COP 21

Anaerobic digestion's and gasification's contribution to reduced emissions in EU's transport, agricultural and energy sectors

December 2015

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Preamble: *on top of the obvious and significant substitution of natural gas, conventional electricity and fossil oil derived fuels, anaerobic digestion also adds to reduced greenhouse gas (GHG) emissions by substitution of fossil-resource based mineral fertilizers, by avoided methane emission from animal husbandry and by carbon sequestration via soil build-up of humic organic matter*

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Anaerobic digestion (AD) and gasification make a major contribution to reduction of greenhouse gas (GHG) emissions in the EU and the world. The generated products – biogas, biomethane and biofertilizer – substitute fossil energy, circulate nutrients and provide adequate waste management as well as more sustainable agriculture.

Currently AD and gasification produce the following in the EU-28:

- **Energy for heat, power and transport:** Currently, around 9.6 billion Nm^3 biomethane equivalent are produced each year (EBA) [1], constituting a calorific value of 420 PJ of energy in the form of renewable electricity, heat and 'advanced biofuels' (i.e. fuels made from waste). This corresponds to 900 kg of CO_2^{eq} per MWh when producing electricity from bituminous coal (US Energy Information Administration), 56,1 kg CO_2^{eq} per GJ when using natural gas for heating (IPCC Default), 73,2 kg of CO_2^{eq} per GJ when using diesel as car fuel). Approximately 12,5 million tonnes of CO_2^{eq} are avoided each year in Europe by replacing fossil energy for these energy applications.

In addition to current output, there is significant potential for further biogas production from various feedstocks:

Taken AD and gasification together, a conservative estimate for the total production of biomethane equivalent in 2030 is **48 billion Nm^3 per year**, in other words a combined renewable energy production of 1700 PJ and 62,5 million tonnes of CO_2^{eq} savings for the entire EU-28.

Based on feedstock potential and with the right policies in place, by 2030, the industry could produce renewable energy equivalent to approximately 10% of the EU's current natural gas consumption, for use in electricity generation, heating/cooling and as a transport fuel.

[1] EBA 2015

In addition to the current output in renewable energy and the apparent and obvious link to the GHG emission abatement by replacing fossil fuels, there are surplus reductions in GHG emissions which make anaerobic digestion unique as a renewable energy technology. AD therefore brings by far the best reduction in CO_2^{eq} per unit of energy produced.

- The EU is largely dependent on animal husbandry for feeding the continent. Animal production also produces 1.27 billion tonnes of manure each year. Methane emissions from manure storage contribute significantly to the overall GHG emissions, making agriculture one of the major contributors. Nonetheless, when manure is brought to a digester rather than having it stored for up to nine months, the methane which is naturally produced by anaerobic bacteria in the manure is captured and put to good use for renewable energy. Since methane is equivalent to 21 CO_2^{eq} digesting manure has a huge potential in lowering the carbon footprint of modern agriculture. Dependent on the animal and type of manure, approximately 20-60 Nm^3 of biogas is produced per tonne, which on average is equivalent to approximately 180 kWh of energy or 150 kg CO_2^{eq} from energy substitution AND 250 kg CO_2^{eq} of avoided emissions from manure storage under conventional practice (being higher than the CO_2^{eq} reduction when only looking at the renewable energy component!). As indicated annually 1.27 billion ton of manure is produced in Europe, offering both a burden as well as a huge potential. Countries like Germany already digest 14% of animal manure produced and member states like Denmark have indicated they aim for 50% of manure being digested by 2020 before being spread on land. We estimate that throughout Europe approximately 3,3% of all manure is being digested, equalling ALREADY avoided GHG emissions of 10,5 million tonnes of CO_2^{eq}. If we were to move to a level of 33%, the avoided GHG emissions would amount to 105 million tonnes of CO_2^{eq}. The GHG emission abatement by avoided emissions when collecting manure and converting it to energy, indicates that this technology can significantly outperform other renewable energy approaches when scoring against t CO_2^{eq} per MWh energy.

- **Biofertiliser production**: biogas installations do not only produce energy but also digestate. This is the residual part of organic matter treated by AD, and is rich in plant available nutrients. The microbial processes which convert biomass into bio-energy, also convert mineral nutrients (N, P, K,…) to more plant available form. When substituting synthetic mineral fertilizer N by mineral nitrogen from biobased renewable sources, GHG emissions can be reduced by up to 6 kg CO_2^{eq} per kg mineral N replaced (FP-7 Improved Nutrient and Energy Management through Anaerobic Digestion ; www.inemad.eu). In the EU-28, current synthetic mineral N use corresponds with 11 million t synthetic N, leaving a huge potential for GHG reduction when moving to a circular approach for mineral N fertilizer use.

- **Carbon sequestration:** in addition to mineral fertilizers which can be refined / extracted from biogas operations, also the residual organic fraction has considerable value as a soil enhancer. The fraction which resists microbial breakdown in an AD reactor is considered to be recalcitrant and adds to the soil organic matter and therefore sequesters carbon from the anthropogenic C-cycle. On average (based on product degradability), approximately 30-50% of organic matter is not broken down in the reactor. Subsequently, in the soil a fraction will break down and mineralise in the first year whereas a significant portion will resist humification and can rightfully be considered as a kind of C-sink. At the moment, each year approximately 237 million t digestate is produced in the EU and used as an organic soil enhancer. At an average dry weight of 8-10%, of which 67% consists of organic matter, the initial contribution to carbon "sequestration" is 30 kg OC/t digestate or 7.1 million t/y total carbon (C). Of this initial introduction, roughly 41% remains recalcitrant to degradation in the soil for more than one year (~ humification coefficient generically used in common soil organic carbon simulation models (NDICEA; Introductory Soil Carbon Balance Model). Applying the same dosage annually, this corresponds to an equivalent of 10.5 million t/y CO_2^{eq} introduced into soil. Which sub-fraction of this could be considered as recalcitrant to mineralisation over prolonged time periods and which could therefore be argued as being removed from the anthropogenic C-cycle, would require further assessment. Nevertheless, the pathway in which digestate and AD contributes to CO_2 emission abatement is via sequestration in the soil is evident from a qualitative perspective. **COP21 should encourage countries to implement soil organic carbon restoration plans, increasing the current soil organic carbon from <2% to ~ 3% AND to take into account the net difference as sequestered carbon.**

Additionally, the microbiological biogas process produces CO_2 and CH_4 in secluded tanks, the CO_2 is continuously converted in significant amounts to carbonate and precipitated to $CaCO_3$, $MgCO_3$ which itself increases the chemical buffer capacity and provides the digestate end-product with liming characteristics. This carbon is not yet taken into account (also not for the purposes of current calculations) but provide a consistent sink for carbon sequestration as organic carbon is first converted to CO_2 and finally to $CaCO_3$, $MgCO_3$ being thus successfully removed from atmospheric carbon. Further research is required to bring this significant mechanism into the relevant carbon mass balances.

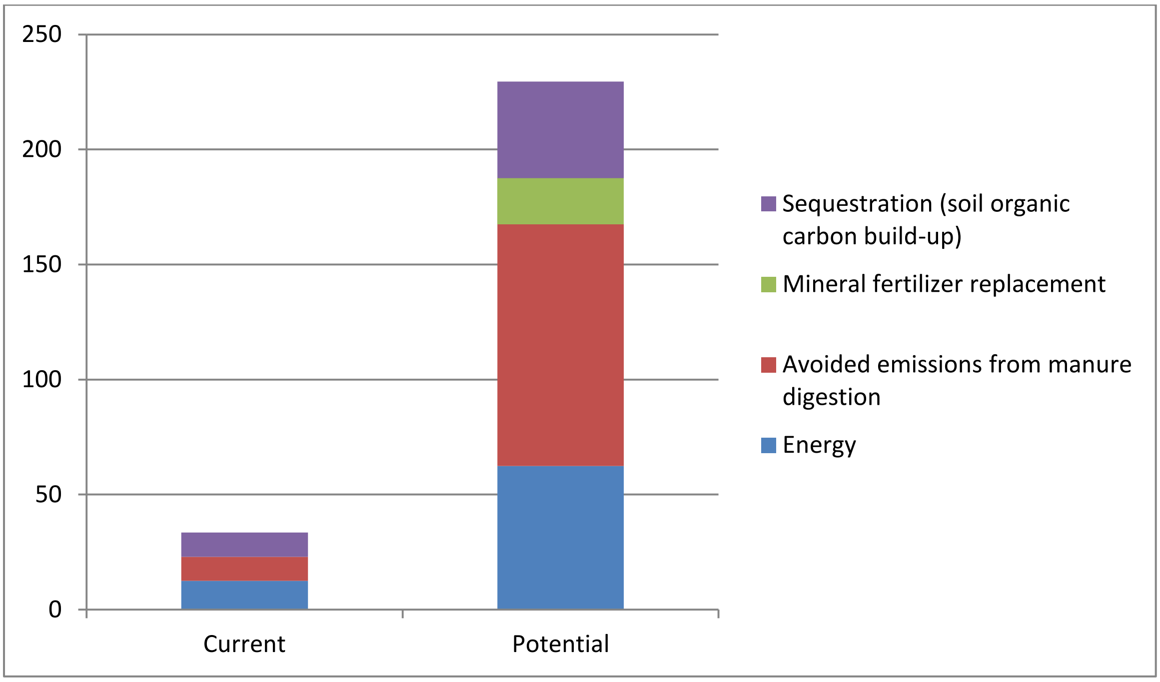
Table 1: Overview of GHG savings achieved through anaerobic digestion

	Current GHG savings (mio t CO_2^{eq})	Potential GHG savings in 2030 (mio t CO_2^{eq})
Energy	12,5	62,5
Avoided emissions from manure digestion	10,5	105
Mineral fertiliser replacement	-*	20**
Sequestration (soil organic carbon build-up)	10,5	42
Sequestration ($CaCO_3$ and $MgCO_3$ formation)	Further research required (very significant savings!)	

* Note: in order to realize full potential of the biofertilizer market, the intended Fertilizer Regulation Revision (2003/2003) under the circular economy package needs to open the door for biobased fertilizers to enter the market.

** Assuming 30% of synthetic mineral N to be replaced by biofertilizers by 2030; this can occur via the currently existing fertilizer industry.

Graph 1: GHG savings achieved through anaerobic digestion today and in 2030 (Mio t CO_2^{eq})



In conclusion, AD has four ways of reducing GHG emissions of which only the replacement of fossil fuels is well known and considered. The abovementioned additional GHG reductions should be fully recognized and accounted for in national action plans to reduce GHG emissions and to make European agriculture more sustainable.

This also implies that AD should enjoy benefits coming out of the European Trading System (ETS) on CO_2^{eq} certificates in reflection of the logic that this technology reduces more GHG emissions than can merely be attributed to the substitution of fossil energy by renewable energy.

For more information on the AD and gasification sector, please visit www.european-biogas.eu