is often beneficial because

manure has a high nitrogen content relative to carbon content, while organic waste often

has an opposite relationship. In addition, the consistency of the mixture is usually better than using

of pure organic waste. These factors contribute to a better process with less interference

microbiological processes, and thus a more stable biogas process with a high gas yield.

After treatment in a biogas plant, the substrate is converted into a so-called organic fertilizer which is suitable

as fertilizer and soil conditioner. Biogas can be produced by various temperature conditions,

common are mesophilic utråtning at 35-42 ° C and thermophilic processes at 50-60 ° C.

**Biogas**

**reactor**

**Organic waste**

|  |
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*Table 1.1: Biogas Yield and methane content in biogas for fat, protein and carbohydrates.* *Source: Schnur*

*(2008) and Swedish Gastekniskt Center (2009).*

**Substrate**

**Biogas Dividend**

**Nm**

**3**

**/ Kg VS**

**Meta Content in%**

Fat

1.37

70

Protein

0.64

80

Carbohydrates

0.84

50

*Table 1.2: Biogas Yield and methane content in biogas depends on the substrate.* *Source: Swedish Gastekniskt*

*Center (2009).*

**Substrate**

**Biogas Dividend**

**m**

**3**

**/ Ton of wet weight**

**Meta Content**

**gas in%**

Sewage sludge

15

65

Source Sorted waste

204

63

Offal

93

63

Swine Manure

26

65

**Advantages in the production and use of biogas and organic fertilizer**

The production and use of biogas reduces greenhouse gas emissions in three ways (other benefits are

discussed further down in the chapter):

1 Reduction of methane and nitrous oxide emissions that had occurred during storage of manure in

fertilizer basement and when organic waste had been composted or been burned

2 Reduction of CO

2

Emissions when biogas replaces fossil fuels, such as oil, diesel and gasoline

3 Reduction of CO

2

and nitrous oxide emissions when organic fertilizer replacing artificial fertilizers

Because the use of manure and organic waste contributes to the reduction of greenhouse gases both

production and the application, the reduction of greenhouse gas emissions will be greater than the

expected emissions from fossil energy sources such as biogas replaces. Therefore, reduction of

greenhouse gas emissions would be greater than 100% when such fossil fuels are replaced. Svenskt

Gasteknisk Center examined in 2010 lifecycle emissions from Swedish biofuels compared to fossil

fuel. The results are presented in Table 1.3. and outlined in Figure 1.2 below.

The various greenhouse gases is illustrated in a simplified diagram in Figure 1.2 below. If no

produced any biogas plant will absorb CO

2

, The cow eats the plant and produce manure of

this. Part of the manure is broken down anaerobically and leads to methane and nitrous oxide emissions. At the same

the use of fossil fuels in the transport sector lead to emissions of CO

2

. Overall it in this picture

released 70 CO

2

Molecules and 2 CH

4

Molecules. Since methane is a much stronger greenhouse gas, will

total emissions equal to 110 CO

2

-Eq (see upper part of Figure 1.3). The plants will take up a lot of emissions

CO

2

But in this picture there is a net increase of greenhouse gases in the atmosphere at 110 CO

2

-Eq.

|  |
| --- |
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If we now replace the fossil fuel (equivalent to 70 CO

2

Equiv) with biogas, avoids

the emission of CO 70

2

Molecules from the fossil fuel **and** methane emissions from manure

(A total of 110 CO

2

-Eq, see lower part of Figure 1.3). That is to say, by replacing the emission from

fossil fuels in the 70 CO

2

-Eq, reducing emissions by a total of 110 CO

2

-Eq. This corresponds to a

reduction of around 150% compared to fossil fuels (see Table 1.3 and Figure 1.2).

Of course this is a simplified account that does not take into account greenhouse gas emissions from the cow,

transport of manure, the construction of a biogas plant etc.

*Table 1.3: Reduction of the life-cycle emissions by use of biogas produced by various substrates compared to*

*emissions from fossil fuels.* *Source: Svenskt Gastekniskt Center (2010).*

*Figure 1.2: Net emissions of CO*

*2*

*replacing diesel with biogas.* *CO*

*2*

*Emissions from the combustion of organic*

*matter not included in the emission inventory, because it is considered part of the "fast carbon cycle" (see*

*Figure 1.3 below).* *This is why biogas buses are considered zero emission vehicles.*

**Substrate for biogas**

**% Reduction relation.** **to**

**fossil fuel**

Corn

75

Sugar beet

85

Organic household waste

103

Waste from food industry

119

Fertilizer

148

Emissions from diesel bus

Avoided emissions from

diesel bus

Avoided emissions from

manure

Net emissions

-40

-20

0

20

40

60

80

**CO**

**2**

**-Eq**

**Net emissions of CO**

**2**

**Equivalents using**

**biogas bus instead of diesel bus**

**Total**

**emission**

**reduction**

|  |
| --- |
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*Figure 1.3: Illustration of GHG savings in biogas production.*

**Without biogas production**

**The biogas production**

|  |
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In addition, biogas can have many other benefits as an energy carrier, partly because:

• biogas is a renewable energy source and can help in the transition to a low carbon society

• by replacing fossil fuels such as diesel fuel reduces the discharge of components that contribute to

local air pollution

• gas powered vehicles leads to lower noise levels than diesel powered vehicles

• biogas production makes it possible to reuse the phosphorus in the organic waste (organic fertilizer is a

high-grade fertilizer product and the anaerobic treatment leads to greater plant availability

of nutrients than aerobic treatment)

• the production of biogas from waste products, will be able to utilize the resources of

waste in an environmentally better way (over a lifetime) than by combustion with

energy utilization

• production of biogas occupy no arable land if the production is based on

waste and manure

• use of organic fertilizer instead of mineral fertilizer can improve soil structure, resulting

in higher yields and leads to less use of pesticides, as well as the greenhouse gas emissions associated with

production of mineral fertilizers reduced

• biogas production can lead to regional development and employment

**Distribution system for biogas**

Biogas can be transported in the same way as natural gas - either by pipeline or flakes

(Cylinders). When biogas will be led into an existing natural gas network, the gas must be upgraded to

natural gas quality first. When biogas is transported in a separate piping systems, one need not

upgrade the gas. Transportation of gas cylinders can be as compressed gas (CBG, compressed biogas) or

as liquefied natural gas (LBG, liquid biogas). CBG is suitable when transporting relatively small

gas volumes over short distances and is currently the most common way to transport the biogas.

The gas cylinders are mounted on a trailer and filled to about 300 bar. To transport the biogas LBG

gas must be cooled to -162 ° C and can then be transported by LNG trailers or tankers. While a

CNG trailer can transport about 6000 Sm3 per trip, a trailer with liquid gas could

transport approximately 32 000 Sm3 on a trip.

**How biogas is used**

Methane in biogas can be burned and such, provide an energy benefit. If one does not have a

application of energy in the gas, it is possible to burn the gas without using energy (flaring). For

landfill gas and biogas produced by the manure, the production and flaring help reduce

greenhouse gas emissions. But climate dividend doubled and the costs more than halved, if

biogas replaces fossil fuels. Biogas production from organic waste (followed

flaring) will produce a net emission, which means that there will only be an environmental gain if biogas

replace fossil fuels

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Biogas can be used for heating, electricity generation or transport to replace

for fossil fuels. When biogas is used for *heating* burning it in a gas boiler or in a

direct-acting gas burner. To *produce electricity* used biogas in a gas turbine or an

piston. If electricity generation is part of a CHP plant (Combined Heat and

Power) is the excess heat from electricity production used, for example for heating

homes through a district heating system. To use biogas as *fuel,* raw gas upgraded

to natural gas quality. When the biogas is upgraded to a quality which can be used in vehicles, the

often referred to as biomethane. Biomethane can be used in cars, buses, trucks and fuel to ship.

Biogas used for heating

Biogas can be used for heating buildings in the form of direct-acting burners or using

by hot water in a gas boiler. In addition, the biogas is used in district heating systems. To carry

biogas from the production site to the application, it can either be transported in a gas network or

tanker / flakes. If the building previously used natural gas are not needed to make changes, but if

building previously used an oil boiler must be replaced, or rebuilt. Replacement of

Natural gas provides a significantly lower environmental gain than replacement of oil boiler.

Replacement of oil fired boiler, however, associated with significantly higher costs. In Klif report

"Costs and reducing greenhouse gas emissions through the supply chain" (CPA, 2011), it was estimated that

heating of buildings where gas is transported to a local gas network can provide 351 000 tonnes of CO

2

-

reduction with a cost of 1266 NOK / ton CO

2

-Eq if there are enough people

buildings within a few miles radius. If buildings are more spread out, the gas is transported

that CBG and measures the cost increases to 2050 NOK / ton CO

2

-Eq. Both measures have as a prerequisite

biogas replaces oil heating. Following this Parliament has made ​​the following decisions in [settings.](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.stortinget.no/Global/pdf/Innstillinger/Stortinget/2011-2012/inns-201112-390.pdf) [390 S](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.stortinget.no/Global/pdf/Innstillinger/Stortinget/2011-2012/inns-201112-390.pdf)

[(2011-2012):](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.stortinget.no/Global/pdf/Innstillinger/Stortinget/2011-2012/inns-201112-390.pdf) *"Parliament asking the government prohibit the burning of fossil fuel in households and*

*the base load of other buildings in 2020. "Replacing* oil boilers will thus happen anyway according to the Parliamentary

decisions and lie inside the baseline as soon as means to trigger the measure is introduced. If the new

production of biogas is to replace oil heating which is included in the prohibition leads to no

or only minimal reductions in greenhouse gas emissions compared to the baseline scenario.

The use of biogas for heating has some challenges related to seasonal variations in heat demand,

since it is difficult to save gas without getting problems with precipitation. Saving Biogassubstrat (one

sanitize the form of the organic waste that is not yet fed into a reactor) may be a

option so that biogas is first produced in the winter when the heat demand is greatest.

If biogas can be directed into an existing gas network, for example in Rogaland, will

costs related to transporting the gas to be lower since the use of an already

established infrastructure. Since when biogas replaces natural gas instead of oil, the emissions reduction

also be lower.

Biogas used in the process industry

Biogas can replace natural gas used in industry. According to Norwegian industry is the most appropriate to

replace natural gas used in aluminum production with biogas. This application requires that

biogas, liquefied and distributed as LBG. Since this is a costly process, especially for

smaller units, the cost of measures as described in Klif report (2011) High: 2650 NOK / ton CO

2

-

|  |
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eq. In addition, the use of biogas within quota regulated sector lead to a reduction of Norwegian emissions, but

not necessarily have an effect on global greenhouse gas emissions.

Biogas used for electricity production

The biogas can be used to produce electricity. This may occur with or without the use of

excess heat. The size reduction of greenhouse gas emissions this causes depends on many

factors, including whether the electricity will replace existing electricity production, covers increased consumption,

or are in place for energy conservation. Since most of the Norwegian electricity currently has a low emission

CO

2

per kWh, the replacement of existing electricity generation with biogas having a very small

effect in reducing CO

2

Emissions in a socio-economic analysis limited to Norway. The measure will therefore

have a very high abatement cost per tonne of CO

2

-Eq.

Norwegian electricity production is part of a north European power market, and changes in

production capacity must be considered in this context. A mechanism is that increased production will

initially lower the price and increase consumption. At the same time, a lower power to reduce

production plants with high production costs, typical thermal power plants. Another factor

is that power generation with industrial emissions are regulated under the EU emissions trading system. Reduced

emissions in the power sector will enable the sale of allowances to industrial companies which could increase their

emissions accordingly. On the other hand, increased production of renewable energy could expedite

political decision on the reduction of the total number of allowances available. It is considered outside

scope of this report to provide a full assessment of the impact of biogas used for

electricity production will have on greenhouse gas emissions ..

Biogas as fuel

After upgrading of biogas to the biogas (biomethane) can be used the same way as natural in

vehicles adapted gas operations, both cars, buses, trucks and ferries. The use of gas as a fuel

require customized vehicles and filling stations. There are currently three different types of vehicles that can

use gas as a fuel:

1 dedicated gas vehicle / mono-fuel, only use gas as fuel. It uses compressed

gas (CNG / CBG or LNG / LBG).

2 bi-fuel, may use two fuel types (petrol and gas), but not simultaneously. Gasoline will be back-

up if the gas tank is empty.

3 dual fuel vehicle uses two fuels simultaneously (diesel and gas). At cruising speeds, the steady

speed used most biogas (80-90%), while the proportion biogas reduced to 75-80% by

town.

There are relatively few cars with gas operations in Norway at present, but an increasing number of buses and

trucks. These vehicles are usually more expensive at purchase, but cheaper in operation

compared to vehicles using fossil fuel. A gassdrevent vehicles will

biogas, natural gas, or a mixture thereof.

The supply of gas powered cars are currently relatively limited and the cars are significantly more expensive than

equivalent diesel or petrol cars. Gas Cars usually have a fuel tank as well as back-up. On

Because of this pay gas vehicles a higher fee, partly because of the higher weight

as two fuel tanks provide. Additionally calculated CO

2

Component of the registration tax in two different ways

|  |
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for gas vehicles, depending on the size of vehicle spare tank (fuel tank). When the fuel tank is larger

than 15 liters classified the car as "bi-fuel" vehicles (gas and petrol), and the contribution to the one-off tax

calculated from CO

2

Emissions as the car *only runs on gasoline.* Gas Cars with fuel at

maximum of 15 liters are considered "mono-fuel" vehicles (gas vehicles) and the fee is calculated from CO

2

-

emissions that the car *only runs on fossil gas.* Given that the car is running with *bio* gas, both

calculation therefore overestimate CO

2

Emissions of the car. As shown in Table 1.4 below, the

price difference between otherwise identical diesel, petrol and gas vehicles in total be over 100 000.

*Table 1.4: Differences in price and one-time as well as the overall difference in investment costs for gassbil compared*

*with diesel and gasoline.* *Source: Committee Biogas Energy Gas Norway and Zero 2013*

**VW Touran 5 seater**

**VW Passat**

**Price (£)**

**Fee (£)**

**Net Price**

**Difference**

**Price (£)**

**Fee (£)**

**Net Price**

**Difference**

Gas

444 970

141 139

586 109

-

435 534

152 981

588 515

-

Gasoline

362 576

126 765

489 341

96 769

392 986

130 703

523 689

64 826

Diesel

378 596

122 171

500 767

85 342

377 013

107 879

484 892

103 623

When biogas is used in vehicles, replacing fossil fuels such as diesel and gasoline, reduces this

greenhouse gases, but this application also has many other benefits. One of these

benefits are lower emissions of particulate matter (PM) and nitrogen oxides (NO

x

). Particulate emissions from

road transport has its origins in the exhaust gas as well as tear-off from roads (road damage) and

blasts. A gassdrevent vehicle will have virtually zero emissions of particulate matter in the exhaust gas, but will

contribute as much particulate matter from road damage and disturbance. Nitrogen occurs in the engine due

of the high temperatures, which is N

2

and O

2

from the air to respond to NO

x

.

Euro demands that vehicles must meet before they can be sold on the European market has tightened

the requirements of PM and NO

x

Emissions significantly over the last 10 years, see Figure 1.4. for NO

x

Requirements.

It has unfortunately proved that emission reductions by measurements Euro requirement is based on

does not match the emissions measured under real driving. Norwegian Institute for Air Research

(NILU) and the Institute of Transport Economics (TOI) commissioned by the CPA and Roads

autumn 2011 a report showing that diesel vehicles have particularly high levels of NO

x

Emissions by

town with a lot of starts and stops and low speeds, and that these emissions are even higher at

cold start, see Figure 1.4 (TOI, 2011). Unlike diesel vehicles, we have seen that the discharge of

gas vehicle remains at a low level at this type of driving. There are however differences between

the various gas vehicles too. Engines that run with a "lean" mixture, ie low fuel

relative to the amount of air in the engine will be able to discharge at the level of diesel vehicles. Engines

using stoichiometric mixture (i.e., as much air as fuel), however, has much lower carbon

NOx than diesel vehicles, see figure 1.5 below.

The limit value for NO

2

is exceeded in most major cities in Norway. The levels of particulates and NOx in

Norwegian cities leads to negative health effects in the population and it is therefore necessary that these

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emissions are reduced significantly. Today, most buses and trucks diesel, a transition to

gas operation of these could reduce local air pollution significantly.

*Figure 1.4: NOx: maximum permissible emission given by Euro standards for petrol and diesel cars and results from*

*measurements by a Euro 5 diesel under different conditions.* *Source: Institute of Transport Economics (2011).*

*Figure 1.5: NO*

*X*

*Emissions from diesel and gas vehicles.* *Standard deviations values ​​from different driving cycle for testing.*

*EEV is a class issue (Enhanced Environmentally Friendly Vehicle) located between Euro5 and Euro6-*

*requirements.* *Source: Nylund and Koponen (2012).*

Noise impact affects many people in Norway and causes including stress, sleep problems and

cardiovascular diseases. In Norway, road traffic is by far the largest source of environmental noise and while

have succeeded in reducing noise from other sources during the past few years, the road noise only increased. Noise from

vehicle arises from two sources: engine noise and noise from the tires (rolling noise). At slow speed (below approx. 50

0

0.5

1

1.5

**g / km**

**NO**

**X**

**Emissions in g / km:**

**requirements for petrol and diesel cars and measured values**

Petrol vehicles - Requirements

Diesel Cars - claim

Test of Euro 5 diesel

0

5

10

15

20

25

30

**g / km**

**Emissions of NO**

**X**

**from different vehicles**

Diesel (EEV)

Gas, stoichiometric (EEV)

Gas, lean burn (EuroV)

|  |
| --- |
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km / h) the engine noise to be dominant, while at higher speed will be rolling noise of tires

contributors. Engine noise from a gassdrevent vehicle is about half as high as that of vehicles with

diesel engine. A gas vehicles will therefore be considerably lower noise levels in urban than

dieseldrevent vehicle (HOG Energy, 2010).

**How can bio fertilizer used**

When biogas is produced from organic waste, sewage sludge and manure remains a nutritious

mass called bio fertilizer. In order to achieve the most energy efficient and environmentally friendly biogas production,

It is important to use the nutrient rich organic fertilizer for new biomass production. When bio fertilizer

used as a fertilizer or soil conditioner and replace chemical fertilizers, reduced greenhouse gas emissions

and consumption of energy and material resources related to the production of mineral fertilizers, while

phosphorus recycled. Phosphorus is a finite resource and it is therefore important to recycle it. To

able to apply organic fertilizer as a fertilizer product, it must satisfy the fertilizer product regulatory requirements for

maximum concentrations of heavy metals and must be taken to reduce and prevent

product contains organic pollutants, pesticides, antibiotics, chemotherapeutics or

other environmental foreign organic substances that can cause harm to health or the environment. It

most useful organic fertilizer is achieved if the raw materials used in the biogas plant is based

the organic waste that meets the environmental good quality standards.

If sewage sludge is used as substrate in the biogas process, there are some limitations on

spreading of organic fertilizer on agricultural land. How bio fertilizer can not be spread in areas where

vegetables, potatoes, berries or fruit to be grown over the next three years. To prevent

concentration of heavy metals in the soil, thus the food is not allowed to spread organic fertilizer

based on sludge frequently than once every 10.år. Mixing sludge with organic waste and

manure can in some cases reduce the usability (and thus the economic

value) of organic fertilizer. In addition, the use of sludge as raw material lead to a deterioration of the

fertilizer product if the sludge contains significant amounts of organic pollutants or

by use of precipitants in sewage sludge which binds phosphorus such that there is no

plant available. This can lead to limitations in the possibility of using organic fertilizer which

fertilizer or soil conditioner. At the planning and design of biogas plant must be both

raw material base and application of organic fertilizer assessed by the question of mixing of the various

raw materials.

Organic fertilizer can be used directly as fertilizer or can be processed, for example by separating it into a

wet nitrogen and a dry fosforrik portion. When bio fertilizer is separated in a wet and a dry part, enabling

This transportation of the dry phosphorus rich part of areas in need of phosphorus supply. The dry

section can also pelleted and thus further processed into a salable product. Compared with

fertilizer, dosed with the same amount of nitrogen, and organic fertilizer at or biomass growth.

Especially good fertilizer effect on silty soils (pers. comm, Trine Sogn, UMB).

Bio fertilizer applied to agricultural soil or soil mixes and growing media also have a positive effect

on soil quality and runoff. Through the reversal of any organic material is soil's ability to

retain nutrients improved to achieve better ventilation, better structure and thus increased

ability to maintain water supply to the plants during dry periods, and that the Earth's domestic hot

improved.

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**Value chain biogas**

As described in this section may biogas produced from various raw materials and used in various

applications. Some possible chains for biogas production and use is shown in Figure 1.6 below.

Both sewage sludge and manure can be processed in small-scale or large-scale biogas plants.

Organic waste from households, large households, commerce and industry can be used either

directly in a biogas plant for disinfection, or is converted to biosubstrat in a

pre-treatment first. The pretreatment leads to a more stable biogas process with a higher

gas yield. If operating conditions not be made ​​for biogas production in Norway, the

wet organic waste or biosubstratet could be exported. Export of organic waste and

biosubstrat practices. Biosubstrat go to the biogas plant in Denmark. In Sweden it is the sorted

food waste. Some organic waste follows waste from households and commercial waste in exports to

Sweden. Mepex (2012) estimated that 225 000 tonnes of organic waste eksportertes to Sweden and

Denmark in 2010. There is also a possibility that biogas will be exported.

*Figure 1.6: Value chain for biogas production and use.* *Do not exhaustive.* *Logistics joint is not illustrated.*

*CHP: combined heat and power (heat & power plants).*

Fertilizer

Household

waste

Sewage sludge

Industrial waste

Abroad

Large-scale

biogas plants

Small-scale

biogas plants

Biogas

Up

grading

Transport

sector

CHP

Fertilizer

SURFACE-

plant

Combustion

Flaring

Gas Supply

**Value chain biogas**

Heating

NOT EXCLUSIVE

Bio fertilizer

|  |
| --- |
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**"Optimal production and use of biogas" - what does that mean?**

To elucidate optimal production and use of biogas, we have made ​​some simplistic considerations

about the advantages and disadvantages of various substrates and applications. This is not an exhaustive analysis

the optimal resource utilization. It is here seen biogas production based on

manure, organic waste, sewage sludge and energy crops. The application areas are

considered here include use as fuel for electricity generation and heating of buildings.

1 Reducing greenhouse gas emissions:

A. Production of manure as substrate will be substantially higher

greenhouse gas savings per GWh produced, than the use of sewage sludge, biowaste

waste and energy crops.

b Sambehandling of manure and organic waste will overall provide a

higher biogas yield than separate treatment of the substrates. Therefore, this will also provide

a greater reduction of greenhouse gas emissions.

c Use as replacement of fossil fuels like oil, natural gas, diesel and

gasoline will have a greater effect on the Norwegian greenhouse gas emissions than is achieved by

electricity production. Replacement of oil will have a greater effect than the replacement of

natural gas given equal efficiency of the engine.

2 The reduction of emissions of other environmental or hazardous substances

A. The use of biogas as a fuel will reduce local air pollution and noise

compared to the use of diesel

b bio fertilizer can be used as a substitute for chemical fertilizers and thus reduce

emissions and resource use associated with the production of fertilizers

3 Alternative uses of raw materials - what could the resource have been used if not

had produced biogas and organic fertilizer applied, and whether this alternative

use more appropriate

A. Failure to produce biogas from manure, it will be spread as

fertilizer on agricultural land. Conversion of manure for organic fertilizer could

better fertilization effect compared with the spread of manure directly.

b If organic waste is not used to produce biogas, waste will either

collected separately and composted and then used as fertilizer, or

remain in the waste that goes to waste incineration plants with / without

energy utilization. Something waste and segregated organic waste exported to Sweden

and Denmark respectively incineration with energy recovery or biological

treatment. Some of the waste from industry utilized today in animal fodder. This is according to

Several studies a more high-value use of the resource (Mepex 2012). Composting

will also provide an organic fertilizer that can be used as fertilizer and soil improvement products,

but without having to utilize the energy in the waste. In addition, composting provide emissions

methane and nitrous oxide. By composting reactor required energy for ventilation and cooling.

Incineration of waste will provide a utilization of energy, but the heating value of

fraction is due to the high water content is usually low compared to

the amount of energy you can get utilized in biogas production. The energy released

the combustion of organic waste used in Norway today to process steam,

water heating and electricity. The energy produced from

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waste incineration plants replaces the use of other fuels. Combustion will

cause one does not get recycled nutrients, such as phosphorus and nitrogen.

C. Sewage sludge is used for soil improvement, regardless of whether it is used as

biogas or not. Approx. 2/3 of the current sewage sludge goes to agriculture, the remaining amounts

go mostly to parks and vegskråninger or earth producers. These

applications will also be possible for biogas production.

d Energy crops will often be used as foodstuffs, or alternatively it is possible to cultivate

foods on agricultural land is used for energy crops.

4 Alternatives to applications of biogas - what other option than biogas is available in

market and the advantages / disadvantages are there when using other substitution substances than

biogas

A. Transportation: main alternatives to fossil fuel today's biofuels and electricity.

Electric vehicles are currently not an appropriate option for all transportation needs.

First generation biofuel such as biodiesel and ethanol have proved to be more

conflictual replacements for fossil fuels in terms of greenhouse gas emissions,

competition with food production and land use. Biogas produced from waste and

manure will be significantly less confrontational.

b Electricity Production: Norwegian electricity production is already largely

renewable, and there are several sources of clean power generation (hydro, wind, solar, etc.)

c Heating: heat energy can be produced by many different sources, such as

utilized heat from waste incineration in several places. In addition, the need for

heating often be reduced significantly by using after isolation and other

efficiency measures.

5 Contribution to the achievement of the Norwegian environmental goals or commitments, such as reduction of

greenhouse gas emissions in Norway and the achievement of the goals of the Renewable Energy Directive

a reduction of greenhouse gas emissions, the production of biogas from waste products

including manure and use of gas as fuel in Norway will measure

help reduce greenhouse gas emissions both in agriculture and in the transport sector in the

Norwegian greenhouse gas inventory. If the production and / or exploitation occurs in

abroad, the effect on the Norwegian greenhouse gas inventory is reduced.

b Renewable Energy Directive targets: If biogas is used for electricity production or

heating can help to achieve the target for renewable energy in 2020 as percent

of the total energy produced. If biogas is used in the transport sector, this count

double the achievement of objectives for renewables in the transport sector.

6 Economic and commercial profitability.

A. This is further explored in Chapter 4 of this report.

7 Regional effects, reduction of noise, air pollution and industrial development in

districts

A. The use of biogas as a fuel will reduce emissions of components that contribute to local

air pollution, such as particulate matter and nitrogen dioxide. The effect will be greatest when

biogas replaces diesel vehicles running mainly in urban areas.

b manure will typically have higher density in rural areas, and it is therefore more appropriate

adding biogas plants that utilize animal manure to these places. Structure

biogas plant in livestock dense areas will thus also contribute to economic development

in rural areas.

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8 High efficiency of the process

A. Production of biogas will utilize energy from organic waste more efficiently than by

Disposal by incineration.

b Use of biogas in a gas engine will have a relatively low efficiency.

C. Utilization as heat or combined heat and power production (CHP) will have

a high efficiency.

Overall shows the above simplified considerations that biogas production based on

manure and organic waste is a good use of resources and reduces greenhouse gas emissions and

other positive environmental effects over a lifetime. There are several reports that have come to a similar

conclusion. Mepex underwent in 2012 a number LCAer where comparisons of composting,

combustion and biogas handling and use of compost and organic fertilizer were compared. The studies

compared different environmental parameters (energy, climate change, resource use, etc.) over a lifetime.

The studies indicate that biogas production and substitution of fossil fuels with biogas and

substitution of mineral fertilizer with organic fertilizer shows the best environmental consequences of life

compared to composting and incineration. In addition, the use of biogas as a fuel for

transport in urban areas, especially the many positive effects that the reduction of NO

X

and

particle emissions.

There will be areas in Norway where the upgrading of biogas to fuel quality will be low

cost effective. In these areas, the use of biogas in a combined heating system or heating

be an appropriate application. Since the efficiency of a gas engine is lower than

efficiency of an electric motor, it may in the long term be appropriate to produce electricity

biogas or use biogas for heating. The released amount of electricity can then be thought

used in electric vehicles for transportation. The total energy loss in such use would probably be

lower. But since there currently is challenging to drive heavy vehicles with electricity, this

opportunity not further examined in this report.

Cowi published in 2012 a report which looked at the economic costs of the use of different

fuel in Denmark. Up to 2020 the biogas that has the lowest socio-economic

cost in U.S. $ / km (Cowi, 2012). Østfoldforskning In a project funded by SLF in 2012 looked at

climate and environmental benefits of biogas produced from manure and food waste that is used to replace

heating, oil heating, heating with electricity and use as fuel. Of these

applicability was used as fuel out as the most favorable application, both in terms

look at climate benefits and looking at environmental benefits. Bio fertilizer should be applied according to this analysis

directly as a substitute for mineral fertilizers, instead dewatering organic fertilizer. For detailed

description of the climate benefits see Figure 1.7 and 1.8 (Østfoldforskning 2012).

Overall, making these assessments, we further report has concentrated on looking at the utilization

of biogas in the transport sector. In addition, we look at feeding biogas into an existing pipeline network in

Rogaland.

In the transport sector, we have focused on the use of biogas in fleet vehicles since this requires the construction of

fewer filling stations, allowing abatement costs are lower than if you want to convert

parts of private market as well. In addition, especially for heavy vehicles few alternatives to fossil

fuel currently.

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*Figure 1.7: Effects on greenhouse gas emissions with different types of biogas produced from food waste.* *For information*

*the fuel scenarios, see Figure 1.6.* *TS = solids.* *Source: Østfoldforskning (2012).*

*Figure 1.8: Effects on greenhouse gas emissions with different types of biogas produced from cattle manure.* *The various*

*scenarios for fuel production represents the direct use of bio fertilizer as fertilizer (Scenario D),*

*dewatering of organic fertilizer in which the solid residue is composted and the aqueous phase either purified in a water purification plant*

*(Scenario E) or used as fertilizer (Scenario F).* *Source: Østfoldforskning (2012).*

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**Biogas and Renewable Energy Directive**

Renewable Energy Directive (2009/28/EC) was incorporated into the EEA Agreement in December 2011, so that Norway has

undertaken to achieve the renewable share of total energy consumption of 67.5% and renewables

10% in the transport sector by 2020. Renewable share of transport shall be calculated on the basis that

denominator includes gasoline, diesel and biofuels used in road and rail transport, and

electricity. The counter includes all renewable energy used in all forms of transport. In addition, this

some more rules for the calculation:

1 Renewable electricity used in non-road transport will count 2.5 times in both the numerator and denominator

2 Biofuels produced from waste, residues, cellulosic material other than food, and

lignocellulosic material, double counting in the counter

3 All biofuels, including biogas, which will count as renewable must meet the sustainability criteria

as described in the directive

All gas from biological materials, such as biogas from waste, manure, and sewage sludge,

considered renewable under the Directive if it also meets the sustainability criteria.

Landfill gas is also defined as a renewable energy source. If biogas is used for transport and

from wastes, residues, non-food cellulosic material and ligno-cellulosic material, counts

biogas double the achievement of objectives for renewables in transport (see point 2 above) and

national revenue requirements.

Biogas can be used to fulfill the national revenue requirement for biofuels for road traffic

and renewable Directive target overall share of renewable energy target of 10% renewable energy

transport. In June 2012, Norway submitted a plan to the Authority showing how to achieve

objectives of the Renewable Energy Directive. It is not explicit in the action any portion biogas

transport, but it is not an obstacle to biogas in practice can contribute to the achievement of objectives in 2020. In Figure

1.8 digit appears from the action plan for how transportation goal can be achieved.

Biogas can help to achieve the 10% target in the transport sector, for example, 1 TWh biogas

replaces biodiesel or bioethanol. A biogas consumption of 1 TWh is equivalent to the energy consumption of around 4

000 buses. Given that biogas is produced from waste, this can replace 2 TWh of 1 gen-

biofuels (see item 1 in Figure 1.9).

Another option to achieve the 10% renewable energy in transport is to use approximately 0.7 TWh

with biogas (double counting) while keeping the current blend of biodiesel and

bioethanol constant (ie 3.5% of fuel sold for road traffic). This is illustrated in Figure 1.9 which

Option 2

By the way it was in October 2012 the European Commission put forward a proposal to amend Directive to

Renewable Energy Directive which proposes limits on the contribution of biofuels based on

starch, sugar or oil seeds, and also suggest that certain types of biofuels to count fourfold

as well as biofuels that count double. So depending on what kind of material is biogas

manufactured by it will be able to count more, if this change directive is implemented as proposed

available at present. It is expected that it may take time for the changes proposed directive is

processed in the EU and it is unclear how the final wording could be. If the proposed amendment

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of limitations for biofuels based on sugar, starch and oil are maintained and made

also apply to Norway, it will provide increased incentive such as more use of biogas or biofuels

counts double and quadruple.

Option 3 in Figure 1.9 shows how the 10% target can be achieved if the modified directive should be

adopted as proposed. Here, 0.18 TWh of biogas (given that it counts four double) be enough to

achieve the target, given that the contribution of biodiesel and bioethanol (based on starch, sugar or oil seeds)

must be limited to maximum half of the 10% target.

*Figure 1.9: Renewable energy in transport as described in the present action plan and three alternative*

*ways to reach the 10% target.* *While the green portion of the bars ("biogas") equals actual consumption of*

*biogas, showing the bright green part of the bar ("Biogas weighted") not actual use of biogas, but additional*

*contribution in the calculation of the share of renewables due.* *double counting (see section 2 in the list above).* *Option 1 is 1*

*TWh of biogas (with double counting), option 2, or 3.5% conventional biofuels (gasoline and*

*diesel fuel for road traffic) and increased turnover of biogas so that the 10% target is reached (with double counting for biogas);*

*Option 3 is the option if the change directive for renewable directive is adopted and biogas are 4 -*

*double counting.*

x2

x2

x4

0

1

2

3

4

5

**2005**

**2010**

**2020**

**1**

**2**

**3**

**TWh**

**Renewable energy in the transport sector.**

Biogas weighted

Biogas

Biodiesel

Electricity for non-road transport

Electricity for non-road transport

**figures from the Norwegian action plan**

**options for the 10% renewables by 2020**

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**Chapter 2 - Status of biogas in Norway**

Biogas produced and used in Norway today in very small amounts. This applies whether you

compares Norway with neighboring countries, and it is especially true if one compares with biogas

other forms of energy produced or used in Norway. Both with regard to infrastructure and

costs, it is difficult to compete with established forms of energy such as hydropower and fossil fuels,

and in spite of existing instruments have not gained biogas significant extent in Norway so far.

In Figure 2.1 below the total production in Norway and neighboring countries shown. The figure shows the total production of

including biogas recovery of landfill gas for Denmark, Sweden, Finland and Norway. In Figure 2.2 is

annual output divided by the population. One can see that Norway is lower than neighboring countries in both

comparisons, both total production and production per capita.

Total production of biogas in Norway in 2010 was about 0.5 TWh including collecting

landfill gas. The same year formed the comparison Norwegian hydropower production at 118 TWh and

natural gas production (excluding LNG) of more than 1,000 TWh. Also, compared with most

other forms of energy used in Norway is biogas low. In Figure 2.3, annual production of

biogas compared to other bioenergy used in Norway in 2010.

*Figure 2.1: Annual amount of biogas produced in Denmark*

*(2009), Sweden (2009), Finland (2007) and Norway (2010).*

*Source: NILF (2011).*

*Figure 2.2: Annual recoverable amount of biogas per person*

*Denmark (2009), Sweden (2009), Finland (2007) and*

*Norway (2010).* *Source: NILF (2011).*

*Figure 2.3: Biogas compared to other bioenergy - traded amount of energy in Norway 2010.*

*Source: IEA Bioenergy (2011).*

0

200

400

600

800

1000

1200

1400

**Denmark**

**Sweden**

**Finland**

**Norway**

**GWh**

0

50

100

150

200

250

**Denmark**

**Sweden**

**Finland**

**Norway**

**kWh / capita**

0

1

2

3

4

5

6

7

**Pellets and**

**briquettes**

**Biogas**

**Wood and bark**

**Fuelwood**

**TWh**

|  |
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**Production**

Norwegian biogas is currently mainly collected landfill gas and biogas produced on sewage sludge and

food waste. There are also some farms are producing biogas for internal use based on

manure.

Earlier studies finds that annual production from sludge and food waste facility located at

approximately 220 GWh annually, with the bulk of sludge plants. Table 2.1 lists the annual

the quantity of biogas. Especially for organic waste will in the coming 1-2 years

likely to be a significant increase in output. As shown later in this chapter, several plant

during startup or planning to start in the near future. Table 2.1 also shows that a significant

amount of biogas produced in Sweden and Denmark based on Norwegian raw materials. For landfill gas is

accumulated amount measured at the respective facilities and reported to CPA. Landfill gas is the largest

proportion of current biogas production, but it is uncertain how much of the collected

quantity which is actually used for useful purposes. An estimated utilization rate is 50%.

Remaining quantities flared.

*Table 2.1: Produced biogas from landfills, sewage sludge and food waste.* *Of the collected landfill gas is about 50%*

*utilized.*

**Raw material**

**Annually produced biogas**

**(GWh)**

**Base year**

**Source**

Sewage sludge

164

2008

8

Waste Norway, 2010

Food waste, household and industry

63

2010

Mepex, 2012

Collected landfill gas

270

2010

CPA, 2012

**Total Norway**

**497**

Food waste exported to biogas

production in Sweden and Denmark

132

2010

Mepex, 2011

**Collection Construction - landfill gas**

Of the total amount of landfill gas that occurs at present is less than 1/3 as recovered. According to

Cure 2020 is established about 85 methane gas plant adjacent to the landfill (CPA,

2010a). The amount of landfill gas that originated and accumulated amount increased up to the millennium, but

is now slightly declining as a result of the disposal ban for degradable waste. A time series can

seen in Figure 2.4. The resource base is initially decreasing, but Klimakur points to a large

potential to streamline and optimize existing facilities. Cure estimate in addition that it is

realistic to establish some new plants - up to 5 pcs. There is also considerable potential in utilizing

collected landfill gas better. Today, approximately 50% being used for production of electricity and heat, while the

remaining 50% is flared.

8

CPA has found recent calculations of the aggregate amount of biogas produced on sewage sludge. Figure is probably

little changed from 2008 to 2010.

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*Figure 2.4 Methane gas from Norwegian landfills distributed in pooled amount and emissions.* *Source: CPA / SSB (2012).*

**Production plants - existing**

A large proportion of the production plants for biogas is connected to municipal treatment plants

wastewater biogas production as a side activity. The produced biogas is used extensively

degree of internal heating in the treatment plant or electricity generation. Some sludge plant BEVAS in

Oslo upgrading biogas to fuel quality.

A small, but growing, percentage of plants is however more focused oriented towards

biogas production. These typically use food waste and industrial waste as feedstock and supplies biogas

externally as fuel, heating or electricity to the grid.

It is in Table 2.2 provides an overview of existing plants for biogas production in Norway. The above is

mainly based on information from Waste Norway and annual reports or other public

available information on individual systems. Capacity is available for installations where such information is

available, either from the individual plants or waste from Norway (2012). Several of the figures are not precise,

but is intended to give a relative idea of the size. This is mainly large plants that

production capacity is available.

The overview in Table 2.2. suggests a total *production* capacity of approximately 300 GWh. Energy

not used internally in the system, thus *providing* energy amount represents about 40% of this.

It is in the large urban areas where it essentially delivered energy from biogas plants. This

takes the form of biogas to fuel (Oslo and Fredrikstad), delivery to the gas network (Stavanger Region)

or production of district heating and electricity (Drammen and Ecopro in Verdal).

Of the 30 major plants are 29 wholly or partly owned by municipalities. The exception is Halden

Recycling AS, which operates on behalf of Halden Municipality. 25 of the plants operated in connection with

sewage treatment in municipalities and using sewage sludge as substrate. Nine of the plants treat

also food waste, and five to six plants have a form of sambehandling of food waste and sewage sludge or

0

200

400

600

800

1000

1200

198

7

198

9

199

0

199

1

199

2

199

3

199

4

199

5

199

6

199

7

199

8

199

9

200

0

200

1

200

2

200

3

200

4

200

5

200

6

200

7

200

8

200

9

201

0

**Energy (GWh)**

Landfill Gas

collected

Landfill Gas

emissions

|  |
| --- |
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50

manure. The most common use of biogas is for heating purposes, and a significant amount of this is

to internal heating in waste treatment or biogas production. Eight of the plants produce

electricity for their own use or for sale to the power grid. A few industry report that gas goes to flaring. Probably

the flaring utilized to varying degrees by several plants of variations in production and demand.

Nine plants are listed with the production of organic fertilizer. Probably there are several plants that supply organic fertilizer,

because this is a byproduct of gas production.

The 4 farm plants on the list mainly produce heat for internal use based on

manure and food waste or waste from the food industry. Probably there are less

farmsteads, but here it does not exist a complete overview.

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*Table 2.2 Existing biogas producers 2012.* *Rene landfill gas is not included.* *Only major / known farmsteads are included.* *Based on Waste Norway (2011), as well as other public*

*available information.* *We reserve the right to have information on individual plant may be incomplete or not updated.*

**Construction Name**

**County**

**Raw material**

**Product**

**Flaring**

**Production**

**capacity**

**Delivery**

**capacity**

*Larger contact:*

***Industrial Waste***

***Food waste***

***Fertilizer***

***Sewage sludge***

***Landfill***

***Fuel***

***Electricity***

***Heating***

***Bio fertilizer***

***GWh***

***GWh***

**BEVAS (Oslo)**

Oslo

x

x

x

x

24

14

**Raumarike biogas plants (Oslo)**

Akershus

x

x

(X)

x

x

x

45

45

**VEAS (Oslo / Bærum / Asker / smoke municipality)**

Akershus

x

x

x

x

72

**Southern Follo RA (Hill / vestby municipality)**

Akershus

x

**Northern Following RA (Oppegård / Hill / Ski Municipality)**

Akershus

x

x

2

**Gardermoen RA (Ullensaker / Doylestown municipality)**

Akershus

x

**FREVAR KF (Fredrikstad)**

Østfold

x

x

x

x

x

x

12

2

**Alvim RA (Sarpsborg)**

Østfold

x

**Halden recycling AS**

Østfold

x

x

**Bodal RA (Rakkestad municipality)**

Østfold

x

x

1

**Mysen RA (Eidsberg Municipality)**

Østfold

x

**Fugelvik RA (Moss Municipality)**

Østfold

x

**Sandefjord RA (Sandefjord)**

Vestfold

x

**Lillevikskjæret RA (Larvik)**

Vestfold

x

**Lindum Energy AS (Drammen)**

Buskerud

x

x

x

x

x

16

16

**Monserud RA (Ringerike municipality)**

Buskerud

x

**Sellikdalen RA (Kongsberg municipality)**

Buskerud

x

x

**Knardal Beach RA (Skien and Porsgrunn)**

Telemark

x

**IATA Treungen (Nome / Drangedal / Nissedal / Amli Municipality)**

Telemark

x

**Saulekilen RA (Arendal)**

Aust-Agder

x

x

**Odderøya RA (Kristiansand)**

Vest-Agder

x

x

x

**SNJ / IVAR (11 municipalities in the Stavanger region)**

Rogaland

x

x

x

x

30

20

**RA Voss (Voss)**

Hordaland

x

**HIAS RA (Hamar / Whitstable / Ringsaker / Strange / Vang)**

Hedmark

x

x

x

x

x

x

22

**Mjøsanlegget AS (HIAS / GLT / GLØR)**

Oppland

x

x

x

x

8

**Rambekk RA (Gjøvik Municipality)**

Oppland

x

**HRA Trollmyra (Spruce / Skidders / Jevnaker Municipality)**

Oppland

x

x

x

x

x

x

12

**Høvringen RA / Trondheim**

Sør-Trøndelag

x

x

4

**Ladehammeren RA / Trondheim**

Sør-Trøndelag

x

x

5

**Ecopro AS (Statkraft heat and 51 municipalities in Central Norway)**

Nord-Trøndelag

x

x

x

x

x

x

30

30

*Lookout points:*

**Holum farm**

Akershus

x

x

x

1

**Tomb Agricultural School**

Østfold

x

x

0.7

**Aana Jail**

Rogaland

x

x

x

x

**NORSØK Tingvoll**

Møre and Romsdal

x

x

x

**Total:**

**284**

**127**

|  |
| --- |
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**Production plants - Planned**

There are about 18 plants for the production of biogas under planning or construction. Overall

they represent a significant capacity increase - in the order of 350 GWh of energy produced. This

to about double the current production capacity (excluding landfill gas). It is

Table 2.3 provides an overview of these facilities.

Of the 18 plants, seven plants a familiar startup time and is relatively close to realization. Two of these

plants are extensions of existing, while five new entrants. It is mainly municipalities

behind these plants with Borregaard and Fiborgtangen as significant exception. Unlike

existing plant the new plants largely rely on food waste and organic waste from

food processing or pulp and paper industry. Furthermore, a majority of the plants produce biogas

in fuel quality. Fiborgtangen plan to provide bus fleet in Trondheim, Oslo's new

plant will supply buses and other vehicles in Oslo and Bergen considering producing

fuel for their buses. Altogether, the seven plants to be harvested in the period 2013 -

2014 a production of about 300 GWh. Several of the planned facilities will have biogas production

as a main activity, and overall it is likely that the proportion of energy supplied will be larger for the

planned facilities than the existing ones.

11 plants are under investigation or CPA missing information about startup time. For some of these

we provide information about planned capacity for a total of about 80 GWh.

**Export of organic waste for biogas production in Denmark and Sweden**

According to the study done by Mepex Consult for Waste Norway (2011) exported a significant amount

organic waste for biological treatment and incineration with energy recovery in countries outside Norway.

About a third of this goes to the biogas plant. Total estimated biogas production in Sweden

and Denmark based on Norwegian organic waste to 132 GWh in 2010. It is uncertain

basic data, partly because several players did not want to give up their levels of

competition concerns.

|  |
| --- |
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*Table 2.3 Planned plant for biogas production.* *Based on Waste Norway (2012), as well as other publicly available information.* *We reserve the right information about that individual plants can*

*be incomplete or not updated.*

**Construction Name**

**County**

**Raw material**

**Product**

**Planned**

**Startup**

**New /**

**expansion**

**New**

**capacity**

*Larger contact:*

***Industrial Waste***

***Food waste***

***Fertilizer***

***Sewage sludge***

***Landfill***

***Fuel***

***Electricity***

***Heating***

***Bio fertilizer***

***GWh***

***GWh***

**Vestby (Follo Ren IKS)**

Akershus

x

x

x

x

x

2014

N

11

**Borregaard**

Østfold

x

x

2013/2015

N

35/46

**FREVAR KF (Fredrikstad)**

Østfold

x

x

x

x

x

2013-Q2

U

13

**Grødaland / HÅ (IVAR)**

Rogaland

x

x

(X)

x

x

x

x

2014-Q2

N

65

**Rådalen (Bergen)**

Hordaland

x

x

(X)

(X)

2014

N

23 to 25

**Mjøsanlegget AS (HIAS / GLT / GLØR)**

Oppland

x

x

x

2012

U

10

**Fiborgtangen Growth AS / AS Biokraft**

Nord-Trøndelag

x

x

x

x

2014

N

130

**Total:**

**287-300 GWh**

*In Progress / CPA missing information on startup:*

**Eidsvoll municipality**

Akershus

x

(X)

(X)

(X)

N

2-3

**Biogas Østfold**

Østfold

x

x

N

Unknown

**Vesar**

Vestfold

x

x

x

x

x

N

> 30

**Bioenergy Finnøy AS**

Rogaland

x

x

x

x

N

Unknown

**Lindum Odda**

Hordaland

x

x

x

N

7

**HRA Trollmyra (Spruce / Skidders / Jevnaker Municipality)**

Oppland

x

x

x

U

4

**Agroenergi AS**

Sør-Trøndelag

x

x

x

x

x

N

15 to 20

**Hugaas Biogass**

Sør-Trøndelag

x

x

x

x

x

N

3

**Vefsn municipality**

Nordland

x

x

x

N

Unknown

**Stokmarknes (Troll Last year power etc.)**

Nordland

x

x

N

10 to 20

**Troms County**

Troms

x

x

x

N

Unknown

**Total:**

**71-87 GWh**

|  |
| --- |
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**Use of biogas**

As shown in the above paragraphs apply today an estimated 60% of the amount of energy in biogas

from production facilities within the plant where it is produced. The remaining 40% used

external energy use comes in the form of electricity to the electricity supply, heat supply to

heating network, which upgraded gas to the gas mains or fuel, or flaring. Enova

potential study (2008) mapped the proportion of the produced biogas is used for different purposes

without distinguishing between external and internal use. Based on information from 16 plants will Enova

an allocation of 18% for electricity, 53% for heating, 19% to flare, 2% to upgrade (fuel)

and 9% unknown. Fuel ratio is probably higher today, partly as a result of the plants to Oslo

municipality.

Around 50% of the collected landfill gas is used for heat and electricity production,

remaining amount flared.

**Gas Supply**

In Rogaland, developed 440 km network of gas energy company Lyse. Light is owned by 16 municipalities in

Rogaland. Gas network supplied primarily by fossil gas, but it blends well into biogas

Sentralrenseanlegget in North Jæren (IVAR). The gas used for building heating, fuel and

industries. Total supply network in Rogaland about

620 GWh of fossil gas and biogas.

**Gas Buses**

Number of buses equipped gas operations have experienced strong growth in Norway in recent years. By the end of 2012

there are about 400 gas-powered buses in operation in the country (Table 2.4). The objectives of cleaner air in the individual

cities have, in addition to climate concerns, has been an important driving force. The trend of increasing proportion of gas buses

Also in Europe. Manufacturers selection of gas-powered buses have increased in recent years.

Only gas buses in Oslo and Fredrikstad using biogas today. This is primarily due to lack of

provided biogas. Trondheim and Bergen plans conversion into biogas when this becomes

provided. Number of gas buses will likely increase substantially in the years to come. Nettbuss Østfold has agreed

the purchase of 97 new buses with Fredrikstad / Sarpsborg in 2013 and go on biogas

(Bus Magazine, 2012). Oslo's new biogas plant to Raumarike will also have the capacity to

supplying a significant number of buses.

**Other Vehicles**

In addition to the bus there are several vehicles that use biogas today. This is considerably heavy

Vehicle and fleet vehicles. Posten / Bring report having 100 biogas vehicles. Veolia in Oslo reported having 64

refuse trucks operating on biogas. 4 dairy cars from Tine run on biogas. It is firm AGA as

operates filling stations for biogas in the eastern area. AGA receiving biogas from FREVAR and BEVAS and

distributes this to its 7 filling stations in Oslo, Bærum, Asker and Fredrikstad.

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| --- |
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*Table 2.4 Buses gas operation in Norway.* *Source: HOG Energy (2010), HOG Energy (2012), Bus Magazine (2012).*

**Number of buses**

**gas operation**

**Of this number of buses with**

**biogas operation**

***Existing***

Oslo

65

65

Bergen

81

0

Trondheim

180

0

Stavanger

35

0

Fredrikstad

7

7

Haugesund

16

0

**Total existing**

**384**

**72**

***Planned***

Fredrikstad / Sarpsborg

97

97

|  |
| --- |
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|  |
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**Chapter 3 - Potential for production and use of biogas in Norway**

**Potential for biogas production in Norway**

**Definition of potential and method**

To investigate how large the potential for total biogas production in Norway is, it is first important to

define clearly what is meant by "potential". Different types of potential are relevant here:

The *theoretical potential* energy contained in the total amount of raw material available which can

utilized in biogas production - in other words, one takes no account of whether the raw material already

used for other purposes, whether it is related high costs of exploitation, or whether resources should

utilized for other purposes. This thus provides a picture of the overall upper limit of what can be exploited

if one disregards the economic, practical, technical, administrative and other constraints.

The *technical potential* describes the potential under the given structural, ecological and legal

conditions are usable. In order to arrive at a technical potential by 2020, it made ​​a

assessing the amount to be used of the theoretical potential, without taking into account

commercial profitability by utilizing raw material. The technical potential is taken not

as to whether an alternative use of the raw material had been more appropriate from an environmental

or resource perspective.

The *commercial potential* is the amount of biogas at a given time will give

commercial profitability of exploitation. This potential will depend on the

framework set by the company itself (required return), by governments (taxes,

taxes, subsidies) and market (interest rate, demand). In a biogas strategy can

framework leveraged to increase the commercial profitability.

The *unrecognized portion of the potential* is usually much less than the commercial potential,

since not all plants that are profitable have been released yet, both because of lack of

capital and risk appetite.

In this report, we estimate a *realistic potential by 2020,* which is a potential that lies between

the technical and commercial potential at present, see figure 3.1 below. Here we take the

in what we consider to be realistic to be able to collect the raw material (for example, 50% of

food waste arising in the household) but also to the application that is most

appropriate on the basis of an environmental and resource perspective. In general, we are assuming that forage production is

a more high-grade utilization of the resource than biogas production, but that biogas is a better

treatment than the incineration of waste.

|  |
| --- |
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*Figure 3.1: Different types of potential*

**The realistic potential for biogas production in Norway 2020**

To arrive at the realistic potential for biogas production to 2020, we have

Based on the report written by Østfoldforskning Enova where the theoretical potential for

biogas production was investigated (Østfold Research, 2008). In this report, the theoretical

potential is estimated to be around 6 TWh without forest resources, or up to 26 TWh if

forest resources are included. We have not included forestry in this paper.

To get from the theoretical potential of Enova report to the realistic potential that we

believe is possible to use up to 2020, we have gone through the assumptions in the study and removed

the quantities already used for something else today, such as waste

food industry used for feed production. Furthermore, we have for the various waste streams

set a percentage estimate of what might be possible to exploit in 2020. Some of the estimates are

relatively rough, but is primarily intended to provide an image of magnitude. For food waste from

households, we estimated that 50% can be separated, but we waste from large households and

trade implies a higher scrap rates (80%). A higher degree of separation of food waste than

this could provide crude fractions and thus a reduced value for bio fertilizer. It is emphasized that

We have based the assessment on waste statistics exist (that 2008 figures). In Mepex

report "E *increased utilization of resources of organic waste"* (2012) points out the need for better

statistics of the amount of different organic waste, especially from industry and food industry.

Detailed assumptions for potential update can be seen in Appendix 1 Based on these

assumptions, we believe that the potential for biogas production in Norway by 2020 could be around

2.3 TWh. Note that this energy includes what is already being produced at present, see

Table 3.1. Figure 3.2 shows the distribution of potential in the various categories on the basis of

raw material origin. Broadly speaking, one can divide the potential into 30% from manure, 20% of

industrial waste, 20% of food waste and 30% of sewage sludge, landfill gas and straw. The wet organic

waste (food waste from households, large households and trade, and organic waste from

industry) is in Figure 3.2 marked with reddish color and represents over 40% of the realistic

potential. Potential corresponds including 880 000 tonnes of organic waste and 3.9 million tonnes

manure.

Theoretical potential

Technical potential

Business Economics

potential

Utilized part of

potential in 2012

Realistic potential

in 2020

|  |
| --- |
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There is some waste streams that are not included here, but which may eventually be included in

biogas production such as vegetable waste, and cellulosic materials such as birch. Estimates

presented here is nevertheless considered accurate enough to create a strategy for biogas initiative in Norway

to 2020.

*Figure 3.2: The realistic potential for biogas production.*

By the realistic potential for biogas production in Norway in 2020 of 2.3 TWh is something already

utilized at present, there are no concrete plans to utilize in a short time, and which it

no plans. In table 3.1 below is made ​​rough estimates of dividing up the realistic

potential of the amounts already used, quantities of which there are specific plans and

quantities that are not triggered. This shows that there remains a significant potential.

Figure 3.3 shows an estimate of how much of the potential induced spread of raw materials. As we see

here is a lot of potential for landfill gas and sewage sludge already recovered, while it remains a major

potential for both manure and organic waste.

*Table 3.1: Utilization of the realistic potential at present.*

**Status**

**Amount (TWh)**

The total realistic potential

2.3

Are utilized today in the biogas production

0.5

Specific plans for utilization

0.3

The remaining realistic potential by 2020

1.5

**32%**

**22%**

**14%**

**7%**

**12%**

**7%**

**6%**

**The realistic potential for biogas production**

**in Norway in 2020 for feedstock origin**

**(Total of 2.3 TWh)**

Fertilizer

Waste from industry - total

Food waste from households

Food waste from the catering and

Trade

Landfill Gas

Straw

Sewage sludge

|  |
| --- |
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*Figure 3.3: Parts of the potential that is already utilized for various raw materials that can be used for biogas production.*

Figure 3.4 shows that around 20% of the realistic potential for biogas production has already been exploited

As of today, and there are plans to utilize an additional 15%. About half of the triggered

potential recovery of landfill gas, while the other half is dominated by biogas plants

from sewage sludge. Biogas strategy may aim to release the remaining 65% of the potential,

and to ensure that the planned 15% actually being built.

*Figure 3.4: Dividing potential.*

0

0.5

1

1.5

2

2.5

Wet

waste

Fertilizer

Sewage sludge

Landfill Gas

**TWh**

**Exploiting the potential of biogas production**

Remaining theoretical potential

Remaining realistic potential

Utilized for biogas production

Norway 2012

**35%**

**65%**

**20%**

**15%**

**65%**

The portion of the theoretical potential

that is unrealistic and / or

impractical to utilize in

2020

The portion of the theoretical potential

is realistic to utilize in

2020

Most of the realistic potential

which is not induced even

Most of the realistic potential

that there are concrete plans for

Most of the realistic potential

previously allocated

**Theoretical potential**

**A total of 5.8 TWh**

**Realistic potential**

**A total of 2.3 TWh**

|  |
| --- |
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**The potential long-term**

When considering potential beyond the short time horizon to 2020, for example, to look at it

is possible to exploit by 2030, the two main things that can affect potential:

• The amount of raw material that is available may change as a result of:

o Increased recycling rate for food waste so that the resource base for

biogas production increased

o Reduced waste, resulting in less substrate for biogas plants, or

conversely increased waste for example due to population growth

o Access to new raw material, for example,

♣ algae

♣ Forrest and sludge from beneath fish farms

♣ cellulosic substrates

• Increased biogas yield per ton of feedstock may increase, for example due to:

o Preparation of raw material increases dividend

o Changed the production method, such as pyrolysis

o Optimisation of biogas production

Since these factors is difficult to predict and will depend on the general conditions set

forward, we have chosen not to quantify them here. There is still a reasonable assumption that the total

potential will increase considerably in the future. When, for example, utilizing forest resources,

Enova has estimated that this could provide an additional 20 TWh. Pretreatment of raw materials and more optimized

biogas processes may increase the biogas yield by up to 50%.

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**Climate impact of utilization of various raw materials**

The distribution of the potential for energy production is shown in Figure 3.2, by different raw materials.

If you ignore the smaller categories (landfill gas, sewage sludge and straw) is the distribution of

*energy potential* between organic waste and manure around 60:40, see figure 3.5 below. Waste

includes both food waste from households, large households, trade and organic waste from

industry. However, when a look at *greenhouse gas reduction* is the only biogas production based on

manure which leads to a reduction of emissions in the production stage. Biogas Processing

organic waste provides only a minimal reduction of greenhouse gas emissions when it replaces combustion

or composting of waste. Greenhouse gas gains come here first the application of biogas.

*Figure 3.5: Potential for biogas production from manure and organic waste in energy units.*

**43%**

**57%**

**Energy potential of biogas production**

**Total energy production = 1.7 TWh.**

Fertilizer

Wet organic waste

|  |
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**Regional distribution of potential**

Both substrates for biogas production and demand for biogas and bio fertilizer is unevenly

distributed in Norway. The maps below show the distribution of raw materials for biogas production (manure,

sewage sludge and organic waste from households, Figure 3.6, 3.7 and 3.8). It has not been possible to

produce the amount of organic waste from the catering trade, commerce and industry in such maps

Due to a lack of basic data. There is thus a significant proportion of resources that are not

shown in the map. Overall, the maps indicate that the largest resource base is located on the south-west coast

of Norway, as well as in Eastern Norway. But there is also access to significant resources further north on the coast.

Figure 3.9 shows the phosphorus content in the soil, this gives a picture of the fertilizer needs of the soil. When

phosphorus content is over 12 estimated at Earth has very little or no need for added phosphorus.

This information should be combined with information on land use areas, the intensive

production can still required supply of phosphorus. The map indicates that there are many areas in

Norway where it may be difficult to get deposited organic fertilizer that fertilizer product due to a

Already a high phosphorus content in the soil. Meanwhile, it is especially in these areas may be advantageous to

convert manure to bio fertilizer which it is possible to dewater and transport to rural areas as

has a low phosphorus content. Many areas in Eastern has a low phosphorus content and therefore a large

requirements for fertilization. Here, the production of biogas from organic waste being particularly positive because

bio fertilizer can find a good use as fertilizer.

Figure 3.10 and 3.11 illustrates the demand for biogas as we have chosen to illustrate using

energy demand in the transport sector, here shown that energy consumption in buses. Figure 3.10 shows the total

energy consumption for buses per municipality, while Figure 3.11 shows the buses are already running with

gas operation (natural gas or biogas). Theoretically it is possible to convert all the buses to run on gas, but

Figure 3.11 shows part of the potential that exists today and is designed for the use of biogas.

In Figure 3.12 and 3.13 it is shown how biogas plants in operation in 2012 are located, and how

planned facilities will occur (plants with known starting point and relatively close to realization). It is

also shown the facility that manufactures / planning to produce fuel.

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*Figure 3.6: Distribution of the theoretical biogas potential from manure. The map is obtained by total*

*energy potential for biogas production from cattle, swine and poultry (2180 GWh) is distributed in proportion of*

*current farm within each 5 x 5 km route.*

**Fertilizer**

|  |
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*Figure 3.7: The distribution of the theoretical biogas potential from sewage sludge. Based on local distributed statistics.*

**Sewage sludge**

**Sewage sludge**

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*Figure 3.8: Distribution of organic waste from households. Organic waste from households is divided*

*based on population. Note that organic waste from large households, commerce and industry are not*

*included in the geographical distribution.*

**Wet**

**household waste**

|  |
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*Figure 3.9: Distribution of phosphorus content in soil samples (Source: Soil and Environment, 2013).*

**Average PAL level**

**soil samples. Kommunevis.**

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*Figure 3.10: Distribution of the energy demand for buses with fossil fuels* .

**Buses 2012**

**Buses in 2012**

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*Figure 3.11: Distribution of the energy demand for buses with* gas operation.

**Buses with gas operation in 2012**

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*Figure 3.12: Distribution of existing biogas plants. Based on information from Waste Norway (2011) and Waste*

*Norway (2012).*

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*Figure 3.13: Distribution of existing biogas plants. Based on information from Waste Norway (2011) and Waste*

*Norway (2012).*

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**Chapter 4 - Economic assessments of production and application of**

**biogas**

In this chapter, we review the economic and commercial costs

biogas production and use. The full economic cost of the

value chain is presented as cost per emission reduction in CO

2

-Eq, while in part analyzes the

production costs are presented in NOK / kWh without emission effects included in the cost figure. They

commercial costs are presented as profit or loss per kWh biogas produced

or applied.

Assessments are conducted concerning current

9

cost and benefit effects by producing and

applying biogas. The analysis is a static description of the benefits and costs in 2012, which means it

unposted expected price or technology. Potential development cost figures in

future and the effects of which are discussed in the last part of the chapter under "Outlook, error sources

and sensitivity analysis. "This sub-chapter also includes several side calculations that illustrate

effect of changes in the underlying assumptions and figures that calculations based

on.

The socio-economic assessments are largely based on the CPA report, "Costs and

reduction of greenhouse gas emissions through the supply chain "TA 2704/2011 and Farming report:

"Climate measures in agriculture - Treatment of manure and organic waste with more

biogas plants. 1 Edition "(2010). We also collected data through a survey which

industry players the chance to provide input and suggestions for updates on our assumptions

and the figures (12 inputs total). At the request of the respondents, we have chosen to let the answers be

anonymous.

Complete list of assumptions, background figures and sources are in Appendix 2 a).

9

At current costs means the latest cost figures, CPI-adjusted to 2012 values.

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**Economic calculations**

An economic analysis of a project aiming to assess all costs and new effects

implementation of the measure will have on society. As far as possible you will want to quantify the various

effects to make it easier to assess whether it is profitable for society that the measure is

completed. There will always be certain effects that may be difficult to appreciate. These effects must

we therefore endeavor to make a qualitative assessment of to create a comprehensive picture of the effects.

The assessment of whether a measure should be introduced or not will therefore depend on both the quantized and

the non-quantized effects.

We have chosen an incremental approach to the calculation of costs and benefits. In the first step, we only

production stage, which means that one has not included the costs and benefits using

biogas. In step two, we include the costs and benefits of production in the complete value chain, such

the cost-benefit effects of the application will be included here. This means that it is only in step two

(Value chains) to see the full picture, and it is this that should be used as

assessment basis when assessing the economic impact of biogassatsing.

All calculations of emission reductions is done by looking at changes in the Norwegian emissions. It is not

made regarding how the measures will affect global emissions, either inside or outside the

European emissions trading system. We have valued CO

2

Emissions in this assay, but rather computes

the social cost per tonne reduced CO

2

-Eq. The reason for this is that as of today

date does not exist a unified carbon price for Norway. If we have valued CO

2

Emissions by

use a carbon price would we be calculated measure net benefit to society, but we make no

such conclusions in this report.

**Part 1 - Production**

Here we will focus on the two substrates which we believe have the greatest remaining realizable potential

for biogas production in the short term, manure and organic waste. The total potential

manure and organic waste, we will in this chapter call *full potential* . Sludge from

wastewater treatment plant we have chosen to stay outside, as it untapped potential is small compared

with the other substrates. Sambehandling of organic waste and manure will be

advantageous as this may increase the total gas yield as compared to separate treatment of

raw materials. The increased gas yield is difficult to quantify and it has not been possible to estimate

costs sambehandlingsanlegg, so this type of construction will not be considered as a separate

alternative in this analysis. Another point to focus on separate treatment is to illustrate

Differences in cost and profitability between the two substrates.

Cost figures presented here should be considered averages to produce the given

quantities of biogas. Typically, it will be part of the potential which is more accessible, and has lower

production costs. For example, biogas plants that have easy access to appropriate

dispersal areas for bio fertilizer have lower transportation costs than plants located farther away

such areas. Similarly, there will be facilities that have better access to energy-rich waste types

for higher gas yield, and hence lower costs per kWh. At the same time, part of the potential

have higher costs than the average value reported here.

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***Production of biogas from manure***

We have in this analysis looked at the social cost of producing biogas from

the manure. Reference situation for the calculations is that the manure would be stored in

manure storage and then be spread as fertilizer on legal dissemination areas and legal

proliferation hours. In the reference situation, it is further assumed that there is produced biogas

manure.

The different parts of the production chain are included in the analysis are shown in Figure 4.1 below. We appreciate

not reduce CO

2

Equiv of money in this part of the analysis, but include reductions in

cost ratios (U.S. $ per reduced CO

2

-Eq) when looking at value chains later in the chapter.

*Figure 4.1: Sketch of the model of the production chain of biogas from manure used in this*

*analysis.*

New Effects

As stated in Chapter 3, we have estimated that the realistic potential for biogas production is 30%

The total quantity of manure which is about 3.92 million tons of manure. This is in line with

Government targets given in Report. 39

10

(2008-2009). This amount of manure can produce 740

GWh of biogas. Simultaneously, one can obtain a reduction in emissions of methane and nitrous oxide equivalent

142 000 tonnes of CO

2

Equiv of avoided emissions associated with the storage and spreading of manure. In this

math, emissions from transportation of manure and organic fertilizer included, while emissions from

production and upgrading of the gas is expected to be negligible and are not included.

Reduction in methane and nitrous oxide emissions are reduced by storage in manure storage. For the same reason

you will get a reduction in ammonia emissions of 3400 tons annually, valued at 9 million

10

http://www.regjeringen.no/nb/dep/lmd/dok/regpubl/stmeld/2008-2009/stmeld-nr-39-2008-2009-

. Html? Id = 563 671

**Fertilizer**

**Transport to plant**

**Biogas Production**

**Bio fertilizer**

**Upgraded biogas**

**Storage at plant**

**Transport back to the farm**

**Bio fertilizer replaces manure**

|  |
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76

Dollars

11

. The emissions reduction will also result in manure nitrogen container that would

disappeared by the formation of ammonia (NH

3

). Under the assumption that the production of biogas and

storage of organic fertilizer non-polluting, and organic fertilizer does not contain contaminants to such an extent that

it can not spread, the organic fertilizer having a higher fertilizer value than the initial manure

because of the increased nitrogen content. The value of organic fertilizer will be valued at the same amount

fertilizers can be saved (calculated on the basis of increased nitrogen content compared with manure),

which in this case gives a saving of 28 million annually. Reduction

fertilizer production will lead to further reductions in emissions of greenhouse gases that sum to 9

500 tonnes of CO

2

-Eq per year. Total reduction in greenhouse gas emissions from biogas production based on 3.92

million tons of manure will be:

*Reduced methane and nitrous oxide emissions from storage of manure +*

*reduced emissions from fertilizer savings =*

*142 000 tonnes + 9500 = 152 tonnes 000 tonnes of CO*

*2*

*-Eq*

Costs

Costs related to biogas production from manure can be divided into investment and

operating costs. We have looked at two relatively large plant sizes: industrial plant of 110 000 tonnes annually

processing and joint construction of 55 000 tonnes per year processing. It is possible to think

in the construction of small farming facility, rather than larger communal plants. Analyses conducted by

Østfoldforskning (Østfoldforskning, 2012) shows that a centralized solution with a large biogas plant

will give the same climate benefits as several smaller facilities, because increased CO

2

Emissions from transport of

manure offset by an increase in biogas yield in a larger biogas plants. At the same time, the analyzes show that

the centralized solution is economically more profitable solution. There is also an increased

risk of methane leaks, small farmsteads, which means that you need to include a costly

oversight. In view of this, we have chosen not to include small farmsteads in this analysis.

*Investment*

Given Bioforsk its base report to Cure 2020 (Bioforsk, 2010), we calculated that

required 38 industrial plant (110,000 tons) and 55 large public facilities (55,000 tons) to treat

3.92 million tons of manure. This corresponds to an excess capacity of approximately 100%, which will be

necessary to mix in sufficient quantities in liquid feedstock

12

. Each industrial plant

is estimated to cost 73 million, while public facilities have an expected investment cost of 42

million per plant *.* Investment costs include planning, startup, site preparation and actual

facility with pre-and post stock. Land Charges and satellite stock is not included (see discussion

during transportation costs below). With a lifespan of 20 years and an economic interest of 5

%, The annual total cost of capital 406 million.

11

It has emerged that the valuation ahead can be significantly higher (up to 54 million), due Norwegian

violation of the Gothenburg Protocol. This will not lead to significant changes in the costs.

12

The feed may consist of one or more types of manure, which include poultry manure has a large

need for fluids in the treatment process. Slurry of cattle and pigs do not require intervention by

water. Excess capacity is calculated here should be viewed as an average need for overcapacity.

|  |
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*Expenditure*

Operating expenses for the biogas plant includes transportation costs for manure and organic fertilizer,

labor costs associated with the operation of the facility, maintenance and electricity consumption in the facility, and

costs associated with cleaning and upgrading biogas.

*Transport costs* include transportation of manure to biogas and transport

bio fertilizer back to the farmer. By excluding satellite store and only have central storage of bio fertilizer

the biogas plant, it is expected that the transport costs will increase because in less could

based on the total transport

13

of manure and organic fertilizer. In addition, there will be an average of almost

twice as much organic fertilizer as the initial manure, because of the intervention of

fluid in the manufacturing process. Here we will assume that all transport is possible for 50% of the manure,

and we assume that bio fertilizer transported approximately the same average distance

manure. The transport distance is set to 10 km which, according to Farming report,

average distance from the biogas plant to the farm, when 30% of the manure should be utilized and

the assumption that the number and size of plants is as presented above. In order to minimize

transport costs, it is necessary to have a centralized solution, which employ large tankers

with suitable filling and draining properties. This means that in our model will not be the farmer deliver

manure in biogas plant, but biogas producer will bring (or arrange pickup)

at the individual farm. Based on the survey, we estimated that the economic

transportation cost will be in excess of 1.3 NOK / tonne kilometers

14

. The total transportation cost is

when 243 million annually, of which two thirds of this will accrue to the transport of organic fertilizer.

A possibility to reduce transport costs for organic fertilizer would be to have storage facilities

bio fertilizer by spreading areas (satellite store). We have received input that it will cost about

600 000 NOK for storage of 1200 tons of organic fertilizer, which means that the investment costs in our case is

3.5 billion kroner for storing 7 million tons of organic fertilizer. That is, the annual capital costs will

be between 300-450 million (lifetime 10years-20years), which is more than we have estimated that

it costs to transport bio fertilizer (about 160 million). According to our calculations, the

transport intensive solution at least as cost effective as the solution with satellite store, so we have

chosen to include only the former further calculations.

*Labour costs* associated with operation of the biogas plant. Bioforsk estimates in its report that it is required

About 30 FTEs to process 1 million tons of manure. This corresponds to approximately one man-

per common facilities and two FTEs at industrial plants. We have received feedback that this is possibly a

slightly conservative estimate and has therefore decided to scale up staffing needs of 40 employees per

million tonnes of treated manure, representing nearly half a man extra per plant. In addition

We have updated wage to the average salary for employees in the renovation, which was

excess of 430 000 in 2012. Overall, this will result in labor costs of 68 million.

It does not include labor costs for the spread of bio fertilizer, since we assume that the work

spreading of organic fertilizer replaces the work of spreading manure in the baseline situation.

13

All transport means here that bio fertilizer shipped to the farmer and the manure back to the plant, in the same

trip.

14

It is also assumed that 20% of business economic costs / prices will be taxes. It

commercial transportation cost we have gathered from the survey is 1.6 £ / tonne.

|  |
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This will be an underestimation of the costs, since there are several tons of organic fertilizer than it is

manure.

We have chosen to keep Bioforsk report's estimate of *maintenance costs and electricity* , as we

has received no objections to these via the survey. Electricity consumption is set to a sum

equivalent to 8% of the quantity of biogas and the use of a power of 0.50 NOK / kWh (incl.

grid, plus tax)

15

. Annual maintenance costs are set at 2% of the investment costs.

This will allow the cost of electricity and maintenance of respectively 30 million and 127 million

million per year.

*Upgrading* of gas is listed as an additional cost of 13 cents per kWh (excluding taxes). Not

all applications will require that the gas is upgraded, but the value chains we are looking at, we have assumed

that need to be upgraded biogas to natural gas quality. In this model, we have therefore assumed that

production and upgrading of biogas takes place in the same place, and that the gas sold pre-

upgraded. Upgrade costs will be approximately 93 million annually.

The ***total production costs*** for 740 GWh of biogas produced from manure,

sums up to 966 million annually. As shown in Figure 4.2 under the capital cost of the

biggest expense (around 45% of total spending), while the transport of manure and organic fertilizer

accounting for 25% of the cost. By including the value of bio fertilizer and environmental benefits of reduced

ammonia emissions are **net cost** 929 million annually, which is equivalent to 1.25 U.S. $ / kWh biogas.

Distribution of the different cost and benefit items shown in Table 4.1 and Figure 4.5. Reductions

greenhouse gas emissions from production are not included in this cost figure. Emissions reductions will

could be taken care of by their inclusion in value chains in Part 2

*Figure 4.2: Distribution of the social production costs of biogas from manure.*

*In addition, production will contribute to a reduction in greenhouse gas emissions equivalent to 152 000 tonnes CO*

*2*

*-Eq.*

15

It is not believed that the biogas is used to produce electricity system.

**42%**

**25%**

**7%**

**3%**

**13%**

**10%**

**Economic production costs**

**740 GWh of biogas from manure.**

**Total Cost = 966 million.**

Annual capital costs

Transport

Work

Electricity

Maintenance

Upgrade

|  |
| --- |
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***Production of biogas from organic waste***

In this analysis, we look at the social cost of producing biogas from

organic waste (food waste from households, large households and trade, and organic waste

from industry). As described in Chapter 3, we believe that in the short term is realistic to produce

around 990 GWh of biogas from organic waste. This corresponds to 880 000 tonnes of waste by

different waste fractions, as described in Annex 1 A small part of this potential is already

utilized today (around 63 GWh, which is around 6%), but for simplicity it is not taken into account

this assay. It is not expected that the cost per kWh will change greatly, although

potential would be somewhat less than estimated here. The various parts of this production chain

are included in the analysis are shown in Figure 4.3 below.

*Figure 4.3: Sketch of the model of the production chain of biogas from organic waste used in*

*this analysis.*

If you are not producing biogas from organic waste, alternative management solutions be

material utilization directly for feed production, composting and subsequent material utilization

as fertilizer or incinerated with energy recovery. It is not desirable that

biogas production displaces feed production, so this part of the waste is removed in the realistic

potential. We have not included costs related to the separation of waste, which will underestimate

costs or overestimate potential. In the baseline situation, we have assumed that 80% of the

wet organic waste will be incinerated and 20% is composted, in Norway. Presumably, this distribution

vote well for household waste and similar waste, while there is more uncertainty about how the

various fractions from industry (which is part of our potential) is treated today. We have not included

the loss of "organic fertilizer" from composting in the reference situation, which will overestimate the benefits

something.

The analysis is also based on the assumption that there is sufficient processing capacity for waste

Norway and neighboring countries that it is not profitable to build more incinerators in Norway beyond

under development today. This means that biogas plants can not be built *instead* of building out

**Transport to plant**

**Pretreatment**

**Biogas Production**

**Bio fertilizer**

**Upgraded biogas**

**Storage at plant**

**Transport to the spread area**

**Bio fertilizer replacing artificial fertilizers**

**Organic waste**

|  |
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incinerators, but *in addition to the* existing treatment capacity. It included a

side calculation at the end of the chapter called "crossroads Analysis," which illustrates the change in

production costs if the biogas plant can displace the developer hands of incineration capacity in

Norway, that is constructed in place of (extensions) incineration.

New Effects

Gas yield of biogas treatment of organic waste is almost 6 times higher per ton

raw material than manure. In total, 880 000 tonnes of organic waste to produce 990

GWh of biogas per year.

The reduction in emissions of greenhouse gases in the production of biogas from organic waste will be

considerably less than the biogas production based on manure. It will reference situation

be no emissions of greenhouse gases (methane and nitrous oxide) by composting and incineration of waste.

Incineration and composting of organic waste will provide approximately equal emissions: 0.03 tons CO

2

-Eq

per ton of organic waste. Emissions from the biogas production is so small that we have chosen to ignore

From these emissions (waste Norway, 2009).

Most waste incineration plants in Norway uses combustion energy to

electricity production and / or district heating supply. When the wet organic waste is not incinerated, the

energy production from incineration plants basically reduced. We have assumed that

energy production in incineration plants must be maintained, and that therefore must be burned more

waste to compensate for the energy loss seen by removing the wet organic waste. In order to increase

incineration of waste in Norway, prevent waste export (or import waste). By

move from combustion such as Sweden to Norway, the Norwegian emissions increase and thus counteract

impact of emission reductions in production stage.

If CO

2

Emissions from transportation of bio fertilizer included, the emission reduction from the production of

990 GWh of biogas from organic waste will be 25 000 tonnes of CO

2

-Eq, which means that emissions

increases relative to the reference situation.

Bio fertilizer remaining after production of biogas will help increase the socio-economic

usefulness. Assuming that the organic fertilizer contains no contamination to the extent that it does

may spread, the spread of bio fertilizer supply earth nutrients that v **in** lle been exploited by

Disposal by incineration. Fertilizer value of bio fertilizer is valued based on the content of nitrogen and

phosphorus applied to the soil by spreading on agricultural land. Altogether, the total

fertilizer value of organic fertilizer from organic waste 61 million annually.

Organic fertilizer also has an indirect value in that it reduces the need for production of

fertilizers, resulting in the reduction of greenhouse gas emissions. Based on the nitrogen content is

estimated that bio fertilizer will displace fertilizer production equivalent to approximately 19 000 CO

2

-Eq.

This means that the total emission of biogas production from 880,000 tons

organic waste will be:

|  |
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*Emissions Increase the production of biogas - reduced emissions from fertilizer savings =*

*25 000 + 19 000 = - 7000*

*16*

*tons of CO*

*2*

*-Eq.*

This means that the production of biogas from organic waste isolation increases emissions

greenhouse gases. As we show in Part 2 of value chains, offset this when biogas is used as fuel

thus replacing fossil diesel.

Costs

*Investments*

The investment costs for the plant to treat organic waste is calculated on the basis of

investment costs of plants to Lindum and EGE. Both of these pre-treatment

attached biogas plants, which we assume is included in the investment costs. We also assume that

These costs include storage facilities for organic waste and bio fertilizer affiliated with the

biogas plant. Average investment costs for the two plants, upscaled to 880 000

tonnes of waste, the annual cost of capital of 354 million, for the full potential. This corresponds to 16

facility that can process every 55 000 tonnes of organic waste per year

17

.

*Expenditure*

The economic operating costs will be costs associated with labor, electricity and

maintenance which *exceeds* the corresponding costs by incineration or composting, ie

costs compared with incineration or composting. We have chosen a very simple

approach by assuming that operating costs per tonne of treated biowaste material will be approximately

equal to biogas in reference situation with no combustion and no composting. Presumably,

be somewhat lower costs by running a biogas plant, so this method may overestimate

cost anything.

In the baseline situation would wet organic waste have been transported to a processing location,

as an incinerator. We assume that the distance to biogas plants on average will be equal

large as for the other study sites, allowing the transport of waste to the biogas plant is not

entails an economic (s) cost. In contrast to the production based on animal manure,

we can not assume and transport of raw materials and bio fertilizer. Consequently, there is a greater

cost of transportation of bio fertilizer in this case. If biogas plants as well be near

cities, where the supply of raw material is large, this will typically involve greater distances to appropriate

dispersal areas. Therefore, we have assumed that the average distance for organic fertilizer based on

wet organic waste spreading areas will be twice as large as in the case of manure.

Bio fertilizer is estimated to be approximately 2.5 times heavier than the original wet organic waste

(Waste Norway, 2009). The reason for this is that the mixed liquid in the treatment process, such

manure. Based on these assumptions, the cost of transportation of bio fertilizer intended for

118 million annually.

16

Rounding means that summation is not correct. The actual figures are 25 400 + 18 600 = - 6 800

17

There will also be incorporated in liquid production process for organic waste, but the capacity is given in

tonnes of raw material and not the actual hydraulic capacity that it operated with manure for plants.

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Total ***production*** for the treatment of organic waste in biogas plants will add up to

591 million annually. The distribution of different inputs is shown in Figure 4.4 below. If one

draws from the fertilizer value of organic fertilizer, reducing cost and **net production** is

534 million annually, equivalent to 54 cents per kWh. Classification of the different cost and

New records are displayed in Table 4.1 and Figure 4.5. This provides an *economic* cost of treatment

610 U.S. $ / ton organic waste. As can be seen in Figure 4.4 and 4.5 are capital costs that clearly

biggest expense. CO

2

Emissions from the production stage is not included in these cost figures.

Emissions are still cared for by their inclusion in value chains in Part 2 of the analysis.

*Figure 4.4: Distribution of the social production costs of biogas from biowaste*

*waste. In addition, production will increase greenhouse gas emissions by 7,000 tonnes CO*

*2*

*-Eq.*

***Summary - production***

The economic analysis of biogas production shows that there is considerable variation in the

social costs of production based on the two different substrates. Net

production cost per kWh biogas is over twice as high when using manure (1.25

NOK / kWh) compared to using organic waste (0.54 £ / kWh), while the cost of triggering

full potential will lie in between these (0.84 £ / kWh).

In Figure 4.5, the cost divided by the different inputs for the production of biogas from

manure and organic waste. As you can see here there is some difference in the cost of capital (in

NOK / kWh), but the main difference consists of the fact that all the operating costs of the plant are considered

with for manure (transport, labor, electricity and maintenance), but not for waste. As

described above, this is primarily because the waste in the baseline situation is treated in a combustion

or composting facilities that have similar operating costs biogas plant, so that

opportunity cost of treatment in biogas plants is relatively cheaper. Since the reference situation

of manure is that one does not need to operate a treatment facility, all costs considered

as additional costs. In addition, organic fertilizer have a higher value when the organic waste is used in

**59%**

**20%**

**21%**

**Economic production costs**

**990 GWh of biogas from organic waste.**

**Total Cost = 591 million.**

Annual capital costs

Transport

Upgrade

|  |
| --- |
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biogas production because the reference case, 80% of the waste going to incineration

nutrients would have been deposited with the ashes. The biogas production made available

these nutrients by organic fertilizer spread.

*Figure 4.5: Economic costs and benefits of biogas production in dollars per kWh. Decrease / increase*

*in greenhouse gas emissions are not included.*

These cost figures would still not give the full picture, since the reduction / emission of greenhouse gases not

valued in dollars and deducted from the cost. Comparing reduced emissions

production measures, the biogas from manure get considerably better.

Biogas production from organic waste will result in a marginal emission *applicants* of 7000 CO

2

-

eq, while production from manure gives an emission *reductions* n corresponding to 152 000 CO

2

-Eq.

It should be noted that the output measure does not include any uses of biogas, which will

contribute the majority of emissions reductions in the value chains. Applications and emissions effects will be

included in the value chains presented in part 2

As mentioned previously, it will be part of the potential which is more accessible, and has lower

production costs than stated here. Similarly, part of the potential have higher

costs. By triggering a small proportion of the potential, one can choose to implement only the most affordable

solutions, which means that the cost per kWh will go down.

Sambehandling of raw materials will likely have production costs that fall somewhere in

between the two separate treatment costs. A higher gas yield from sambehandling the isolated

sets lead to total potential (number GWh) will increase and cost per kWh will be reduced compared to

release the full potential of the separate treatment of the two substrates. In general, the profitability

Production

Reduced emissions of NH

3

Reduced fertilizer use

0.0

0.2

0.4

0.6

0.8

1.0

1.2

1.4

Cost

Income

Net

Cost

Income

Net

**NOK / kWh**

**Economic net production cost in NOK per kWh**

**of manure and organic waste**

Work

Maintenance

Electricity

Upgrade

Transport

Annual capital costs

**Costs:**

**Income:**

**Net:**

**Fertilizer**

**Organic waste**

**1.25**

**0.54**

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| --- |
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by sambehandling increase, the higher proportion of organic waste. The latter is not

sambehandlingseffekter, but follows from the biogas production from organic waste is more

profitable than production from manure.

Which substrate is best to focus on the biogas production will depend on what the objective is

with production. We have therefore chosen to include both output measures of value chains

presented in Section 2

*Table 4.1: Socio-economic cost and benefit effects of biogas production from manure and*

*organic waste. Decrease / increase in greenhouse gases is not included.*

**Economic costs and**

**new effects**

**Fertilizer**

**Wet**

**waste**

**Total**

**potential**

**(Mill.kr)**

**(Million)**

**(Million)**

Investments

5062

4410

9472

Annual capital costs

406

354

760

Annual operating expenses

560

241

801

*Transport*

*243*

*118*

*361*

*Work*

*68*

*0*

*68*

*Electricity*

*30*

*0*

*30*

*Maintenance*

*127*

*0*

*127*

*Upgrade*

*93*

*123*

*217*

Annual savings fertilizer

-28

-61

-89

Annual value of reduced NH

3

Emissions

-9

0

-9

**Annual net costs**

**930**

**530**

**1460**

**Annual amount of gas produced (GWh)**

**740**

**990**

**1730**

**Additional cost biogas (U.S. $ / kWh)**

**1.25**

**0.54**

**0.84**

Non-quantized effects

There are several effects that are not quantified, but which nevertheless should be taken into consideration. Among other

that some new effects using organic fertilizer which has not been intercepted. When manure,

especially the easily degradable components, are broken down in the soil, use a lot of oxygen and creating

anoxic conditions that contribute to nitrous oxide emissions. Good supply of easily degradable carbohydrates

also enhances processes that reduce nitrate to nitrous oxide. Since bio fertilizer will have a lower content of

degradable material than manure, the use of organic fertilizer as a substitute for manure

lead to less oxygen consumption in the soil and thus result in lower nitrous oxide emissions. In addition, the

bio fertilizer have a positive effect on soil quality and runoff and form a stable carbon stock as

thereby helping to reduce greenhouse gas emissions. The omission of these effects may lead to a

underestimation of bio fertilizer actual value, and thus an overestimation of the net

production costs (especially for bio fertilizer from manure). On the other hand, parts

of organic fertilizer from biogas production from organic waste be too polluted to

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used for soil improvement. In addition, we have not withdrawn from the fertilizer value of organic fertilizer from

composting in referansescenrioet, then this is not valued or included in the analysis. These effects

suggests that the total value of production of organic fertilizer from waste is overrated.

Which of these effects is most difficult to assess.

There are other effects that are difficult to capture in this type of calculations. For example, the

employment be a typical effect omitted

18

. If one puts biogas plants in rural areas will

this could lead to more jobs in these areas. The effect this has on society

whole, is still not obvious. If jobs by biogas plant draws people from cities to

districts, this will have a regional political importance. The socio-economic impact will

however, depend on whether the restructuring of human capital will lead to increased productivity. That

this will be the case, workers who start working in biogas plants being unemployed

or employed in less productive jobs in the reference scenario without biogas plants. It is therefore highly

uncertain about jobs in biogas plants will have a positive, negative or neutral effect on

employment and productivity.

There are often discussions about repercussions from the establishment of new businesses, and then

especially in rural areas. Employment has already been discussed, but biogas plants will also lead to increased

demand for construction products, transportation, technology, knowledge and more. To

find the actual value to society of such effects it is necessary to go through one

similar exercise was done for employment. One will typically end up with a similar

conclusion, ie that it is very difficult to say whether these effects will contribute an added value for

society, when comparing resource use against the reference scenario.

The model we have outlined, with storage for both manure and organic fertilizer at the biogas plant,

could reduce the storage requirements for manure the farmer. The scarcity of

storage capacity can save the farmer for some charges, thus increasing the

economic profitability of biogas production from manure.

Finally, it should be noted that the transfer of income from incineration and composting plants to

biogas plant is not considered a cost, but a distribution effect. In the baseline situation, the

incineration and composting facilities that receive a gate fee for accepting waste. The

biogas production is the biogas plant that receives gate fee'en instead. This means that the full

income biogas plants get through the gate fee'en, will give a corresponding reduction in the income of

treatment plants (composting or incineration) that would treat the waste in

reference situation, so that the social cost / income is zero.

This review of non-quantized effects is not exhaustive, as there may be other

effects we have not described here.

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According to the Treasury Department's guidelines for economic analyzes, the general rule is that

employment effects should not be included.

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**Part 2 - Value Chains**

Here we will look at the *economic* impact of the production and utilization of biogas in two of

value chains that are described in the value chain report (CPA, TA 2704/2011): the use of biogas in

buses / fleet vehicles and feeding of biogas in natural gas grid in Rogaland. Costs and emissions

associated with the production of biogas will be included in the user actions, so that the entire value chain is

represented in each measure. After input from agencies and industry stakeholders, it is clear that the fuel is

most appropriate application of biogas, as well as utilization via gas grid in Rogaland *.* This

coincides with our own assessment (see Chapter 1). We have therefore chosen to only quantify these two

value chains.

In value chains, only including investment and general operation of the distribution system, but not

operating costs of the actual transportation of the gas. The reason for this is that in the reference scenario, the

be needed to transport both diesel and natural gas to retail outlets. We have therefore made a

rough assumption that the cost of transporting diesel or natural gas is comparable with

the cost of transporting the biogas so that the shuttle does not entail a

social cost. For natural gas, this is probably a fair assumption, while the comparison

transport of diesel fuel is less obvious. A given amount of energy gas takes much more space than

equivalent amount of energy fuel, which means that the tankers running multiple trips back and forth between

production facilities and sales outlets with biogas. On the other hand, it is expected that

petroleum products in the cut must be transported substantially longer than the average for biogas, which can

compensate for the difference in energy density. It is therefore difficult to estimate the cost of transport is

over-or underestimated in this analysis.

***Value chain - biogas buses***

In this chain, we look at the use of biogas as a fuel for buses. As described in section

1 is the application in fleet vehicles in the short term, easier and less expensive than the use of private cars

since it requires less infrastructure. Buses are selected as an example of fleet vehicles, but

cost of application in other heavy vehicles in fleet operations are assumed to be comparable. Since

gas operation reduces the emission of air pollution compared with diesel operation, and it is

mainly in urban areas that a reduction in air pollution will have a great value, has

we have chosen to concentrate on city buses in this analysis.

The value chain thus shows emission reductions and costs of using biogas buses, as a

substitute for diesel buses. We have assumed that the buses purchased does not displace existing

capital, but replaces the purchase of new diesel buses. In other words, the reference situation that

bus operators purchasing new diesel buses, which have lower emissions of components that contribute to

local air pollution than older diesel buses.

We see here two chains, where biogas in the one produced by manure, while

production in the second chain is based on organic waste. In both value chains used

biogas as fuel. We have chosen to show both value chains to illustrate the range of

cost between manure and organic waste. In addition, we illustrate what the costs

if the full potential is triggered, ie the separate treatment of manure and

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organic waste. Both value chains shows costs and emission reductions for the full potential of

the two substrates, but this can easily be changed by a linear scaling

19

. Cost Effectiveness

will be independent of the size of the measure.

New Effects

Beneficial effects on *the production* of biogas are described in sections presented above. As

described the production from manure lead to a CO

2

Reduction of 152,000 tonnes of CO

2

-

eq, given that the potential is triggered. Production of organic waste causes *increased emissions*

equivalent to 7000 tons of CO

2

-Eq for the potential. In addition, there will be a new value associated with

reduction of ammonia and nutrients in organic fertilizer, which is appreciated and drawn from

production costs. The reduction in greenhouse gas emissions from *the use* will come from

replacement of diesel with biogas. The magnitude of this reduction will depend on the quantity

biogas, and the difference in energy consumption between diesel and gas-powered buses. At present diesel buses more

energy efficient than gas buses, so one needs 1.25 GWh of gas to replace one GWh with

diesel. In addition, gas-powered vehicle leaking of methane from the engine. These emissions will

offset some of the reduction in greenhouse gas emissions, but the effect is relatively small. For biogas produced

of manure (740GWh) will reduce CO

2

Emissions from the substitution of diesel, including an increased

methane emissions from the engine, be 153 000 tonnes of CO

2

-Eq. For biogas produced from organic waste (990

GWh) substitution contribute to emissions reductions equivalent to 203 000 tonnes CO

2

-Eq.

Greenhouse gas emissions for the entire value chain of production from manure is then given by:

*Reduced methane and nitrous oxide emissions from + reduced emissions from application =*

*152 000 + 153 000 = 305 000 tonnes of CO*

*2*

*-Eq.*

The value chain where manure is used in production providing:

*Emissions Increase the production of biogas + reduced emissions from application =*

*7000 + 203 000 = 196 000 tonnes of CO*

*2*

*-Eq*

The distribution of emissions through value chains shown in more detail in Figure 4.8. Triggering the entire

realistic potential can thus achieve a total reduction of greenhouse gas emissions equivalent to 500

000 tonnes of CO

2

-Eq. Of the total emission reduction, around 29% come from the production stage,

while almost 71% of reduction is the replacement of diesel with biogas, as shown in Figure 4.6.

Another advantage of using biogas in urban buses is that you can reduce local air pollution,

particularly the levels of NO

X

and particulate matter (PM10). Health and environmental value of such a reduction would

depend greatly on where the reduction occurs. Since the benefits but also the potential for replacement of

buses, the largest in the major cities in Norway, we have assumed that the measures implemented in major Norwegian cities.

NO

X

Emissions from gas bus depends on the engine type: stoichiometric engines provide very low NO

X

-

emissions, while the engines which use little fuel compared to the amount of air (lean combustion) will

19

Cost functions will most likely not be linear, but a linear scaling may nevertheless be

a good approximation to the actual cost figures.

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provide emissions equivalent to emissions from diesel engines (see also Figure 1.5). Institute of Transport Economics

estimates that an average gas buses will reduce NO

X

Emissions by 50% compared to a

diesel bus

20

. At the same time reduce PM10 emissions by around 80%. The reduced air pollution is

valued at 175 million per year for the amount of gas from manure (740 GWh) and 232

million per year for the amount of gas from organic waste (990 GWh). Altogether this gives a

benefits due to improved air quality almost 408 million per year.

*Figure 4.6: Distribution of emissions reductions in the production and use of biogas in city buses, by*

*feedstock.*

Costs

In order to use biogas in buses is required that the gas is compressed. Costs related to

upgrading of biogas, we have included in the production costs of biogas, while we have chosen to

the costs of compression to apply part, as not all applications require

the gas is compressed. Compression cost is taken directly from Klif value chain report (CPA,

2011), and have then been verified through the survey. After removing the fees are

the social cost of compression 5 cents per kWh.

On average driving a city bus 50 000 kilometers per year. Gas Buses spend an average of 25% more energy than

diesel buses, which means that one can not replace the corresponding amount of energy in diesel

amount of gas you use. That is, if one uses 1.25 kWh with biogas in a gas bus, can

you only replace one kWh with diesel. With an energy consumption of 5.0 Sm

3

gas per mile will

thus requires less than 3,000 gas buses to utilize 740 GWh of biogas and 4000

gas buses to utilize 990 GWh of biogas, providing just under 7,000 buses for the

potential. The additional cost of purchasing a biogas bus compared to a diesel bus is about 250

000 without tax per bus. It is assumed that the remaining operating costs (excluding fuel expense)

20

Based on an underlying assumption that gas buses have stoichiometric engines.

**61%**

**39%**

**Potential for emission reductions in the production and**

**application of biogas buses allocated to raw materials.**

**Total emission = 500 000 tonnes of CO**

**2**

**-Eq.**

Fertilizer

Organic waste

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for gas buses is approximately equal to the equivalent cost of diesel buses, which means that

incremental cost of operation is only given by the difference in fuel costs.

By using biogas will save costs associated with the purchase of diesel. This will result in an

annual cost of 340 million biogas from manure (740GWh) and

NOK 451 million manufacturing organic waste (990GWh). This provides a cost reduction of

340 + 451 = 791 million, if all the realistic potential realized.

In addition to the buses must be invested in a distribution system for biogas, the gas containers (flakes)

and fuel stations with backup system to ensure operational stability. It is believed that a backup

system can ensure the operation of two filling stations, and two filling stations can operate 150 buses. In addition, the

such a system may require 10 flakes, to transport biogas from production facilities

filling stations. Upscale it to full potential (about 7000busser) corresponds to a

investment of 2.079 billion dollars.

The annual incremental cost of operation of the distribution system is assumed to be 6.5% of

investment cost. Costs for the transportation of gas from the plant to the filling stations are

believed to be comparable with the corresponding transport costs for diesel fuel filling station, so that

this does not imply an economically extra cost.

Overall, the economic capital and operating costs for the distribution system and

biogas buses totaled to 241 + 319 = 560 million annually, to exploit the full potential.

The net cost for the production and use of biogas consisting of (production cost

biogas) + (increased expenses related to the use of biogas buses) - (reduced expenses due

reduced air pollution and reduced fuel use). For the full potential net cost 914

million. This gives an emission reduction of 500 000 tonnes of CO

2

-Eq. Cost-effectiveness of

the potential is thus 1800 NOK / ton CO

2

-Eq. Due to the very different gas yield is large

difference in production cost when using manure and organic waste in

production. This difference continued into value chains. The value chain using

manure in the production gives a measure price of 2,300 U.S. $ / ton CO

2

-Eq and organic waste provides a

measures price of 1100 NOK / ton CO

2

-Eq. Detailed overview of the costs and effects as well as new

distribution of these through value chains illustrated in Tables 4.2 to 4.4 and Figure 4.7 to 4.10 below.

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*Table 4.2: Cost and benefit effects in the value chain of production based on manure and application of*

*city ​​buses.*

*Table 4.3: Cost and benefit effects in the value chain of production based on organic waste and the use of*

*city ​​buses.*

**Organic waste: 990 GWh / year used in city buses.**

**Value chain: production based on**

**organic waste, used in city bus.**

**Costs**

**Reduced**

**greenhouse gas emissions**

**(Million / year)**

**(Tonnes CO**

**2**

**-ekv/år)**

Production

534

7000

Compression of CBG

50

Application - Investment and operating costs

319

*Annual capital cost bus*

*128*

*Annual capital cost terminals and backup*

*93*

*Annual capital cost flakes*

*21*

*Operating tank and backup*

*77*

Methane emissions from motor

8000

Reduced fuel use

-451

211 000

Reduction of NO

X

and PM10

-232

**Total**

221

196 000

**Cost (U.S. $ / tonne CO**

**2**

**-Eq)**

1100

**Fertilizer: 740 GWh / year used in city buses.**

**Value chain: production based on**

**manure, applied in city bus.**

**Costs**

**Reduced**

**greenhouse gas emissions**

**(Million / year)**

**(Tonnes CO**

**2**

**-ekv/år)**

Production

929

152 000

Compression of CBG

38

Application - Investment and operating costs

241

*Annual capital cost bus*

*96*

*Annual capital cost terminals and backup*

*70*

*Annual capital cost flakes*

*16*

*Operating tank and backup*

*58*

Methane emissions from motor

6000

Reduced fuel use

-340

159 000

Reduction of NO

X

and PM10

-175

**Total**

693

305 000

**Cost (U.S. $ / tonne CO**

**2**

**-Eq)**

2300

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*Table 4.4: Cost of the value chain for biogas produced from both manure and organic waste and*

*use the bus*

**The potential: 1730 GWh / year used in the bus.**

**Value chain: biogas produced from both**

**manure and organic waste,**

**used in the bus.**

**Costs**

**Reduced**

**greenhouse gas emissions**

**(Million / year)**

**(Tonnes CO**

**2**

**-ekv/år)**

Production

1464

145 000

Compression of CBG

88

Application - Investment and operating costs

560

*Annual capital cost bus*

*224*

*Annual capital cost terminals and backup*

*163*

*Annual capital cost flakes*

*37*

*Operating tank and backup*

*135*

Methane emissions from motor

0

15 000

Reduced fuel use

-791

369 000

Reduction of NO

X

and PM10

-408

**Total**

914

500 000

**Cost (U.S. $ / tonne CO**

**2**

**-Eq)**

1800

|  |
| --- |
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*Figure 4.7: Economic costs and savings through the value chain of production based on*

*manure* and application *in city buses. Each column shows the costs / savings to the total emission.*

*Figure 4.8: Distribution of emissions through the supply chain, as a share of total emissions.*

Production

Reduced fertilizer use

Reduced NH

3

Emissions

Compression

Annual capital cost bus

Annual capital cost terminals and

backup

Annual capital cost flakes

Operating tank and backup

Reduced fuel use

Reduction of NOx and PM10

Cost of measures

0.00

0.20

0.40

0.60

0.80

1.00

1.20

1.40

1.60

1.80

2.00

0

500

1000

1500

2000

2500

3000

3500

4000

4500

5000

Costs

Revenue

Net

Costs

Revenue

Net

**NOK / kWh**

**£ / tonne CO**

**2**

**-Eq**

**Value chain - production of biogas from manure, used in city buses.**

Upgrade

Maintenance

Electricity

Work

Transport

Annual cost of capital

**Biogas production from manure**

**Application in city buses**

**Biogas production from manure**

**Application in city buses**

-20

0

20

40

60

80

100

Production

Reduced

fertilizer use

Net

emission reduction

the production

Methane emissions from

engine

Replacement of diesel

Total

emission reduction

**%**

**Emission reduction in the production of biogas from manure and**

**use in city buses. Total emissions: 305 000 tonnes of CO**

**2**

**-ekv/år.**

**Production**

**Application**

|  |
| --- |
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*Figure 4.9: Economic costs and savings through the value chain of production based on*

*organic waste and use in city buses. Each bar shows the cost / savings divided by total*

*emission reduction.*

*Figure 4.10: Distribution of emissions through the supply chain, as a share of total emissions.*

Production

Reduced fertilizer use

Compression

Annual capital cost bus

Annual capital cost terminals and

backup

Annual capital cost flakes

Operating tank and backup

Reduced fuel use

Reduction of NOx and PM10

Cost of measures

0.00

0.10

0.20

0.30

0.40

0.50

0.60

0.70

0.80

0.90

1.00

0

500

1000

1500

2000

2500

3000

3500

4000

4500

5000

Costs

Revenue

Net

Costs

Revenue

Net

**NOK / kWh**

**£ / tonne CO**

**2**

**-Eq**

**Value chain - production of biogas from organic waste, used in city buses.**

Work

Transport

Annual cost of capital

**Biogas production from organic waste**

**Application in city buses**

**Application in city buses**

-20

0

20

40

60

80

100

Production

Reduced

fertilizer use

Net

emission reduction

the production

Methane emissions from

engine

Replacement of diesel

Total

emission reduction

**%**

**Emission reduction in the production of biogas from organic waste and**

**use in city buses. Total emissions: 196 000 tonnes of CO**

**2**

**-ekv/år.**

**Production**

**Application**

|  |
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***Value chain - Gas network in Rogaland***

In Rogaland, an existing infrastructure for transporting natural gas via pipeline. One possible

use of biogas will be to replace fossil gas with biogas in this pipework. Another

alternative supply chain that we describe here is the production of biogas on farms and feed

of raw gas in a rågassnettverk. The biogas is upgraded so central before feeding the natural gas grid.

This may be a possible option in that area. Annex 5 presents such a case, written by Bright.

It is beneficial to place the biogas for manure in Oslo, because of the large

livestock density, while there is less supply of organic waste. We have therefore chosen to exclude

Separate treatment of organic waste in biogas plants of this value chain. Instead, we use a

kind sambehandlingstiltak (studied in Klif value chain report in 2011), where we assume a 1:18

weight ratio of organic waste and manure. In Klif value chain report, 30% of

manure in Rogaland used as potential, as we have here upscaled this to around 100%

of manure in Rogaland (500 GWh). Costs and gas yield does not reflect a real

sambehandlingstiltak but is a combination of the cost of a separate treatment of the two

substrates. We see two different production possibilities: biogas production based on

manure and biogas production based on the treatment of manure and organic waste

(18:1 ratio). Both production measures are scaled to produce 500 GWh to reflect

access to raw materials in the area, while the comparison of costs and emission reductions are

easier when the energy quantity is equal. Production costs are then 537 million and 624 million annually

respectively. sambehandling of manure with organic waste and separate treatment of

manure.

New Effects

Greenhouse gas reductions will be somewhat less at feeding biogas in the natural gas network

compared to the use of vehicles, because the measure is smaller (fewer GWh). In addition, you get a

greater reduction in greenhouse gas emissions by reducing fuel consumption by 1 GWh, compared to

reduce natural gas consumption by 1 GWh. However, because gas buses are less efficient than

diesel buses will replace fewer GWh of diesel than one substitution of

natural gas. These effects pull in opposite directions, so that one ends up with the CO

2

Reduction per

GWh is about the same (for buses and gas network in Rogaland), if one compares

value chains that use separate treatment of manure. The reduction in greenhouse gas emissions from

use 500 GWh of biogas as a substitute for natural gas network in Rogaland in

the order of 206 000 tonnes of CO

2

-Eq annually for separate treatment of manure and 180 000 tonnes

CO

2

-Eq by sambehandling. The reduction of greenhouse gas emissions is lower for sambehandling ago

it is mainly manure that contribute to emissions reductions in the production stage. 104

000 tonnes of CO

2

Equiv of emission reduction comes from the substitution of natural gas in both cases.

In the same way as for the bus measure will be a new performance / cost reduction by reducing

Procurement of natural gas. The economic value of reducing natural gas purchases by 500

GWh is 139 million.

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Costs

The major advantage of using biogas via gas grid in Rogaland, is that infrastructure

Distribution system already exists. This means that the costs will be significantly lower than if

you had to invest in gas network as well. The economic incremental costs land on

485 million and 398 million respectively for the separate treatment of manure and

sambehandling of manure with organic waste .. The corresponding cost ratios of 2200

per tonne CO

2

-Eq and 2,400 kr / ton CO

2

-Eq. Detailed overview of cost and benefit effects

can be seen in Tables 4.5 and 4.6 below.

*Table 4.5: Economic costs and savings in the supply chain of biogas from manure and*

*feeding of biogas in the gas network in Rogaland.*

**Value chain: feed of 500 GWh / year**

**biogas from manure.**

**Costs**

**Reduced**

**greenhouse gas emissions**

**(Million / year)**

**(Tonnes CO**

**2**

**-ekv/år)**

Production

624

102 000

Saved purchases of natural gas

-139

104 000

**Additional cost biogas**

485

206 000

**Cost (U.S. $ / tonne CO**

**2**

**-Eq)**

2400

*Table 4.6: Economic costs and savings in the supply chain for biogas based on sambehandling*

*(1:18) and the feeding of biogas in the gas network in Rogaland.*

**Value chain: feed of 500 GWh / year**

**biogas from sambehandling (1:18).**

**Costs**

**Reduced**

**greenhouse gas emissions**

**(Million / year)**

**(Tonnes CO**

**2**

**-ekv/år)**

Production

537

76 000

Saved purchases of natural gas

-139

104 000

**Additional cost biogas**

398

180 000

**Cost (U.S. $ / tonne CO**

**2**

**-Eq)**

2200

***Summary - value chains***

Value chains are presented here to provide a comprehensive picture of the cost and benefit effects when

produces biogas based on various substrates and apply them in different applications. According to our

calculations is the most cost effective solution to produce biogas from biowaste

waste and then use biogas in city buses (any other fleet vehicles that run in city), which

gives a cost of 1100 USD per tonne reduction in CO

2

Equivalent. Maximum CO

2

Reduction will be

first gain if the full potential exploited, which will provide a reduction in greenhouse gas emissions of 500 000 tonnes of CO

2

-

eq. 61% of the total emission reduction stemming from the production and use of biogas from

the manure. This means that if you only select the most cost effective solution will be

maximum to achieve an emissions reduction of 196 000 tonnes of CO

2

-Eq.

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To get a fair comparison between the two applications (use as fuel for buses and

feeding into the gas grid), one must compare the value chains using the same substrate in

production, in other words manure. Despite the fact that it is not necessary investments

new infrastructure, it turns out that it is higher *socioeconomic* additional cost by inputting

the gas in the gas network in Rogaland (0.97 £ / kWh) than when the gas used in city buses (0.93 £ / kWh).

Cost of the measures, given in dollars per reduced CO

2

Equivalent, is also lower if the biogas is used in

buses than the gas network in Rogaland. The main reason for this is that the new site is larger by

use in city buses. Firstly, fuel cost is high compared to the price of natural gas, so that

saving more by direct substitution. In addition, replacement of diesel buses with gas buses lead

to a reduction in local air pollution, which is highly valued when reductions happen in cities. Without

the latter reductions in NO

X

and PM10 would gas network in Rogaland be significantly more

cost effective both in terms of dollars per kWh and per tonne reduced CO

2

-Eq. For example,

bus would measure using manure in the production stage going from 0.93 to 1.17 U.S. $ / kWh and from

2300 to 2800 U.S. $ / ton CO

2

-Eq, if one excluded the valuation of local air pollution.

Non-quantized effects

One of the effects that are not taken into account in the value chain with city buses, the value of the lower

noise levels during the transition to gas buses. Inclusion of this will then increase the

economic benefits of the measure. Another effect that appears from this analysis,

the difference between the use of biogas in and outside the quota system. Transport is outside

quota system so that emissions reductions in this sector should be seen as more valuable because the

not only reduces the Norwegian emissions, but also global emissions. Since we in this report only looks at

Norwegian emissions reductions, would not this kind of effects included in the calculations. If you include

reflections on global emissions, will transfer the application to be relatively more attractive than

Applications that use biogas within quota system (that is, for example,

electricity production and application in industry).

Many of the same effects that were discussed during the manufacturing section will also apply here. Both

employment effects have positive repercussions are not included, as it is very difficult to determine what

that actually would have been the use of resources in the reference scenario. If resource use were initially

very effective to switch to biogas production have negative effects on productivity and

Thus the economic profitability. But if one goes from an ineffective

resource use, such as low productivity among the employed, the repercussions probably provide a

added value for society.

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**Business Economic profitability analysis**

The main difference between the economic and corporate financial calculations is that

former includes non-priced public goods such as climate change and local air quality. The interest rate (s) will also

be different, where the corporate financial metrics used interest rates that reflect

cost of capital in each sector. In addition, distributional effects, such as income from the sale

of biogas, only included in the corporate financial statements. In this type of calculation will also

taxes (which are also distributional) be of great importance.

**Production**

Production chains (Figure 4.1 and 4.3) will not change even if you go over to commercial

calculations. The difference is that instead of calculating the cost to society of producing

biogas, we are now seeing the costs set by the manufacturer. Business administration costs will typically

be higher than the economic, especially because of the tax to the state and higher

return. However, commercial revenues will typically be higher, because revenues

often be distributional effects that are not included in the economic analysis. Since it is

enterprises and not individual consumers, we assume, all costs and prices without VAT.

***Production of biogas from manure***

Revenue

We have assumed that the biogas producer is unable to charge a gate fee for processing

manure in biogas plants, since farmers then probably would choose to spread manure directly in

Instead of letting biogas producers get manure. The only income is interest-

livestock facilities have, will be the sales of biogas. We have estimated that the upgraded biogas is sold to

the price of natural gas, 32 cents per kWh

21

. Natural gas price includes taxes, but we assume that

biogas will be exempt from these. That *biogas producer* gets the full amount, 32 cents per kWh,

such as income, while an equivalent *natural gas producer* will be left with 28 plat per kWh due

CO

2

Taxes that go to the state. Total Income for biogas producer sums then to 240 million annually,

the production of 740 kWh biogas.

Expenses

The costs will also vary compared with the economic calculations. Higher

return (interest rate) will increase the cost of capital, while the tax provides a general increase for all

costs. We have calculated the cost of capital at a rate of 8%. Annual capital costs for

the measure will then be 516 million, representing a 27% increase compared with the

economic cost of capital.

21

We have received input that biogas currently sold at a higher price than natural gas. The reason for this is probably that

There is a certain willingness to pay for a more environmentally friendly alternative to natural gas. However, we have chosen to

selling prices are equal to each other because we believe that such payments will be limited to individual companies and

consumers' environmental values, one can not base a sustainable business model.

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We have calculated the fees estimated by assuming that about. 20% of the sales price, no sales tax, taxes.

The exception is energy prices and energy taxes as we have found actual numbers. Based on this, we

concluded that the total commercial production cost of producing 740 GWh

biogas from manure is about 1.2 billion, or U.S. $ 1.60 / kWh.

We have not included costs for the manufacturer when handling bio fertilizer, when we base ourselves on

assumption and transport of bio fertilizer and manure, and that the farmer receives bio fertilizer

no charge. It is conceivable that this is an underestimation of the real costs associated with handling

bio fertilizer, but is not expected to make a big difference in the total cost.

With an income of 32 cents per kWh and a production cost of 1.60 U.S. $ / kWh will be

commercial deficit in the production and sale of biogas in excess of 1.27 NOK / kWh. The

In other words, not economically profitable to produce biogas from manure.

***Production of biogas from organic waste***

Revenue

Biogas plants for organic waste, in addition to revenues from biogas (32 cents per kWh) could

rely on income from those who deliver waste to the plant gate fee. This is because alternative

therapies for wet organic waste also requires that the waste producer pays a

processing fee, and a biogas plant will therefore require a similar amount for receiving and

treatment of organic waste. Based on figures from various incinerators, we found that

700kr/tonn is a reasonable estimate of the gate fee'en of waste deposited at the facility. It is conceivable that

gate fee'en will vary between different types of plants and various types of waste delivered. We have not

taken into account here. Revenues at a biogas plant for organic waste will be around 95 cents per

kWh, of which two thirds of this income from gate-fee'en, see Figure 4.11.

In the business economic analysis is not calculated fertilizer value of organic fertilizer. This is

because organic fertilizer is little negotiable today, which means that the commercial selling price will be

zero or negative. This may change as there is a market, but it is too early to

to say something about the price of organic fertilizer will be appreciated in this market.

Overall, income (benefits) must be much higher than the economic calculations.

This is because sales revenue and gate-fee'en considered distributional effects in the

economic analysis (moving income or expenses from one player to another).

Expenses

The commercial production costs will be substantially higher than the corresponding

social cost. In particular, operating costs increase, since the manufacturer must

påberegne costs of all operating items as economically just would have been seen as

distributional effects. It is also inclusive of charges in the same way as for manure plant,

which will increase costs further. Annual cost to produce 990 GWh of biogas from 880 000

organic waste will add up to 938 million, ie, 95 cents per kWh. This provides a

|  |
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*commercial* processing charge of £ 1100 / tonne organic waste treated in

biogas plants.

Revenues and expenses are almost identical, and the annual deficit for the production of 990GWh

is just 2 million. This represents a loss of 0.2 cents per kWh. During our

assumptions are therefore separate treatment of organic waste in biogas plants very close

commercially profitable.

***Summary - production - commercial ratings***

As expected, there is a great difference between the commercial cost of using the two different

substrates. The difference is greater here than in the economic calculations because biowaste

Waste has two advantages over manure: higher gas yield per ton substrate and the ability to

take a street-fee. In our calculations, a biogas plant using livestock manure go

*loss* of 127 cents per kWh, while biogas plants for organic waste will have a deficit

of 0.2 cents per kWh. Looking at the potential as a whole, *the deficit* remain at 55 cents per kWh.

Figure 4.11 illustrates the relative sizes of the corporate financial accounting records by

production of biogas from manure and organic waste. As you can see,

the main difference in costs driven by transport costs are higher for manure than for

organic waste. This is because manure transport paid by biogas producer, the

Unlike waste delivered at the facility. In addition, there will be significantly greater amounts

raw materials and bio fertilizer that must be transported in relation to production based manure. The figure

also illustrates the importance of revenue from gate-fee'en for the profitability of farms.

Biogas plants using organic waste in production is 2/3 of their income from the street-fee'en,

a source of income such as livestock farms do not have access to. Comparison of

commercial costs and revenues for biogas production from manure and based

the organic waste is shown in Table 4.7.

These calculations show that it will not be profitable for private operators to build something other than pure

wet organic plant. This means that in order to trigger the manure potential, for example,

through sambehandling, it must be designed instruments directly in production based on

manure.

|  |
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*Figure 4.11: Business Financial income and expenses for the production of biogas from manure and*

*organic waste.*

*Table 4.7: Business Financial income and production costs of biogas from manure and*

*organic waste*

**Business Economic costs and**

**income from biogas production**

**Fertilizer**

**Wet**

**waste**

**Total**

**potential**

**(Million)**

**(Million)**

**(Million)**

Investments

5062

4410

9472

Annual capital costs

516

449

965

Annual operating expenses

674

489

1162

*Transport*

*292*

*141*

*433*

*Work*

*81*

*18*

*100*

*Electricity*

*37*

*49*

*86*

*Maintenance*

*152*

*132*

*284*

*Upgrade*

*112*

*148*

*260*

Annual production costs

1189

938

2127

Income from gate-fee

0

-617

-617

Sales of upgraded biogas

-240

-319

-559

**Overall deficit**

**950**

**2**

**950**

**Annual amount of gas produced**

**740**

**990**

**1730**

**Loss per kWh**

**1.27**

**0,002**

**0.55**

Deficits

Income from gate-fee

Sales of upgraded biogas

0.0

0.2

0.4

0.6

0.8

1.0

1.2

1.4

1.6

Cost

Income

Net

Cost

Income

Net

**NOK / kWh**

**Business Financial income and expenses for the production of biogas**

**based on manure and organic waste**

Upgrade

Maintenance

Electricity

Work

Transport

Annual capital costs

**Fertilizer**

**Organic waste**

**Costs:**

**Income:**

**Net:**

**0,002**

**1.27**

|  |
| --- |
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**Use of biogas**

Applications will here represent the demand side by two different uses: city buses and

gas network in Rogaland. It is assumed that the upgraded biogas and natural gas have the same purchase price

per kWh (32 cents), which is inclusive of taxes (excluding VAT). The same rate (7%)

on investments in the "bus capital" as in Klif value chain report.

The calculations are not presented as a business account, but as an assessment of the additional costs

using biogas versus diesel or natural gas.

The investment costs for bus operators will consist of the incremental cost of purchasing gas buses

(Relative to diesel buses), filling stations, flakes and backup systems. On the operational side, the purchase and

compression of biogas be operating, while bus companies will save on reducing procurement

of diesel. This means that by choosing gas buses the bus companies incur additional costs (in

compared to diesel buses) at 4 cents per kWh biogas they use. The low cost can be greatly

explained by the fact that diesel prices are high, while the fees for diesel is significantly higher than for gas.

The reduced purchase of diesel will therefore almost offset the increased investment costs.

For companies that provide gas over gas network in Oslo, will not substitution of natural gas for biogas

mean an additional cost, while biogas can be purchased at the price of natural gas. This means that there

the most economically profitable to use biogas over gas network in Rogaland. Costs and

revenues for the two applications shown in Table 4.8 and 4.9.

Applications will not be exclusive, so both use these measures can be implemented simultaneously.

The limiting factor will initially only be the supply of gas.

|  |
| --- |
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*Table 4.8: Business administration increased cost using gas buses relative to diesel buses.*

**Business Financial extra cost -**

**application of 745 GWh / year of biogas buses**

**Costs**

**Cost per**

**energy unit**

**(Million / year)**

**(U.S. $ / kWh)**

Purchasing gas (upgraded biogas / natural gas)

240

0.32

Compression

46

0.06

Investment and operating costs - Application

315

0.42

Reduced fuel use

-568

-0.95

Net Cost biogas

32

0.04

**Additional cost (U.S. $ / kWh)**

**0.04**

*Table 4.9: Business administration increased cost relative to natural gas by feeding of biogas in the gas network in*

*Rogaland.*

**Business Financial extra cost -**

**500 GWh / year to Gassnett Rogaland.**

**Costs**

**Cost per**

**energy unit**

**(Million / year)**

**(U.S. $ / kWh)**

Purchasing gas (upgraded biogas / natural gas)

161

0.32

Saved purchases of natural gas

-161

-0.32

Net Cost biogas

0

0

**Additional cost (U.S. $ / kWh)**

**0**

|  |
| --- |
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**Prospects, uncertainty and sensitivity analysis**

In this section we attempt to highlight the various factors that may affect the cost estimates. We have

Among other things, a sensitivity analysis to identify which parameters

22

the greatest

impact on the cost effectiveness of their production and use measures. This, combined with

knowledge about the uncertainty in our sampling, gives us an idea of ​​how robust cost estimates

our is and also an indication of the value chain measures will be most effective. In addition

we accentuate the parameters we expect will vary over time.

**Prospects**

***Future development costs for the production of biogas.***

As more biogas plants built and put into use, there is reason to believe that the experience and

acquired skills could lead to learning effects that may make future investments

and operating costs are reduced. Among other things we are working a lot with dry processes for biogas treatment

of manure. Drying processes need less water supply and reducing the need

processing and transport needs of organic fertilizer, which leads to a reduction in the investment-

and operating costs. The fact that the construction and operation of biogas plants is relatively new in Norway, increasing

likelihood that learning effects could be significant for costs. In addition to potential

reductions in investment costs will particularly develop technology that can increase gas yield

could be probable and significant. Furthermore, the development of processes and technologies that

enables a more efficient for the treatment of organic fertilizer (dewatering, etc.) could reduce

transport costs and increase usability of bio fertilizer, although it will require increased

investment costs for treatment. These learning effects and technological developments will

however, only take place if one starts to build biogas plants and investing in R & D, ie

cost reduction in the future is contingent on the construction of certain fixed soon with the current

costs.

There is a growing awareness that phosphorus is a finite resource and demand of phosphorus rises

substantially in line with economic growth and increased standards of living in populous countries such as China,

India, Brazil and Russia. Bioforsk has estimated that by an increase in phosphorus consumption by 3% per year

commercial resources currently being emptied during 100 years to a few hundred years. The economic

value of phosphorus is therefore expected to increase significantly ahead of time. Ammonia emissions are also

expected to get a higher valuation, especially in light of the present violation of the Gothenburg Protocol. Both

these factors will favor the lower cost of measures, but the impact will be very small

relative to changes in other parameters. For example, an increase in the valuation of ammonia and

phosphorus by 50% did not cause any visible change in the costs, value chain with city buses will

still land at 1100 kr / ton CO

2

Equiv of organic waste and 2,300 U.S. $ / ton CO

2

-Eq for

manure.

Future revisions of the fertilizer regulations may change the reference cost of treating

manure. If such revision entails a significant cost increase in the baseline situation

22

The parameters defined the background figures are based on estimates. The list of these can be found in

Appendix 2

|  |
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for example by increasing requirements for storage and distribution space, one will see a corresponding significant

reduction in the social costs for the production of biogas from manure.

The social cost of biogas production from organic waste based on

assumption that it will be under capacity for the treatment of this waste in

reference situation, when the export of waste is included as a "treatment". If the future

waste streams makes it profitable to expand treatment capacity in Norway rather than

export waste and biogas plants can reduce the development of the second treatment, the

costs of production of biogas from organic waste is reduced. The reason for this is that

reference situation then will include investment costs for development of new

waste incineration plant or expansion of existing and thus make reference situation

expensive, which makes the production of biogas are relatively cheaper. It is not unlikely that it can be

profitable or politically desirable to increase incineration capacity in Norway, since waste

expected to increase significantly

23

up to 2020. See subsection "the divider Analysis" below for more details

and estimates of production costs under different reference scenarios.

***Future development costs by using biogas***

For the application of biogas buses will again be reason to believe that learning effects may

reduce the cost of biogas buses come. Bus transport is currently dominated by diesel vehicles

and has been for a long time. Gas Buses are a relatively new technology which currently is less energy efficient.

Higher fuel prices and strong regulatory pressure against vehicles running on fossil fuels will lead to

energy efficiency of diesel buses. There is reason to believe that these mechanisms would also provide incentives

to technology for gas vehicles. As gas buses are a more mature technology than

diesel buses, it is likely that the potential for energy efficiency is higher for gas than for buses

diesel buses.

***Future development of competing energy sources***

It is of course very uncertain developments in energy prices into the future. Both gas and oil

traded in global markets with pronounced fluctuations in price, which in turn will affect the price of diesel.

Oil prices are currently very high from a historical perspective, even if the world economy at the moment

still struggling with the aftermath of the financial crisis. There is reason to believe that the world economy after

each will strengthen which would normally imply higher demand for oil and thus higher prices.

This will result in diesel and gasoline will be more expensive, so that biogas as a fuel will remain relatively

cheaper. In the long term, increased focus and investment in renewable energy around the world increase the supply by others

forms of energy, which alone could push oil prices down. Concern about global warming and

measures to reduce greenhouse gas emissions, however, will make fossil fuels more expensive, which

turn means that the biogas will be more profitable for both the corporate and economically.

Natural gas has in recent years become an increasingly important energy especially since the price of other

fossil fuels has increased dramatically. This has led to increased exploration and extraction of gas and a

reduction in gas prices relative to oil and coal. There are indications that this production rate will increase

23

According to SSB household waste will increase by 36% between 2012 and 2020, while the total amount of waste will increase by

22% in the same period. (SSB, 2012).

|  |
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forward rather than decrease. Lower gas prices may make the use of gas buses relatively

cheaper, but also result in reduced revenues for biogas producers because biogas price

expected to be reduced in line with the natural gas price. While increased production of gas and production

of renewable energy has pushed the price of gas down, include Germany announced a sharp reduction

of nuclear energy production by 2030. This coupled with the fact that solar and wind power for less

predictable power production than, say, gas and hydropower, can lead to increased demand

for gas, which can slow the rate reductions.

**Other uncertainties**

***Gate-fee***

When biogas built in addition to the existing processing of waste, the total

treatment capacity in Norway will increase, which is expected to reduce gate-fairy for the most

competitive segment debris. If incineration plants will maintain their

energy production will have to attract the waste through price reductions, which would otherwise have been

treated abroad. Price reductions will not result in an economic loss if both seller and

buyer is in Norway. But in our scenario will lead to price reduction of profits for a

incineration plants (seller) in Norway and a corresponding gain for waste owners (buyers) in

abroad, resulting in an economic loss to Norway. The reduced revenues

incineration plants will affect the cost of measures for biogas production. The size of the

income loss in combustion plants will depend on how much competition there is for this

waste, the higher the competition will result in higher income. As of today, the competition is high and Sweden

is regarded as the price for the market (mainly between Norway and Sweden, but also to some extent

other European countries). In the current situation will thus profit loss could be of some significance,

While this may change as conditions in the waste market changes. As

outlined in the production of biogas from organic waste, we assume that

incineration plants maintain their energy supply by replacing the wet organic waste

who moved to the biogas plant with waste. The amount of waste that must be incinerated to

replace energy from the organic waste depends on the heating value of the organic waste

and the heating value of residual waste. With the fuel values ​​we use for the different waste fractions will

amount of waste that needs to in order to maintain energy production in incineration plants be

small, which means that the loss of income due to reduced gate fee provides little impact on the costs.

As shown in table 4.10 is the impact on the costs of reductions in gate-fee'en less than

loss of income, for all measures that include organic waste. The value chain with the use of bus

and production from organic waste has the biggest trick, which is an increase of

measures the cost of just under $ 100 for a reduction of gate-fee'en of 200 NOK / tonne

treated waste.

|  |
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*Table 4.10: Changes in the costs of loss of income due to reduction in gate-fee.*

**Changes in the cost picture as a result of loss of income from reduced gate fee**

**Unit**

**Original value**

**Reduction in gate-fee**

**200 kr**

**400 kr**

Bus - organic waste

£ / tonne CO

2

1130

1220

1310

Bus - The potential

£ / tonne CO

2

1830

1860

1900

RO - Sambehandling

£ / tonne CO

2

2210

2220

2230

***Climate in the short and long term***

One aspect that may be important for calculations of emission reductions and costs of action

assessment of climate change is how the climate impact of emissions reductions calculated. Inter alia

the choice of time horizon for climate effects have great importance for assessing the impact of the measure. For

to compare measures across greenhouse gases, it is common to convert all emissions of CO

2

-Eq,

something we have done in this report. The most commonly used method to convert the CO

2

-Eq is

using the conversion factor GWP

100

(Global Warming Potential). This factor describes the effect

emissions of a particular gas has on global warming over a hundred-year period, relative to CO

2

The

this method is used for the reporting of greenhouse gas emissions under the Kyoto Protocol, and we have

chosen to follow this standard, because as of today, these are used in the greenhouse gas inventory.

The conversion factors used for reporting under the Kyoto Protocol, the IPCC recommended in

its Second Assessment Report (SAR) from 1996. It has been decided to use conversion factors recommended in the IPCC

its Fourth Assessment Report (AR4) of 2007 for the second commitment period.

In addition to the goal of stabilizing the anthropogenic global warming to 2 degrees over the long term, it is

recently been an increased focus on the short-term effect emissions have on global

warming. In addition to reducing global warming in the long term, the climate also contribute to

slowing the rate of temperature rise. A rapid rise in temperature would represent a

additional problem because it then becomes difficult to adapt to the changes. There is a big difference in how

large warming effect of different greenhouse gases in the short and long term. To estimate the long-term

effect of climate change is often used to calculate the greenhouse gas emissions of CO

2

Equiv using

GWP

100

as described above. We have also chosen to illustrate the climate impact of an intervention on shorter

term in its own calculations using a conversion factor with shorter time horizon GWP

10

. GWP

10

describes greenhouse effect, given that CO

2

-Eq, by emitting a climate driver (greenhouse gases and

air pollution) over a period of ten years, as opposed to GWP

100

which uses a 100-year

perspective. In Table 4.12, we have calculated how emissions reductions and cost ratios change

if one looks at defining themselves to look at the effect of the measures in a more short-term perspective, ie

by convert to CO

2

-Eq using GWP

10

. In addition, we have included calculations of GWP

100

-

values ​​from IPCC AR4 (2007) as adopted for use in reporting in 2015 under

Kyoto Protocol's second commitment period.

|  |
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We compare words:

• greenhouse effect in a hundred-year period, using the conversion factors from the Kyoto Protocol

first commitment period (GWP

100

)

• greenhouse effect in a hundred-year period, using the conversion factors from the Kyoto Protocol

second commitment periods (nyGWP

100

24

)

• greenhouse effect in a ten-year period using the GWP

10

using conversion factors

"Metrics Report" Cicero wrote on behalf of the CPA connection. "Action Plan for short-lived

climate drivers "(Cicero, 2012). methodology is also described in Fuglestvedt et al. (2010).

The reduction in methane from biogas production from organic waste is very small, so the effect

of the different GWP factors will be almost negligible. We have therefore chosen to do this analysis

for manure measures.

*Table 4.11: Current GWP*

*100*

*, NyGWP*

*100*

*and GWP*

*10*

*for methane and nitrous oxide*

**GWP**

**100**

**nyGWP**

**100**

**GWP**

**10**

Methane

21

25

91

Nitrous oxide

310

299

273

*Table 4.12: Emission reductions and cost ratios calculated using different GWP values.*

**Biogas from manure**

**Emission reduction**

**(Tonnes CO**

**2**

**-Eq)**

**Cost ratio**

**(U.S. $ / tonne CO**

**2**

**-Eq)**

**GWP**

**100**

**nyGWP**

**100**

**GWP**

**10**

**GWP**

**100**

**nyGWP**

**100**

**GWP**

**10**

Production

152 000

166 000

440 000

-

-

-

Coach

305 000

317 000

572 000

2300

2200

1200

Gassnett Rogaland

200 000

216 000

400 000

2400

2300

1200

As shown in the table measures the cost of biogas measures based on manure significantly lower

in the short term than in the long term. The reason for this is that a large part of the emission reductions come in

form of methane. Methane has a much stronger impact on the climate in the short term than in the long term relative to

CO

2

because methane only staying a short time in the atmosphere (12 years (IPCC AR4, 2007)). This in turn means

that if one adds the term greenhouse effect increased weight, biogas measures based on

manure be relatively more cost-effective compared to measures that only reduce CO

2

(Seen in

according to whether the measures were evaluated against a target of stabilizing the climate in the long term).

Measures costs for the use of biogas buses to replace diesel or by replacing gas

with biogas in the gas line at the Rogaland reduced by respectively 48% and 50% when we move from

calculate CO

2

-Eq with GWP

100

GWP

10

.

24

We call GWP

100

Values ​​from 2007 to nyGWP

100

, To easily distinguish them from GWP

100

Values ​​as

used today.

|  |
| --- |
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2007 values ​​nyGWP

100

based on recent research results and attributes including methane

relatively greater effect on the climate than previously. If these values ​​are used to calculate the greenhouse effect

of biogas from manure measures, measures costs. Costs of production

of biogas from manure by the application of biogas in buses or as a substitute for

natural gas grid in Rogaland reduced by 4% when the nyGWP

100

Values ​​used.

***Way Kill Analysis***

As background for the economic calculations in this report, there is a presumption

that we have sufficient capacity to handle the waste produced in Norway. This means that there

placed a savings because it reduces the need for development of incineration capacity.

If this picture should change as the need to increase processing capacity in Norway, either

because waste is increasing significantly more than expected, or the need for waste management in North

Europe leads to increased profitability for treatment, the social cost

the construction of biogas plants will be lower. Another reason why the treatment capacity in Norway

extended may be that there is a political desire to treat their own waste, although it is not a real

need for capacity expansion. Regardless of the reason behind, we stand at a crossroads where we *either* can

decide to build incineration capacity *or* build biogas plants instead.

If we assume that referansesitasjonen is the need to expand the disposal capacity

Norway, the economic cost of production of biogas change significantly.

The reason for this is that the construction of biogas plants will reduce the need to develop

incineration capacity. To illustrate how this situation will change costs we have here

made an additional calculation. We have made calculations for both treatment cost in U.S. $ / ton

organic waste and the production of biogas in U.S. / kWh. These numbers, we then used to

we calculate the cost of biogas production relative to combustion.

In principle it is not a biogas plant is a perfect substitute for an incinerator in that

biogas plant will only treat the wet organic waste, while the incinerator also

treat waste. Nevertheless, the construction of a biogas plant freeing capacity in existing

incinerator that reduces the need for further development. We have not made any

assumptions about how much capacity will have to be developed, but compares rather

kosta ends the development and treatment of organic waste in biogas plants to the development and

treatment of organic waste in incinerators. Furthermore, we have also made an assessment of

cost per unit of energy produced, which will also reflect the amount of energy produced by

the different treatment methods. Since there will be large differences between the

economic cost-benefit effects for different application of biogas, district

and electricity, we have not considered the value chain in this calculation.

Table 4.13 and Figure 4.12 shows how the social costs of biogas production

change when we change the reference situation. Scenario 1 assumes that there is sufficient

processing the waste market, so that biogas plants will be extra capacity.

Energy production in incineration plants will be maintained by replacing the lost wet organic

waste with waste that normally would have been burned in Sweden or other countries. This is the scenario

we have used in the main analysis and reflects current situation. Scenario 2 assumes that

biogas plants can prevent the expansion of existing incinerators. Scenario 3 assumes

|  |
| --- |
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the biogas plant will displace construction of incinerators. This is a less likely

scenario in that incinerator also treat other types of waste biogas plants not

can process.

In both scenarios 2 and 3 the cost of incineration deducted from the cost of

biogas plant, so that the net economic cost of capital decreases. The net

energy production to be lower in scenario 2 and 3, then one must subtract the energy it wet organic waste

would have produced an incinerator

25

. The investment costs, given in £ / tonne annually

processing, which is the basis for the analysis are: 5000 U.S. $ / tons per year of biogas plants, 6350

U.S. $ / tonnes per year expansion of incineration capacity in excess of 11 450 kr / tons per year in new construction

by incineration.

*Table 4.13: Costs of treating organic waste in biogas plants and production costs*

*biogas and associated net energy production at three different reference scenarios.*

**Economic costs of biogas production with different reference scenarios**

**Scenarios**

**Treatment**

**cost**

**Manufactured**

**energy**

**Net energy**

**production**

**(U.S. $ / tonne of waste)**

**(U.S. $ / kWh)**

**(GWh)**

1

Biogas plants are built in addition to

existing incinerators

606

0.54

988

2

Biogas plant replaces the expansion of

Incinerator

96

0.15

584

3

Biogas plant replaces the construction of

Incinerator

-314

-0.47

584

*Figure 4.12: Illustration of the three different scenarios. The costs of incineration deducted from the cost*

*for biogas plant, so the incremental cost of biogas production decreases. The additional cost of*

*reference situation is by definition always zero.*

25

This type of energy accounting does not give the full picture, since it does not take account of the shape energy

comes in (bio-gas, district heating, electricity).

**0 kr / kWh**

**0.54 NOK / kWh**

**0 kr / kWh**

**0.15 NOK / kWh**

**0 kr / kWh**

**-0.47 NOK / kWh**

Reference

situation

Biogas

Reference

situation

Biogas

Reference

situation

Biogas

Treatment

capacity

(Tonnes per year)

**Economic increased cost of biogas treatment of organic waste**

**3 different reference scenarios**

Biogas plant

New building incinerators

Expanding existing incinerators

Existing treatment capacity

|  |
| --- |
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As shown in the table reduces the cost of production of biogas powerful if we assume that

biogas plants *replace* expansion of incineration capacity instead of getting *in addition* to

existing treatment capacity. Ranked on the basis of cost per tonne of treated waste reduction

cost of construction of a biogas plant by approximately 84% if it replaces the expansion of

existing incinerators. If the biogas plant replaces the construction of a new

incinerators society will be able to achieve cost savings. The reason we get these

results is that incinerators demand more investment in terms of cleaning systems

furnaces and materials that can withstand high temperatures, which will lead to higher investment costs.

An element that can change the cost picture is if the development of biogas plants require increased

separation of organic waste. A biogas plant can only process organic waste, while a

incinerators do not make equal demands on sorting. If the construction of biogas plants

subject to increased sorting will increase the cost of treating waste in a

Biogas plant relative to the three reference scenarios.

If we consider the cost per unit of energy output reduces the cost by 72% if

biogas plants replace expansion of existing incinerators. But in that net

energy production is reduced, as well as incineration and biogas plants produce different

types of energy carriers, there is a need to nuance this picture somewhat.

First and foremost, a reduction in net energy production give less available clean energy that can

replace fossil fuels in the application. This will isolation suggests that the costs

(U.S. $ / tonne CO

2

-Eq) for scenario 2 will increase relative to scenario 1, if the value chain is included. In

Additionally, the overall environmental impact depend on the energy used. We have the value chains for

buses provided that biogas is used as fuel in fleet vehicles. If the waste instead had

treated in a combustion plant had been able to received the energy in the form of electricity and / or

heat. What electricity and heat used for and what it replaces, will be essential to

assess the treatment of waste overall for best environmental effect. For district heating will

environmental benefits typically greatest when it replaces heat from oil heating. If incineration

also produces electricity, this could in theory replace everything from hydropower to oil-fired heat. It is

also possible to replace the fuel if the marginal power used to power electric vehicles. It

economic net benefit of treating waste in a biogas plant versus a

incinerators will therefore vary somewhat based on what energy used. On a general basis,

we still say that expanding disposal capacity of biogas plants is relatively cheaper if

option is increased incineration without energy recovery. If a possibly developed

incineration capacity is used to replace fossil fuels either for heating or

electricity production, the relative cost of a biogas plant increase.

Although additional calculations made in this section only looks at a limited part of the value chain, we can

nevertheless draw some conclusions: If in the future we are in a situation where it is necessary to increase

Norwegian waste treatment capacity for the economic costs associated with

*production* of biogas from organic waste will be lower, relative to the current cost structure.

Biogas production will become relatively more profitable if it can replace all or part of

construction of incinerators, while lower energy production will reduce the usefulness later

value chain. To say anything more specific about measures the change in costs (£ / tonne CO

2

) Must

application of biogas and energy from combustion plants considered. The main thing this

addition, the analysis shows is that profitability assessment of biogas production will be very

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111

differently if they are in a situation where there is a need for more waste compared to an

situation where existing processing capacity is sufficient.

**Sensitivity Analysis**

We conducted a sensitivity analysis to determine which parameters

26

used in the

calculations that yield the greatest impact on the final cost (production and abatement cost).

The parameters that have the greatest sensitivity will affect the cost picture to the greatest extent, ie it here

important to have accurate numbers. While this indicates also how measures will have the greatest effect. To

make the presentation as simple as possible we have chosen to analyze only selected parameters and

target variables

27

. We have taken us 12 target variables and studied how these vary by 19 different

parameters. The parameters are chosen according to how insecure they are, and how much influence we believe

the parameters have on the target variables a priori. In the analysis, each parameter varied by -50% and

50%. We have only varied one and a parameter to cultivate the effect they have on the various

target variables. The disadvantage of this is that you will not get the potential samvarianseffekter, where

parameters counteract or reinforce each other's impact.

The following parameters have some uncertainty:

• Investment Cost biogas plants

• Gas Dividend

• Operating costs (labor, electricity, maintenance)

• Calorific values ​​for different waste fractions

• Emission factor for waste incineration

• Gate fee for biogas plants

• Business Economic Interest

• Additional cost for gas buses relative to diesel buses

• NO

x

Emissions from gas buses relative to diesel buses

• Cost of investments in filling stations etc.

The following parameters are included because the expected significant variation over time:

• price other fuels (diesel, electricity, natural gas)

• Fuel gas buses

Some parameters, eg. investment costs, is both uncertain today while it is expected that

these costs change significantly over time.

The analysis summarized in tables and figures in Appendix 2

26

With the parameters defined in the underlying figures are based on estimates. For example

investment cost, gas dividends, interest, etc.

27

Target variables are measured at cost either £ / MWh or £ / tonne CO

2

And spans both

economic and commercial values

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***Domain***

The overall analysis shows that the most critical parameter values, the gas yield (kWh

biogas per ton of waste or manure) and the investment costs of the construction of both types

biogas plants. Bus initiative stands out in that it is the fuel consumption of gas buses and

diesel price which is the strongest drivers of variation in cost-effectiveness. The variations in the

traditional operating the biogas plant that works, maintenance and transportation, is less

importance to both economic and commercial profitability. Generally they vary

commercial numbers any more than the social, which means that uncertainty in

figures will have greater impact on the commercial profitability of the various measures.

Table 4.14 shows the uncertainty ranges

28

the various target variables.

*Table 4.14: Uncertainty intervals for the different target variables from the sensitivity analysis.*

**Uncertainty Intervals**

**original**

**value**

**mine.**

**max.**

**max-**

**my**

**Production - manure**

NOK / kWh

1.25

0.87

2.37

1.49

NOK / kWh - commercial

1.27

0.81

2.67

1.86

**Production - organic waste**

NOK / kWh

0.54

0.36

0.96

0.60

NOK / kWh - commercial

0,002

-0.31

0.31

0.63

**Production - The potential**

NOK / kWh

0.84

0.69

1.13

0.45

NOK / kWh - commercial

0.55

0.36

0.82

0.46

**BUS - manure**

U.S. / CO

2

-Eq

2275

903

3417

2514

**BUS - organic waste**

U.S. / CO

2

-Eq

1128

-353

3344

3697

**Bus - The potential**

U.S. / CO

2

-Eq

1827

317

2988

2671

**BUS - Business Administration**

NOK / kWh

0.04

-0.30

0.25

0.55

**Gas Supply RO - manure**

U.S. / CO

2

-Eq

2351

1485

3461

1976

**Gas Supply RO - sambehandling (1:18)**

U.S. / CO

2

-Eq

2207

1460

3074

1614

28

Intervals are found by picking out the maximum and minimum values ​​for each target variable, which means that

minimum value and a maximum value does not need to be triggered by the same parameter.

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***Economic profitability***

As shown in Figure 4.13, the action cost (U.S. $ / tonne CO

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Equiv) of using biogas buses in

mainly driven by the fuel consumption of gas buses and diesel price. High fuel prices will reduce

the costs through increased savings in reduced fuel purchases. This means that it is cheaper to

reduce greenhouse gas emissions, the higher diesel price is for a given gas. A current problem

with gas buses is that they use about 25% more energy than diesel buses, which increases

cost of the use of gas buses relative to diesel buses. In addition, the gas buses' high

energy mean that you get to replace diesel buses fewer than energy use would suggest, and this will

result in lower emission reductions. Since the majority of emissions reductions come from

substitution, this effect will have a major impact on the cost-effectiveness (U.S. / CO

2

-Eq).

The diesel price and fuel consumption are known quantities today, the uncertainty in these expected

to be minimal. On the other hand, uncertainty in future fuel prices could affect

costs ahead of time. If diesel price increases over gas prices, this will lead to it being

relatively cheaper to run gas buses. Technological advances may also be possible to make changes to

fuel consumption, so that gas buses are more fuel-efficient over time. This will probably also

happen for diesel buses, but since diesel technology is more mature, we expect a larger

energy efficiency for gas buses. A likely scenario would be that the price of diesel and

fuel efficiency of gas buses increases, which in isolation would lead to a significant reduction in

the costs using biogas buses. The net effect will depend on the size

parallel movements happening with gas prices and energy efficiency of diesel buses.

*Figure 4.13: Sensitivity analysis of abatement cost in NOK per reduced CO*

*2*

*Equivalent, when all the realistic*

*potential used in city buses.*

-500

500

1500

2500

3500

**£ / tonne CO**

**2**

**-Eq**

**The costs of measures for supply chain with production of the potential and application in**

**City buses**

+50%

-50%

0%

1827

0

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| **Page 114** |

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If one looks at the value chains of biogas from manure and organic waste separately,

diesel price will get a less dominant role. Fuel consumption for gas buses will still be

the most driving factor. For value chain of biogas production from manure will

investment costs are relatively more important, while for the value chain of production based on

organic waste gas will yield a more central role. Figure 4.14 shows the relationship between

sensitive ethylene and estimated uncertainties

29

in 2020 for the various parameters of the value chain where biogas

used in city buses and production based on respectively manure and organic waste. The

is also indicated in which direction (decrease or increase) the costs are expected to move

in. Overall Chart 4.14 shows that the parameters that affect the cost of measures to the greatest extent (far upper

the figure) are largely expected to lead to a reduction of cost of measures to 2020 (green label

the figure). We also see that the uncertainty in the parameters is high.

In the sensitivity analysis varies the costs of producing and using the realistic

potential of buses between 300 NOK / tonne CO

2

-Eq and 3000 NOK / ton CO

2

-Eq. For the same

value chain with production from manure, measures the cost varies between £ 900 / tonne

CO

2

-Eq and 3400 NOK / ton CO

2

-Eq. For biogas production from organic waste will

equivalent charge interval to -400 £ / tonne CO

2

Equiv to 3300 U.S. $ / ton CO

2

-Eq.

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The uncertainty is meant essentially variability in the sense that the internal uncertainty in number in addition to the expected

future development are included.

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*Figure 4.14: Preparation of impact on abatement cost and uncertainty in parameter values ​​in 2020. Color coding indicates*

*direction measures the cost is expected to change as a result of development of each parameter until 2020.*

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Investment

biogas plants

Transport

costs

Labour

costs

Maintenance

Gas Yield

Electricity price

Diesel price

Fuel stations,

flakes, back-up

Fuel

gas bus

NOx emissions

Additional cost

gas bus

**Cost of measures for supply chain with production of biogas**

**based on animal manure and the use of buses**

2020 - reduced cost of measures

2020 - unchanged abatement cost

2020 - increased cost of measures

**Increasing uncertainty in the parameters**

Investment

biogas plants

Calorific value

biowaste

Gas Yield

Diesel price

Fuel stations,

flakes, back-up

Fuel

gas bus

NOx emissions

Additional cost

gas bus

Calorific value

MSW

Emission factor

combustion waste

Transport

costs

2020 - reduced cost of measures

2020 - unchanged abatement cost

2020 - increased cost of measures

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**Increasing uncertainty in the parameters**

**Cost of measures for supply chain with production of biogas**

**based on organic waste and use in buses**

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By feeding biogas to the gas grid in Rogaland picture looks a little different. This value chain

generally have higher costs than the previous example, because the proportion of manure in

production measure is higher. It is also generally higher uncertainty of both

investment costs and the gas yield of biogas production from manure, because it is so

few existing facilities. There are both low investment and operating costs associated with this

application, which means that production costs will dominate.

The investment costs for biogas plants using manure in our model about 4

times lower (per ton of feedstock that can be treated annually) than the investment costs for

biogas plants treating organic waste. It may thus be that the investment costs

for manure plants are somewhat underestimated. On the other hand, it is expected that

investment costs can be reduced ahead of time, if sufficient focus on research. It is

thus uncertain about future investment costs will be higher or lower than

investment costs we have assumed in this analysis. When it comes to gas proceeds think we

that this is underestimated, and we expect the gas yield may rise ahead of time assuming a certain

R & D efforts. This suggests a higher future gas yield, which will result in

future action cost decreases. Figure 4.15 shows the effect on the costs of variation in the

different parameter values.

Uncertainty interval value chain of production based on sambehandling and application of

gas network in Rogaland in this analysis 1500 NOK - 3500 NOK / ton CO

2

-Eq.

*Figure 4.15: Sensitivity analysis of abatement cost in NOK per reduced CO*

*2*

*Equivalent, when 500 GWh produced by*

*sambehandling (1:18) and fed into the gas grid in Rogaland.*

-500

500

1500

2500

3500

**£ / tonne CO**

**2**

**-Eq**

**The costs of measures for supply chain with sambehandling and feed off the gas at**

**gas network in Rogaland**

+50%

-50%

0%

2207

0

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| **Page 117** |

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***Commercial profitability***

The financial cost of production using manure will primarily be driven

gas yield (kWh biogas per ton manure). This is because the number of kWh biogas produced will

determine the income of the producer, as well as production cost (U.S. $ / kWh) is directly influenced by

increasing the amount of energy. Figure 4.16 shows that changes in the cost of investment in biogas plants will

be very crucial for the commercial profitability.

As mentioned earlier, both investment and gas yield very uncertain quantities due

lack of biogas plants primarily use manure as feedstock. However, based on

same argument as above, over time most likely go towards a better

profitability for the producer.

In the sensitivity analysis varies the commercial cost of producing biogas from

manure between 0.81 NOK / kWh and 2.67 U.S. $ / kWh.

*Figure 4.16: Sensitivity analysis of corporate economic losses measured in NOK / kWh when biogas 740GWh*

*manufactured by based on manure.*

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Business Financial deficits in the production of biogas from manure**

+50%

-50%

0%

1.27

0.00

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Biogas production from organic waste has a slightly different profile than the production cost

based on manure. Investment costs and gas yield will still be essential for

profitability and investment costs will have a relatively larger impact on production based

the organic waste than from manure. The major difference in relation to manure

Located in the street fee'en. As shown in Figure 4.17, this is the major driving force behind variations in

profitability. Landfill ban has probably helped boost profitability at other

therapies, including treatment in a biogas plant, by enabling a higher gate-fee.

The investment costs are less uncertain for wet organic plant than animal manure plant, because

there are several existing and planned facilities as points of reference. There is more uncertainty

the gas yield, as this is very dependent on the availability of the different types of organic waste. Some

types of waste is very high in energy and will provide a high gas yield, whereas other substrates may provide a

significantly lower gas yield. It is therefore natural to assume that there will be considerable variation in

profitability for each system. Gate fee'en is also expected to vary between different plants,

means we consider the overall cost estimate as very uncertain. Figure 4.18 illustrates the sensitivity and

future uncertainty, and expectations of future business profitability. Overall, suggesting

shape that future costs are reduced.

Uncertainty interval for the commercial cost of producing biogas from

organic waste is -0.31 NOK / kWh to 0.31 U.S. $ / kWh. That is, presumably, a good portion of this

measure be commercially profitable.

*Figure 4.17: Sensitivity analysis of corporate economic losses measured in NOK / kWh when biogas 990GWh*

*produced from organic waste.*

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Business Financial deficits in the production of biogas from organic waste**

+50%

-50%

0%

0,002

|  |
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*Figure 4.18 Preparation of fluctuations in production and uncertainty in parameter values ​​in 2020. Color Coding*

*indicates the direction of the production cost is expected to change as a result of development of each parameter towards*

*2020.*

Commercial profitability of bus measure will vary fried with diesel prices, fuel consumption

gas buses and the price of natural gas, as shown in Figure 4.19 below. Higher fuel prices means that biogas is

relatively cheaper, and it becomes more advantageous gas buses. In the business economic analysis will

also high taxes on diesel to be a major contributor to profitability by switching to gas buses.

If one example removes veibruksavgiften of diesel (about 38 cents / kWh) or add a corresponding

tax on gas, then the loss of bus companies increase of 4 per cent per kWh to 42 cents per kWh. It should

here mentioned that this applies to all gas buses and not just those running on biogas. Fuel

the gas buses will affect the cost through several channels: reduced consumption will increase

investment costs that requires fewer buses, filling stations etc. for a given quantity of gas.

Meanwhile, several diesel buses could be replaced, and the savings in reduced dieslinnkjøp becomes larger.

As the figure shows, the effect of reduced fuel purchases clearly stronger than the effect via

investments, which means that it is economically profitable to use more fuel-efficient

gas buses.

**Business Financial losses during production**

**of biogas from organic waste**

Gas Yield

Labour

cost

Investment

biogas plants

Maintenance

Electricity price

Interest

(Bedok)

Gate-fee

Natural gas price

Transport

costs

2020 - reduced

deficit

2020 - unchanged deficit

2020 - increased deficits

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**Increasing uncertainty in the parameters**

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*Figure 4.19: Sensitivity analysis of corporate economic loss for the bus company that uses*

*gas buses, measured in NOK / kWh.*

The uncertainty in the discussed variables is relatively small today, while the time evolution is considerably more

uncertain (see Figure 4:20). Diesel price may be changed directly via price or that the fees be changed.

Similarly, natural gas prices could vary over time. A likely scenario would be that both

price of diesel and natural gas price increases over time, as technology allows

energy efficiency of gas buses to a greater extent than for diesel buses. Increased fuel prices and more

energy efficient gas buses will reduce costs, while increasing natural gas prices will lead to higher

expenses. Since both diesel rate and energy consumption have a greater effect on costs, it is

reasonable to assume that the overall effect will be a reduction in costs over time.

The financial cost of using biogas buses vary in this analysis

between -0.30 NOK / kWh and 0.25 NOK / kWh biogas used. This means that here too it is expected that some of the

potential is already commercially viable.

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Business Financial losses by the use of biogas buses**

+50%

-50%

0%

0.04

|  |
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*Figure 4.20: Preparation of impact on business economic cost using biogas and uncertainty*

*parameter values ​​in 2020. Color coding indicates the direction of the cost is expected to change that, due to developments in*

*each parameter towards*

**Business Financial losses by**

**application of biogas buses**

Diesel price

Interest

(Bedok)

Natural gas price

Additional cost

gas bus

Fuel stations,

flakes, back-up

Fuel gas bus

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**Increasing uncertainty in the parameters**

2020 - reduced cost using

2020 - unchanged cost using

2020 - increased cost using

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***Summary - sensitivity analysis***

The two parameters that had the greatest impact in the social production costs,

both substrates, the *investment costs* for the plant and the *gas yield* per ton of feedstock. Since

use of gas mains in Rogaland has very low costs, the total cost of this

value chain being driven by production costs. This means that the investment costs for

biogas plant and gas proceeds will be crucial for the total cost of this value chain.

It is expected that the experience and technological advances will help the investment costs are reduced

and that the gas yield increases over time, which in turn will lead to higher cost efficiency in the production stage.

This development depends on technological progress, which means that R & D investment will be

particularly important to reduce manufacturing costs.

Business Economic production costs will have a strong correlation with the economic

kosta ends, ie investment costs and gas proceeds are drivers here, too. The biggest

difference between the economic and commercial cost drivers is that

biogas plants that use organic waste in the production receive additional income through gate-

fee'en they can take waste treatment. The analysis also shows that this income is the

strongest driver of cost reductions in the production stage. One of the conclusions one can draw

from this is that the commercial profitability of biogas production from manure

would have been substantially higher if these plants had access to a corresponding future.

For the purposes of gas in city buses are *fuel* for gas buses (relative to diesel buses) and

*diesel price* (relative to natural gas price) the strongest drivers of variation in cost. The

expected that the energy efficiency of the gas buses will be higher than for diesel buses. A

likely future scenario is that the price of diesel and natural gas prices will increase. This would then mean

both the economic and commercial profitability of using biogas buses,

will improve over time. R & D will also be able to engage in technology development, while the difference between

price of diesel and natural gas prices can be maintained or increased by the difference between the fee

the two types of fuel, but this will only impact on the commercial profitability.

An important observation is that the commercial profitability of the production of biogas

based on organic waste and the use of biogas buses varies almost as much between

negative as positive values. This means that some of these measures should be profitable already

with current costs.

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**Chapter 5 - Existing measures and barriers**

**Existing instruments**

**30**

There are currently a number of measures affecting the production and use of biogas directly or

indirectly. Figure 5.1 provides a schematic overview of the value chain of biogas and bio fertilizer with

examples of how various existing measures hit. The figure is not exhaustive, but

illustrates some of the relationships and shows that the current measures are effective in multiple joints in

value chain.

*Figure 5.1 Examples of how the value chain existing tools meet (not all measures are taken).*

The figure points to two important measures affecting the supply of raw materials, namely landfill ban of

vårorganisk waste and delivery support in manure. Delivery Support manure to

biogas plant is a pilot scheme from 2013 administered by SLF with a limit of one million

million per year.

To increase production have been established arrangements for investment from both Enova and from

Innovation Norway - which targets different sizes of plants.

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The information in this section is based mainly on descriptions of Earth Course Assessment (CPA, 2010a),

Climate Courses sectoral report for farming (CPA, 2010c), sector report for waste (CPA, 2010b) and Mepex report

*Increased utilization of resources of organic waste*(CPA, 2012).

Fertilizer

Household

waste

Sewage sludge

Industrial waste

Large-scale

biogas plants

Small-scale

biogas plants

Biogas

Up

grading

Transport

sector

CHP

Fertilizer

SURFACE-

plant

Combustion

Flaring

Gas Supply

Heating

NOT EXCLUSIVE

**Innovation Norway -**

**investment**

**El certificates**

**SLF - delivery support**

**Transnova -**

**investment**

**Exemption**

**veibruksavgift**

**Disposal Prohibition**

**Enova -**

**investment**

Bio fertilizer

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To increase the use of biogas in the transport sector will be exempted from veibruksavgift be one of the

important work the agents, together with investment to build infrastructure from

Transnova. The system of green certificates could affect the development of heat & power plants, which also

Biogas can be a source of energy.

Appendix 3 provides a more detailed description of existing measures in the waste sector (Appendix 3a),

agricultural sector (3b), transport (3c) other sectors (3d), as well as overall measures

affecting biogas (3e).

***Waste Hierarchy***

Framework Directive on Waste (2008/98/EC) lays down a fairly detailed waste hierarchy to be

serve as a guideline for the design of waste policy and its instruments. This

hierarchy shows that waste prevention should have priority. It is further stated that the preparation of

waste for reuse shall be given priority over recycling, which will be given priority over

Another utilization of contents (for example incineration with energy recovery and use of waste

fill materials to replace materials that would otherwise be used). Finishing shall have the lowest

priority. The order of priority may be waived for specific waste streams when justified

including technical, economic and environmental considerations. Framework Directive also contains

specific targets for reuse and recycling of household waste.

The state - including the state pollution authorities - are already committed to taking into account

the waste hierarchy and work to achieve recycling targets.

*Figure 5.2: Avfallshierakiet*

**Prevention**

**Preparation for reuse**

**Recycling**

**End-**

**treatment**

**Energy Utilization**

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Priorities in the Waste Framework Directive implies that biological treatment of organic waste by

composting or biogas production and use of residual products from this fertilizing purposes or

soil should be given priority over incineration with energy recovery unless an overall assessment

of environmental, resource and economic factors have come to a different conclusion.

Through controlled landfill ban today organic waste away from landfills, primarily to reduce

greenhouse gas emissions from the disposal of this waste. Organic waste is then either delivered to

incineration with energy recovery, composting or biogas plants. Rest Product

of compost used as fertilizer products or fertilizer, while biogas plant both

producing biogas for energy purposes and provides an organic fertilizer which may be used as a fertilizer product.

***Description of existing measures***

The description of existing measures are divided into measures that increase the supply of raw materials to

biogas plants, measures that increase the production of biogas and actions that increase

application of both biogas and organic fertilizer. The breakdown of the value chain in these three categories are shown

in Figure 5.3 below.

*Figure 5.3: Layout of the value chain in categories that measures directed against*

**Access to**

**feedstock**

**Production**

**Application**

Fertilizer

Household

waste

Sewage sludge

Industrial waste

Large-scale

biogas plants

Small-scale

biogas plants

Bio fertilizer

Biogas

Up

grading

Transport

sector

CHP

Fertilizer

SURFACE-

plant

Combustion

Flaring

Gas Supply

Heating

NOT EXCLUSIVE

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**Existing measures - access to raw materials for biogas plants**

Measures affecting the supply of raw materials for biogas plants is given in Table 5.1. Regulatory

instruments in particular waste industry are important tools. In addition, requirements for

field equipment and support for R & D activities. A more detailed description of these

instruments are also found in Appendix 3

*Table 5.1 Existing measures of resource waste, sludge and manure*

**Existing measures for access to raw materials**

**Comments**

*Economic*

**Tax on the disposal of waste**

**D - Support**

Research Council (Energix program Norklima

program), SLF: Development of mitigation in

agriculture

**Delivery Support from the Norwegian Agricultural Authority**

Is being established. Given to agricultural enterprises that supply

manure to biogas plants. Given in terms of £ / tonne.

Pilot Scheme, will be evaluated in 2017

*Legal*

**Ban on landfilling of organic waste** in

Waste

National prohibition to dispose of wet organic waste (such as

food waste and organic material from the food industry)

2002

**Ban on landfilling of biodegradable waste** in

Waste

From 2009. Prohibition to deposit paper, wood, textiles,

sludge, organic waste with total organic carbon (TOC)

of more than 10%

**Requirements for the collection and treatment of landfill gas** from

landfills receiving biodegradable waste.

Waste Regulations, Chapter 9

Regulations require the collection and treatment of

landfill gas (either energy recovery or flaring)

**Minimum energy recovery by incineration** in

Waste

The permit requires - usually at least 50% - to

process heat or district heating.

**Requirements for the handling of animal waste plastic** li-product regulation

Claims for such sanitation. Management facilities

animal waste must have a permit from the Authority.

Ban on export of waste in Regulation (EC) No

1013/2006 on cross-border transport of waste

(Cross-regulation)

CPA may make objections to a planned export of

organic waste from households and similar waste

catering and trade, in cases where treatment

abroad will only involve energy while

treatment in Norway involves material

**Prohibition of spreading manure** in given periods of

year on frozen ground in Fertilizers Product Regulations

To prevent runoff. Increases motivation for alternative

Use of manure.

**Requirements for fertilizer plan** in Fertilizers Product Regulations.

Fertilizer Plan is an action taken to prevent runoff. Here

the need for fertilizer calculated on the basis of soil

nutritional status and estimated crop. This also motivates

for alternative uses of surplus manure. FSA

manage.

**Requirements for disposal of bio fertilizer** in agriculture and

green area (maximum content of impurities, etc.) in

Fertilizers Goods Regulations.

Fertilizers Goods Regulations governing the maximum content of

heavy metals. Application of digestate in agriculture following

same requirements as for other organic fertilizer products.

FSA supervises.

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**Existing instruments - the production of biogas**

Existing means of production processes is given in Table 5.2. On the production side, it is primarily

investment through Enova and Innovation Norway is operative instruments today.

*Table 5.2 Existing measures the production of biogas*

**Existing instruments for the production of biogas**

**Comments**

*Economic*

**Enova - investment aid** to large biogas plant

period 2012-2014

Supports projects with energy of at least 1 GWh.

The maximum aid intensity of 30% of investment.

**Innovation Norway - investment** to less

farmsteads for biogas production

Up to 35% support for investment and 50% to

study / expertise.

**D - Support**

Research, Energix program Norklima

program

*Legal*

**Requirements for permits** under the Pollution Control Act of

establishment of waste, including

biogas plants

Permission granted by the County

**Requirements for permission to handle animal waste** in

By-product Regulations

Requires permission / approval from the FSA to

treat certain types of organic waste, so-called category II and

III waste.

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**Existing measures - use of biogas**

Existing instruments that regulate or promote the use of biogas is given in Table 5.3.

Investment (through Transnova) for use of biogas for transport is one of several

measures aimed at the user side of the value chain. Vehicles fees affect all vehicles, including

gas vehicles. Because of the high weight, the gas vehicles higher than one-diesel and

gasoline cars, so this is an obstacle to increased use of biogas in the transport sector. Furthermore biogas

not required veibruksavgift, CO

2

Fee, the basic fee for mineral oil or electric charge. This affects the

competitive relationship with other forms of energy in favor of biogas. Another measure affecting

biogas electricity certificate scheme.

*Table 5.3 Existing instruments use of biogas*

**Existing methods for the use of biogas**

**Comments**

*Economic*

**Transnova - investment and more** - the use of biogas in

transport

Supports include reports, filling stations, and

testing of new vehicles.

**One-time, vehicle.** Larger trucks and buses are exempt. Vans,

Minibuses and taxis have reduced rates.

Calculated on the basis of weight, engine power and

CO

2

Emissions and NO

X

Emissions. For details see

Appendix 3c.

**Annual fee, vehicle**

Imposed on vehicles exceeding 7500 kg.

**Weight annual fee, vehicle**

Imposed on vehicles over 7,500 kg.

**Re-registration fee, vehicle**

Calculated on the basis of weight and age of the vehicle.

**Veibruksavgift**

Equivalent to 53 cents / kWh for gasoline, 38 cents / kWh

for fossil diesel

**CO**

**2**

**Tax**

Equivalent to 10 cents / kWh for gas and 5-6

cents / kWh for diesel, LPG and natural gas.

**Basic fee mineral**

Equivalent to 10 cents / kWh. Does not include

fuel and jet fuel.

**Electricity consumption tax**

11.61 cents / kWh ordinary rate

0.45 cents / kWh reduced rate

**Green certificates -** aid scheme for producers of electricity from

renewable sources

Norwegian-Swedish cooperation from 2012 to the end

of 2035.

**Regulations relating to guarantees of origin electricity**

A guarantee of origin is a proof of the

sources of a given quantity of electricity is produced

from.

**Quotas** for energy plants over 20 MW

The emissions trading regulations. Biogas provides zero-counting

if it is not mixed with fossil fuels.

*Legal*

**Natural Gas Act**

Prohibition of discrimination

system users.

**Connectivity Obligation for electricity producers** in § 3-4 of the Energy Act

Affiliation duty was introduced on 1 January 2010, as

that all economically viable

projects are entitled to grid connection.

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**What is being done in other countries?**

**Sweden**

Sweden has invested heavily in the production of biogas for use as fuel for vehicles (fordonsgas) and

European leader in the use of biogas in the transport sector. Total produced

over 1.4 TWh from the 233 biogas plants in Sweden. 50% of the amount of energy being upgraded to

fuel quality (Biogasportalen.se, Energimyndigheten.se).

In the period 2003 - 2008 was 650 million SEK assign to biogas projects in Sweden through

investment programs Klimp (Climate Investment Program) and LIP (Local Investment Programme). They

200 projects have received funding have contributed to the reduction of 170 000 tonnes of CO

2

-ekv/år in the period

2003-10, and are considered in the report "6518 *Biogas ur manure, waste and and residual products "* to be a

significant driving force for the implementation of most Swedish biogas projects.

In addition, it is used both central and local measures to increase demand for biogas

fuel. It includes grants for the purchase of biogassbil, special benefits for

company car taxation for biogas cars, free parking and biogas taxis are still the first taxi in the queue

(Mepex, 2012; Energ Sweden, 2012).

In addition, it created an "environment scheme", where "green cars" have to pay fordonsskatt for 5 years from

vehicle is used. This promotes the general use of vehicles with low emissions, but also provides an advantage

the biogas vehicles. To qualify as environmentally optimized requirement was previously a maximum emission of 120 g

CO

2

/ Km in the combined cycle, and that the car must meet EU's latest emission standards (Euro 5 and Euro 6).

From 2013, this requirement was changed to a calculated maximum emission depending on the vehicle's own weight (see

below). This requirement includes passenger cars, recreational vehicles, light trucks and light buses that are used in

Sweden for the first time from this date. All vehicles sold as environmentally optimized before this will continue to be

environmental cars.

*Calculated maximum CO*

*2*

*Emissions = (the car's curb weight in kg - 1372) \* 0.0457 + (95 or 150),*

*where 95 is used for petrol and diesel cars while 150 used cars that use biofuels.*

Super Environment cars must emit a maximum of 50 g CO

2

/ Km in the combined cycle, and meet the latest EU

emission standards (Euro 5 and Euro 6). Upon initial registration in Sweden will be given a so-called

super environment car premium. This is 40 000 SEK for individuals and sole proprietorships. When the car

owned by another company or organization's premium of 35% of the price difference between the new car price

the super eco-car and the price of the closest comparable vehicle (maximum 40 000 SEK).

In some municipalities it is cheaper, or free, to park a vehicle that meets local requirements

an environment car. Stockholm parking introduced free parking for super green cars on all outdoor

visitor parking (not P-houses and garages) which they have responsibility.

Upon purchase of passenger cars and light trucks by the state government must be of environmental cars.

In 2010, 25% of the Swedish food waste collected for biological treatment. New interim to

reach the goal of 35% collection set for 2018 (Environmental Protection Agency, 6518, 2012). In addition, there is also

goal that 60 percent of the phosphorus in sewage sludge and bio fertilizer should be returned to productive land in

2015, half of which is arable land (Environmental Protection Agency, 6518, 2012).

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To promote manure based biogas production has the Swedish Countryside Ministry in its

program allocated funds for investment support to farms but livestock that will build biogas plants

on the farm (Environmental Protection Agency, 6518, 2012).

In 2010 it presented a proposal for a national multisectoral biogasstrategi as suggested

means of double biogas production in Sweden from 1.5 TWh to 3-4 TWh (ER 2010:23). This

strategy is not adopted, but the following is proposed to increase the production and use of biogas:

• Investment priority should be given to the substrates, which makes it possible to close the circuit, i.e.

waste, sludge and manure

• Biogas production from manure compensated for its climate and environmental benefit with a

special production support or methane reduction compensation of 20 cents per kWh produced

biogas

• Customization of rules for conversion of agricultural tractors and trucks

meta operation

• Tax on fertilizers should be considered

• Biogas in heavy vehicle premieres and regular system of taxation of vehicles including

property taxation of company cars, etc.. adapted so it becomes more attractive to use biogas

in heavy vehicles in fleet operations

• More R & D in bio fertilizer and utråtningsprosesser to improve profitability

biogas plants and improved utilization of nutrients

• Participants in the industry are encouraged to work together to exploit economies of scale

• Requirements for coordination of sewage sludge planning with other waste and energy planning

• Collection of landfill gas should be streamlined

• Strengthen general instruments for renewable fuels, including biogas

**Denmark**

Biogas production from manure in Denmark is largely driven by the agricultural economic

conditions. Since Denmark has much fossil power generation, biogas mainly been used to

electricity production and heating rather than the production of fuel. In March 2012, it was concluded

an energy agreement in Parliament (discussed more thoroughly below), as decided by increased s Totten to use

of biogas for the production of heat, as well as new additions to increase the use of biogas in gas network,

processing and transport. To increase the production of biogas from manure, the cluster

established arrangements with investment into biogas plant and guaranteed prices for the supply of

electricity from biogas. Investment support involves 20% subsidy up to 30 million DKK per

plants and 60% municipality guaranteed loans. 75% of the substrate must be manure. In addition

comes as feed-in tariffs in 2010 was 0.772 DKK / kWh electricity produced from biogas. Tariff

adjusted annually (Mepex 2012).

Energy agreement will lay the framework for the country's climate and energy policy up to 2020-2050, there

Biogas is part of the focus areas. The agreement states that it shall be carried out an ambitious development

of biogas for example by introducing the following measures:

• Increase the existing support for biogas cogeneration

• Increase other use of biogas (natural gas network, in industrial processes or

transport) through financial incentives

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• Increase support to manufacturing facilities from 20 to 30 percent

Developments should be monitored closely by a working group which will also supervise biogas projects. The

allocated substantial financial resources to this working group. Further measures should

proposed for development rate in 2012 - 2013 is not considered to be sufficient.

In the present scenario, there is significant spare capacity on existing facilities. Biogas plants for

manure receives a great deal of food waste from the catering and other industries in Denmark, but

little food waste from Danish households. A portion of food waste to the Danish biogas plants comes from

Norway (Mepex 2012).

Denmark has banned the landfilling of organic waste and has built up a significant

capacity for incineration of waste from household and industry. Incineration with energy recovery

is now the main solution for organic waste generated in households (Mepex 2012).

Denmark until 2003 requirements for the collection of food waste from catering centers that generated more

than 100 kg / week. The requirement was removed when it was forbidden to take food waste as feed for

livestock to prevent infection. Much of this food waste is subsequently delivered to the biogas plant.

The focus on biogas in agriculture, however, can lead to a further increase in biogas capacity

receipt of organic waste from agricultural and industrial waste (Mepex 2012).

**Germany**

Germany adopted in 2010 a "Energiwende" (energy conversion) with a target for renewable energy

to be the main source of energy in 2050 (60% of total energy consumption and 80% of

electricity production) (BMU, 2011). To reach this goal, it was decided many instruments,

including some that affect biogas production. Biogas production in Germany is largely

based on energy crops as sambehandles with manure. The gas is then used to

electricity production. The manufacturer of biogas receive a feed-in tariff (feed-in tariff) for

electricity depends on the following criteria (source: "Biogashandbuch Bavaria" and the Wood Venture)

• When the system came into operation. The sooner, the higher feed-in tariff (a reduction of

1.5% per year). How were you given an incentive to make investment decisions as early as

possible. Feed-in tariff is calculated based on the year the plant was in operation and is thus guaranteed for

20 years.

• How big the plant is. The smaller, the higher feed-in tariff. This meant that small

plant was profitable.

• If raw material consists of plants, crop residues and manure ("NawaRo"). This meant that

it was profitable to invest in energy crops instead of waste products.

• If there are more than 30% manure as input to the plant.

• If the heat from the heat & power plant is utilized, for example, by feeding in a near-or

district heating networks.

• If the unit is particularly innovative - that, for example, using micro gas turbines or

upgrading biogas to natural gas quality.

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For small plants (<150 kW

el

) Which started in 2007, uses only "NawaRo" as input in

system (including 30% manure), which recovers heat from heat & power plant, the tariff

be:

*Basic tariff of € 10.99 cents / kWh + NawaRo bonus on 6 € cents / kWh + manure bonus of 4*

*€ cents / kWh + heat bonus of 2 € cents / kWh =****€ 22.99 cents / kWh.***

With an exchange rate of 7.4 NOK / EUR is equivalent to a feed-in tariff of **1.7 U.S. $ / kWh** , which is then

guaranteed for 20 years from the year in which production began.

**Which barriers experienced?**

In the following barriers experienced by biogas industry and other key stakeholders will be

discussed. The chapter is mainly based on input received through the survey and

input event organized by CPA. In addition, forms review of reports and other relevant

fabric background for the description of the existing barriers.

The survey was sent out by the CPA in December 2012 to around 100 players in biogas.

Both manufacturers, users, government agencies, research institutions and NGOs

chance to comment on the conditions of the biogas industry. The question regarding barriers were

as follows:

*Describe what you see as the key barriers to increased production and use of*

*biogas in Norway.*

Overall, it received 35 responses to this question, with a good spread of different players. Answers

points to the barriers in terms of financial, legal and knowledge related species with regard to access

of raw material, production and use of biogas. The answers are presented later in this chapter,

systematized in general statements and by the various links in the value chain. More information

survey are also found in Appendix 4

Input meeting was held on 11 January 2013. A total of more than 50 people from different parts of

biogas industry, government, research institutions and environmental and advocacy organizations.

Approximately 14 participants made presentations in which their views were presented. In addition, many

comments and questions along the way from an engaged audience.

**Access to raw materials for biogas**

In terms of access to raw materials point questionnaire that resources are spread out geographically, and

that it is often young actors. The supply of raw materials is small today, and it's uncertain future

access. Moreover plays more into the competition with foreign enterprises for raw materials is a barrier.

It is pointed out that a large proportion of organic waste is incinerated, and this is mentioned as a problem

in relation to available resources. Results from the survey presented in Figure 5.4.

The input meeting it was pointed out the need to introduce legal measures to promote

of resources for food waste, ie demand for separation of food waste from households and

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possibly from industry with similar waste. Furthermore, there were suggestions that the planned aid amount in

Delivery Support manure into biogas plant is considered to be too low.

There were also suggestions of a lack of knowledge and technology in relation to the exploitation of new substrates

such as energy crops, marine resources and various mixtures of raw materials.

*Figure 5.4 Input from the survey - access to raw materials.*

**Production of biogas**

During production pulled lack of commercial profitability emerged as the major barrier.

This is considered by nearly half of respondents in the survey. Some

specifies that their answers are for the agricultural sector. Lack of simple and predictable

aid is a variant of the same barrier. Results of the survey regarding

barriers to increased production seen in Figure 5.5.

Several contributions also point out that lack of long-term framework makes it risky to make decisions

about investments in facilities and infrastructure. It was also pointed out that current legislation makes it difficult

to the public-private partnership. It is also noted that it is necessary to clarify the requirements and regulations of

relation to the management of bio fertilizer and management of nutrients in the waste and manure.

Lack of knowledge and experience and the need for technological development is also frequently mentioned. It is

recorded a need for more knowledge about the following points:

• Optimal operation of the biogas plant

• Ideal mixtures of substrates (eg waste + farmyard manure)

• manure-based systems

• Energy efficiency in plant

• Technology adapted to Norway for cold climates

• The use of organic fertilizer

• Processing of biogas

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Difficult access to raw materials, uncertainty, small players

Competition from abroad for raw material

Distributed / spread resource

Lite appropriate regulations for manure / digestate

**Barriers - Access to raw materials**

**(Number of comments from survey)**

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*Figure 5.5 Input from the survey - production.*

**Use of biogas**

Results of survey on barriers to increased use is shown in Figure 5.6. Low

energy prices are considered as an important barrier. Biogas can not compete with the established

energy forms. For city buses reinforced this by the fact that gas engines have relatively low efficiency and

thus high fuel consumption. However, it is likely that there will be a type of development, so that

efficiency of gas engines are on par with gasoline / diesel engines.

Further preferred investment costs of vehicles (including buses) up by more. It is generally

higher investment costs for a gas vehicles compared to petrol / diesel. It is pointed out that

registration tax on vehicles has a misalignment since it provides disfavor for biogas vehicles due

that they have a high weight. If, in addition, has a large fuel tank as back-up, the CO

2

Emissions

for petrol by calculating CO

2

Component of the registration tax. Otherwise, the CO

2

Emissions for

natural gas. More on this as well as some examples of this can be found in Appendix 3c.

Moreover, the lack of commercially developed distribution network / infrastructure and gas market

referred as an important barrier of several. It was also pointed out that it must be established filling stations in Norway,

and retailers of biogas vehicles are ready to import.

Unpredictable conditions in the transport sector is highlighted, particularly with regard to exemption from

veibruksavgift.

In terms of bio fertilizer is considered a lack of appreciation of organic fertilizer as a barrier. It must also be stated that

regulations in relation to the fertilizer does not promote the use of organic fertilizer. The market for bio fertilizer is not well

established, and it is pointed out a need for support for this.

*Figure 5.6 Input from the survey - application.*

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Missing bedrifsøkonomisk profitability

Lack of knowledge of experience of operation of plant

Lack of simple and predictable støtteordnigner

**Barriers - Production**

**(Number of comments from survey)**

5

4

5

2

Lack of infrastructure for gas

High investment cost vehicle

Low energy prices

Unpredictable conditions in the transport sector

**Barriers - Application**

**(Number of comments from survey)**

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**General**

In general, there are many who point out that a major barrier is the lack of long-term and

predictability with regard to legislation, tax levels and support that allows the potential for

production and use of biogas is not triggered.

Lack of knowledge in public administration in general was also cited as a barrier. The

also pointed out that there is insufficient political support of the work of biogas in most places, but

Oslo is highlighted as a positive exception. Lack of knowledge of relevant industries in general

stated also that barrier. Missing markets and consistency between production and consumption was also

highlighted as a key barrier. The cost generally in the value chain is also pointed out in many

inputs. Results from the survey in relation to general barriers seen in Figure 5.7.

The input meeting were several pointed out that biogas not be seen in a larger perspective. One has

consider production and biogas in a value chain, with many "spin-off" - effects, including

regional development and the creation of new jobs. Better documentation of climate effects

production / use of biogas was also mentioned.

It was also pointed out the challenge of exporting leak if not created equal conditions for

biogas in Norway as in neighboring countries. Benefits of biogas as reduced greenhouse gas emissions and

higher share of renewable energy will flow to others.

It was also strongly emphasized that bio fertilizer must be included for the attainment economy

biogas projects. Organic fertilizer is today often not considered as a resource, but as waste.

*Figure 5.7 Input from the survey - general barriers.*

4

6

6

High cost / Maglet support

Lack of predictability with respect. taxes / subsidies / regulations

Lack of knowledge in both industry and government

**Barriers - General**

**(Number of comments from survey)**

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**Summary of barriers**

Based on the feedback above summarizes the major barriers to be:

• Lack of long-term existing financial instruments. This is particularly true

advantage that exemption veibruksavgiften provides. The Government has announced that the exemption

veibruksavgift for biogas are removed during the period 2015-2020. This creates uncertainty and small

willingness of private investors to make investment decisions in production facilities, infrastructure

and equipment for the use of biogas. Enova biogas program of investment has also

relatively short duration (2012-2014).

• Lack of commercial profitability. In spite of existing instruments can not

investment and operating costs of biogas production are covered with today's energy prices.

This particularly applies to systems based on manure.

• The regulations in the agricultural sector limits the possibility of using organic fertilizer.

Fertilizer Product Regulations will discriminate use of liquid bio fertilizer, since the requirements of Regulation

related concentrations of heavy metals to solids. Dewatering of organic fertilizer will be

helping to raise the cost of treatment costs.

• The regulations in the agricultural sector provides few incentives to apply manure to

biogas production.

• To the time of raw material. The rules in the waste management system is not designed to promote the use of

waste for biogas production. A large proportion of organic waste is not sorted out and go to

combustion.

• One-time fee for vehicles. Calculation examples show that for private cars may even be tax

10-65% higher for a gas vehicles compared to the corresponding bensin-/dieselkjøretøy.

• The market for biogas is small and gas infrastructure deficiencies. This makes it difficult to

adjust supply and demand.

• Lack of knowledge (R & D needs) of the substrates that yield the highest gas yield compared

for biogas production from manure, new substrates and sambehandling of

manure and organic waste.

• Lack of knowledge *dissemination* in the industry in terms of biogas production based on

manure, sambehandling of manure and biowaste and use of new substrates.

• Lack of knowledge (R & D needs) the overall environmental benefits (including greenhouse gas emissions) associated

the production of biogas and organic fertilizer. This makes it difficult to appreciate the positive effects

of biogas production.

• Lack of knowledge *dissemination* in the industry regarding the use of organic fertilizer in agriculture.

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**Chapter 6 - New instruments, strengthening of existing measures and**

**instrument menus**

In this chapter, we give first a brief summary of the findings in this report so far, since

these add conditions for many of the reviews for remedies. It follows a

discussion of some relevant measures and a summary of the feedback from

survey. After this, we present a tool menus that can form the basis for

to achieve different goals. Finally, the possible new measures and proposals for strengthening existing

means.

**Brief Summary of assumptions**

By the realistic potential for biogas production by 2020, about 20% have already deployed. These

plants are mainly plant based on the sewage sludge and the accumulation of landfill gas. In addition

there are some biogas plants have been built in recent years, which is under construction or near

realization, these plants are larger than many of the existing facilities and are more

based on organic waste. The remaining potential for biogas production in the short term

dominated by organic waste and manure. In the longer term, other raw materials become important,

but it is not discussed further here.

Organic waste and manure can combine to enable the production of around 1.7 TWh of biogas

annually, if the potential is triggered. Around 40% of the potential is in manure, while

About 60% is made up of organic waste. The production of biogas from manure avoids

release of significant quantities of methane and nitrous oxide from the current operation, while

emission reduction of production from organic waste will be negligible since combustion and

composting of waste and relatively small emissions. In order to maintain energy production

incineration plants after wet organic waste is removed, one must also increase metabolism

of waste in Norway, which in turn results in increased Norwegian emissions. In the *production stage* of biogas is

thus only manure that contribute to emissions reductions, 152 000 tonnes of CO

2

-Eq

,

while

organic waste leads to a marginal increase in emissions of 7,000 tonnes CO

2

-Eq.

If the biogas is utilized as a fuel, for example buses, one will also obtain a reduction of

greenhouse gas emissions because it replaces a fossil energy source. When one looks at the entire value chain in such a

example, about 29% of emission reductions occur in the production stage, while about 71% of

emission reduction occurs in the application of the biogas by the utilization of the entire realistic

potential of manure and organic waste.

When one looks at the value chain for the production of biogas from the manure and biowaste

waste and then using biogas as a fuel, the utilization of the full potential cause

a reduction in greenhouse gas emissions by about 500 000 tonnes of CO

2

-Eq. Around 60% of the emissions reductions

derived from biogas produced by manure, with a relatively high abatement cost of 2300

£ / tonne CO

2

-Eq. The remaining 40% of the emission reductions attributable to the production and application of

biogas from organic waste, which has a lower abatement cost of 1100 U.S. $ / ton CO

2

-Eq. It

average cost of measures for the potential is 1800 NOK / ton CO

2

-Eq. In this calculation

however, it is not considered that sambehandling of manure with organic waste will

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could lead to an increased gas yield and thus a lower-cost option, so that the actual

measures the cost can be less than 1800 U.S. $ / ton. It is also important to remember that there are effects that are not

is quantified in the economic calculations that can lead to changes in

action costs. It is also assumed that biogas plants are in addition to existing facilities,

that is, they result in a net increase in capacity for waste in Norway. If one

instead had looked at the situation where the matter will increase the capacity and to choose between

biogas and incineration, the cost of measures to be different and probably lower.

The production of biogas from manure is nevertheless considerably more cost-intensive than

production from organic waste, both from an economic and commercial

perspective. In the socio-economic consideration is due to two main factors:

1 Firstly, the reference scenario (alternative-cost) associated with the treatment of

manure that is spread on the fields. You do not need to build and operate a plant,

or transporting manure far. For organic waste is however reference to

burn or compost the waste, which anyway would give charge of transporting

waste, the operation of a combustion or composting plants etc. Hence, the biogas treatment

of waste is not as great additional cost in the economic calculations

compared with manure. However, considered the spring of 2013 stricter

manure storage and spreading of manure care regulation, which will entail costs among

Others increased storage capacity for manure. Alternatively, these requirements could be met

through provision of manure for biogas plants. In this case, the economic

cost of biogas processing of animal manure are reduced.

2 The most decisive reason, however, the low gas yield from manure, which makes

requiring many more or larger biogas plants than needed for wet organic waste,

To produce the same amount of energy. On the other hand, plants that treat

organic waste require pre-treatment, which is necessary for

livestock facilities. Investment Cost per unit of energy that is produced is still 50%

higher for manure than for waste facilities

In the commercial calculations get wet organic waste another advantage compared with

manure: the supply of organic waste to a facility that will deliver waste to pay

a street-fee

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. We have estimated this to be 700 U.S. $ / ton. This means that biogas production based

the organic waste is virtually economically profitable if biogas is sold to

natural gas price. This assumes, however, that organic waste is separated as fraction. For

getting tripped *the* potential for biogas production from organic waste watching it therefore appears that

it may be necessary to introduce measures to obtain the wet organic waste fraction in a

form that makes it suitable for biogas production.

This suggests that it will not be necessary with strong economic incentives in

production stage. Here barriers as lack of long-term and predictable, both with respect.

raw materials and the demand for biogas and bio fertilizer, be more decisive for the potential

not triggered, than actual profitability. To reduce these barriers, increased predictability

legislation, tax levels and support is important. Feedback from the survey

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Gate fee: The price of waste owner pay on delivery to the disposal facility, in dollars / ton waste

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indicates that the lack of profitability in the production stage is one of the main barriers to

investment is a very in demand means here. This suggests that access to capital is a

barrier to get triggered systems. It is also possible that some of the assumptions in our calculations are

too optimistic. In addition, in the commercial calculation provided that they have access to

organic waste and that there is a buyer for biogas. If you want to trigger potential should

therefore concentrate on instruments that allow the creation of a market for biogas, as well as the

wet organic waste actually delivered to the biogas plant. In order to secure raw materials for biogas plants are

measures that increase the degree of separation of wet organic waste and measures to prevent alternative

treatment (such as the ban on incineration of waste) can be introduced.

The use of biogas as a fuel for buses, according to our calculations almost commercially

profitable. It therefore requires only minor incentives to trigger this type of application. At the same

analysis shows that profitability is dependent on high fuel prices, or more accurately a large enough

difference in price between diesel and gas. Both natural gas and biogas are exempt veibruksavgift, which

can be seen as an indirect support to the gas at around 50 cents per kWh. If gas is required

veibruksavgift in line with other fuels, the commercial *deficit* for bus companies

who choose gas buses rather than diesel buses will increase from 0.04 to 0.44 NOK / kWh.

If the biogas production in Norway to achieve maximum reduction of greenhouse gas emissions, the entire

potential is triggered, both from manure and from organic waste. If biogas production should be seen

as a measure to achieve very specific goals, such as reducing greenhouse gas emissions

specifically from the agricultural sector, it has introduced measures which triggers the production of biogas

manure. Since biogas from manure has been found to be considerably more expensive than

biogas from organic waste (partly because of high investment costs and low

gas yield), it may be appropriate to invest in research and development in areas such as

concerning biogas production from manure to develop new solutions that lower costs.

It is also high uncertainty in these cost estimates, because one does not have empirical data from larger

biogas plants in Norway. One possibility would be to establish means intended to trigger a few

construction, and use these facilities for better empirical data on investment and operating costs. In addition

can be conducted R & D in part to optimize gas production technology,

Composition of raw materials, the quantity and properties of organic fertilizer for fertilizer effect and

emission factor for proliferation compared with emission factor of rågjødsel. After this, one can have

a better basis for designing measures to establish more plants.

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**Discussion of some relevant measures**

**"Push" or "pull"?**

To get triggered a significant biogas production must achieve profitability in the value chain.

This is however not necessarily tantamount to provide support at all levels. If, for example,

provides a significant support to the use of biogas used in the transport sector, this will create a greater

demand for biogas ("pull"), which in turn will increase the price of biogas, thus profitability

production stage.

An alternative is to "push" the substrates into the value chain, for example by introducing legal

instruments required separation of organic waste and requirements for biological treatment of

waste. Increased supply of raw materials will reduce the cost of production of biogas and lower the price of

final product.

As we have seen in Chapter 4 of this report, biogas production from organic waste

significantly more economically profitable than production from manure. Causes

this is that the gas yield from organic waste is higher and because waste facility receives a gate-fee when

it receives organic waste. If one introduces strong "pull" measures will therefore

mainly trigger the construction of biogas plants that use organic waste as substrate.

However, it is important not to make the processing of organic waste so profitable, that this reduces

focus on waste *prevention* .

To get triggered increased use of manure as a resource in biogas production, it means that

"Pusher" raw material in the market efficient. Financial aid and legal instruments will

could have an impact on this. Investment and / or production support combined with requirements

the incorporation of manure or differentiated rates based intervention, are examples

described in this chapter. Furthermore, also stringent requirements for storage and distribution of

manure described as a legal instrument.

**Investment or production support?**

When you will provide support directly to a biogas plant, there are basically three options:

1 Investment for the plant

2 Production support per kWh produced gas or per tonne treated

3 A combination of investment and production support

An investment provides greater predictability for the manufacturer than production support in that

support determined when the investment made while a production support may vary with time. This

greater predictability in investment aid reduces the risk of investment and reduces

Thus the annual cost of capital. Another advantage that it is possible to associate the allocation of

investment support for an interference requirements for manure, or any other requirements.

Investment provides weaker incentives to maximize gas production than

production support.

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A production support in U.S. / kWh will provide a stronger incentive to maximize biogas production than

use of investment. Whether there is a need for such an incentive is however unclear. If one

is not combined with a requirement for incorporation of manure in the plant, a production support cause

that plants will generally choose to treat organic waste, since the gas yield is higher here,

and that one gets revenue from gate-fee. If you want your plants to treat manure

it is possible to either connect production support for an interference requirements for manure, or

differentiated rate on the basis of interference percent. In order to provide sufficient predictability to

players in the market, the size and conditions of a production support be guaranteed in

several years. If you do not have this predictability, the risk of investment is increased,

which in turn increases the cost of capital. Since production support depends produced

gas flow, this provides greater risks associated with revenues compared with investment.

This increases the capital cost of the plant.

A production support can be designed to either be granted only to new biogas plant, or so that

existing facilities are supported. In this way one can avoid discrimination between new and old

plants, which are much more difficult if an investment introduced.

A combination of investment and production support, where production rests on a guaranteed

level for a long enough time to come, can be a good solution for market participants. It is conceivable that one

In such a model can reduce the number of years of production support should be guaranteed for comparison

with a clean production support. A disadvantage of this model is that it will require some increased

administrative resources to manage both schemes.

**How fast increase of biogas production is desired?**

If there is a desire to have caused much of the potential in the space of a few years, you

tool design provide incentives for this. Some examples of this are:

• High production support facility begins production early

o For example, 0.80 NOK / kWh for biogas production starting in 2014, guaranteed

for example 15 years ahead

o Reduction of the amount of aid by 0.05 NOK / kWh for each year later the plant begins

production, guaranteed for 15 years

♣ Construction starting up in 2015, is a support amount of 0.75 NOK / kWh

♣ Construction starting up in 2016 is a support amount of 0.70 NOK / kWh etc.

• Increased investment to plant being built early

o For example, 50% investment support facility that will be completed by 2015

o Cool down to today's 30% investment up to 2020

While this may lead to a rapid increase in the development of biogas, it is important to note that

It also may reduce the ability of learning and adaptation during which increases the risk

for unsound.

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**How to prevent fossil natural gas displaces biogas?**

The application is fossil natural gas and biogas perfect substitutes (assuming that biogas is

upgraded to natural gas quality). For example, by providing support to purchase gas-powered vehicle,

therefore not only support biogas use, but also to the use of fossil natural gas. The effect on local

air quality will be similar to the application of these two fuels, but the effect on inter alia

greenhouse gas emissions and contribute to a transition to renewable energy is very different. When introducing

instruments in use since for biogas is therefore important to consider whether they should simultaneously introduce

measures that prevent increased use of fossil natural gas. This can be a difficult balancing act, since

Fossil natural gas is used as back-up to ensure adequate supply of biogas

value chain. If the gas price to the consumer increased significantly (for example, due to increased

tax on fossil natural gas), therefore the cost of biogas use also increased although not to the same

scope. Measures that limit natural gas use could destroy the construction of infrastructure

and supply side and introducing biogas depends.

A possible solution to this could be to increase the tax on fossil natural gas, unless there is a

Biogas interference, for example at least 30%. Incorporation requirement may be increased as

biogas production in Norway increased. Incorporation requirement may also be replaced by a wagering requirement per

tank station, ie fossil natural gas is exempt from tax provided that, for example, a maximum of 50% of

turnover of the gas per calendar year.

**Use of tax on alternatives to biogas**

One way to increase the production and use of biogas is to increase the prices of alternative fuels

through a surcharge. The fee does biogas relatively cheaper than the alternative and thus incentives to

substituting for example diesel with biogas. Use tax is often the most cost-effective

instrument for reducing a problem such as greenhouse gases. The reason is

that it leaves the decision on how emissions should be cut to end users who are often the

know best how to do this at the lowest possible cost. Taxes on polluting energy sources will

also be in line with the Pollution Control Act intends that the polluter should pay. Decentralized

decision making tax cost effective but is also what makes the instrument is less

apt to elicit specific solutions such as the use of biogas to reduce emissions from

transport. For example, an increase of CO

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Tax on fuel with 0.40 NOK / liter for our

calculations make biogas business sense, given that the bus companies to purchase biogas

natural gas price without tax. This will increase the production and use of biogas in the transport sector. It is

however, difficult to estimate how much of the potential for the use of biogas which is triggered by such

tax increase because the fee can also trigger other solutions such as increased involvement of

biodiesel / bioethanol, more electric cars or more fuel efficient vehicles. We have therefore chosen to ignore

From this type of financial instruments when below has made instrument packages as we

assumes that the primary objective is to increase the production of biogas. Nevertheless, it is clear that any

form of higher prices for alternative fuels will provide increased incentives for the production and use of

biogas and the relatively moderate tax increases may make it economically profitable to

produce and use biogas.

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**Discussion of legal and informational measures to increase the supply of organic waste**

**the biogas plant**

There are some measures that can help to increase the supply of organic waste for biogas plants,

including:

• Requirements for separation and biological treatment of waste

• Prohibition of incineration of waste

• National target for biological treatment of waste

A legal instrument for achieving greater separation of food waste is to *introduce a rejection of*

*food waste* . Municipalities are above pollution law to provide for the collection and

treatment of household waste. Industry actors are not bound by municipal election of

handling solutions, but has an independent responsibility for delivering waste to approved.

It may be appropriate to align the requirement for sorting the food waste from households and

catering / commercial and non organic waste in general, because the food waste from

residential / institutional households are harder to get into the market without sorting / recycling

from other waste. Increased availability of organic waste from other types of employment (such as

food processing) for biogas production, is expected to be easier when the waste largely

generated in the clean waste streams.

The requirement for separation of food waste can for example be paid to municipalities over a certain size and

or businesses in the catering trade and generating over a certain amount of food waste

per week. The requirement for separation of food waste should be organized so that it leads to recycling, and not to

central sorting through the MBT method (mechanical-biological treatment), because experience shows that

source separated food waste and cleaner than compost and biogjødselprodukter Central sorted waste.

To ensure that the separated waste goes to biological treatment and nutrients

bio fertilizer / compost used, it introduced an additional requirement that the *unsorted food waste should go*

*Biological treatment* and *nutrients to be returned to circulation* . This requirement may be directed to

waste possesses as an obligation to deliver food waste for biological treatment where residual products

(Compost and organic fertilizer) is utilized. This requirement may also be aimed at the treatment plants.

Requirements for separation and biological treatment of waste will not necessarily lead to a

capacity building for biogas treatment in Norway, but can also lead to increased exports. We know that

In 2010, exports totaled about 70 000 tonnes of food waste from Norway to Denmark and Sweden for biological

treatment. In addition, this instrument also lead to increased composting instead

Biogas treatment.

Requirements for separation of food waste and biological treatment could lead to an increase in the number of

biogas plants in Norway. Predictability in the municipal food waste, will provide plant owner

long term perspective of access to raw materials required for construction of facilities. If plants

dimensioned so that it is possible to treat the waste beyond household waste, this can also lead

an increase of biogas processing of industrial waste.

*An alternative means to demands for separation of food waste is to introduce a ban on incineration*

*of food waste.* requirement may be directed to plant victory, partly also to possess waste (municipal,

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private and public entities). If the claim is directed towards the combustion plants, the plants themselves

controlling residual waste delivered to the facility. Since it is not technically possible to sort it all out

food waste from other waste, the requirement structured as a percentage of claims against the content of food waste in

residual waste that can be incinerated. This requirement may lead to increased exports of waste to

energy for example in Sweden or Denmark.

A requirement for separation of food waste can be combined with a *national target* for *the amount of biowaste*

*waste* to be biologically treated in a particular year. To facilitate the objectives, it may

limited to food waste and non organic waste in general. For example, a specific target as

to be achieved within a given year be a control signal to municipalities and private operators of their choice

Waste solutions. Such a goal can be a basis to determine other specific measures to

achieve the objective. It may be considered whether to set various interim destination, eg. in two stages

with an evaluation when the goal of stage 1 is reached, as this provides the opportunity to assess the environmental benefits of

measures and change remedies under this process.

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**Feedback from the survey - instruments**

The replies have been received in connection with the survey provided a number of suggestions to

means necessary to increase the resource base, improve production and increase the use of

biogas both in transport, but also for heating purposes. It should be noted that the value chain

both for bio fertilizer and biogas is important and measures are proposed to increase the demand for

both types of products.

To increase resources for biogas, it is pointed out both economic and legal instruments.

Ban on incineration of waste and requirements for separation of food waste from household,

catering and trade proposed by others. It also proposed subsidies for biogas production

based on manure and other raw materials.

In connection with the production of biogas and bio fertilizer, it is primarily economic instruments

mentioned. This agrees well with the answers given regarding barriers in the

survey - the main problem is the lack of profitability in the production stage.

Operating mentioned by others, while a form of investment for production is the instrument that

mentioned most frequently. Supporting production from manure is specifically mentioned by several.

For the final market are the financial instruments in the majority. Support vehicles and infrastructure, and

long-term tax exemptions on both biogas and bio fertilizer is suggested by many. Change of

registration tax, so it gives poor results for "heavy biogas cars" and "green certificates" for

Biogas is also mentioned. But legal remedies have been proposed, including requirements for municipalities and

public enterprises to use biogas.

In general, the more input on support for research and development. Need for more effective

processing and optimization of substrate compositions, improve resource utilization / increase

gas yield, mentioned by several. Need for knowledge about fertilizer effect and climate using

bio fertilizer is also important R & D areas.

*Figure 6.1: Summary of the survey - instruments*

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RAW MATERIAL

Requirements for separation of wet organic fraction

Ban on burning of organic waste

Support for the introduction of manure

PRODUCTION

Operational production

Investment manufacturing facility

APPLICATION

Investment vehicles / buses

Investment infrastructure

Requirements for biogas in public / fleet vehicles

Green energy prices / increase the CO2 tax

Operational use of digestate

Long-term tax freedom (veibruksavgift)

GENERAL

Support for research and technological development

**Means - the number of inputs from the survey**

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**Examples of tool menus**

To increase the production of biogas, it is appropriate to consider several type of instruments

context, depending on the goals to be achieved and in what way. One goal is of course to

increase the production and use of biogas, but this can help achieve other goals simultaneously.

Examples of goals include reducing emissions of greenhouse gases (or in some specific sectors), increased proportion

renewable energy in the transport sector, increasing employment in rural areas, increased resource utilization in

organic waste, more recycling, etc. Depending on the goals that are most important to achieve, can

means be assembled in different ways. Furthermore, different combinations of instruments

used to achieve the same objective. We outline three tool menus in this chapter to

illustrate some possibilities. It is of course possible to imagine many other remedies menus,

such combination of pull and push factors, which can achieve the same or different

objectives. Instrument menus presented are not impact rated, but it's done

some qualitative considerations about the advantages, disadvantages and risks of each menu.

***Instrument Menu 1: "pull"***

It is possible to create a tool menu based on pull-factors in the value chain, as discussed earlier,

For example, focusing on the use of biogas in the transport sector. A possible menu is to introduce

• Feed-in-tariff

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the biogas producer, the sale of biogas filling stations

• Subsidy to tank station that covers the incremental cost of biogas relative to retail

• Fee for nitrogen and phosphorus in fertilizers

To ensure that the biogas is used in the transport sector, one can imagine a tool that provides a

guaranteed feed-in-tariff for biogas sold at filling stations. Fuel stations are then obliged to sell

biogas at a price that is slightly lower than the gas price to the transport market. If a subsidy to

filling stations, the state pays the difference between the feed-in-tariff and retail, as illustrated in Figure 6.2 below.

*Figure 6.2: Illustration of the feed-in-tariff*

For filling stations already sell gas as fuel, this solution does not cause any

costs. Fuel stations that have gas pumps at present will have to invest in this. It may

conceivable that imposes stations that have a large sales volume to offer gas, alternatively, one can

imagine a investment aid stations. If the measure is aimed

fleet vehicles, it will not require as many new gas pumps. One can imagine that means therefore

for some years directed towards fleet market, with a view to include private car market later.

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A feed-in-tariff acts as a price guarantee to ensure that the manufacturer will cover production costs.

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In Chapter 4 we have seen that the basis of our calculations, the use of biogas buses in a

commercial loss of 4 cents / kWh (including investment and operating costs for

filling stations, flakes and backup system). This is partly based on the biogas purchased at

natural gas price. If biogas can be purchased for around 4 cents / kWh less than the natural gas price,

measure be profitable for bus operators. One of the assumptions here is that the difference between

price of diesel and gas prices remain constant. If the gas charged veibruksavgift so

the difference is reduced, the retail price of biogas is further reduced in order to maintain

profitability of bus companies.

To stimulate biogas production from manure can feed-in-tariff for biogas

set at different levels depending on the amount of manure used in biogas production, see

Figure 6.3 below. Since biogas production from organic waste, according to our calculations,

economically profitable if the biogas can be sold to natural gas price, need feed-in-tariff

for biogas made from waste to be very much higher than the price of natural gas

This combination of feed-in tariff and subsidies designed as described above will cause the

we increase the production of biogas, and that the biogas will be used for transport purposes. The amount

biogas from manure that is triggered depends on the slope of the feed-in-tariff. By

Guide rise in feed-in tariff steeper or flatter can get triggered more or less of

potential for biogas produced from manure.

*Figure 6.3: Possible feed-in-tariff for biogas sold at filling stations. The figures are only illustrative.*

To ensure that organic fertilizer is used as fertilizer in suitable areas can impose a tax on

nitrogen and phosphorus fertilizer. This will make it more attractive for agriculture to use

organic fertilizer instead of using fertilizer. The fee will also make it more attractive to use

manure as fertilizer on the soil, ie the instrument is less effective governance with a view

the increased biogas production. This instrument can also cause adverse regional effects since

regions with easier access to bio fertilizer and manure will have greater profitability than regions

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without such access. Simultaneously, the instrument does not prevent it from spreading too much organic fertilizer in some

areas. A stricter manure care regulations than the current regulation with closer monitoring is considered

the most appropriate means to prevent such eutrophication.

A risk factor in this menu is that we assume that organic waste is delivered to

biogas plants. Given that the street-fee'en for waste equals combustion, composting and

Biogas treatment, there is no greater incentives for supplying organic waste to

biogas treatment versus other treatment. Given that the feed-in-tariff is set high enough, even for biogas

produced by wet organic waste, it is conceivable that this creates enough "pull" that it will be possible for

biogas plants to provide a lower gate fee than incineration and composting plants. This will

reduce the risk of a shortage of raw material is a limiting factor.

One such tool menu will help to reduce greenhouse gas emissions in the agricultural sector because it

can ensure that a portion of the potential manure is triggered by setting a sufficiently high level of support

for biogas produced in the manure. At the same time the menu to increase the use of biogas in

vehicles to air pollution especially in urban areas is reduced, and that the share of renewables in

transport increased. If 0.7 TWh of biogas is used in the transport sector can, as

described in Chapter 1, achieving renewable target in the transport sector without increasing the wagering requirement for

biodiesel and bioethanol from the current 3.5%. In addition, the menu at a good utilization of organic fertilizer, as

creating incentives for spread of suitable areas.

***Instrument Menu 2: "push":***

An alternative to the tool menu based on "pull" factors, using multiple "push" -

Factors triggering potential. A possible menu are:

• Requirements for separation and biological treatment of waste and the return of nutrients to the

cycle

• National target for biological treatment of organic waste

• Investment of biogas plants depends on the percentage incorporation of manure in

biogas plant

• Investment of gas-powered vehicles

• Support for the transport of organic fertilizer for appropriate distribution areas

Such menu will cause many of the same effects as an instrument menu 1

To increase the supply of food waste from households and similar waste from any food service

and trade, it is possible to introduce legal measures leading to increased separation and subsequent

biological treatment. This requirement can be combined with a national percentage targets for the amount of

food waste to be biologically treated. This can result in a higher proportion of this waste

utilized for biogas production, while some may go to composting. Requirement

separation of food waste will not necessarily lead to a capacity-building for biogas treatment

Norway, but can lead to increased export of organic waste to Sweden and Denmark.

Investment is as previously described an efficient way of getting fired production plant

for biogas. If desired, parts of the biogas production is to use animal manure may

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to make the size of investment support for biogas plant depends on the manure-

interference ratio, see Figure 6.4 below.

Investment support for gas-powered vehicles to ensure that biogas is used in the transport sector and that

it thus leading to an improvement in air quality. Since gas engines with "lean" engine technology

For emissions that are approximately equal to diesel vehicles, investment aid should be linked to a commitment

On selecting stoichiometric engines or technology similar low emissions of NO

X

and particles.

A guide to gas-powered vehicles, however, will not be effective governance with a view to using *bio* gas

transport sector, but will also increase the number of vehicles that use *fossil natural* gas

fuel. However, this is a minor problem, when you get improved air quality regardless of

It is natural gas or biogas is used as fuel. The produced biogas is not

used in the transport sector will be used in other sectors where it will replace the same quantities

natural gas.

To ensure that the digestate spread on suitable areas can introduce a scheme which provides grants

the transport of digestate to areas that need fertilizing. In particular in animal dense areas,

which Rogaland, is eutrophication from manure already a challenge at present. With the

expected increase in livestock production, this problem could increase further. Establishment of

biogas plants that use organic waste in production (both separate treatment and

sambehandling with manure) will lead to an increase in the available amount of digestate as

fertilizer product, since waste otherwise would have been burned and thus not used as fertilizer. In areas where

there is little or no need for fertilization, the digestate having a low or negative value, and it is

appropriate from an environmental perspective transporting digestate to other areas. One can for

such as designing support scheme allowing transport of digestate outside a certain radius, will be covered

of the scheme. This will ensure that the manufacturer did not have an increased cost of transport

digestate to suitable distribution areas. The support should be linked to the quality requirements for digestate (low

content of heavy metals and other pollutants).

*Figure 6.4: Proposed investment into biogas plant depends on the substrate*

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Another alternative (or addition to transport support) is a support for processing of bio fertilizer. Although

fields in animal dense areas will require fertilization with nitrogen, but have little need for supply

of phosphorus. By separating bio fertilizer nitrogen in a wet and a dry fosforrik part, one could make a

nitrogen-rich product that can be spread on the ground in the area. The dry, phosphorus rich part can then

transported to areas further away where necessary for fertilization with phosphorus. In order to optimize

application of organic fertilizer can simultaneously introducing a support for analysis of organic fertilizer, as well as

Update fertilizer calculator so that it also covers different types of organic fertilizer.

***Instrument Menu 3: Energy***

An alternative to push and pull the menus is a tool menu that has as main objective to increase renewable

energy production by increasing biogas production. Given that there is a goal that biogas will

employed in a particular sector or for a specific purpose, or that the biogas should be produced by a

certain raw materials, one can introduce a simple production support in U.S. / kWh. By aligning the support

produced amount of energy given incentives to maximize gas production both through

optimization of production technology and through the choice of energy-rich feedstock. Our calculations in

Chapter 4 indicate that biogas production from organic waste is almost economically

profitable, given that waste is available and that the biogas plant is a street-fee of 700 NOK / tonne waste.

To ensure access to raw materials for biogas plant, the gate fee at the biogas plant would be less than or equal

gate-fee combustion and composting. A production support at 18 cents / kWh, according to our

calculations make it possible for the biogas plant to reduce the gate-fee'en with 200 kr / ton

waste, which could increase the supply of raw materials for biogas production. Because funding is directed to

amount of energy produced will support while providing an incentive to choose the raw material with high gas yield.

It is possible that plants may require different gate-fee for raw materials depending on the expected

gas yield, so that the supply of raw material is increased.

An alternative to a production support in NOK / kWh is a delivery support for organic waste to

biogas plant in £ / tonne. The difference in relation to a production aid is that in this case not get separated

between raw materials that provide a high gas yield and those only gives a low yield. This instrument is

therefore not as effective management with a view to getting produced with maximum energy.

As shown in Chapter 4 of biogas production based on pure manure not commercially

profitable at present (loss of around 1.27 £ / kWh). This means that a production support per

kWh will probably all the wet organic potential is triggered before any manure will be applied.

If the energy potential triggers (both manure and organic waste), the

average deficit be around 55 cents / kWh. One possibility to get triggered more of

potential than just the wet organic waste, is to provide a production support at around 55 cents / kWh,

provided that the biogas plant sambehandler manure and organic waste. In order to redeem the

potential in this way, the ratio of substrates to 4 tons manure

per 1 ton of waste.

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**Review of possible new measures**

The following provides an overview of new or strengthening of existing measures that will:

• Increase access to raw materials for biogas plants

• Increasing biogas production

• Increase the use of biogas and bio fertilizer

The input to possible new measures in this chapter come from a variety of sources, such as Mepex

report (2012), Sector Report Waste Cure (TA 2592/2010; CPA 2010b), Value Chain Report for

sambehandling (TA 2704/2011) and the input that we got from the survey and the

input meeting conducted in the context of this work.

We review first instruments that can increase the supply of raw materials. Subchapter is divided into the

measures aimed at organic waste and the targeting manure. Each

These subsections are further divided into economic, legal and informational tools. Afterwards

are reviewed the various means for biogas production and use of biogas and

bio fertilizer.

To increase readability, it posted a reading guide for each instrument proposal shows

which subsection you are in:

OBJECTIVES

Instrument

**Increased access**

**of raw material**

**Increased biogas**

**production**

**Increased**

**application**

**Fertilizer**

**Fertilizer**

**Wet**

**Wet**

**Biogas**

**Bio fertilizer**

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***The review is organized as follows:***

1 Measures to improve access to raw materials

1.1 Organic waste

*1.1.1 Legal instruments*

- Requirement for separation of food waste

- Requirements for biological treatment of waste and utilization of

nutrients in organic fertilizer

- Prohibition of incineration of waste

- Objections to the planned export of household waste and similar waste

business

*1.1.2 Economic instruments*

- Introduce a tax on incineration of waste if the waste is not separated

*1.1.3 Informative instruments*

- National target for biological treatment of waste

1.2 Fertilizer

*1.2.1 Legal instruments*

- Delivery obligation for manure from farms located within a certain

distance from a biogas plant

- Stricter requirements for environmentally-efficient storage and dissemination of

manure

- Incorporation Requirements manure in the feedstock for biogas plants

- Introduce emission standards for greenhouse gas emissions from manure

*1.2.2 Economic instruments*

- Delivery Support manure

- Support for separating manure in a wet and a dry part, if

dry part comes into biogas plant

- Reward Scheme for reducing emissions from manure

*1.2.3 Informative instruments*

- Information campaign on biogas production to agriculture

2 Measures to increase the production of biogas

*2.1 Economic instruments*

- Investment into biogas plant

- Production Support for biogas plants

- Combined investment and production support for biogas plants

- Investment support for pre-treatment of organic waste

- Innovation Support for biogas and / or pre-treatment

- Simplified application procedure for funding from Enova / Innovation Norway

3 Funding for increased use of biogas and bio fertilizer

3.1 Increased use of biogas

*3.1.1 Legal instruments*

- Development of standards for biogas

- Turnover Requirements for biogas in the transport sector

- Receipt Obligation for biogas in gas company

- Forced incorporation of biogas in natural gas

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- Gas Vehicles in Public Procurement

- Requirements for collection of landfill gas

- Requirements for the use of the collected landfill gas

*3.1.2 Economic instruments*

- Increased CO

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Tax on fossil fuels

- Continuation of the exemption veibruksavgift for biogas and possibly natural gas

- Investment aid for the purchase of gas vehicles (private cars and / or taxi)

- Investment aid for the purchase of gas vehicles to fleet operations

- Investment aid for the purchase of gas buses

- Investment for the construction of filling stations

- Reduced disposable gas-fueled vehicles

- Support for the replacement of oil boiler to gas boiler if biogas is used

- Feed-in tariff for biogas at gas station

- Introduce a tax on natural gas unless it met a%-vis requirement

biogas intervention

3.2 Increased use of bio fertilizer

*3.2.1 Legal instruments*

- Stricter requirements for the storage and distribution of fertilizers

- Change the requirements of fertilizer products Regulations for heavy metal content in bio fertilizer

- Development of standards / content declaration for bio fertilizer

*3.2.2 Economic instruments*

- Support for the analysis of bio fertilizer

- Development of fertilizer calculator that includes bio fertilizer

- Support for the transport of organic fertilizer for appropriate distribution areas

- Support for the processing of organic fertilizer (pelleting or similar)

- Tax on nitrogen and phosphorus in fertilizers

*3.2.3 Informative instruments*

- Information campaign on the use of organic fertilizer

4 Transverse measures

4.1 Transverse measures to increase biogas production

- Study Support related to the optimization of environmental and climate benefits

- Improved communication between players

- National Working Group on biogas

4.2 Transverse measures to increase knowledge

- Improved statistics

- Research and development (R & D)

4.3 Transverse measures to reduce the risk of negative effects of biogas initiative

- Meta Leaks biogas plant

- Storage bio fertilizer

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**1** **Measures to improve access to raw materials - organic waste and**

**manure**

**1.1 Organic waste**

***1.1.1 Legal instruments***

Requirements for separation of food waste

Description: The requirement for separation should be organized so that it entails demands for recycling, and not

Central sorting of waste, because experience shows that source-separated food waste for cleaner compost and

bio fertilizer than central sorting through the MBT method (mechanical-biological treatment) provides. If the

central sorting is used, this will reduce the value of bio fertilizer.

Many municipalities have already introduced source separation of food waste from private households. To obtain

access to food waste from the remaining municipalities and waste from the catering trade and commerce,

requirement can be introduced incrementally.

That claim is paid to *food waste* from households and catering industry / trade and not *wet organic*

waste in general, arguing that food waste from households / large households are more difficult to

get into the market without separation from other waste. Increased availability of organic waste from other types of

business (such as food processing) for biogas production, is expected to be

easier when the waste is largely generated in the clean waste streams.

The desired effect: Increase the supply of waste for biological treatment in general, and biogas treatment

particular.

Possible drawbacks: The instrument does not necessarily ensure increased access to food waste for biogas production

in Norway, as this can also lead to increased exports to biogas production in neighboring countries. It can also

lead to increased composting instead of biogas production. In addition, the requirement of an initial phase of the

the imbalance between supply and demand of food waste and available treatment capacity, but

This will stabilize over time. Instruments will likely result in increased treatment costs for

organic waste. If the instrument shall apply to all municipalities and affected industries, higher

Treatment costs can be problematic for smaller municipalities and businesses.

The implementation of this requirement will result in increased administration and supervision, as well as other

similar measures.

Conducted in neighboring countries, the Government of Sweden has adopted an interim that 50% of

food waste from households, commercial kitchens, shops and restaurants sorted out by 2018.

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Requirements for biological treatment of waste

and utilization of nutrients in

bio fertilizer

Description: A request for biological treatment of food waste will ensure that this waste stream going to

composting and biogas treatment. At the same time require nutrients in organic fertilizer to

utilized, ensures that nutrients are returned to circulation.

The desired effect: Increase the supply of food waste for biogas production, and the return of nutrients

the cycle.

Possible drawbacks: The instrument does not necessarily ensure increased biogas treatment of food waste in Norway,

as this can also lead to increased exports to biogas production in neighboring countries. No distinction is made between

different types of biological treatment, so it is conceivable that the measure will lead to increased composting in

Instead of increasing biogas treatment. The implementation of the requirement will result in increased administrative and

Authority, like other similar means.

Conducted in neighboring countries, the Government of Sweden has approved a measure (but not a direct requirement) on

at least 60% of the phosphorus compounds in sewage mud (this is also bio fertilizer included) shall

returned to productive land by 2015.

Ban on incineration of waste

Description: A ban on the incineration of waste can be directed to the owner of the incinerator,

and may be supplemented by specific requirements aimed at waste possesses (households, private and

public enterprises). This means that incineration plants can only accept waste with

a smaller amount of food waste and that they are obliged to ensure compliance through self-

receiving inspection. Special requirements for waste possesses (as sorting requirements) can simplify the obligations of

incineration plants.

If the claim is paid to the municipality is responsible for the collection of household wastes,

municipality to make a choice whether to sort food waste, or export the waste with food waste in.

Similar action has private and public entities.

The desired effect: Increased access to food waste for biological treatment, especially biogas treatment.

Possible drawbacks: Experiences of rejection shows that it is difficult to achieve more than about 70%

separation of food waste from households. The ban on the incineration of waste, this will make

it required extensive initial inspection and any after sorting at each

incineration or establishing their own pre-treatment prior to combustion. This instrument can

lead to increased exports of waste where food waste is not separated. No distinction is made between different types of

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biological treatment, so it is conceivable that the measure will lead to increased composting rather than increased

Biogas treatment. The implementation of the requirement will result in increased administration and supervision, as

other equivalent means. Feasibility: Medium, due to extensive sorting and

control systems that must be implemented.

Conducted in neighboring countries: No.

Objections to planned exports

household waste and similar waste

business

Description: Norway may restrict exports of waste for energy recovery abroad if the waste

can be recycled at the Norwegian plant. A prioritization between material and

energy utilization can be determined by national legislation or the national waste policy.

The desired effect: Improve the raw material for the Norwegian biological treatment, including increased

recycling of organic fertilizer / compost.

Possible drawbacks: It is uncertain whether we have the authority to use this tool. In addition, the

such a scheme probably entail significant administrative costs, because it would require an individual

consideration in each case to argue the objection.

Gjennomførbarehet: Poor.

***1.1.2 Economic instruments***

Introduce a tax on incineration of waste

if the waste is not separated

Description: Change regulations on fee for disposal of waste to include combustion of

waste with food waste. Fees can for example be designed to apply per tonne of waste that has

a certain proportion of food waste when it comes to combustion.

The desired effect: Introduce a financial incentive to sort food waste from other waste before the waste

incinerated and thus increase the supply of food waste to biological treatment and thereby increase

biogas production.

Possible drawbacks: A charge like this can also lead to increased exports of waste to incinerators

outside Norway instead of increasing the supply of waste for biological treatment in Norway. As the

waste from households and some industries will always have a residual content of food waste, must take charge

this into account, for example by setting a percentage imposed on the amount of food waste which can be accepted in

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waste for incineration without charge. It would be difficult to determine a meaningful limit

content of food waste in the residual waste. Even with 50% separation of food waste from other waste will be

between 10 and 20% organic portion of municipal waste. It is also difficult to determine the appropriate fee level for

this instrument. This instrument can lead to increased exports of waste where food waste is not

separated. No distinction is made between different types of biological treatment, so it is conceivable that the instrument

will increase composting rather increased biogas treatment. The implementation of the requirement to provide

increased need for management and supervision, as well as other similar means. Adherence to

also apply incineration plants significant administrative and organizational costs.

Feasibility: Can. Norway removed the overall disposal fee for combustion

of waste in 2010. This tax was aimed in part to reflect the environmental costs of emissions

from incineration plants. The charge was removed to establish more equal conditions of competition between Norwegian

and Swedish incinerators. This proposal will in many ways be to reintroduce a tax on

combustion which can lead to the export of waste containing food waste.

Conducted in neighboring countries: No.

***1.1.3 Informative instruments***

National target for biological treatment of

food waste

Description: It can set a national goal for the amount of organic waste to be biologically

treated in a particular year. To facilitate the objectives, it may be limited to food waste and

not wet organic waste in general. For example, a concrete targets to be achieved within a specific

year to a control signal to municipalities and private companies for their choice of management solutions

for their own waste. Such a goal can be a basis to determine other specific measures to

achieve the objective. It may be considered whether to set various interim destination, eg. in two stages

with an evaluation when the goal of stage 1 is reached, as this provides the opportunity to assess the environmental benefits of

measures and change remedies under this process.

Based on current statistics and measures recommended in Chapter 6, may be a relevant target that 50

% Of food waste from households as well as catering and trade should be collected separately and go to biological

treatment. For food waste from the catering trade and commerce, it may also be appropriate to establish a

higher utsorteringsmål.

The desired effect: Correcting political focus on the biological treatment of waste, and thus

biogas production. This is a tool to implement other measures to increase the biological

treatment of food waste.

Possible drawbacks: Due to weaknesses in current waste statistics, it can be difficult to

estimate the results.

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Conducted in neighboring countries: Yes. Sweden established goal of 35% biological treatment of waste from

households, restaurants, commercial kitchens and stores by 2010. This goal could not be achieved, but

Government has set new interim for 2018 by at least 50% of food waste from households,

large households and commerce to be sorted out and treated biologically to energy and nutrients

is used.

**1.2 Fertilizer**

***1.2.1 Legal instruments***

Obligation of manure from

farms located within a certain

distance from a biogas plant

Description: Impose farm with livestock, within a certain distance of a biogas plant, to

delivering manure to biogas plants.

The desired effect: Greater supply of manure for biogas plants

Feature: This instrument can be effectively control, provided that biogas production based on free

providing manure makes good business sense for biogas plants to be built enough of these.

Possible drawbacks: The instrument will result in increased costs and less flexibility for farmers.

Farmers are likely to be negative for the establishment of biogas plants.

Feasibility: Can not find good enough arguments for the farm with satisfactory

storage / distribution. Obligation will face strong opposition from farmers unless combined

with an adequate supply support, or other form of compensation. There may be practical

problems if there is / are enough processing capacity in an area where the obligation is introduced

Conducted in neighboring countries: No. But in Denmark, many farms have joined forces for the establishment

large common biogas production from manure and organic waste with binding

agreements for delivery. The demand for increased storage capacity for manure that came in the nineties was

main reason for interest in joint biogas plants.

Stricter environmental and climate efficient

storage and spreading of manure

Description: Through the requirements for the storage and spreading of manure in terms of quantity,

time and diffusion method, one can better utilize the industry in manure, and reduce

emissions to air and water. MD and CPA working on revising fertilizer products Regulations Part III spring

2013.

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Any new technical requirements for manure storage and new requirements for storage capacity can result in some

farm will prefer to increase its storage capacity in relation to biogas plants rather than storage

own property. Because of economies of scale, such a bearing could be cheaper and better. If the

requirement of how much manure you can add soil intensifies, then it will be necessary to redistribute

manure to another farm or region. This will mean increased costs in transportation,

but could provide significant environmental benefits in terms of reduced emissions to air and water. The effect

however, will be highly dependent upon the design requirements of the revised regulation.

The desired effect: The aim of the revision is to reduce water pollution in accordance with

water regulations and emissions of ammonia and greenhouse gases. However, regulation and

formulation of the essential for the establishment and operation of biogas plants, especially for

manure. There is a parallel to the disposal ban on organic waste that has forced

voted second and more expensive solutions such as treatment in biogas plants.

Feature: This instrument is managing effectively to reduce emissions to air and water from storage and

spreading of manure. The design of these regulations will determine the extent to which it can simultaneously

encourage increased supply of manure for biogas plants.

Possible drawbacks: Stricter requirements for the storage and spreading of manure may result

loss of income from reduced livestock in livestock dense areas, significant investment and

operating costs for the construction of manure storage, alternative biogas plants, and from increased transport of

manure to biogas plants and new agricultural areas.

Feasibility: Good, that's Environment Ministry to revise these regulations,

with MAF. CPA has primary responsibility for the preparation of proposals for new regulations. However,

provisions of the regulations first determined by negotiations between MD and LMD.

Conducted in neighboring countries: Denmark and Sweden has stricter requirements for the storage and dissemination of

manure than Norway. In Denmark, the demand for increased storage capacity for manure one

precipitating cause of the farmers got together on joint biogas plant with storage of manure

at the plants.

Incorporation Requirements manure in the feedstock

the biogas plant

Description: It is a requirement that the raw material for biogas plants must contain a certain proportion

manure.

The desired effect: A minimum amount of manure handled in biogas plants

Feature: Can be effective if other management framework ensures the construction and operation of

biogas plants in sufficient scope.

Possible drawbacks: Biogas production will be less profitable for biogas producers. The reason for

this is that manure will take up part of the processing power, but provide much less

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gas yield than an equivalent amount of organic waste will be provided. Also, they will lose income from

gate fee'en for organic waste

Feasibility: Can smoothly implemented as a condition for getting funding for

biogas plants, both investment and production support. Otherwise difficult.

Conducted in neighboring countries: No.

Introduce emission standards for greenhouse gas emissions

from manure

Description: Requirements for greenhouse gas emissions from the storage and spreading of manure

The desired effect: Emission requirements mean that there is less greenhouse gas emissions from the storage and distribution of

manure. A portion of the manure will be able to go to the biogas plant emissions to meet the requirements.

Feature: This instrument is managing effectively as long as it's good enough control - and

sanction schemes

Possible drawbacks: Implementation is very difficult, inconvenient and expensive because it is challenging to

quantify emission reductions

Feasibility: Very bad

Conducted in neighboring countries: No.

***1.2.2 Economic instruments***

Delivery Support manure

Description: As an alternative or addition to the obligation of manure to biogas plants can be

a support to farmers as a dollar amount per ton of manure delivered. From 2012, the Ministry

introduced the Agricultural Agreement a subsidy of 15 € / ton of manure delivered to the biogas plant.

The budgeted amount, one million dollars / year covers almost 67 000 tonnes of manure, ie approx.

0.5% of the total fertilizer amount.

The desired effect: Increased supply of manure to biogas plants and reduced operating costs

biogas plants, since the transport is done by the farmers. The effect of a delivery support at 15 € / ton

manure provides a subsidy that reduces the commercial deficit by 0075

NOK / kWh, assuming the delivery support is used to reduce transport costs

biogas plant.

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Feature: This instrument can be control effectively, provided sufficient size support amount.

To get the effect of significance is assumed that the amount of aid must be increased significantly beyond 15 € / tonne and the

disposable budget amount increased accordingly.

Possible drawbacks: Delivery support will encourage decentralized and poorly coordinated transport. This

will result in higher costs compared to a centralized transport solution, where installations are

responsible for retrieval manure and organic fertilizer delivery.

Feasibility: God is already in use.

Conducted in neighboring countries: No.

Support for separation of manure in a

wet and a dry part, if the dry part

supplied to the biogas plant

Description: There are several advantages of separation of manure, the dry section contains

most of the phosphorus, while the wet part is mostly nitrogen-containing. In livestock dense districts will

often surplus of phosphorus, both in soil and manure. Transport of the phosphorus-rich part

of manure from these areas could reduce phosphorus inputs to water. Furthermore, the

wet fraction being smaller in volume so that the storage time

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on farms is increasing even at unchanged

storage capacity, which contributes to the spread-growth 'needs. The wet fraction will also

rapidly lowering into the soil so that nitrogentap through NH

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Emissions to air decreases. The drier

and phosphorus-containing fertilizers fraction can be fed to the areas in need of phosphorus, optionally also

organic substances, either directly or via treatment in biogas plants. What is economically

most beneficial will vary.

The desired effect: Increase the supply of fertilizers based feedstock for biogas plants with lower transport costs

than the transport of all manure and reduce water pollution problems through redistribution

of livestock manure.

Feature: A support as mentioned above for delivery to the biogas plant is possibly effective management provided

that support is high enough and that other means ensuring that there are enough biogas plants.

Possible Disadvantages: Can be cost-intensive because it must build new facilities for separation and storage. In

As with delivery support will this solution encourage decentralized mobility management

which will increase the overall transportation costs. Furthermore, it is possible that a part of the energy content of the

manure is lost for biogas production

Feasibility: Medium

Conducted in neighboring countries: No.

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"Shelf life" is calculated here on the basis of how much manure storage is at the farm. A shelf life of such

6 months means that it is possible to store the amount of fertilizer that occurs within six months

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Reward scheme for reduced

greenhouse gas emissions from manure

Description: It provides a compensation for documented reductions in greenhouse gas emissions from

storage / spreading of manure

The desired effect: Reduced greenhouse gas emissions from the storage and spreading of manure. Treatment

of manure in biogas plants can be a way, probably the most effective, achieving reduced

greenhouse gas emissions from the storage and spreading of manure.

Feature: Can be managing effectively assuming a one manages adequate documentation, control and

remuneration is high enough.

Possible drawbacks: Measurement / documentation is difficult and it is hard to decide who should

get paid support, farmers, biogas plant or shared. Furthermore, it would probably require very high

reward rates, compared with eg. CO

2

. The tax or permit price for the effect of

importance. There is uncertainty about the effectiveness of the measure because of uncertainty

emissions from the storage and spreading of manure and organic fertilizer, and measurement / monitoring of these

emissions. The current calculation methodology in emission inventory will capture only a portion of

emission reductions

Feasibility: Poor

Conducted in neighboring countries: No.

***1.2.3 Informative instruments***

Information campaign on

biogas production to agriculture

The desired effect: Increase the supply of manure for biogas plants

Attribute: Very little effective control while the commercial profitability of

biogas production from manure is poor. It can act as a supplement to other

means.

Possible drawbacks: Little to no effect without other measures

Feasibility: Medium to good

Conducted in neighboring countries: Yes, there have been several information campaigns, but often in

connection with the introduction of other new virkemidler.2. Measures to increase the production of biogas from

organic waste and manure

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**2** **Measures to increase the production of biogas**

***2.1 Economic instruments***

Investment into biogas plant

Description: It provides an investment for biogas plants, to be achieved economically

profitability of investment and operation.

The desired effect: Increased production of biogas.

Feature: This instrument is effective management.

Possible drawbacks: Favors plants that use organic waste if not support differentiated

Feasibility: Technical and administrative feasibility is good, but can be politically

difficult because of the financial requirements to funding authorities.

Conducted in neighboring countries: only combined with production support

Production Support for biogas plants

Description: Payable production support for biogas plant (NOK / kWh or enough / ton

processed) so that it can be achieved commercial profitability of the investment and operation. It is

possible to have different supporting amount depends on the amount of manure treated in the plant.

The desired effect: Increased production of biogas.

Feature: This instrument is moderately effective management. Uncertainty about the duration and magnitude of

support will make sure it can be built few plants unless production support is guaranteed for many

years.

Possible drawbacks: It is likely that plants will prioritize the most profitable raw material, usually

organic waste that has a higher energy content and provides a substantial income through gate fee'en.

If it is desired to produce biogas from manure can act as an incentive in that

production support graded by percentage of manure in production. It may be economically

difficult for authorities if the aid amount is determined for several years, or the owner of

biogas plant if the amount of aid change from year to year.

Feasibility: Technically good, but politically difficult to achieve sufficiently high level of support for vertical

manure.

Conducted in neighboring countries: only combined with investment

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Combined investment and

production support for biogas plants

Description: paid investment and production support to biogas plant, so as to obtain

commercial profitability of investment and operation.

The desired effect: Increased production of biogas.

Feature: This instrument is effective control, but uncertainty about the duration and magnitude of

production support will be an obstacle for many establishments, albeit to a lesser extent than by just

introduce a production support.

Possible drawbacks: It can be financially difficult for authorities if the amount of aid is

established for several years, or the owner of the biogas plant if the amount of aid change from year to

years. Also this measure favors organic waste as a raw material in the production, but it can

solved through differentiation.

Feasibility: Technically good, but politically difficult to achieve sufficiently high level of support

manure.

Conducted in neighboring countries: Yes, in Sweden and Denmark

Investment to pre-treatment

plant for organic waste

Description: Scheme for investment in pre-treatment that accepts organic waste and

producing a biosubstrat that can be used in biogas plants. In practice this means a form of

sterilization / disinfection of food waste before it is sent to the biogas plant. Some municipalities may

focus on getting biosubstratprodusenter selling biosubstratet for biogas plants. Today, there are few

plant in Norway that provides substrate for biogas plants. The economy of plants located in the payment

for examining the delivery of waste to the facility. CPA has informed that at one of these

substratanleggene export substrate to Denmark where it needs to be paid particularly high cost to

provision of substrate for biogas plants.

The desired effect: increased access to processed biosubstrat to stimulate increased biogas production.

Feature: Will lead to better knowledge of the pretreatment technology, techniques and

substrate compositions that provide the greatest gas yield.

Possible drawbacks: Possible that biosubstrat are exported, so this does not necessarily increase

biogas treatment in Norway.

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Conducted in neighboring countries: In Sweden, energy authorities decided to allocate 67 million

million for 10 projects aimed at pre-treatment of substrates, production of biogas and

efficiency of biogjødselhåndteringen. The project aims to increase R & D knowledge about more

Effective Pretreatment for faster utråtning and increased gas production. The Swedish

project is part of Sweden's efforts to support the market introduction of new technologies and solutions

that enhances profitability and promotes the production of biogas (energimyndigheten.se).

Innovation support to biogas and / or

pre-treatment

Description: Investment or production support to biogas and pre-treatment using

use of *innovative* technology and new substrates in biogas process.

The desired effect: Stimulating technology in biogas production

Features: This instrument is effective management.

Possible Disadvantages: Difficult to define what is innovative technology / substrate at any time.

Simplified application procedure for funding from

Enova / Innovation Norway

Description: Several players said in the survey that was conducted in conjunction with

preparation of this report that the application process for grants was too difficult and / or

time consuming. By simplifying the application procedure it is possible that several biogas plants is triggered.

The desired effect: Increase the construction of biogas plants

Features: This instrument trust management effectively, because it will only increase the number of plants, if

application procedure is the only barrier.

Possible drawbacks: A simplified application procedure will increase the risk that subsidies are given to the "wrong"

plant.

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**3** **Funding for increased use of biogas and bio fertilizer**

**3.1 Increased use of biogas**

***3.1.1 Legal instruments***

Development of standards for biogas

Description: A standard for product quality for biogas will facilitate the application of biogas, both

the seller of biogas and the buyer. This will also make it easier to mix natural gas and biogas.

The desired effect: Simplify application and thus increase demand for biogas

Features: This instrument is little effective control, since the demand for biogas will depend on

several more weighty factors such as infrastructure etc.

Possible drawbacks: Know that this is not a barrier, but being a driving force for the expanded use of

biogas. It should be considered whether a Norwegian standard or an international / European standards should

priority.

Conducted in neighboring countries: There is no international technical standards for biogas by

feed the natural gas network, but some countries have developed national example Sweden, Switzerland, Germany and

France. Sweden developed in 1999 a national standard for biogas for use as fuel, and this

standard is also used to feed the natural gas grid (IEA Bioenergy, 2007).

Switzerland also has regulations (G13), with two different qualities that are approved for feed in

natural gas network, one for the limited and one for unlimited feed. The requirements for gas for unlimited

input is stricter than limited. Germany has a standard for biogassinnmating (G262)

based on standards of natural gas, DVGW G260. Here, too, allowed two different qualities

(Limited / unlimited feed). France has since 2004 had a de facto standard for

gassinnmating in the national gas grid. This has stricter limits for oxygen content than

the other standards, and also has a number of limitations on heavy metals and halogens (IEA

Bioenergy, 2007).

Turnover requirements for biogas

transport

Description: Biogas is already covered by wagering requirement for biofuels for road traffic. The

introducing a requirement especially for biogas as a percentage of the total amount of fuel sold, or as a percentage of

gas sold to transport, one can rightly measure more specifically at increasing the turnover of the *biogas* in

transport sector and thus create "pull" the market specifically geared towards use in

transport sector.

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The desired effect: Increase the use of biogas in the transport sector.

Features: This instrument is effective management.

Possible drawbacks: Administrative charge in relation to the reporting and monitoring of

wagering requirement. This can result in high costs for fuel suppliers if there is little

biogas available in the market.

Feasibility: Medium. This instrument requires that there is sufficient gas vehicles to ensure

use in the transport sector.

Receive Obligation for biogas in gas company

Description: If gas retailers were required to receive biogas (as for electricity in

today, mandatory connection for power producers), biogas producers had been secured

take-off of the gas, so the risk of investing in biogas plants is reduced.

The desired effect: Guaranteed purchase of biogas, so that production becomes more profitable / less

risky.

Possible Disadvantages: Difficult to guarantee the effect on profitability without having a guaranteed selling price for

biogas.

Forced intervention of biogas

natural gas

Description: By introducing a wagering requirement of biogas of the total volume of gas sold, the

created a vacuum in the market for biogas.

The desired effect: Increasing demand for biogas.

Features: This instrument is effective management.

Possible drawbacks: The gas here will be able to go for heating etc., ie this is not channeling the gas

into the transport market instrument is thus not effectively control if the goal is to increase

biogas use in the transport market. This can result in high costs for gas suppliers

if there is little available biogas in the market.

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Gas Cars in public procurement

Description: Entering gas vehicles in public procurement can increase gassbil share in

automotive and thereby stimulate both tickets demand and the demand for biogas in

petrol station.

The desired effect: Increasing demand for biogas for transport purposes.

Disadvantages: Will also encourage the use of natural gas

Requirements for collection of landfill gas

Description: Organic waste breaks down anaerobically in landfills can cause methane emissions.

Amount of methane produced decreases gradually as the organic waste is broken down. The

is possible to collect approx. ¼ of the methane gas generated in a landfill using the so-called

gas extraction system. The collected gas can be either flared without energy recovery or used for

electricity and / or heat. Even if gas is not used for energy production, the

collection followed by flaring reduce greenhouse gas emissions, because methane (which is a very potent

greenhouse) is converted to CO

2

(Weaker greenhouse gas). The gas can also be upgraded to

gas quality, but because of impurities in the gas, this is a difficult and expensive process. Man

can imagine that an increased accumulation of landfill gas can be done by several landfills have installed

equipment for collecting this gas or by improving the efficiency of existing

gas collection system. Cure (2010a) examined both measures and estimated that 5 new methane plants

can lead to greenhouse gas reductions equivalent to 26 250 tonnes of CO

2

-Eq per year at a cost of 343

Dollars / ton CO

2

-Eq. Upgrading of existing 85 plants were estimated to contribute 70 560

tons of CO

2

-Eq per year at a cost of 123 dollars / ton CO

2

-Eq.

The desired effect: Reduced methane emissions from Norwegian landfills.

Possible drawbacks: Due landfill ban for biodegradable waste, the future

supply of biodegradable waste sent to landfills can be very limited. Already deposited waste will still

emit methane for decades, but in diminishing degree, so that methane emissions from landfills will be reduced

even without further action. If the recovery rate at each landfill will be increased, this

necessitate upgrading of existing outlet facility. These upgrades can be

varying scope and associated costs related to this.

Feasibility: Low. For most landfills with gas recovery plant is underway already a process

evaluation of existing solutions and of the need to upgrade. It is doubtful

it is possible to impose further requirements for these plants now that will lead to a significant

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emission reductions than required by certain requirements. If additional requirements for withdrawal efficiency should

realized now for all current landfills in operation, it must be by an amendment of section 9 of the

Waste disposal and optionally establish other incentives (such as financial

support) to landfills choose to upgrade methane gas outlets. When there are large

differences between the various dumps respect. gas production size and opportunities for increased

gas accumulation, the specific requirements for extraction efficiency had to be individually through revised

discharge permits or orders. For closed landfills can also increase gas production to be in conflict with current

land use.

The opportunities for state governments to require additional emission reductions from landfill

also limited by the fact that these emissions already paid for through the state

disposal fees for waste.

Conducted in neighboring countries: The general requirement of collecting landfill gas for landfills in operation

which have deposited or depositing biodegradable waste, states of the EU Landfill Directive. The

In this context been considered whether this requirement could be further specified, but

preliminary conclusion is that these are requirements that must be determined for each landfill.

Requirements for utilization of recovered

landfill gas

Description: Organic waste breaks down anaerobically in landfills can cause methane emissions.

Amount of methane produced decreases gradually as the organic waste is broken down. The

is possible to collect approx. ¼ of the methane gas generated in a landfill using the so-called

gas extraction system. The collected gas can be either flared without energy recovery or used for

electricity and / or heat. The gas can also be upgraded to natural gas quality, but

Due to impurities in the gas, this is a difficult and expensive process.

The desired effect: increased energy utilization of methane gas from Norwegian landfills.

Possible drawbacks: Harnessing the collected landfill gas to produce energy (electricity or heat) requires

additional investments, which is not necessarily proportionate to the profits of energy production.

Introduction of the claim must be based on the ratings for each landfill.

Feasibility: Low if the claim is to be realized alone, good if this requirement is realized simultaneously

that other incentives are introduced. Most individual landfills that represent deposits with the greatest

energy potential is already beginning to utilize gas for energy purposes. If additional requirements

the energy utilization of the collected landfill gas to be realized for landfills beyond these, should

this is done simultaneously with the introduction of other incentives (such as financial

support) to landfills choose to upgrade methane gas outlets.

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***3.1.2 Economic instruments***

Increased CO

2

Tax on fossil fuels

Description: An increase in CO

2

Tax on fossil fuels

The desired effect: Increase profitability by using biogas relative to fossil diesel or gasoline.

Possible disadvantages: Increased CO

2

Tax on fossil fuels will provide a skewed distribution effects. Those

necessary to use a car and unable to switch to gas or other environmentally friendly vehicles,

will be hardest charged the fee. In addition, the instrument little control effectively, since it will also provide

an advantage to other types of biofuels and electricity.

Continuation of exemption veibruksavgift

for biogas and natural gas optionally

Description: The price difference between fossil fuels and biogas is an important driver in the

commercial profitability of biogas vehicles. If biogas is required veibruksavgift,

reduced price difference and biogas are less profitable. This could possibly be compensated for by increasing the

CO

2

Tax on fossil fuels simultaneously.

The desired effect: Increase profitability through the use of biogas in vehicles.

Features: This instrument is moderately effective management. It will encourage greater use of natural gas vehicles,

but does not ensure that biogas is used since gas vehicles also use natural gas. This can

solved by the simultaneous introduction of a higher tax on natural gas to biogas are significant

less expensive compared to natural gas, but this can hamper growth of biogas market since

biogas users like to use natural gas as a back-up.

Possible drawbacks: Veibruksavgift to cover the costs caused by vehicle use

the road, such as air pollution, accidents, road wear and noise. Gas Vehicles will contribute to many of these

disadvantages in line with other vehicles and exemptions for these inconsistent.

Feasibility: Good. This should be very easy to implement, as there is talk of a

continuation of an already existing instrument.

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Investment aid for the purchase of

gas vehicles (private cars and / or taxi)

Description: By reducing the investment cost of gas vehicles, the share of gas in the vehicle

fleet increased. At present gas vehicles both more expensive and have a higher fee, see details

this Annex 3c. By reducing the purchase tax so that the investment cost for gas vehicles

whole is aligned with the corresponding gasoline or diesel vehicles, the demand for

gas vehicles increased. This will be a revenue-neutral measure, since most consumers

alternative would buy gasoline or diesel. If the "subsidy" provided in the form of reduced fee,

the effect of such cabs less, since they already pay a reduced fee.

Alternatively, the grant is given as a lump sum when buying gas vehicles (as in Sweden).

The desired effect: Increase the use of biogas for transport purposes.

Features: Heavy steering effectively. All measures that are aimed at increasing the proportion

gas vehicles will also increase the use of natural gas. This can be solved by the simultaneous introduction of a

higher tax on natural gas to biogas is considerable less expensive compared to natural gas, but this

can inhibit the growth of biogas biogas market since users often use natural gas as a back-

Save.

Possible drawbacks: Gas cars have a fuel tank as well as back-up. In some gas vehicles, this

additional tank so large, that theoretically can run most of the time with gasoline operation. In addition

may NO

x

Emissions become a problem, since some types of gas vehicles have higher emissions of NO

x

. This can

solved by putting demands on engine type to get investment support.

Conducted in neighboring countries: Yes, in Sweden

Investment aid for the purchase of

gas vehicles to fleet operations

Description: An investment of (heavy) vehicles used in fleet operation (eg buses and

vans), can be an effective way to increase gas vehicle portion of the vehicle fleet. Because these

vehicles are able to use the same fuel station every day, the investment cost

lower than the cost associated with increasing gas vehicle share in the private market.

The desired effect: Increase the use of biogas for transport purposes.

Features: Heavy steering effectively. Similarly as for investment for other gas vehicle,

instrument could increase the use of natural gas instead / as well as the use of biogas.

Possible drawbacks: It is important that vehicles with low NO

X

Emissions is selected, otherwise the instrument increase

challenges in cities with high NO

2

Concentrations. This can be solved by setting requirements for low NO

x

-

emissions for the vehicle to be eligible.

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Investment aid for the purchase of

gas buses

Description: The bus market will likely be even easier to increase the number of gas vehicles than in

fleet vehicles in general, partly because the user of public transport will often be concerned

environmental consequences of the choice of transport mode. An investment specifically targeted at

gas buses can be a very effective policy instrument.

The desired effect: Increase the use of biogas for transport purposes.

Features: Heavy steering effectively. As with investment for fleet vehicles, will

instrument could increase the use of natural gas instead / as well as the use of biogas.

Possible drawbacks: Same as for investment for fleet vehicles.

Investment for the construction of

filling stations

Description: The investment in filling stations for gas-powered vehicles can be a barrier to an increased

share gas vehicles in the vehicle fleet, both for private vehicles and fleet vehicles. By providing

investment support for these, development accelerated.

The desired effect: Increase the use of biogas for transport purposes.

Features: Small management effectively. This instrument will facilitate but do not ensure that the proportion of gas vehicles

increases. A distinction is made between natural gas or biogas.

Possible drawbacks: means will also increase the use of natural gas, unless combined

introduced a higher tax on natural gas to biogas is considerable less expensive compared to natural gas.

However, this can hamper growth of biogas biogas market since users often use natural gas

as back-up. Another option is to link investment support for a requirement of a minimum amount

or percentage of biogas sold in future years.

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Reduced disposable gas-fueled

vehicles

Description: By reducing the investment cost of gas vehicles, the share of gas in the vehicle

fleet increased. At present gas vehicles both more expensive and have a higher fee, see details

this Annex 3c. By reducing the purchase tax so that the investment cost for gas vehicles

whole is aligned with the corresponding gasoline or diesel vehicles, the demand for

gas vehicles increased. If the "subsidy" provided in the form of reduced fee, the effect of the

such as taxis less, since they pay a reduced fee. Alternatively, the subsidy granted

as a lump sum when buying gas vehicles (as in Sweden).

The desired effect: Increase the use of biogas for transport purposes.

Features: Small management effectively. This instrument will facilitate but do not ensure that the proportion of gas vehicles

increases. A distinction is made between natural gas or biogas. This will be a revenue-neutral

instrument, since most consumers would otherwise purchase gasoline or diesel.

Possible drawbacks: Gas cars have a fuel tank as well as back-up. In some gas vehicles, this

additional tank so large, that theoretically can run most of the time with gasoline operation. In addition, the

all measures that are aimed at increasing the share of gas vehicles also increase the use of natural gas,

unless it also introduced a higher tax on natural gas to biogas are significant

less expensive compared to natural gas. However, this can hamper growth of biogas market since

biogas users like to use natural gas as a back-up.

Support for the replacement of oil boiler to gas boiler

if the biogas to be used

Description: Parliament has made ​​the following decisions in [Recommendation 390 S (2011-2012):](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.stortinget.no/Global/pdf/Innstillinger/Stortinget/2011-2012/inns-201112-390.pdf) " *Parliament requests*

*government prohibit firing with fossil fuel in households and the base load of other buildings in*

*In 2020. "* When you now must develop means to effect this replacement, it is possible to

add up to the oil boiler to replace the gas boiler that uses biogas.

The desired effect: Increasing demand for biogas

Features: This instrument is effective management. By attaching support directly into biogas use, one can

ensure that the demand for biogas increases as much as you want by customizing support level.

Possible drawbacks: The biogas will be used for heating, resulting in fewer positive

environmental impact than the application in the transport sector.

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Feed-in tariff for biogas at gas station

Description: By introducing a guaranteed selling price for biogas refueling can guarantee

profitability of biogas producer, given that the feed-in-tariff is high enough. More details about the instrument

can be found in the tool menu 1

The desired effect: Increasing the production of biogas, and ensure that it is used for transportation purposes.

Feature: This instrument has good management efficiency. By adjusting the tariff will trigger

desired amount of biogas production. Since the feed-in-tariff only applies to sales to service stations will

it is likely but not guaranteed that the biogas will be used for transportation purposes.

Introduce a tax on natural gas unless

it fulfilled a%-vis requirement

biogas intervention

Description: As described above, all measures which are aimed at increasing the proportion of gas vehicles

also increase the use of natural gas, unless it simultaneously introduce a higher fee for natural gas

so that biogas is considerable less expensive compared to natural gas. A possible remedy here is to introduce

for example, a CO

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Tax on natural gas, but unless it is mixed in a certain proportion of biogas. The requirement

the interference percentage can be increased gradually as more biogas becomes available on the market.

The desired effect: Increase production and use of biogas.

Feature: This instrument is partially effective governance. It ensures that the proportion of biogas increases relative to

natural gas, but not the production and use of gas generally increases.

Possible drawbacks: By introducing a tax on natural gas demand for such

gas-powered vehicles is reduced, because these can also use natural gas.

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Instrument

**Increased access**

**of raw material**

**Increased biogas**

**production**

**Increased**

**application**

**Fertilizer**

**Fertilizer**

**Wet**

**Wet**

**Biogas**

**Bio fertilizer**

**Legal**

**Economic**

**Informative**

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To

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Instrument

**Increased access**

**of raw material**

**Increased biogas**

**production**

**Increased**

**application**

**Fertilizer**

**Fertilizer**

**Wet**

**Wet**

**Biogas**

**Bio fertilizer**

**Legal**

**Economic**

**Informative**

**3.2 Increased use of bio fertilizer**

***3.2.1 Legal instruments***

Stricter requirements in fertilizer products Regulations

for storage and distribution of

Fertilizer

The desired effect: The revision of fertilizer products Regulation, the main purpose being to ensure that emissions

to water and air is limited and most of the added nutrients (such as nitrogen and P) used

of crops. It is possible that this will lead to requirements for manure and mineral fertilizers

favors the use of organic fertilizer

Feature: This instrument is moderately effective management for increased use of bio fertilizer. Depends

much of the design. Any stricter other fertilizers will increase the profitability of

to use organic fertilizer. Maximum Requirements for supply of phosphorus and covering all fertilizers will probably

be beneficial for the application of organic fertilizer but does not ensure provision of agriculture in the districts

has a large feed imports that livestock production is large compared to the need.

Possible drawbacks: Such requirements would increase costs for farmers who have too much manure.

Feasibility: Good

Conducted in neighboring countries: No.

Changing demands in the fertilizer product regulation to

heavy metal content in bio fertilizer

The desired effect: Harmonised requirements for all fertilizers / soil improvers regard. Containing

heavy metals will improve the bio fertilizer position compared to eg manure and

mineral fertilizers.

Feature: As of today, the requirement for heavy metal content related to tonnes of dry matter. Through

biogas process goes down solids content, organic material is methane instead. Content

nitrogen, phosphorus mm. but also heavy metals remain the same in absolute amounts, but in relation to

amount TS increases. Therefore requires a smaller amount of organic fertilizer to supply certain quantities

nitrogen and phosphorus. One can replace relation to dry weight, with a ratio of nitrogen and phosphorus.

Possible drawbacks: bio fertilizer can be perceived as "less pure" than other fertilizers

Feasibility: Good

Conducted in neighboring countries:?

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Instrument

**Increased access**

**of raw material**

**Increased biogas**

**production**

**Increased**

**application**

**Fertilizer**

**Fertilizer**

**Wet**

**Wet**

**Biogas**

**Bio fertilizer**

**Legal**

**Economic**

**Informative**

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Instrument

**Increased access**

**of raw material**

**Increased biogas**

**production**

**Increased**

**application**

**Fertilizer**

**Fertilizer**

**Wet**

**Wet**

**Biogas**

**Bio fertilizer**

**Legal**

**Economic**

**Informative**

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Instrument

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**of raw material**

**Increased biogas**

**production**

**Increased**

**application**

**Fertilizer**

**Fertilizer**

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**Wet**

**Biogas**

**Bio fertilizer**

**Legal**

**Economic**

**Informative**

Development of standards /

declaration of contents for bio fertilizer

The desired effect: the development of standards / content declaration will make use of bio fertilizer more

attractive. The revised regulations fertilizer products will be requirements for fertilizer plan to plan

added amounts of nutrients. If instead of standard introduces a declaration of

content of nutrients such as nitrogen, phosphorus and potassium based on calculations and / or analysis

bio fertilizer will improve its position clear in relation to manure and mineral fertilizers.

Attribute: Medium control effectively, especially by a declaration of contents of the nitrogen content,

phosphorus and potassium. It can be based on a calculation based on the incoming raw optionally

supplemented by analyzes.

Possible drawbacks: Possibly costs, but these are believed to be small especially for content declaration.

Feasibility: Good

Conducted in neighboring countries: Unknown

***3.2.2 Economic instruments***

Support for the analysis of bio fertilizer

The desired effect: increased use of bio fertilizer

Attribute: Medium control effectively the same reason that the introduction of standard / content declaration

Possible disadvantages: Additional administration

Feasibility: Good

Conducted in neighboring countries:

Development of fertilizer calculator

containing organic fertilizer

The desired effect: Make use of bio fertilizer more attractive, in the same way that "the development of

standards / content declaration "and" support the analysis of digestate. "

Attribute: Medium control effectively

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Instrument

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**Wet**

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**Fertilizer**

**Wet**

**Wet**

**Biogas**

**Bio fertilizer**

**Legal**

**Economic**

**Informative**

Possible Disadvantages: None known

Feasibility: Good, consistent with expected changes in fertilizer products Regulations

Support for the transport of organic fertilizer for

suitable distribution areas

The desired effect: better utilization of bio fertilizer.

Feature: It is good management efficiency if one adds the requirement to spread the area to receive

Center. By adjusting the amount of aid will also be able to ensure that it is more profitable to spread

bio fertilizer in relation to the use of fertilizers or other ways to treat organic fertilizer.

Possible Disadvantages: Costly for budgetary authorities, especially if it should happen

further growth in livestock and fertilizer production areas without the need for more fertilizer.

Feasibility: Good, except for costs

Conducted in neighboring countries: Not available

Support for the processing of organic fertilizer

(Pelleting or similar)

The desired effect: Increased use of / demand for bio fertilizer by creating products that are

easier to handle / transport

Attribute sure management efficiency depends much on products

Tax on nitrogen and phosphorus in

fertilizer

Description: It is a tax on the content of nitrogen and possibly phosphorus fertilizer. The fee

will raise the cost of fertilizer and thus increase the value of manure and organic fertilizer. This could increase

value of organic fertilizer and thus the motivation for the supply of manure and organic waste

the biogas plant, if the processing and storage at the biogas plant can help to improve the utilization

of nitrogen and phosphorus in these raw materials.

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Instrument

**Increased access**

**of raw material**

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**Bio fertilizer**

**Legal**

**Economic**

**Informative**

The desired effect: The main purpose of a tax on nitrogen and possibly phosphorus fertilizers to

reduce the loss of nutrients and emissions to water and air and better utilization of such manure

and organic waste. Any increase in the amount of manure and waste for biogas plants will therefore

simply be a side effect.

Feature: This instrument can be regarded as medium to good governance effectively when the main objective is to ensure

better utilization of manure with less loss and reduced discharge of nutrients to water and

ammonia to air. However, there are several ways to accomplish this than treatment in biogas plants and

value of manure will be increased in nearly the same rate as the value of organic fertilizer. This may result

fewer want to give up the manure into biogas plant management effectiveness in terms of

biogas target is probably relatively small.

Possible drawbacks: Previous experience with a nitrogen charge until 2003 and financial calculations

shows that the tax must be fairly high (50-100% of the price of fertilizer nitrogen to have a

effect of importance on the use of mineral fertilizers). It will not accept farmers without some form of

compensation, for example. in the form of a rollback. This instrument can also have an adverse regional

effect, since agriculture in areas with low animal and get biogas plants will not have easy access to

fertilizer and organic fertilizer.

Feasibility: Significant resistance among industry players and agricultural management including LMD

Conducted in neighboring countries: Denmark has a very small fee, Sweden had a charge in the period

1980-2010

***3.2.3 Informative instruments***

Information campaign on the use of

bio fertilizer

Description: Information campaigns on the use of organic fertilizer could increase knowledge and thus

demand / willingness to pay for organic fertilizer. It will, however, depend on whether one has positive news to

inform.

The desired effect: More bio fertilizer applied most cost effective

Possible Disadvantages: None known

Feasibility: Good

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**4** **Transverse measures**

This chapter describes the transverse measures that will:

• Contribute to increase biogas production in general

• Contribute to increased knowledge

• Help to reduce the risk of negative effects of an biogassatsing

***4.1 Transverse measures to increase biogas production***

Study Support related to the optimization of climate and environmental benefits: In order to optimize both

positioning and dimensioning of the biogas plant, for example, models such as those of

Østfoldforskning (2012) is used. A possible remedy is to provide evaluation support for projects

during planning so that they can make use of such a tool. Using such a model,

be possible to quantify climate benefits and cost of the enterprise for different solutions. If the

selected facility will have a very favorable climate benefit at the expense of corporate profitability, the

imagine that Enova / SLF / MD can provide support to cover the increased costs.

Improved communication between the players: Since the value chain of biogas and bio fertilizer involving

many different actors, it is advantageous that collaboration across traditional sectoral divisions

occurs. In the survey conducted in this work, it was pointed out that there is a

need to establish platforms that meeting point for players. In Sweden, it created some

Web portals for biogas consisting of various stakeholders, such as www.biogasportalen.se and

www.sgc.se.

National Working Group on Biogas: A working group to follow up the developments in the biogas market

over time may contribute to the adaptation of means to a changing market. Simultaneously,

working group to monitor the development of biogas production and ensure that any

objectives are achieved. Denmark has established a working group to monitor developments

for biogas development and guide biogas projects under Energiavftalen adopted in March

2012. It is set by nearly 10 million Danish kroner to the Working Group for the period 2012-2015.

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***4.2 Transverse measures to increase knowledge***

Better statistics: As of today, there are no good statistics on the amount of biogas produced and

used or quantity of waste used for this in Norway. It may be appropriate that the SSB

establish such statistics for biogas production and improves the static for wet organic industrial waste.

This will make it easier to adapt programs in a better way.

Research and development (R & D): R & D may contribute to reduced costs for biogas production and increased

environmental benefit. In particular, some areas that need increased research activity:

• Process Optimization (temperature, time, etc.) and substrate compositions and how these

affecting gas yield

• Pretreatment increasing biogas yield

• New technology such as dry processes that can reduce the investment cost to

biogas plants

• New substrates / raw materials, such as birch wood chips, park and garden, seaweed, ("eaves

meadows ") and waste from agriculture (straw, potato waste, waste from vegetable production, hay, grass and

silage that keeps feed quality)

• Better documented effect of the use of organic fertilizer on soil ecology, plant growth and reduced

need for pesticides.

• Better documented effect on greenhouse gas emissions in biogas production and storage and

application of organic fertilizer

• Knowledge of cost-effective technology in smaller facilities and sambehandlingsanlegg, custom

Norwegian conditions.

• Knowledge of dense storage of organic fertilizer, and emissions of methane, nitrous oxide and ammonia.

R & D needs for biogas production from manure

It is relatively large uncertainties associated with the calculated values ​​for costs, emission reductions,

environmental benefits and other benefits that are used in Klimakur / rural sector report / value chain report and

Now in this report biogas, especially for production based on manure. This is because in

Norway's only a couple of small biogas plants for manure and no major. The same applies

plant sambehandling of organic waste and manure. Costs and experiences with

operation of such facilities abroad are not easily transferred to Norway. The main

uncertainty factors are:

• Uncertainty about the actual costs of major facilities for manure and

sambehandlingsanlegg of manure and organic waste.

• Uncertainty about gas yield of the different fertilizer types and combinations of fertilizers

and admixing of other substrates.

• Uncertainty about the size of emissions reductions through treatment of various types

manure in biogas plants in the baseline scenario. Among other indications

the proliferation of bio fertilizer reduces emissions of nitrous oxide and runoff than rågjødsel but

documentation is inadequate.

• uncertainty in valuation of environmental benefits from reduced emissions of ammonia, nitrates and

phosphorus compounds.

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• uncertainty with respect to the fertilizer effect of organic fertilizer compared with either

manure and mineral fertilizers

Production costs (U.S. $ / kWh) for biogas from manure is sensitive to changes in

above factors. Investment costs and gas yield is, as mentioned earlier, the factors

affecting the manufacturing cost to the greatest extent. This sensitivity, coupled with the above

uncertainty, resulting in a wide range of measures both cost and production of biogas

based on manure. With so much uncertainty, it is difficult to find investors who will

invest, and it becomes difficult for the authorities to design instruments. D is required to

reduce this uncertainty.

Further research contribute to further improvements in technology that will improve the economy by

plants, especially if it leads to reduced investment costs or increased gas yield. To

carry out a part of the above research will be necessary to establish one or more

full scale pilot plant for manure possibly combined with organic waste and / or other

substrates. There is currently construction is completed as planned and will serve as pilot.

These can be completed relatively quickly, but it will require adequate financial support. Examples

in such systems are described below. Based on experience from pilot plants will be better able to determine

which combinations of investment, production and support or other means that will

be necessary to create commercial profitability.

It may also establish programs under the Research Council of the above R & D needs and

a new long-term research program ala ORIO program, which can operate with information and

knowledge transfer and provide support for more current research and problem solving.

Example of pilot plant huge gardens with manure

The project "Biogas Vestfold Grenland" now conducted on behalf of 17 municipalities in Grenland and

Vestfold. The planned facility will be built in an area with high agricultural production, both

regard to access to land and livestock within driving distance of 5 -20 km. The plant is first and

mainly produce gas for fuel, but also something to heat. The facility will cater for 18 000

tonnes of source separated household waste, general industrial waste and may be suitable for receiving

manure. The annual mesophilic utråtningsprosess and use of best available technology

preparation and sanitation. With some additional investment in the plant have a capacity to take in

to approx. 60, 000 tons of manure, which amounts to approx. 30% of the total volume of manure

Vestfold. The progress of the project is such that it should be sent out tender documents in June and

potential role as a pilot plant to be clarified by 1 June 2013.

Also on Jæren There are opportunities to establish a large biogas plant for treatment of

manure, combined with organic waste from the food industry.

Example of pilot plants: Less farmsteads from manure

In connection with the Veterinary College and Veterinary Institute will be moved to Campus Ås shall

building a new barn. It is planned / considered the establishment of a biogas plant that will

treat about 6,000 m

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manure per year. In addition, it will be appropriate, as seen from a

Research point of view, the construction in such a way that alternative additional raw material may be used, for

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such as food waste, fish waste and / or straw. The plant will be located near the Research and

teaching environments on Hill, where two years ago established a biogas laboratory and will be

very suitable as a pilot plant for research.

***4.3 Transverse measures to reduce the risk of negative effects of biogas initiative***

The rapid development of biogas production is a risk of any adverse effects, such

as error support level instruments or an assessment of the environmental benefits. There are two

areas where one can consider introducing measures to reduce this risk, supervision

plants to prevent methane leaks and demands for tight storage of bio fertilizer.

Meta Leaks biogas plant: Methane is a much stronger greenhouse gas than CO

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So that even small

methane emissions can have a major effect on climate. A leak in the biogas plant can be difficult to

detect and emissions can more than offset the projected reduction in greenhouse gas emissions from

biogas production and use. That is, this can lead to a net discharge instead of a

reduction of greenhouse gas emissions. Typically, the risk will be greater for small biogas plant, such

such as farmsteads, which monitors the gas yield accurate enough to detect the leak. This

is one of the reasons we in this paper have seen most of the major facilities where one expects

better control of the expected and the actual gas yield. Double Diaphragm on utråtningstanken

can reduce such emissions. It may also be appropriate to introduce a supervisory

for biogas plants where methane emissions are measured, for example by using a camera that makes it

possible to detect even small leaks (see for example www.gaskamera.de).

Storage bio fertilizer, bio fertilizer N will for biogas treatment remain somewhat organic

the material that can lead to the formation of methane when it is stored. Depending on how

biogas process has been completed, this discharge may be higher or lower. Off

economic considerations will biogas plants try to optimize biogas process and among

Others choose residence time in the tank so that most of the methane has been recovered. It will however also

be a compromise between being able to have enough throughput (i.e., low residence time) and

bring out the maximum gas yield. Especially biogas plants based on organic waste will be

an incentive to reduce residence time in the tank, since it will mean that they can accept more waste

that they get a gate-fee for. By introducing a requirement for dense storage of digestate, where methane is captured,

such emissions by fermentation of organic fertilizer significantly reduced.

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**Appendix 1: Potential for biogas production**

This appendix describes in greater detail how the realistic potential of biogas by 2020

examined in this report.

The potential is calculated based on figures from the report "Potential Study for biogas in Norway"

(Østfoldforskning 2008) that was written for Enova. It is considered that the resources in waste will be

utilized in the best possible way, ie waste that is currently used such as animal feeding, not

count in the biogas potential. We have not updated waste gas or dividends that were

estimated in the report in 2008, which means that we do not take into account any growth in the period 2008-2012,

but does not take into account the growth or reduction by 2020. Biogas Yield per ton can

likely to have increased somewhat since 2008 due to more optimized biogas processes and will probably

increase to 2020, which may cause an underestimation in our estimates of the realistic potential.

Detailed assumptions about the potential assessment:

1 Food waste from households, assumptions from the report written by Østfoldforskning (2008)

429 kg of waste per person and a portion of wet organic waste at 24.3% is retained. The figures are not

updated to take account of an increase in population. It is also not taken into account a

reduction in the dining win in households. It is also assumed that there may be a realistic (but

ambitious) goal is to collect 50% of this waste. To achieve a high collection rate

need for such a coverage of source separation (ie the proportion of municipalities

have recycling) of around 85%, and sorting degree in all these municipalities 60%

(Meaning that 60% of food waste generated in households actually being sorted out). It is further

assumed that all collected waste is treated in biogas plants, which means that nothing goes to

incineration or composting. Potential of 322 GWh is equivalent to 245,000 tonnes of food waste

with a gas yield of 1314 kWh / ton. Gas outcome is the same as used in the report

written by Østfoldforskning

2 Food waste from the catering trade and commerce: The total amount of food waste from the catering

and trade has not been updated in relation to Østfoldforskning report. We assume that it can be

realistic to have a slightly higher collection rate from that source than from households, so that

collection rate is set to 80%. It is further assumed that all collected waste is

treated in biogas plants, ie no waste incineration or composting.

Potential of 159 GWh is equivalent to 218,000 tonnes of food waste in a biogas yield of 732

kWh / ton. Gas outcome is the same as used in the report written by Østfoldforskning

3 Organic waste from the industry:

A. Waste from slaughterhouses: Offal after sterilization can be used as feed for fur animals and

pets. Kjøttbeinmel can be used as fertilizer. In addition, the fat can be used as fuel oil.

Enova report estimated 320 GWh as the theoretical potential for biogas production.

Utilization as feed is preferred over biogas production, so that the potential

reduced. Given that about half of slaughter waste used for biogas production, the

potential of 160 GWh.

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b Waste from fishing / aquaculture: Enova report estimates a potential of 640 GWh, but

also points out that around 70% of this is already used as animal feed today. We estimate therefore

that 20% of the theoretical potential can go to biogas production, ie about 130

GWh. It is, however, a discussion on whether fish waste should be tapped into biogas, or

other applications in industry may be more appropriate.

c waste from dairies and bakeries and corn husks: This can be used for feed production,

protein production and combustion, so here we reduce the potential to one half of

estimate made by Enova in 2008. When the contribution from dairies and bakeries respectively

56 GWh and 25 GWh, while corn husks contributes around 28 GWh.

D. Waste Brewing: This used already as feed in its entirety and is therefore not included

etc..

AD sludge from pulp and paper industry: This waste is burned mainly in the day, but

biogas production will be a more appropriate exploitation of this potential above

waste hierarchy. We believe that it is not realistic to utilize more than half of

this biogas production by 2020, so that potential is 45 GWh.

4 Halm: This can be utilized as bedding, and for the combustion. If the straw used as litter, it will

be included in the manure potential for "use". In addition, this is a very scattered resource,

it is assumed will be difficult to get used and which have a high calorific value, so that utilization

incinerators may be appropriate. It is therefore assumed that 30% of the amounts that were

estimated in Østfold Research report is realistic to utilize the biogas production by 2020;

ie 173 GWh.

5 Fertilizer: The estimate of manure is based on the assumptions in the 2008 report, the

been no updates to the amount of manure per animal or animal numbers or distribution

between different animal species. We have the goal of utilization of 30% by volume occurred

manure to the soil and thus ends with a potential of 744 GWh.

6 Sewage sludge: It is estimated that 50% of the potential of sewage sludge is used for biogas. It may

conceivable that this is a somewhat low estimate.

7 Landfill Gas: It is illegal to dispose of organic waste at present. Nevertheless, the existing

wet organic waste in landfills emit methane for many years to come. The amount will decline, but

while we assume that the collection efficiency increases. At present, only about 27% of

methane gas that occurs in a landfill that is collected. We assume that the decrease in the amount of gas

that occurs is compensated for by an increase in the recovery rate due to an upgrade of

plants and the few new plants are being established (see measures proposed in the Cure 2020 (CPA

2010 b)), so that the whole is assumed a zero growth.

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**Sector / Source**

**Theoretical**

**potential according**

**Østfold report**

**Justification for the change in potential**

**(From theoretical to realistic potential)**

**Factor**

**Realistic**

**potential**

**within**

**2020**

GWh

GWh

Food waste from households

644

Assuming that 50% of food waste from

households that do occur are collected

in and that all of this goes into biogas.

0.5

322

Food waste from

large residential and commercial

199

Assuming that 80% of food waste arising

in the catering trade and commerce is collected

in and that all of this goes into biogas.

0.8

159

Organic waste from industry -

total

1401

(See details below)

507

*Waste from slaughterhouses*

*320*

*Many alternative uses*

*(Kjøttbeinmel, fuel oil, etc.), assuming*

*Therefore att 50% goes to biogas production*

*0.5*

*160*

*Waste from fishing / aquaculture*

*640*

*Of the current waste utilized around*

*70% to forage. This can also be utilized in*

*Omega3-production and other*

*applications. Around 20% of*

*waste dumped today. Assuming therefore that 20*

*% Is used for biogas production.*

*0.2*

*128*

*Waste from dairies*

*160*

*Assuming that 50% of the total waste*

*This category is used to*

*biogas production.*

*0.5*

*80*

*Waste from breweries*

*280*

*This will be used as for today. Is therefore*

*set equal to zero here.*

*-*

*Waste from bakeries*

*70*

*Assuming that 50% of the total waste*

*This category is used to*

*biogas production.*

*0.5*

*35*

*Waste from corn husks*

*80*

*Assuming that 50% of the total waste*

*This category is used to*

*biogas production.*

*0.5*

*40*

*Sludge from pulp and paper industry*

*128*

*Assuming that 50% of the total waste*

*This category is used to*

*biogas production.*

*0.5*

*64*

Straw

575

Used mainly as litter, forage and

biofuel plants today, and that something is

present in corn fields. Probably demanding

getting exploited. Assuming therefore that 30% goes to

biogas.

0.3

173

Fertilizer

2480

Assuming that 30% of the total quantities

manure used in

biogas production.

0.3

744

Sewage sludge

266

Assuming that 50% goes to biogas.

0.5

133

Landfills

292

Assuming a decrease in the amount of landfill gas,

but an increase in the recovery

of the gas, so that it is inserted

zero.

1.0

292

**Total**

**5857**

**2330**

|  |
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|  |
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**Annex 2 a): Background figures with assumptions and sources**

**General**

**Source**

**Description**

**Unit**

**Value**

**2012**

**Comment**

1

Energy per unit mass, diesel

kWh / liter of diesel

10

2.3

Energy content upgraded biogas

kWh/Sm3 biogas

10

4

Valuation of reduced NOx

NOK / kg

157

Estimated 50% of the emission reduction

Oslo, Trondheim, Bergen and 50% in

other major cities

4

Valuation of reduced PM10

NOK / kg

2613

Estimated 50% of the emission reduction

Oslo, Trondheim, Bergen and 50% in

other major cities

5

Valuation nitrogen

NOK / kg

11.74

5

Valuation phosphorus

NOK / kg

19.21

5

Valuation of reduced

ammonia emissions (NH3)

£ / tonne

2.67

6

Upgrading of gas, normal

plant

NOK / kWh

0.13

Fee Adjusted

6

Compression

NOK / kWh biogas

0.05

Fee Adjusted

2.9

Energy price light oil major consumer

NOK / kWh

0.46

w / o VAT, excl tax

7,8,9

Energy price diesel major consumer

NOK / kWh

0.57

w / o VAT, excl tax,

large corporate corrected -10%

2

Energy price natural gas major consumer

NOK / kWh

0.28

w / o VAT, excl tax

2

Electricity price

NOK / kWh

0.50

w / o VAT, excl tax

6.10

Life flakes, tank station, backup

year

15

Updated by

survey

6.11

Life coach

year

10

Updated by

survey

11

Life biogas plant

year

20

5

Economic

discount rate

5%

20

GWP100 methane

CO

2 -

eq / CO4

21

20

GWP100 nitrous oxide

310

26

nyGWP100 methane

25

26

nyGWP100 nitrous oxide

299

21

GWP10 methane

91

21

GWP10 nitrous oxide

273

12.11

Work

man / Mton

40

13

Time value - works

Mill. £ / employee

0432

Average Salary - renovation in 2011

19

Emissions from the production of

Fertilizer

kg CO

2 -

eq / kg

Nitrogen

4

|  |
| --- |
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192

**Managerial**

**Source**

**Description**

**Unit**

**Value**

**2012**

**Comment**

Business Economics

conversion factor (excluding energy)

1.2

20% of commercially

price / cost, taxes,

estimates

18

Business Financial rate of

investments in production

8%

Maximum internal rate Enova

6

BI rate - bus

%

7%

1

Gate-fee

£ / tonne

700

Calculated from average gate fee

6 incinerators

6

Electricity% of produced biogas

%

8%

For both manure and

biowaste

11

Maintenance fixed% of

investment cost

%

2.5%

For both manure and

biowaste

2.9

Energy price light oil major consumer

NOK / kWh

0.61

Includes fees, u / VAT

7,8,9

Energy price diesel major consumer

NOK / kWh

0.95

Includes fees, u / VAT,

large corporate corrected -10%

2

Energy price natural gas major consumer

NOK / kWh

0.32

Includes fees, u / VAT

2

Electricity price

NOK / kWh

0.62

Includes fees, u / VAT

6

Upgrading of gas, normal

plant

NOK / kWh

0.15

Verified by

survey

6

Compression

NOK / kWh biogas

0.06

|  |
| --- |
| **Page 193** |

193

**Production separately treating manure**

**Source**

**Description**

**Unit**

**Value**

**2012**

**Comment**

23

Energy Dividend per tonne

manure

kWh / tonne

manure

190

See potensialdel in this report

23

Tons of manure

M tons

3.92

See potensialdel in this report

11

Number of tons of organic fertilizer

M tons

7.17

Calculated from the hydraulic

capacity

11

Construction 110 000 tonnes per tonne of

hydraulic capacity

U.S. $ / tonnes per year

hydraulic capacity

663

11

Construction 55 000 tonnes per tonne of

hydraulic capacity

U.S. $ / tonnes per year

hydraulic capacity

765

10

Transport Cost

£ / tonne

1.3

Increased according. survey

11

Average distance to and from

Farm t / r

mi t / r

20

Approximately 10 km each way

11

kWh of diesel per mil

KWh / mil

60

35 tons of cargo

11

Load per trip

tons

35

6

Storage costs - on farms

-

See discussion in Chapter 4

6

Electricity as% share of

produced biogas

%

8%

11

Maintenance facility as% share of

investment cost

%

2.5%

11

Quantity medium system,

sambehandling

55

Increased New

amount of manure

11

Number of major facilities, sambehandling

38

Increased New

amount of manure

5

Reducing methane

tons CO4

4234

Increased New

amount of manure

5

Reducing nitrous oxide

tonnes N2O

200

Increased New

amount of manure

5

Reduced loss of nitrogen, digestate

tons of nitrogen

2379

Increased New

amount of manure

|  |
| --- |
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**Production separately treating organic waste**

**Source**

**Description**

**Unit**

**Value**

**2012**

**Comment**

14.15

Investment Cost

£ / tonne of biowaste

5000

Average of Lindum and EGE, including

pre-treatment

23

Gas Dividend per tonne of biowaste

kWh / tonne

1120

See potensialdel in this report

23

ktonnes waste realistic potential

ktonnes

882

See potensialdel in this report

27

Landfill gate fee

£ / tonne

300

22

Bio fertilizer per ton of treated waste

bio fertilizer kg / kg

waste

2.5

20

Emissions from combustion and

composting of organic waste

tons of CO

2 -

eq / ton

waste

0.03

10

Transport Cost

£ / tonne

1.3

27

Incinerator Expansion

U.S. $ / tonnes per year

6350

27

Incinerator construction

U.S. $ / tonnes per year

11 467

Total kilometers per tonne digestate t / r

40

Assumption - Doubling of manure-

distance, then it is assumed that there is no

Nearby dispersal areas for

digestate

Transport of organic waste

Mill. £

-

No additional costs in relation to alternative

treatment

Work

Mill. £

-

No additional costs in relation to alternative

treatment

Electricity

Mill. £

-

No additional costs in relation to alternative

treatment

Maintenance

Mill. £

-

No additional costs in relation to alternative

treatment

10

Phosphorus per tonne organic waste

kg phosphorus / ton

waste

1.24

Updated by analyzing data from

survey

10

Nitrogen per ton of organic waste

kg nitrogen / ton

waste

5.29

Updated by analyzing data from

survey

30

Proportion of waste that would be

composted

0.20

Reduced from climate cure -25%

29

Boiler Efficiency

%

0.85

24, 25,

1

Calorific value organic waste

GWh / ton

0.54

The estimated weighted average based

the number of reports and internal numbers

1

Calorific value waste

GWh / ton

3.3

Energy content of waste - from

emission inventory

25

Average energy utilization,

Norwegian incinerator

%

0.77

1

Emission factor combustion waste

tons of CO

2 -

eq / ton

MSW

0.54

Value of emission inventory

|  |
| --- |
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**Bus Measures**

**Source**

**Description**

**Unit**

**Value**

**2012**

**Comment**

6.10

Number flakes to cover 150 buses

10

Adjusted for survey

6.10

Number of filling stations to cover 150

Buses

2

In Trondheim parts 135 buses one

plant, adjusted for

survey

6.10

Cost per flakes

1.0

Adjusted for survey-

commercial

6.10

Cost per tank station

17

Adjusted for survey-

commercial

6.10

Cost back-up system for 150

Buses

11

Business Economics

6.10

Annual operating cost flakes, tank, back-

up as a percentage of the investment cost

%

6.5%

Adjusted for survey-

commercial

6.10

Additional cost biogas bus

Mill. £

0.30

6.10

Mileage per bus per year

km

50 000

Adjusted for survey

6

Methane emissions gas bus

g methane / kWh

0.40

Adjusted for survey

16

NO

X

Emission gas bus

g / km

3.5

16

PM10 emission gas bus

0.01

16

NO

X

Emission diesel bus

g / km

7.00

16

PM10-emission diesel buses

PM10 g / kWh

0.06

6.10

Fuel diesel bus

liters per mil

4.00

Adjusted for survey

6.10

Fuel biogas bus

sm3/mil

5.00

Adjusted for survey

17

Emissions per liter of diesel

kg CO

2 -

eq / kWh

diesel

0266

28% higher than for natural gas

**Gassnett Rogaland**

**Source**

**Description**

**Unit**

**Value**

**2012**

**Comment**

1

90% of manure

GWh

500

1

CO

2

Factor gas

tons

CO

2 -

eq

/ GWh

209

|  |
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January 2013 [, http://www.vvsforum.no/artikkel/4531/veidekke-bygger-biogassanlegg-i-nes-](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.vvsforum.no/artikkel/4531/veidekke-bygger-biogassanlegg-i-nes-kommune.html)

[kommune.html](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.vvsforum.no/artikkel/4531/veidekke-bygger-biogassanlegg-i-nes-kommune.html)

16

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Enova 2011, Program Evaluation - Enova's support for biogas production

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Preliminary study. "

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Intergovernmental Panel on Climate Change

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communicated by phone and e-mail

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30/2012)

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**Annex 2 b): Sensitivity Analysis**

*Table 2b.1: Values ​​in bold (1st column) are the original values ​​from the analysis. Dark green and light green background color indicates the parameters that provide respectively*

*highest and second highest impact.*

**Investment**

**manure**

**Investment**

**biowaste**

**waste**

**Transport**

**cost**

**Labour**

**costs**

**Maintenance**

**Gas Yield**

**manure**

**Gas Yield**

**biowaste**

**waste**

**Calorific value**

**biowaste**

**waste**

**Calorific value**

**MSW**

**value**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**Production - manure**

NOK / kWh

**1.25**

*0.89*

*1.61*

1.08

1.41

1.20

1.29

1.16

1.33

*2.37*

*0.87*

NOK / kWh - Bedok

**1.27**

*0.83*

*1.72*

1.08

1.47

1.22

1.33

1.17

1.38

*2.67*

*0.81*

**Production - organic waste**

NOK / kWh

**0.54**

*0.36*

*0.72*

0.48

0.60

*0.96*

*0.40*

NOK / kWh - Bedok

**0.00**

*-0.29*

*0.30*

-0.07

0.07

-0.01

0.01

-0.06

0.07

0.13

-0.04

**Production - potential**

NOK / kWh

**0.84**

*0.69*

*1.00*

0.74

0.95

0.74

0.95

0.83

0.86

0.81

0.88

1.04

0.72

*1.13*

*0.69*

NOK / kWh - Bedok

**0.55**

*0.36*

*0.74*

0.38

0.72

0.42

0.67

0.52

0.58

0.47

0.63

*0.73*

*0.43*

0.82

0.40

**Bus-fertilizer**

U.S. / CO

2

-Eq

2275

*1401*

*3149*

1876

2675

2164

2386

2067

2483

3417

1613

**BUS biowaste**

U.S. / CO

2

-Eq

**1128**

224

2033

828

1429

*3344*

*423*

1006

1286

1494

1043

**Bus-potential**

U.S. / CO

2

-Eq

**1827**

1294

2359

1473

2180

1466

2187

1759

1894

1700

1953

2349

1450

2528

1361

1743

1918

2020

1770

**BUS - Bedok**

NOK / kWh

**0.04**

**RO - manure**

U.S. / CO

2

-Eq

**2351**

*1485*

*3217*

1955

2747

2241

2461

2145

2557

*3461*

*1711*

**RO - sambehandling (1:18)**

U.S. / CO

2

-Eq

**2207**

*1460*

*2953*

2084

2329

1825

2589

2112

2302

2030

2384

*3074*

*1665*

2432

2011

2171

2244

2282

2183

|  |
| --- |
| **Page 198** |

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**Discharge**

**factor**

**MSW**

**Interest**

**(Bedok)**

**Gate-fee**

**Electricity price**

**Natural Gas**

**Price**

**Diesel price**

**Additional cost**

**gas bus**

**Tank**

**stations,**

**flakes, backup**

**Drifstoff-**

**use**

**gas bus**

**NO**

**X**

**Emissions**

**value**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**-50%**

**+50%**

**Production - manure**

NOK / kWh

**1.25**

1.23

1.27

NOK / kWh - Bedok

**1.27**

1.08

1.49

1.25

1.29

1.41

1.14

**Production - organic waste**

NOK / kWh

**0.54**

NOK / kWh - Bedok

**0.00**

-0.12

0.15

*0.31*

*-0.31*

-0.02

0.02

0.14

-0.14

**Production - potential**

NOK / kWh

**0.84**

0.84

0.85

NOK / kWh - Bedok

**0.55**

0.39

0.72

0.73

0.37

0.53

0.57

0.69

0.41

**Bus-fertilizer**

U.S. / CO

2

-Eq

**2275**

2227

2324

2833

1717

2117

2433

2038

2512

*903*

*3117*

***2141***

***2409***

**BUS biowaste**

U.S. / CO

2

-Eq

**1128**

1006

1286

2281

-24

801

1455

640

1617

*-353*

*2728*

***851***

***1406***

**Bus-potential**

U.S. / CO

2

-Eq

**1827**

1743

1918

1797

1856

*2617*

*1036*

1602

2051

1491

2162

*317*

*2988*

***1637***

***2017***

**BUS - Bedok**

NOK / kWh

**0.04**

-0.02

0.11

-0.10

0.18

*0.25*

*-0.16*

-0.04

0.13

-0.08

0.17

*-0.30*

*0.16*

**RO - manure**

U.S. / CO

2

-Eq

**2351**

2351

2351

2351

2351

2303

2399

2687

2016

**RO - sambehandling (1:18)**

U.S. / CO

2

-Eq

**2207**

2171

2244

2165

2248

2591

1823

|  |
| --- |
| **Page 199** |

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*The figures below show the results from the full sensitivity analysis*

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Net economic cost of production - manure**

+50%

-50%

0%

1.25

0.00

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Business Financial losses during production - manure**

+50%

-50%

0%

1.27

0.00

|  |
| --- |
| **Page 200** |

200

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Net economic production - organic waste**

+50%

-50%

0%

0.54

0.00

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Business Financial losses during production - organic waste**

+50%

-50%

0%

0,002

|  |
| --- |
| **Page 201** |

201

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Net economic production - realistic potential**

+50%

-50%

0%

0.84

0.00

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Business Financial losses during production - realistic potential**

+50%

-50%

0%

0.55

0.00

|  |
| --- |
| **Page 202** |

202

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Value Chain buses - manure**

+50%

-50%

0%

0.93

0.00

-500

500

1500

2500

3500

**£ / tonne CO**

**2**

**-Eq**

**Value chain: city buses - manure**

+50%

-50%

0%

2275

0

|  |
| --- |
| **Page 203** |

203

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Value chain: city buses - organic waste**

+50%

-50%

0%

0.22

0.00

-500

500

1500

2500

3500

**£ / tonne CO**

**2**

**-Eq**

**Value chain: city buses - organic waste**

+50%

-50%

0%

1128

0

|  |
| --- |
| **Page 204** |

204

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Value chain: city buses - realistic potential**

+50%

-50%

0%

0.53

0.00

-500

500

1500

2500

3500

**£ / tonne CO**

**2**

**-Eq**

**Value chain: city buses - realistic potential**

+50%

-50%

0%

1827

0

|  |
| --- |
| **Page 205** |

205

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Business Financial loss for bus companies**

+50%

-50%

0%

0.04

|  |
| --- |
| **Page 206** |

206

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Value chain: Gas Supply RO - manure**

+50%

-50%

0%

0.97

0.00

-500

500

1500

2500

3500

**£ / tonne CO**

**2**

**-Eq**

**Value chain: Gas Supply RO - manure**

+50%

-50%

0%

2351

0

|  |
| --- |
| **Page 207** |

207

-0.30

0.70

1.70

2.70

**NOK / kWh**

**Value chain: Gas Supply RO - sambehandling**

+50%

-50%

0%

0.80

0.00

-500

500

1500

2500

3500

**£ / tonne CO**

**2**

**-Eq**

**Value chain: Gas Supply RO - sambehandling**

+50%

-50%

0%

2207

0

|  |
| --- |
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**Appendix 3 a) Existing and new instruments in the waste sector**

Excerpt from Mepex report (2012)

**Review of existing instruments**

***Norwegian waste policy and requirements for handling organic waste, s 12-24:***

Organic waste is part of the overall national target of 75% recycling by 2010 and

subsequently to 80% based on the amount of waste recycled increased in line with what

is an economic and environmentally sensible level. Waste includes materials,

biological treatment and incineration with energy recovery. A distinction is made between small

recycling options, but officials point out that the material / biological treatment

should be preferred to energy recovery when the methods are otherwise equal. Combustion of

organic waste together with other combustible wastes is therefore defined as one of

recycling methods for organic waste, although most of this waste has high

water content and thus low calorific value.

There is at present no specific national goals for utilization of organic waste. How

resources of this waste to be utilized must be considered from a more general goals and principles.

RM 'one from 1999-2000 indicate that it is primarily desirable to utilize the resources of organic waste

by bringing it back into the natural cycle as fertilizer and soil conditioner. In accordance with the

Pollution Act guidelines shall solution for organic waste selected from an overall assessment

of environmental, resource and economic factors.

Organic waste is also covered by earnings goal of prevention which states that developments in

the quantity to be significantly lower than the economic growth.

***Legal instruments***

Ban on landfilling of organic waste

At the request of the Authority (now CPA) introduced the county governors in most provinces ban on landfilling of

organic waste in the period 1995-2000, but with somewhat different interpretation of the

fractions that were prohibited.

In 2002, the implementation of the EU Landfill Directive in Norwegian legislation introduced a national

ban on landfilling of organic waste through landfill requirements in the regulations.

Requirement to separation of food waste from the catering

Several municipalities established on 90 -'s own regulations that required the collection of biowaste

waste from the catering to animal feed. The requirements on the collection included companies that generated

over than certain amount per week. The limit varied from municipality to municipality with many lay in

range 50 kg per week. These regulations were after a transition phase repealed by amendment

waste definitions in pollution control.

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Ban on landfilling of biodegradable waste

In 2009, the ban on landfilling of organic waste subject to all applicable biological

biodegradable waste with a TOC content> 10%. The ban on landfilling of biodegradable

waste is primarily justified to reduce methane emissions from landfills. Instrument must be considered

as very strong and have discontinued treatment for disposal as waste with the biowaste

waste.

Requirements for minimum energy utilization

Waste not stipulate any precise targets for energy efficiency, but says

*"Incinerators must be designed, built and operated in such a way that all the thermal energy generated by*

*incineration process is recovered as far as practicable. "*

The permissions for waste incineration plants will normally 50% energy recovery as a

minimum which means that incineration plants must utilize heat energy

process steam or district heating.

Licenses and therefore an incentive to increase resource utilization of organic waste that is incinerated

together with other waste, and avoids the creation of waste incineration plants with very low

energy utilization. The average energy utilization by the Norwegian

waste incinerators was 77 percent in 2010 as a share provided by the energy produced.

Requirements for the handling of animal waste

European Union - Regulation on animal by-products (by product Regulation) sets standards for the treatment of

different types of animal waste, the requirements of transport and marketing of waste and requirements for

treatment plants. The requirements vary between different types of animal waste depending on the potential

of infection.

A key requirement for biological treatment is the requirement of grinding to a maximum of 12 mm and

disinfection in a separate hygieniseringsenhet at 70 C for 60 min. All biogas plants must

approval from the FDA for regulations on products.

Requirements for disposal of digestate in agriculture or green area

Fertilizers Goods Regulations set requirements for maximum levels of contaminants mm in fertilizer and soil

produced from waste and use limitations on the use of agricultural and green areas. No one can

sell products before they are enrolled and registered in FDA. Join lan only occur when the

sufficient evidence of manure and soil to be traded.

Requirements for cross-border transport of waste

The provisions on cross-border transport is based on common EU rules which are based on

provisions of the Basel Convention mm. In this framework, it just wastes listed in green

waste list that can be exported without license (permission) from the CPA and the competent authority in

recipient country. For wastes listed in the yellow and red list waste is in principle an embargo, but

permission (consent) may be given. For the export of waste for utilization, for example. exports of organic waste

for biogas plants in Sweden and Denmark, there is normally no problem to get permission.

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In principle must be obtained consent from the Climate and Pollution Agency, and the corresponding

authority in the host country, to export waste. There are however a number of exemptions.

Specific types of waste (green waste) being exported for recycling in EU countries and other selected

land not normally covered by the requirements for consent.

National authorities may impose more stringent requirements for export if it is environmentally

justified in violation of laws.

Requirement for authorization

Waste treatment plants that may cause pollution or be unsightly shall be authorized by

pollution control authorities. This includes composting plants and biogas plants. Authority

to grant permits and conduct inspections of such facilities is delegated to the county governors. The relevant

businesses have to pay fees for government work permits and inspections.

Renewable Energy Directive

Renewable Directive aims to increase the share of renewable energy to establish binding targets for the

some countries. For Norway, the demand for renewables set to 67.5% in 2020. Simultaneously, the general

requirement of 10% share of renewables in the transport sector apply from the same year. The Directive sets conditions

for the production of biofuels and biogas will come here very well.

The objectives of the Directive is ambitious and will be difficult to fulfill.

Approx. 25% of energy associated with the transport, while the proportion of renewable

total amount of transport is at 3.3%

34

The total fuel consumption in the transport sector is about.

50 TWh and is estimated to increase to close to 60 TWh in 2020.

35

To reach the 10% target, the consumption of renewable

fuel therefore increase to at least 6 TWh in 2020. Gross potential for biogas

waste (organic waste, sludge and manure) are different estimates set to between 4 and 6

TWh. This potential can hardly sounds full of fuel. SFT (now CPA) estimated the technical

- Economic potential of biogas to 1.4 TWh. The potential can be increased significantly if the development

Cost Effective 2 generation of biogas production based on forest resources.

Biogas from waste for fuel would be a contributor to a new target in the Renewable Energy Directive, but can with

current technology can not meet the need for renewable fuels in Norway.

***Economic instruments***

Tax on the disposal of waste

The purpose of the fee is to praise the environmental costs of waste treatment and thereby stimulate

recycling. The fee covered the former landfill and incineration of waste, but from 1 October

2010 is the only landfill covered by the fee.

34

Ann Christin Bøeng - Implications for Norway by the EU Renewables Directive - SSB Economic Survey 4/2010

35

KanEnergi / Insa - Assessment of biofuels in the transport sector

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Support for R & D

It is used in different contexts support funding for research, development, testing and evaluation of

processing solutions for organic waste, sewage sludge and manure.

Major projects include *source separation project (1993 - 1998)* and

*Reactor Composting Project (1996 - 1999)*

The last major program was *ORIO - "Organic waste products - resources in circulation"* that helped

support various projects in the period 1999-2004. The program was funded by

Ministry of Environment and Ministry of Agriculture and had a budget of 30-35000000 enough.

Today it is primarily research council that supports various research projects on biogas.

Several projects specifically related to biogas in agriculture is supported in recent years.

***Summary and evaluation of effects of current instruments***

**Legal instruments**

**Prohibition of disposal of**

**organic waste**

The ban on landfilling gave an incentive to introduce recycling of biowaste

waste in the municipalities where the deposition was waste solution. Seemingly the means

that incineration with energy recovery, composting and biogas were equal

treatment methods for organic waste. The prohibition therefore provided an incentive to increase

both biological treatment capacity, increase capacity for treatment of food waste to feed and

increased thermal processing.

**Requirement to sorting**

**food waste from**

**large households**

Means significantly increased the collection of wet organic waste

large households. After termination of the regulations, it appears that more people have quit

sort this waste. There are no good statistics to verify this

impression.

**Prohibition of disposal of**

**biodegradable waste**

The ban was included in the waste disposal regulations in Chapter 2009. Means, according

available statistics from Statistics Norway, first and foremost lead to increased combustion of organic waste

(Household waste) and to a lesser extent to increased recycling.

**Requirements for reduced emissions of**

**landfill gas**

**landfills**

This requirement has led to a significant reduction of greenhouse gas emissions from already deposited

organic waste. Waste does not require containment level or exploitation

of landfill gas that could have contributed to increased resource utilization and further reduction of

greenhouse gases from previously deposited organic waste.

**Requirements for minimum**

**energy utilization**

Requirements for min. 50% energy utilization grass provides an incentive to increase resource utilization of

wet organic waste incinerated with other wastes, although energy yield

by thermal treatment of such waste is low. Importantly, what is with this requirement

avoiding the creation of waste incineration plants with very low energy utilization.

The average energy utilization by the Norwegian waste incinerator

was 77 percent in 2010, measured as a percentage of delivered energy produced.

**Requirements for handling**

**animal waste**

By-product regulation has resulted in increased costs for biological treatment. At the same

Regulations means the hygiene standards on farms raised which contributes to increased

protection against infection and thus increased legitimacy to biological treatment.

By-product regulation has meant that it is no longer allowed to use food waste to

animal feed to livestock due. risk of disease transmission.

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**Requirements for disposal of**

**digestate in agriculture or**

**green area**

Fertilizers Goods Regulations has led to greater focus on producing quality products with

low content of impurities and products, agricultural requested.

These regulations are designed so that the heavy metal requirements related to solids. This gives

advantageous for compost through the process applied solids through the use of

structure material. Biogas plant however consume solids and are therefore penalized,

Although the content of micro contaminants in the waste being processed is the same.

If the requirements were related to fertilizer value instead solids will

heavy burden on agricultural land not be larger than the current requirements, but

it will be easier to use the digestate. Regulations are changing.

**Economic instruments**

**Tax on disposal of**

**waste**

After that there was a ban on landfilling of biodegradable waste in 2009, the tax

had little or no effect to prevent the deposition of organic waste. The loss of

emissions tax on incineration may lead to it being more beneficial to

metabolize organic waste compared to exploit it by composting or

biogas production.

**Investment to**

**biogas plant (Enova)**

The program currently has provided support to 15 plants. The biogas projects under

planning or construction has received support from Enova. There is no facility to be built

without support. The arrangement must therefore be said to have an effect.

There are strict criteria form to get support and much of the investment is

outside the scheme.

**Investment support for the use of**

**biogas in the transport sector**

**(Transnova)**

There are limited resources in the project and Transnova priority development projects

or the use of known technologies in new areas. Transnova has supported the establishment of

filling stations for biogas including in Oslo, Fredrikstad and feasibility studies etc. for the use of

biogas in the transport sector.

**Support for R & D**

There have been no reason to make any evaluations of the R & D -

projects, but in general, support for R & D will be important to address challenges

common to an industry which can lead to better and more cost effective solutions.

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The current legal instruments have been primary purpose is to reduce the amount of organic waste in

landfill. Landfill ban has worked effectively for this purpose and has led to organic waste

that previously went to landfill now available for combustion with energy recovery or biological

treatment.

The tools for organic waste have both been designed to:

• Reducing the environmental impact of waste management

• Ensure a better resource utilization of the waste

Yet there is a distinct difference in the choice of means to reach the two target areas.

The instruments used to reduce the environmental impact has been strong and effective legal

instruments, while for increased resources have been utilized various financial instruments

not have had the same lasting effect.

If we look at the number of biogas plants established in Norway, Sweden and Denmark so there is a noticeable

difference, see Table 3a.1. Different policy instruments are part of the reason for this.

*Table 3a.1: Number of biogas plants in Norway, Sweden and Denmark.*

**Biogas plant**

**Norway**

**Sweden**

**Denmark**

Sewage sludge

23

136

61

Farmstead (Fertilizers)

5

12

60

Organic waste

3

4

5

Sambehandlingsanlegg (manure, organic waste, sludge)

2

21

22

**TOTAL plant**

**33**

**173**

**148**

|  |
| --- |
| **Page 215** |

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**New instruments**

***Requirements for recycling of food waste***

**Description**

This measure was presented in connection with a possible bioavfallsdirektiv for EU

36

And

means that municipalities and businesses must establish recycling and separate collection of

organic waste. A national requirement for separation of organic waste could be directed

with selected stakeholders in the value chain, or to all the players.

It may be appropriate to consider whether certain activities, eg. businesses

generates very small quantities of organic waste, should be excluded from the requirement. For these will

sorting then be voluntary. Recent demands for separation of food waste from the catering

For feed (now discontinued) is an example of this. The claim was normally apply to

Businesses that generated over a certain amount of food waste (eg. than 50 kg / week).

Businesses that generate less waste was excluded.

Furthermore, it is conceivable an incremental escalation, with such larger municipalities (>

50 000 inhabitants) first, then urban municipality (> 10 000 inhabitants). Finally all

or volunteering for the smallest municipalities. Likewise, it is conceivable that businesses

phased in gradually so that the largest avfallsbesitterne comes with first. Such a strategy can

justified by the need to ensure that you start with the players who have the most waste and

where it can be assumed that the cost is greater.

Requirements for sorting should probably be combined with requirements for treatment and recovery. Municipalities and

businesses that separates organic waste will likely seek a biological downstream solution

but this is not provided. In a market with a large capacity surplus at low prices

combustion, as in Sweden today, can some players choose to deliver the sorted waste

for combustion. Claims for treatment should be technology neutral to avoid becoming a

barrier to the further development of technology. In accordance with the conclusions of the environmental analysis must

requirement associated with the solution provides high energy utilization for energy and the return of

residual products in circulation.

**Effect**

Requirements for sorting will result in greater amounts of organic waste available in the market,

which provides the basis for establishing increased biological treatment capacity.

**Legal**

The claim can be established in the Pollution Control Act § § 30 and 33 and included in the Waste Regulations.

Municipalities must take the claim into the municipal waste regulations.

**Cost**

**effectively**

**(+ / -)**

Instruments will provide enhanced sorting and processing of organic waste as municipalities and

businesses that currently do not sort must establish a system for recycling of biowaste

waste of mea H1. Also intended to lead to increased biological treatment when required for sorting

combined with processing requirements.

This requirement can in an initial phase lead to an imbalance between supply and demand, but this will

stabilize over time. The prices in the export market will provide guidelines for the prices in parts of the Norwegian

market.

Cost effectiveness of means will always be dependent on the biological treatment is

cost effective locally. We also see that local conditions affecting the cost. A string

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Working Document on biological treatment of waste, the 2nd draft / DG ENV 2001

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interpretation of the requirement will reduce the cost effectiveness of market segments, eg. in very

sparsely populated areas or areas where it is particularly difficult to sell products.

Conversely, a kind of safety valve in the system increase cost effectiveness, see Other

conditions below.

**Governance**

**efficiency**

**(+)**

The requirement for sorting combined with the requirement for biological treatment of waste which is

sorted out can be arranged very accurate. There is therefore no doubt that the instrument can

designed to ensure that you get significantly increased resource utilization of organic waste. Instrument is

not arranged so that capacity building will inevitably happen in Norway. Increased exports to

Sweden and Denmark may be the result, as increased resource does not happen in Norway.

Exemption Scheme / safety valve can reduce management efficiency means as

it will reduce the scope of both municipalities / businesses that sorts out waste and new

capacity.

**Dynamic**

**efficiency**

**(+)**

Instruments will have a lasting effect in relation to the separation of organic waste and will also in the long term

could affect the capacity situation and the cost of biogas over time as more

waste is available as a raw material. Increased capacity can open sambehandling with

manure and possibly with sewage sludge.

**Administrative**

**costs**

**(+)**

Administrative costs will be associated with the preparation of regulations and interpretation of regulations

and any exemptions, and treatment of any exemption applications.

Interpretation will be linked to when the requirement can be expected fulfilled. Some increased audit activity must

expected. Overall considered administrative costs for the authorities to be low.

Traditionally, the waste industry a loyal industry that quickly adapts to new

framework.

**Other matters**

This requirement implies a significant intervention in the market. There is a certain conflict potential in

means as more municipalities previously conducted economic

analysis and concluded that separation and biological treatment is not worthwhile. An order

the separation can be seen as a violation of the authorities.

It is necessary to consider the exemption schemes and / or some kind of "safety valve" which

exempts municipalities / businesses if careful analysis of environmental and public shows that

sorting does not give any positive value. This is in accordance with the guidelines in

Waste Framework Directive where the waste hierarchy may be waived if a life-cycle assessment indicates

this.

Such exceptions solutions will reduce the effect of the instrument, but can still increase

cost efficiency as the most cost-effective projects prioritized.

**Need for action**

Technical solutions for separate collection of biowaste is currently available for all

organic waste. There will be a need to expand the collection and logistics solutions. It is

Today insufficient national treatment in order to receive the increased amount

requirement will generate. Export to Denmark are possible, but this requires sufficient capacity

the pretreatment as Danish treatment plants can only take pumpable substrate. It is

Today insufficient national capacity for pre-treatment of organic waste. Exports to

Sweden is also possible, but here it is at present little spare capacity. Increased processing

must therefore be established in the biogas plant and / or pre-treatment.

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National target for increased separation and biological treatment of waste

**Description**

A national target for biological treatment of organic waste can in itself be an instrument.

It is proposed to refine the objective of food waste and non organic waste in general. Such

appraisal will involve an easier monitoring of achievement, while the focus is put on

the part of the wet organic waste that it is important to get directed to biological treatment.

The definition of food waste should then include both eat food waste (mats win) and do not eat feasible

food waste.

A specific targets to be achieved within a given year will be a signal to local authorities and private

actors. First and foremost, such a measure could be a basis to determine other specific

instruments to achieve the objective.

Sweden has set the goal of 35% biological treatment of food waste from households, restaurants,

kitchens and stores by 2010.

The aim should apply at the national level and achievement considered for the overall treatment of

food waste. A key question is who should be covered by the target. The most natural here will

be the target includes all food waste that occurs in the value chain from production to consumption. They

sometimes large amounts of food waste (production game) that currently goes to the production of feed should be kept

the definition.

Another question is whether the goal should be technology neutral and just focus on the solutions

that provides the highest environmental benefit. We believe that it is important that the target does not become a barrier to further

technology development and should therefore have a technology-neutral facility.

The solutions must have an environmental performance at the level of biogas or better.

It may be considered whether to set various interim destination, eg. in two stages with an evaluation when

goal of stage 1 is reached. It provides an opportunity to assess the environmental benefits of actions and change

remedies accordingly.

Based on current statistics and measures recommended in Chapter 6, may be a relevant target 50

% Biological treatment / biogas.

**Legal**

A national measure must be determined by Parliament. Performance targets (targets and goals will be met years)

scope / definition (who are covered by the target), impacts, economics and the need for measures must

be clarified, but may be presented as early as next report on waste.

Alternatively assessment work carried out in connection with a national biogasstrategi.

**Effect**

A national target for biological treatment would in itself be a tool, but a relatively weak

means alone. What effect means will depend on the target and the other

measures that are implemented to achieve the goal.

**Cost-effective**

**(+ / -)**

Difficult to assess the overall cost-effectiveness of a target. Without other means will

most profitable measures are implemented.

**Governance**

**efficiency**

**(-)**

The goal does not change the underlying barriers to increased utilization of

organic waste, such isolation means having limited and uncertain effect.

**Dynamic**

**efficiency**

**(+)**

Assuming that the objective and desired growth in plant capacity, the dynamic efficiency

be good.

**Administrative**

**costs**

**(+ +)**

Administrative costs will be small and primarily related to the study strives to clarify

impact of the targets. Since the objective should be limited to food waste and covers the entire value chain,

required a change of the current waste statistics to verify achievement.

**Other matters**

Instruments will be technology neutral and basically there will be no potential for

conflicts.

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***Support for R & D and knowledge transfer***

**Description**

It will in future be a great need for research and development and technology both related to the treatment of

different substrate, the production of biogas and digestate, and operation and application of digestate. Support for

development of cost-effective technologies in small scale (10 to 20 000 tonnes of construction) and

sambehandlingsanlegg adapted to Norwegian conditions are also applicable.

In our opinion, the technological uncertainty in the value chain, which means that it can

be necessary to support a development program for biological treatment. Costs are currently high

while there is a significant potential for cost efficiency in both process and

sale of digestate / compost. Increased gas yield from biogas process will involve increased

environmental benefit.

Support can be channeled to the various research and facility owners. It may also

considered whether the program can be funded establishment of regional operational support

(Operation support system).

The program can build on the experience from Orio program.

**Effect**

The R & D - program itself will not trigger new processing but can contribute to

technology chosen is tested on a small scale better adapted to Norwegian conditions.

The need for such a scheme is greatest if there is a greater national commitment to biogas.

Scheme should be considered and studied in more detail in connection with a possible strategy

for biogas.

**Legal**

A research program should be adopted in the Parliament and can be financed from the state budget, or

with contributions from eg. Energy Fund Research Council, Innovation Norway and possible future

climate fund.

**Cost-effective**

**(+ / -)**

The results of the research may lead to increased production and more cost effective solutions. Biogas

for food waste is still immature and such a development is unlikely, but depends on several

conditions and must therefore be regarded as somewhat uncertain. Basically, this will be the low-cost

that can help to optimize solutions with associated improved cost efficiency.

**Governance**

**efficiency**

**(-)**

The research program will not in itself contribute to increased resource utilization. The result of the research

is also uncertain.

**Dynamic**

**efficiency**

**(+)**

Assuming that the research contributes to the increased cost and better solutions will

instrument has high dynamic efficiency.

**Administrative**

**costs**

**(+)**

Administrative costs associated with processing applications, monitoring and dissemination of knowledge.

It is assumed that the program will have little administration and may be linked to an existing

environment.

**Other matters**

Support for research is a positive measure with little conflict. The program should be substrate-

and technology neutral.

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**Appendix 3 b) Existing measures in the agricultural sector**

**importance for biogas plants**

There are a number of tools for the storage and application of manure, but few of them have

direct effect on the treatment of manure in biogas plants. The only means of direct effect is

investment and R & D on fertilizer, biogas and bio fertilizer.

For storage and application of manure is the number of constraints / requirements with respect.

Storage design and capacity, distribution timing, amount and method. Implementation of

water regulation will in a number of areas requiring reduced runoff of nutrients, particularly phosphorus, from

manure spreading. This will increase the need to sharpen the above restrictions / requirements for storage and

proliferation.

Treatment of manure in biogas plants can help meet several of these requirements. In this

way these instruments an indirect effect.

However, it is up to today only built a few smaller biogas plant for manure

treat approx. a thousand of the total amount of manure in Norway, then one can conclude that

instruments / application of them has had no impact on the treatment of manure in

biogas plants.

**Means direct effect**

***Investment into biogas plant***

*Innovation Norway* can support the establishment of biogas plants by up to 40% of eligible

investment costs, and up to 50% off the cost of feasibility studies and evaluation projects. Support

is limited to projects with clear roots in agriculture and using raw materials from agriculture as

the main source of energy.

*Enova* can give investment to industrial production of biogas, with a minimum of energy supply

on 1 GWh per year. Delivery and sale of gas to be documented. Support is provided as investment support

construction of facilities for biogas production and distribution in the context of production. The

may be granted investment subsidies up to 30% of the cost estimate.

***Pilot Scheme - Delivery Support from the Norwegian Agricultural Authority***

Is being established. Given to agricultural enterprises that supply manure to biogas plants. Given the form of

£ / tonne. The pilot scheme will be evaluated in 2017.

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***R & D***

National development program for mitigation in agriculture (2008-2012)

<https://www.slf.dep.no/no/miljo-og-okologisk/klima/klimaprogrammet>

In agricultural settlement in 2007, it was agreed to initiate a five-year development program

mitigation of four million per year, later extended to six million. The main objective of

development program was to increase skills in actual emissions of greenhouse gases from agriculture and

agricultural policy on emissions. Furthermore, the program should facilitate

implementing and maintaining the effective measures for reducing emissions. There have been several

projects on biogas.

The development program was managed by the Norwegian Agricultural Authority, and the program had a

steering committee consisting of the parties in the agricultural settlement, as well as representatives from

institutions with adjacent fields of interest. By the end of 2012 was initiated a new program;

***Climate and Environment program (2013 -)***

Is a program to help achieve agricultural policy objectives on climate and the environment by providing

grants for studies and information measures.

<https://www.slf.dep.no/no/miljo-og-okologisk/klima/klima-og-miljoprogrammet>

**Indirect measures**

The framework conditions for Norwegian agriculture is - next to conditions in the world market - highly

governed by economic means, not least in the form of import protection and subsidies. The level and

means of subsidies and details with regard to the conditions stipulated annually in

Agricultural Agreement. Grant schemes for agricultural agreement can be grouped into six main categories:

• Provision Fund (including the Agricultural Development Fund)

• Market regulation

• Price Subsidies

• Direct subsidies (subsidies and Regional Environment Programme)

• Development measures

Firms that receive subsidies must meet certain environmental requirements and prepare environmental plan.

Entities that do not have the environmental plan or have a deficient environment plan gets off

production subsidy for specific rates. The plan should also contain a checklist provided

of Norwegian Agricultural Authority documenting the environmental aspects related to agricultural operations.

If it is revealed lack of observation of environmental considerations must be accounted for necessary

measures. The plan shall also include an *fertilization plan* . Further requirements for fertilizing schedule is given in

Regulation fertilization planning. The purpose is to ensure proper resource utilization of

nutrients in the soil and from fertilizers, manure etc. These regulations are

However, no quantitative restrictions on the use of mineral fertilizers.

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***Fertilizers Goods Regulations***

Another important regulation is *fertilizer products regulation* that sets a number of constraints / requirements with respect.

Storage design and capacity, distribution timing, amount and method. Treatment of manure

biogas plants can help meet some of these requirements. In addition, the fertilizer Regulations Part one

number of restrictions on the use of organic fertilizer. In this way, these instruments one

indirect effect.

The regulations are being revised and will be divided into two new regulations. A regulation shall address current portion

II, which deals with the production and sale of organic fertilizer products. The Norwegian Food Safety Authority is

responsible for this revision. The second regulation will deal with Part III of the present Regulation, the

storage and use of manure. The CPA is responsible for this revision.

The regulations are being revised, including To reduce contamination from storage and use of fertilizers (Part III

in regulations) so that the objectives of water regulation is achieved, that Norway complies with its international

obligations with respect. water pollution. In addition, reduced air emissions of ammonia and greenhouse gases

is emphasized. In addition revises FSA Regulations Part II for the production.

The revision is of clear importance to the production and use of biogas / bio fertilizer. The main

areas of importance are:

1 Requirements for raw materials, sanitation and applicability of bio fertilizer (FSA)

2 Requirements for distribution terms. timing and amount of the introduction of the maximum limits for fertilization

with nitrogen and phosphorus which includes all fertilizers

3 Increased storage capacity for manure - eg. 10 months to prevent loss of

nutrients to water and air by scattering

4 Requirements for the design of the bearing to limit emissions of nitrous oxide and ammonia ..

5 Requirements for fertilization plans and documentation / support.

Area 3 and 4 (increase of storage capacity and design of the warehouse) will likely have the greatest impact,

because it would involve major investments in manure storage at the individual farm. Options can be

using storage capacity in biogas plants. This will improve the economy by

biogas plants.

Stricter requirements on area 2 and 5, for some farm, including Jæren cause they have too much

Manure in relation to their spaces, either both nitrogen and phosphorus or simply phosphorus. In that case,

biogas plants contribute to a redistribution so that the requirements for maximum fertilization amounts may

observed. The possibility of a breakdown of organic fertilizer in a wet nitrogen-containing fraction and a dry

phosphorus-containing fraction will further enhance this capability. This assumes that the new

Regulations will allow such redistribution vs the current space requirement in relation to animal's.

Fertilizers Goods Regulations = Regulations on fertilizer products. of organic origin

[http://www.lovdata.no/for/sf/ld/ld-20030704-0951.html.](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.lovdata.no/for/sf/ld/ld-20030704-0951.html) regulations are being revised with

possibility to get a far greater effect than the current one.

Directive gjødslingsplanleggin [g http://www.lovdata.no/cgi-wift/ldles?doc=/sf/sf/sf-19990701-](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.lovdata.no/cgi-wift/ldles%3Fdoc%3D/sf/sf/sf-19990701-0791.html)

[0791.html.](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.lovdata.no/cgi-wift/ldles%3Fdoc%3D/sf/sf/sf-19990701-0791.html)

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**Investment support for biogas plants, elaboration**

***Innovation Norway***

Through bioenergy program, Innovation Norway support the establishment of, among other

biogas plants, as well as feasibility studies and research projects in conjunction with the establishment of such

plant. Grants can be given to facilities that can produce heat, electricity and / or biofuels with

bioenergy feedstock. Each project is evaluated separately with an emphasis on environmental issues and

profitability. It is a requirement that applicants for biogas projects should have a clear grounding in agriculture and

use raw materials directly from agriculture as the main source of energy.

In addition to owners of agricultural property agriculture schools can be applicants. It can be supported

feasibility studies and research projects in bioenergy when it is considered realistic assessment

can result in a profitable investment project. It is emphasized that the project has a certain

size and that the project has the potential sale of the entire amount of energy produced.

Investment into biogas can be up to 40% of eligible costs. Support for legislative and

competence measures may be granted to cover the costs of consultancy for feasibility studies, pilot projects

and reports, as well as expertise and information measures. There can be up to 50% funding for these

measures.

Furthermore Innovation Norway administers a system of support for environmental technology. A significant portion of these

funds are earmarked for pilot and demonstration plant for the production and use of biofuels. For an

project to be supported, it must be economically profitable before grants and commercial

profitable for grants. It is essential that the aid should be causative for the project

realized.

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**Agreement on Agriculture**

*(Taken from the Cure 2020 - Sector Report agriculture (TA-2593/2010)).*

The main financial instrument of the agricultural sector, agricultural settlement. Master Agreement for

agriculture entered into annually between the government, the Norwegian Farmers' Union and the Norwegian Farmers and Smallholders. In

agricultural settlement in 2007, it was agreed to initiate a five-year development program

mitigation of four million per year, later extended to six million. The main objective of

development program was to increase skills in actual emissions of greenhouse gases from agriculture and

agricultural policy on emissions. Furthermore, the program should facilitate

implementing and maintaining the effective measures for reducing emissions. Development program

managed by the Norwegian Agricultural Authority, and the program has a steering committee consisting of

Contracting Parties to agricultural settlement, as well as representatives from institutions with adjoining

interest.

Over agricultural agreement also allocated annually funds earmarked research. The purpose is to help cover

the Contracting Parties need for R & D, with an emphasis on applied knowledge. The funds are managed by a

own board. It is natural that the funds from the Agricultural Agreement contributes to research to reduce

agriculture's environmental impact, and that the agricultural sector can adapt to climate change. In 2009

allocated £ 46 million from the Agricultural Agreement Research. Over farming agreement is initiated

large-scale experiments to test the effects and costs of using more advanced spraying. This

includes equipment that places the fertilizer in bands along the ground or as injecting fertilizer into the ground

using high pressure. In this way the nutrients more available to plants;

nitrate runoff decreases and ammoniakkavdamping decreases with both direct and indirect

climate effects. Reduced autumn plowing of fields is an example of an initiative that has been supported, as in

addition to reduced erosion and runoff of nutrients, reduces emissions of nitrous oxide and

carbon losses.

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**Appendix 3 c) Existing measures in the transport sector**

**Investment and more from Transnova**

*(Section written by Transnova)*

Transnova mainly provides support for testing and demonstration of new technologies. We have also provided support

to a small number of filling stations for biogas. We have no plans to give "rights-based" / general

support the purchase of vehicles. Transnova also do not currently own arrangement for supporting

filling stations for biogas, biogas and other related projects. Applications related to biogas must

therefore compete with other projects for a limited pool of available funds.

**What we have supported**

***Pilot project / study***

Transnova find that there is great interest in increased use of biogas in a number of regions in the country.

Many counties / regions are in a process where we are working with the possibility of

realize production plant for biogas, and to use this gas in vehicles in county

or municipal management. In this regard, Transnova supported various pilot projects where public and

private actors such as seen on the opportunities there are for local production and use of

biogas, and the costs and barriers that must be addressed to achieve this. Moreover, Norwegian

Energy Gas Association in 2012 received funding to develop industry standards relating to, among other common

sales terms, quality requirements and guarantees of origin for the sale of biogas (in preparation).

***The filling***

Transnova has supported businesses (AGA, Lyse Neo and Fredrikstad biogas) who wanted to be

among the first to offer filling stations for biogas to gain the necessary experience and contribute to the

concepts that are viable without government support. These filling stations makes it possible to very

limited geographical areas could benefit from biogas. In the period 2009-2012 is given an overall

support of around 23 million to filling stations, of which 12 stations (some of

stations are not completed). The support and the cost per station varies sometimes substantial (with

size and type of drive).

We have also provided funding for a project (Liquiline) leading to the development of a modular / mobile filling station

for compressed and liquefied biogas.

***K*** jøretøy

On the vehicle side, it provided for the testing of vehicles that are new in the Norwegian context (TINE,

dual-fuel cars from Volvo). This has been supported to gain experience of how the technology works

under Norwegian conditions, while also contributing to the knowledge and experience of Norwegian carriers and

to build up domestic demand for biogas. Use of the vehicle which stores the gas in liquid form

is not yet part of Transnova project portfolio. This may be particularly relevant for

heavy transport, the range and tank volume are important parameters.

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**Use specific vehicle tax**

**Taxes on gasoline, diesel, natural gas and electricity**

Biogas is not required veibruksavgift, energy tax or carbon

2

Tax. It is however subject to fees and

means of several competing energy sources that affect competitive balance in favor of

biogas. Taxes on fuel is one of the most significant existing instruments within

transport sector.

Veibruksavgiften is in 2013 for gasoline at £ 4.78 per liter sulfur petrol and diesel at £ 3.78 per liter

sulfur diesel. Veibruksavgiften for petrol and diesel is based on the socio-economic

costs associated with road traffic. The fee should include cover costs

noise, road damage, accidents, etc.. Biogas, which is not covered by this charge, and can thus be said

indirectly be supported with Range 0.38-0.53 dollars per kWh, compared to petrol / diesel.

CO

2

Tax on gasoline is NOK 0.91 per liter, and CO

2

Tax on mineral oil / diesel is £ 0.61 per liter. For LPG

this is £ 0.68 / kg for natural gas and 0.46 kr/Sm3.

Electric charge is not specifically aimed at the transport, but electric cars are affected. General rate in 2013 is 11.61

cents / kWh. Certain groups pay a reduced rate.

Sulphur tax payable on mineral oil containing more than 0.05 per cent weight percentage of sulfur by 7.8 per cent

liters for each commenced 0.25 percent weight fraction of sulfur.

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**Do not use dependent vehicle tax**

**One-time fee**

Upon initial registration of motor vehicles in Norway paid a one time fee. One-time fee

determined by vehicle:

• weight (kg)

• Motor power (kW)

• CO

2

Emissions (g / km)

• NO

X

Emission (mg / km)

In some cases, such as for motorcycles, registration tax is calculated based on displacement and

engine with a bill of fee. Vintage cars only pay a bill fee.

Motor vehicles used for business activities are fully or partially exempt from registration tax.

**Buses** (with a length of 6 m and more than 17 seats) **and trucks** (with gross weight over 7,500 kg)

**do not pay one time** . Vans (class 2), minibuses and taxis have reduced rates monitor.

passenger cars.

Generally calculated CO

2

Emissions contribution to the purchase tax in two different ways for gas vehicles, depending

the size of the car's spare tank (fuel tank). When this is greater than 15 liters classified car

as "dual-fuel" vehicles (gas and petrol), and the contribution to the registration tax is calculated from CO

2

Emissions

as if the car *only runs on gasoline* . Gas Cars with fuel at a maximum of 15 liters is considered

"Mono-fuel" vehicles (gas vehicles) and the fee is calculated from CO

2

Emissions when the car *only runs on*

*gas (natural gas)* .

**The annual fee**

The annual fee is a "luxury tax" imposed on vehicles with a weight exceeding 7500 kg. The fee is divided into

four groups. In order to encourage lower local emissions were adjusted tax basis of environmental characteristics

vehicle from 2008. Diesel Vehicles in group 1, without particulate filter, then got higher annual fee.

**Weight annual fee**

Weight annual fee imposed on vehicles with a weight of at least 7500 kg. The fee is graded by total weight of the

the vehicle suspension system and the number of axles, to take account of road wear. For diesel-powered vehicles

paid an additional annual fee differentiated environment.

**Re-registration fee**

Vehicles that have previously been registered in Norway pay re-registration fee. This fee

calculated from the vehicle's weight and age (new and heavy vehicles have the highest fee). Vehicles are

divided into four groups:

a) mopeds, motorcycles, motorbikes belt

b) Passenger cars, buses

c) trucks, tractors, vans, combined vehicles, campers, weasels

d) Biltilhengere, including trailers and caravans with an unladen weight exceeding 350 kg

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***How to turn this out for biogas vehicles?***

***Example with three cars:***

1 VW Touran 5 seater

Gas: 150 hp 1.4 TSI EcoFuel SG6 High Line, with 11 liter fuel tank.

Petrol: 1.4 140 PS TSI Highline SG6

Diesel: 140 hp 2.0 TDI Highline SG6

2 VW Passat

Gas: 150 hp 1.4 TSI SG6 Ecofuel High Line, with 31 liter fuel tank.

Petrol: 1.4 160 PS TSI Highline SG6

Diesel: 140 hp 2.0 TDI Highline SG6

3 VW Up!

Gas: 1.0 68 HP Ecofuel High up!, With 10 liter fuel tank.

Petrol: 1.0 75 HP BMT SG5 High up!

The price of gas cars are generally higher than for petrol and diesel cars. The same applies to the fees.

Except for the VW Up!

*One-time fee*

One-time fee is therefore based on its weight, engine power, NO

X

- And CO

2

Emissions. Table 3c.1 shows

size of the various components of the tax for 2013, for gas, petrol and diesel models of the

three passenger cars mentioned above. Table 3c.2 shows the difference between the fee for gas-vs. gasoline and

diesel models. The findings are summarized here:

• The specific weight of the car constitutes the largest component of the registration tax, which turns

unfortunate for gas vehicles with higher weight than petrol and diesel cars (since they are equipped with

both a gas supply system and a fuel tank).

• It depends on the model with the highest engine performance (no clear trend here).

• NO

X

Emissions are low from gas cars and provides very low contributions to the levy. Here comes the gas

and petrol models favorably compared with diesel models.

• Gas cars with small fuel tanks are considered here to have lower CO

2

Emissions than the corresponding

petrol and diesel models, while gas model for the VW Passat (which has a large fuel tank)

considered to have higher CO

2

Emission per km than the corresponding petrol and diesel models. The

explained by CO

2

Emission for VW Passat (gas model) is calculated as if the car only

uses petrol as fuel and CO

2

Emissions for the other two gas cars based on the cars

Only use natural gas.

*Price*

The price is also generally higher since gas models are more expensive to produce than gasoline and

diesel models. See the list of cars in the example in Table 3c.3 below.

*The annual fee*

The annual fee is the same for gas and petrol models (2940 U.S. $ / year). Diesel models are higher (3425 £ / year).

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Re-registration fee

Re-registration fee is based on age and weight, gas cars also come out in unfavorable

this context, since these cars are both relatively new and has a high specific gravity. However,

weight groups is relatively wide in the calculation of this fee. For passenger cars over ports

all models (gas, petrol and diesel) in the same group, either in the group "of 800-1200 kg '(10 527

million) or "of 1200-1600 kg" (15 137 million). This therefore provides tax difference for gas vs. gasoline or

diesel.

*Table 3c.1: Calculation of one-time in 2013 for three cars with gas, petrol and diesel models.*

**Weight**

**Engine**

**NO**

**X**

**Emissions**

**CO**

**2**

**Emissions**

**Disposable**

**fee**

**kg**

**£**

**kW**

**£**

**mg / mi**

**£**

**g / km**

**£**

**£**

VW Touran 5 seater (gas model with a 11 liter fuel tank)

Gas

1622

103 714

110

22 675

28

980

128

13 770

141 139

Gasoline

1441

70 790

103

17 145

34

1190

159

37 640

126 765

Diesel

1485

78 002

103

17 145

137

4785

139

22 240

122 171

VW Passat (gas model with a 31 liter fuel tank)

Gas

1551

90 181

110

22 675

27

945

161

39 180

152 981

Gasoline

1438

70 298

118

28 995

42

1470

149

29 940

130 703

Diesel

1496

79 804

103

17 145

94

3290

120

7640

107 879

VW Up! (Gas model with 10 liter fuel tank)

Gas

956

36 232

50

0

13

448

79

25 234

11 446

Gasoline

865

32 784

55

0

12

420

98

9768

23 436

*Table 3c.2: Comparison of one-time 2013 vs gas model. petrol and diesel model.*

**Differential Fee (£)**

**Weight**

**Engine**

**NO**

**X**

**Emissions**

**CO**

**2**

**Emissions**

**Total**

VW Touran 5 seater (gas model with a 11 liter fuel tank)

Gasoline

32 925

5530

-210

23 870

14 375

Diesel

25 713

5530

3805

8470

18 968

VW Passat (gas model with a 31 liter fuel tank)

Gasoline

19 883

6320

-525

9240

22 278

Diesel

10 377

5530

2345

31 540

45 102

VW Up! (Gas model with 10 liter fuel tank)

Gasoline

3449

0

28

15 466

11 989

*Table 3c.3: Price and duties of the various models (gas, petrol and diesel) for the three passenger cars*

**VW Touran 5 seater**

**VW Passat**

**VW Up!**

**Price (£)**

**fee (£)**

**Price (£)**

**fee (£)**

**Price (£)**

**fee (£)**

Gas

444 970

141 139

435 534

152 981

154 287

11 446

Gasoline

362 576

126 765

392 986

130 703

151 931

23 436

Diesel

378 596

122 171

377 013

107 879

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***References are not user-dependent vehicle charges:***

EC (2008): COMMISSION REGULATION (EC) No 692/2008.

Regjeringen.no (2013): Taxes on car:

[http://www.regjeringen.no/templates/RedaksjonellArtikkel.aspx?id=558365&epslanguage=NO (l](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.regjeringen.no/templates/RedaksjonellArtikkel.aspx%3Fid%3D558365%26epslanguage%3DNO) est

18.jan.2013), Motor vehicle taxes and mil [Jews: http://www.regjeringen.no/nb/dep/fin/tema/](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.regjeringen.no/nb/dep/fin/tema/%2520skatter_og_avgifter/saravgifter/%2520bilavgifter-og-miljo.html%3Fid%3D439335)

[skatter\_og\_avgifter / saravgifter / car taxes-and-miljo.html? id = 439 335 (](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.regjeringen.no/nb/dep/fin/tema/%2520skatter_og_avgifter/saravgifter/%2520bilavgifter-og-miljo.html%3Fid%3D439335) read 18.jan.2013).

Parliament (2012) Parliament Decision on excise duties to the Treasury for fiscal year 2013:

[http://www.lovdata.no/cgi-wift/wiftldles?doc=/app/gratis/www/docroot/ltavd1/filer/sf-20121127-](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.lovdata.no/cgi-wift/wiftldles%3Fdoc%3D/app/gratis/www/docroot/ltavd1/filer/sf-20121127-1217.html%26emne%3Dstortingsvedtak*%2520%252b%2520s%25C3%25A6ravgift*%26%23map006#map006)

[1217.html & topic = Parliament resolution \*% 20% 2b% 20s% C3% A6ravgift \* & # map006 (le](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.lovdata.no/cgi-wift/wiftldles%3Fdoc%3D/app/gratis/www/docroot/ltavd1/filer/sf-20121127-1217.html%26emne%3Dstortingsvedtak*%2520%252b%2520s%25C3%25A6ravgift*%26%23map006#map006) st 17.jan.2013).

Customs and Excise (2013): One-on motor vehicles ETC. 2013 Circular no 1/2013 Mo.

[http://toll.no/templates\_TAD/Article.aspx?id=233414&epslanguage=no (l](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://toll.no/templates_TAD/Article.aspx%3Fid%3D233414%26epslanguage%3Dno) est 18.jan.2013).

Biogas Committee Energy Gas Norway and Zero (2013): Presentation: "Work package 4" Biogas - taxes and

incentives, Gardermoen 30.11.12

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**Appendix 3 d) Existing instruments for use in other sectors**

**Electricity certificates**

Green certificates are a support scheme for electricity produced from renewable energy sources. Current Customers

financing scheme of electricity bills through the power suppliers adds

elsertifikatkostnaden into the electricity price.

Norway was from 1 January 2012 part of a Norwegian-Swedish electricity certificate market that will contribute to increased

production of renewable energy. Until 2020, Sweden and Norway increase power generation based on

renewable energy sources to 26.4 TWh. The electricity needs of more than half of all

Norwegian households. The partnership will last until the end of 2035. NVE manager

electricity certificate scheme in Norway.

In 2012, 3% of electricity consumption covered by green certificates. Based on the average market price

for electricity certificates in 2012, an electricity customer expect electricity certificates in 2013 will be about. 1

cents / kWh of electricity price (including VAT). The NVE website is a "elsertifikatkalkulator", it provides

a calculated estimate of elsertifikatkostnadene will be ahead given different assumptions about price

and annual consumption. .

Source: [http://www.nve.no/no/Kraftmarked/Elsertifikater/](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.nve.no/no/Kraftmarked/Elsertifikater/) (2013.01.29)

**Guarantees of origin**

A guarantee of origin is a testament to the sources of a given amount of electricity is produced from.

In Norway, all power producers receive guarantees of origin corresponding to their generation. A

guarantee of origin equivalent to 1 MWh of electricity produced. It issued three types

guarantees of origin:

• Guarantees of origin of electricity from renewable energy sources.

• Guarantees of origin of electricity from high-efficiency heating production.

• Guarantees of origin for other types of electricity production.

NVE approves construction for guarantees of origin. A plant that is approved for

guarantees of origin are approved for five years. Then the system must be approved again. The power plant

biofuel must also document their monthly fuel mix directly to Statnett, which is

registry administrator.

Biogas plants or plants with a mixture of biogas in fuel mix can thus apply

guarantees of origin as long as the plant produces electricity and production is measured according to the requirement

in the regulations. More information can be found here: [http://www.nve.no/opprinnelsesgarantier](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.nve.no/opprinnelsesgarantier)

**Natural Gas Act and the Natural Gas Regulations**

Regulates the transmission, distribution, supply and storage of natural gas that are not covered by the Act 29

November 1996 No. 72 relating to petroleum activities. The regulations will also apply to

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biogas, gas from biomass and other types of gas so far such gases can technically and safety

injected into and transported through a naturgassystem.

More information can be found here including:

[http://www.lovdata.no/cgi-wift/wiftldles?doc=/usr/www/lovdata/ltavd1/filer/nl-20020628-](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.lovdata.no/cgi-wift/wiftldles%3Fdoc%3D/usr/www/lovdata/ltavd1/filer/nl-20020628-061.html%26emne%3Dnaturgasslov*%26)

[061.html & topic = naturgasslov \* &](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.lovdata.no/cgi-wift/wiftldles%3Fdoc%3D/usr/www/lovdata/ltavd1/filer/nl-20020628-061.html%26emne%3Dnaturgasslov*%26)

**The quota system**

**N** orge is affiliated to the EU emissions trading system. The proportion of Norwegian emissions covered by

quota system, in the third trading period (2013-2020) constitute about 50 percent. Particularly relevant for the

relative to the biogas is that

• emissions from power plants over 20 MW are subject to quotas

• emissions from agriculture are in principle not subject to quotas

More information can be found here including:

[http://www.klif.no/no/Tema/Klima-og-ozon/CO2-kvoter/](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.klif.no/no/Tema/Klima-og-ozon/CO2-kvoter/)

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**Appendix 3 e) Existing instruments - general**

**Investment from Innovation Norway**

Innovation Norway has a bioenergy program to encourage farms with livestock and forest owners

to manufacture, use and supply of bioenergy. Innovation Norway may provide investment support to less

farmsteads for the production of biogas through this program. There can be up to 35% support

investment and up to 50% support for legislative initiatives and expertise. Innovation Norway has other

applications for grants and loans that may be suitable for bioenergy plants.

Source: [http://www.innovasjonnorge.no/](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.innovasjonnorge.no/) (2013.01.29)

**Enova**

Enova, which is owned by the Ministry of Petroleum and Energy, was established to promote environmentally friendly

restructuring of energy and energy production in Norway. This is done through counseling and

financing. Enova financed by returns from the fund for renewable energy and

energy efficiency and through an increase in tariff on electricity. Enova provides grants to

investments leading to reduced energy consumption and increased share of renewable energy. Enova has several

programs that can support the use of biogas, but has created a thematic focus to increase

production of biogas (Enova 2011). This biogas program was initially planned for

period 2009-2011, but is extended to the period 2012-2014. It may be given

investment to the industrial production of biogas, with minimum energy delivery at 1 GWh per

years. Delivery and sale of gas to be documented. Support is provided as an investment for the construction of

biogas production and distribution in the context of production. It may be

Investment subsidies up to 30% of the cost estimate. The aid intensity is dependent on what is required to

to trigger investment and it will not be given to projects that are financially profitable.

Projects with the highest energy yield per dollar subsidies given first priority in the allocation of aid. The

can be given government grants to facilities that produce biogas from organic waste, energy crops or

timber and delivering gas to external customers. It can not be granted for the extraction of gas from

landfills, but upgrading and distribution of such gas can be supported.

Source: [http://www.enova.no/](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.enova.no/) (2013.01.29)

**Research**

Research is the key strategic research agency in Norway. Guests are also

Being a counselor on important issues on agriculture and climate change, develop meeting places and networks, and

help spread knowledge as a basis for learning and debate. The main programs under the auspices of Norway

Research related to biogas is ENERGIX and NORKLIMA.

ENERGIX successor program RENERGI (future clean energy systems). It began formally in

2013 and has a duration of ten years. ENERGIX supports research on renewable energy, energy efficiency,

energy and energy policy. It includes both technological, scientific,

social science and humanities research and development.

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ENERGIX is aimed at realizing the government's current energy and climate policy, but contributes

also to support other key policy areas such as transport, industry and research.

The program caters to Norwegian companies and research and educational institutions to

contribute to long-term expertise to develop the energy sector and related

industries such as the electric power for industry and supplier industries. ENERGIX to generate new

knowledge and superior solutions based on five main objectives:

• safeguarding national security of supply

• sustainable exploitation and use of domestic renewable energy resources

• Reduction of Norwegian and global greenhouse gas emissions

• development of Norwegian industry

• Development of Norwegian research

NORKLIMA is one of the Research Council of Major Programs. Since its founding in 2004 NORKLIMA

helped to reveal extensive knowledge on climate change and the effects of these on the nature and

Community.

The program's main objectives: NORKLIMA to provide the necessary knowledge about the climate system, climate

development in the past, present and future, as well as direct and indirect effects of climate change on natural and

society as a basis for social adaptation.

Application Period: 2004-2013.

Annual budget: 70-110 million. The program is mainly funded by

Ministry of Education and Research.

Source: [http://www.forskningsradet.no/](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.forskningsradet.no/) (2013.01.29)

**Renewable Energy Directive**

Renewable Energy Directive was adopted policy of the EU Council and the European Parliament in December 2008.

Renewable Energy Directive is incorporated into the EEA Agreement and implemented in Norwegian law. Action Plan has been prepared.

More information can be found here including:

[http://www.regjeringen.no/nb/sub/europaportalen/eos/eos-](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.regjeringen.no/nb/sub/europaportalen/eos/eos-notatbasen/notatene/2008/apr/fornybardirektiv-2.html%3Fid%3D522812)

[notatbasen/notatene/2008/apr/fornybardirektiv-2.html? id = 522 812](http://translate.google.com/translate?hl=en&prev=_t&sl=no&tl=en&u=http://www.regjeringen.no/nb/sub/europaportalen/eos/eos-notatbasen/notatene/2008/apr/fornybardirektiv-2.html%3Fid%3D522812)

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**Appendix 4: Survey**

CPA sent in December 2012 the survey of about 100 companies in the biogas.

The survey consisted of the following questions:

1 Describe what you see as the key barriers to increased production and use

of biogas in Norway.

2 What measures do you take to get triggered a significant biogas production and use in

Norway before 2020?

3 Any comments beyond what you have already given in this study, and that you

want to come by now?

Respondents were also asked to contribute to undergo cost figures, and many responded positively to

it. They received a spreadsheet of costs and assumptions.

It came in 39 responses. The answers were distributed as follows:

There were as many companies in manufacturing and distribution that answered the questionnaire, and to minimize clean

users of biogas that responded.

6

5

7

7

10

4

0

2

4

6

8

10

Come. / Intercom.

waste companies

Government agencies

R & D institutions

Interessorg. including

miljøorg.

Production and

distribution

Use of biogas

**Answered questionnaire distributed by actors**

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**Appendix 5: Industrial value chain for biogas Jæren**

*This leaflet is written by Asbjørn Høivik v / Lyse Energi AS*

**Biogas production Jæren**

In South Rogaland, established a first step in an industrial biogas production from IVAR

sludge treatment (SNJ) in Mekjarvik in Randfontein municipality. This plant produces pt

about 15-20 GWh of biogas that will be increased to around 30 GWh annually. It is further prevented a larger

sludge treatment at Grødaland in Ha commune with an estimated biogas production at startup

about 60 GWh. Both the plant and the plant Mekjarvik on Grødaland are based on sludge and

food waste, but is prepared for the reception of animal waste (category 2 and 3 ABP waste) that may increase

the annual biogas production. Biogas plant at Grødaland received an investment grant

under the assumption that the gas produced was upgraded and delivered into the Lyse natural gas.

This means that the heat demand of the biogas plant (reactor / upgrade) on Grødaland not covered

through the burning of the produced biogas, but requires construction of separate heating

based on biomass (recycled wood / dewatered bio fertilizer primarily) to cover up

heating requirements. Through these two facilities will have in place a production of upgraded biogas

about 80-100 GWh. The establishment of this significant because production will also facilitate

for the production of biogas from manure Jæren either in their own facilities or through delivery to

facility at Grødaland. It is also possible to effectively utilized around 20 GWh of biogas from the

disused landfill at Ree in Time community and Sele in Klepp, biogas resources

which is currently wholly or partially flared (which is true to the district heating production in Klepp municipality).

It was earlier plans to create a centralized biogas plant at Grødaland (Ha biopark) which was based

that manure in the area were transported to a central large community biogas plants, but

the cost was too high and it was not possible to obtain sufficient support and political acceptance for

realization of this facility. It has also been noted local resentment against the increasing traffic of

trucks / tractors that such centralization of fertilizer treatment will entail.

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The Climate and Pollution Agency report "Biogas from manure and interaction of

organic waste. Costs and reduce greenhouse gas emissions

through the value chain "is assumed two large centralized plants

Jæren based on sambehandling of manure and food waste,

in principle based on the same concept as earlier planned for Ha

Biopark. Costs for husdyrgjødsel-/biogjødsel-transport was

assumed to be £ 37.50 / ton to give an increased direct

cost element of the produced biogas up to 20

cents / KWh. It can be difficult estimate these costs, good

availability of manure, large amounts at each location

(Effective logistics), short distances and good accessibility of

roads, may reduce transportation costs compared

Climate and Pollution Agency estimates. However, it may also likely that costs can

be higher, the only thing that is certain is that they will vary greatly.

KLIF In its report, provided sambehandling of manure and food waste, presumably to increase

gas yield in relation to biogas reactors using only manure as substrate. It is

However IVAR who "owns" the food waste from households and most of the food waste from

business. As stated in the previous paragraph, the food waste sambehandles with sewage sludge

plants at Mekjarvik and in a later phase also Grødaland. The resort is on Grødaland

dimensioned to receive a certain amount of manure from nearby farms where it is

interest and willingness to pay for the supply of manure. If farmers in some

cooperative constellation and / or other actors also build such large central plant, it will be

difficult to obtain food waste as a substrate in that IVAR "owns" this waste resource has

scheduled to process it in their own facilities. Large biogas plants based on sambehandling of

food waste and manure to Climate and Pollution Agency report implies, it is therefore unrealistic to build in that area.

In Jæren is a good opportunity to build smaller farm biogas plant which may include one or

several farms. Scale advantage by building large or small farm-based biogas plants, according xy

moderate - the variation of unit costs are in the range 1:2 (Source Tormod Briseid).

The main problems of such biogas plants is currently the high investment costs combined with

low reaction speed if it is not used tilleggssubstrater. It is therefore crucial that

costs can be significantly reduced while the gas yield per unit time is increased. A new

solution concept developed by Prof. Rune Bakke Telemark University College. The solution is based on a

formerly known Dutch concept with a relatively small reactor tank in combination with a

traditional fertilizer tank, where the use of suitable granules causes the reaction rate increases with an

factor 50 compared to traditional reactors. The solution also provides possibility that

biogas production can occur at lower temperatures and thus requires less energy supplied. It

produced gas volume can be adjusted using. pump between the slurry tank and the reactor. The high

reaction rate means that the reactor even with only manure as substrate, will provide

a good gas yield. Using solely manure simplifies logistics, operations and facilitates

compliance with the Food Safety Authority regulations. The main advantage of Professor Bakke's solution is that

it can be achieved a savings of about 40-60% in comparison to more conventional solutions. I and

that the reactor vessel is so compactly built, there is no collection volume of biogas

the reactor vessel to more conventional systems have, and it must therefore usually built their own

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gas collection tanks for this type of facility, or alternatively that the reactor directly attributable to a

external gas pipeline network. For small, distributed farm biogas plants is likely this new concept

be essential to achieve profitable solutions, ie production costs down to U.S. $ 0.3 -

0.5 / kWh.

In Jæren can therefore envision multiple solutions - large plant IVAR builds, biogas from

abandoned landfills, medium farm-based facilities in more traditional version that treats

manure from several nearby farms, and where manure from farms / bio fertilizer from

facility that is not directly related to the biogas plant either pumped or transported by

car / tractor and small farm biogas plants based solely on manure.

**Upgrade to biomethane**

For upgrade installations, there are significant economies of scale. Upgrade costs may typically

vary by a factor of 10 (7-70 cents / kWh) depending on plant size. It is therefore primarily

the upgrade since it is important to exploit scale advantages.

When it comes to upgrading costs for IVARS large plants, get a two different calculations

and for that matter also two different environmental depending propane additive included. In today's natural gas network,

based on the North Sea gas which has a relatively high calorific value (Wobbeindeks), a considerable addition of

propane at 4.5 percent by volume. (Like the assessments made in Sweden, it is likely that

Light will also attempt to reduce the gas calorific value when interest in biogas hovedrørnettet increases so

propane appointment can be avoided in the future). Propane appointment represents around 35-50% (approx. £

0.05 / kWh) of the operating costs associated with the upgrade, such as for SNJ will be

about U.S. $ 0.14 to 0.15 / kWh assuming full utilization. For plant on Grødaland is

upgrade cost (including propane employment) is estimated to be around U.S. $ 0.12 / kWh. If the

upgrading facility at Grødaland expanded by 20 GWh, the investments will marginally increase by 10

%. Operating expenses constitutes 70-75% of the total annual costs leading to the

Upgrade marginal cost of expanding the capacity of the plant is around £ Grødaland

0.10 / kWh.

The above empirical data / calculations show that it is possible to come down to £ 0.10 / kWh

upgrade costs for larger plants Jæren and that there is considerable potential for

reduce these costs further if propane appointment can be avoided / reduced in the future.

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***Rørdistribusjon of biogas***

Biogas Transport in pipework (rågassnett) from small farm-

biogas plants to larger central upgrading plant will

be preferred distribution manner if the produced

biogas will be upgraded. In particular, the stage is set for

such a solution Jæren where there is already built a

gas mains of 25 km and through an extension of 10-11

km you reach upgrading plant to IVAR on

Grødaland. Assuming £ 1000-1500/mi

investments cost and a construction value of existing

rågassnett of 20-25 million, the total investment will be about. 35 million

and annual costs approx. 3 million for the rågasstransporten.

Depending on the amount of gas (30 100GWh) carried in

tube will rørtariffen for rågassrøret vary between 3-10 cents

kWh. Enova Support and any impairment of that part of

pipe system that is used today will result in lower

distribution costs, while on the other hand, construction of avgreningsnett to farms increases

costs. Pipeline transport of raw gas (not upgraded gas), even with the smallest volume halve

costs compared to the alternative solution based on road transport of manure / organic fertilizer

from / to the central facility.

**Distribution of upgraded biogas (biomethane)**

It is in principle three ways to distribute the biogas, the piping (existing natural gas network), in liquid

form as LNG or compressed flakes CNG. Cost differences for the various options

very large. The Swedish biogas strategy report stated range for distribution

cost of upgraded biogas from $ 0.1 to 1.1 feeding of biogas into existing

natural gas networks cheapest solution.

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According to. the EU Gas Directive 2 (which will be introduced in Norway, in that the gas market is

classified as so-called "Emerging Market" until 2014) to natural gas pipeline owners / operators committed

to take the upgraded biogas in the natural gas networks. A third party access will require rørtariff published.

For Lyse natural gas pipeline system is estimated that rørtariffen will be NOK 0.07 to 0.08 / kWh. A

essential to use existing natural gas pipeline network to transport the upgraded biogas is that it

put in place a system to "mark" biogas to renewable value that is tilted at

innmatingsstedet can also be taken out of use. It was developed a number of national systems in all

mainly based on mass balance between fed and lifted biogas. However, it is also more

streamlined certification systems in some countries. EU Commission has stated that they do not see the need to make

The EU system until at least 2014 based on the reports that have been made will most likely be a

system based on mass balance. It is important that there is put in place one Norwegian solution.

**Summary**

As indicated earlier, the production cost of the biogas vary in a ratio

approximately 1:2 for biogas plants based on animal manure depending on size (significantly lower

production costs can be achieved for systems which are based on sewage sludge, etc.). This range of variation

is also indicated in the Swedish biogas strategy report (0.3 to 0.7 SEK / kWh). However, it is necessary

for new solutions to realize the potential of biogas from manure, even where

conditions are most at home in the first place.

It is also disclosed that the Jæren the best solution would be to transport raw gas from biogas

distributed systems in an extended existing infrastructure rather than to choose road transport of

manure / organic fertilizer to / from central biogass-/oppgraderingsanlegg. Although there is some

uncertainty sampling, a Jæren to transport raw gas, upgrade it, and

further transport the upgraded biogas to local / regional consumers around £ 0.2-0.3

/ KWh. This estimate is in line with the lowest expenses that are registered in Sweden.

If the gas to be used for transport, must also build and operate gas filling and cover

kosta ends with sales, marketing and accounting as the Swedish estimate is considered to be between SEK

0.25 to 0.40 / kWh. Our experience indicates higher costs, but we hope to reduce these somewhat if

market increases substantially.

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**TA-number**

3020/2013

**Year**

2013

**Pages**

245

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**Title**

Substrate Materials for cross biogas strategy

**Summary**

Production and use of biogas in Norway to reduce emissions of greenhouse gases in several sectors,

reduce ammonia emissions, increase recycling of nutrients, improve local air quality and reduce

noise impact. In addition, the use of biogas contribute to the achievement of Norwegian targets and commitments like

such as renewable target for the transport sector set in the Renewable Energy Directive.

The report calculates the costs and effects of new production and use of biogas from

manure and organic waste. The total, untapped potential of these raw materials is estimated to

be 1.7 TWh in the short term, where organic waste can produce 1 TWh and 0.7 TWh manure. When

biogas is used in city buses are the costs estimated to 2300 £ / tonne CO

2

-Eq and 1100 kr / ton

CO

2

-Eq, for biogas respectively manure and organic waste. Production based on

manure will produce higher emissions (300 000 tonnes of CO

2

Equiv) than biogas production based on

organic waste (200,000 tonnes CO

2

Equiv), despite the fact that the manure gives a lower energy.

The commercial profitability of the two raw materials are very different, with production costs

of 1.27 NOK / kWh for manure and 0,002 NOK / kWh for organic waste.

There are many tools that can help increase the production and use of biogas, and these should be considered in

conjunction with each other to achieve the best effect. Which means which will give the best effect,

depends on what goals you want to achieve. The introduction of measures that primarily increases

demand for biogas and / or organic fertilizer, the most profitable plants being triggered, ie

plants that use organic waste in production. If you want to stimulate

biogas production from manure, it is important to introduce regulatory measures or "push" -

factors. To get triggered so many positive effects as possible, it is important to measures affecting

the entire value chain. The predictability of the regulatory framework is particularly important for the players to bet on

build a value chain for biogas.

4 keywords

Biogas

Fertilizer

Organic waste

Value Chain

4 subject words

Biogas

Manure

Organic waste

Value chain

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**About Climate and**

**Pollution**

Climate and Pollution Agency (CPA) is from 2010

the new name for the Norwegian Pollution Control Authority. We are a

Directorate under the Ministry of the Environment 325

employees Helsfyr in Oslo. Directorate works for a

pollution future. We take

pollution policy and guide, guardian and

nominee for a better environment.

Our main tasks are to:

• reduce greenhouse gas emissions

• reduce the spread of health and environmentally hazardous substances

• achieve a comprehensive, ecosystem-based marine and

water management

• increase recycling and reduce emissions from waste

• reduce the harmful effects of air pollution and

noise

TA-3020/2013