4.3 Environmental impacts of bioenergy. Impacts on land (including compost, digestate, biochar, agricultural intensification, soil health), water and air (carbon capture, climate change mitigation, pollutants as well as GHG) of biomass conversion technologies; land use change impacts, life cycle analyses; Impacts of bioenergy in the developing world; Estimated contribution to the; Agro-environmental assessments in temperate and tropical regions.

1.1 Biomass potentials and biomass mobilisation. Assessments of biomass potentials and land availability at regional, national and international levels; Biomass mobilisation; Biomass logistics; Spatial modelling and remote sensing; Resources mapping.

Spatial and environmental assessment of energy potentials for Anaerobic Digestion production systems applied to the Netherlands

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Currently, Frank is a PhD candidate at the Hanze University of Groningen. His subject is focused on determining the sustainability of renewable energy sources and systems, and renewable system integration. He graduated from the Hanze University with a B Eng. and holds a MSc. in energy and environmental sciences from the University of Groningen. He previously worked at Philips as a process engineer focused on sustainability. Furthermore, Frank is active in lecturing and several initiatives to increase awareness on the subject of renewability and sustainability in his immediate surroundings.

Short introductive summary

Anaerobic digestion (AD) can play an important role in achieving renewable goals set within the Netherlands which strives for 40 PJ bio-energy in the year 2020. This research focusses on reaching this goal with locally available biomass waste flows (e.g. manures, grasses, harvest remains, municipal organic wastes). Therefore, the bio-energy yields, process efficiency and environmental sustainability are analyzed for five municipalities in the northern part Netherlands, using three utilization pathways: green gas production; combined heat and power; and waste management. Results indicate that the Dutch goal cannot be filled through the use of local biomass waste streams, which can only reach an average of 20 PJ. Furthermore renewable goals and environmental sustainability do not always align. Therefore, understanding of the absolute energy and environmental impact of biogas production pathways is required to help governments form proper policies, to promote an environmentally and social sustainable energy system.

Abstract

Part of the renewable goals set by the Netherlands is focused on the development and deployment of decentralized renewable energy production. A large share of the planned decentralized renewable production of 40 PJ in the year 2020 is allocated to bio-energy (e.g. biogas, green gas or combined heat and power) [1]. Within this context, anaerobic digestion can play an important role. Anaerobic digestion (AD) is capable of processing a multitude of biomass feedstocks, whilst producing both biogas and fertilizers. In the year 2013 around 4.88 PJ of energy in the shape of electricity and heat was produced in the Netherlands trough co-digestion of manure with a feedstock [2]. Within this context, a significant increase in production is needed in the coming years to reach the planned production of 40PJ in 2020.

Within this research the focus is placed on reaching the aforementioned goal with locally available biomass waste flows (e.g. manures, grasses, harvest remains, municipal organic wastes). Studies have indicated that there is a sufficient amount of local waste feedstocks available for achieving the aforementioned goals of the Netherlands [3]. However, the focus of the studies aforementioned is mostly on the potential energy yield which can be obtained from the biomass, often not including the energy required in the process of extracting energy from the biomass. Furthermore, the environmental impact of the complex process is also not fully taken into account. Additionally, the question could be raised, from an environmental perspective, whether to focus on quantity or quality of production. Quantity, focusing on producing the largest amount of useful energy; or quality, achieving the highest efficiency or creating the biggest reduction of greenhouse gas emissions and environmental impacts. Therefore, within this research the bio-energy yields, efficiency and environmental sustainability, are analyzed for five municipalities in the northern part Netherlands, using three utilization pathways; green gas production; combined heat and power; and waste management.

The theoretical average energy yield of the municipalities researched is above the needed bio-energy to reach the Dutch target of 40 PJ. However, the average useful energy retained is significantly lower. Only around 57% of the theoretical energy availability in the biomass is utilized as a feedstock, often due to low quality and difficult harvesting circumstances. Utilization can be increased by using higher amounts of manure. However, this has a negative effect on the overall energy efficiency. Due to a higher percentage of manure, the energy in the feedstock steadily lowers, but the energy input in processing (e.g. transport, heating, stirring) stays the same, resulting in negative effects. When de focus is placed on waste treatment, avoided emissions from manure and the replacement of fossil fertilizers can significantly reduce emission and environmental impact, however, at this point the waste production pathway seizes to be an energy producer. Furthermore, from the feedstocks used in the biogas production pathways on average, 70% can be retained in the shape of green gas; 54% in the shape of heat and power; and 42% in the shape of green gas and fertilizer in the waste pathway. Therefore, the Dutch goal of 40 PJ bioenergy in the year 2020 cannot be filled in through the use of local biomass waste streams, which only reach on average of 20 PJ.

Overall, from an environmental perspective, the waste management pathway is preferable, which will influence the overall energy yield. However, when regarding the highest yield green gas production is preferable. The aforementioned indicates that renewable goals and environmental sustainability do not always align. Therefore, understanding of the absolute energy and environmental impact of biogas and green gas production pathways is required to help governments form proper policies which effectively support the European Union in achieving the renewable energy and emission reduction goals, described in the EU energy directive and the EU roadmap 2050 [4, 5].

Where possible I would like to present my findings in an oral presentation.

With kind regards,

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Sources

[1] Sociaal-Economiche Raad. Energieakkoord voor duurzame groei 2013; 2013.

[2] Bureau of Statistics Netherlands. Statistics Netherlands 2015.

[3] Arodudu O, Voinov A, van Duren I. Assessing bioenergy potential in rural areas – A NEG-EROEI approach. Biomass Bioenergy 2013; 58: 350-64.

[4] EUROPEAN PARLIAMENT. DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC 2009; DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009.

[5] EUROPEAN COMMISSION. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN
PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL
COMMITTEE AND THE COMMITTEE OF THE REGIONS. Energy Roadmap 2050. 2011; Brussels, 15.12.2011. COM(2011) 885 final.

Appendix

1) The five municipalities used in the research

The municipalities in figure 1 are analyzed on biomass potential, which includes; manure, roadside or natural grass, harvest remains and straw, and municipal organic waste. For every municipality the minimum and maximum biomass availability is taken into account.

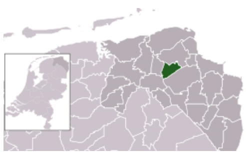
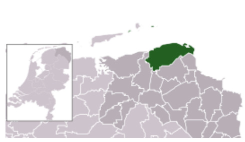
Municipality of Ten Boer	Municipality of Eemsmond	Municipality of Groningen	Municipality of Hoogeveen	Municipality of Noordenveld
				
Population: 7479 Households: 2945 Surface: 45.28 km^2	Population: 15928 Households: 7056 Surface: 189.08 km^2	Population: 198317 Households: 118679 Surface: 78.25 km^2	Population: 54664 Households: 23419 Surface: 127.53 km^2	Population: 31087 Households: 13560 Surface: 200.82 km^2

Fig 1: The municipalities used as cases in this article

2) The efficiencies of the biogas utilization pathways

Within this research three biogas utilization pathways where used to process the produced biogas in a useful product (e.g. green gas, electricity and heat, and fertilizer).

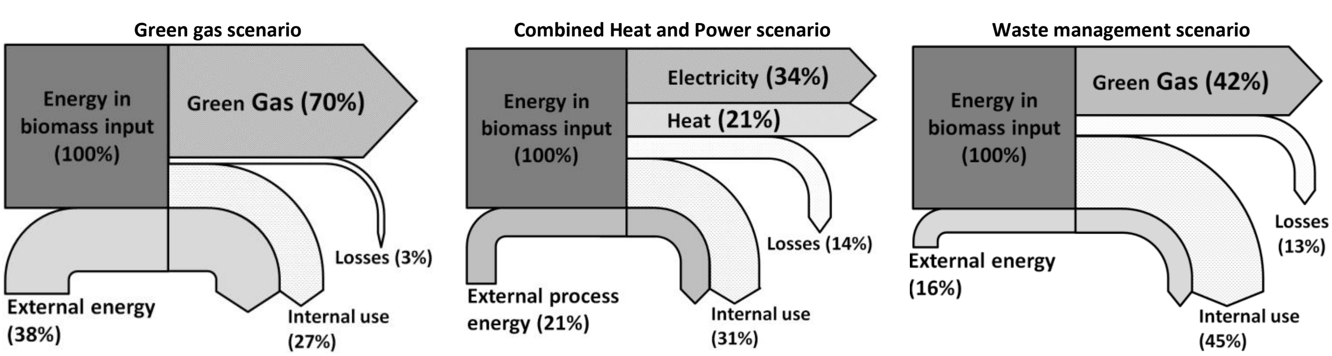


Fig 2: Average efficiency of production chains in the five municipalities

3) The Process Energy Returned on Energy Invested

The Process Energy Returned on Energy Invested or (P)EROI is determined by dividing the useful energy (e.g. green gas, electricity and heat, fertilizer) by the needed energy for processing (e.g. transport, heating stirring etc.).

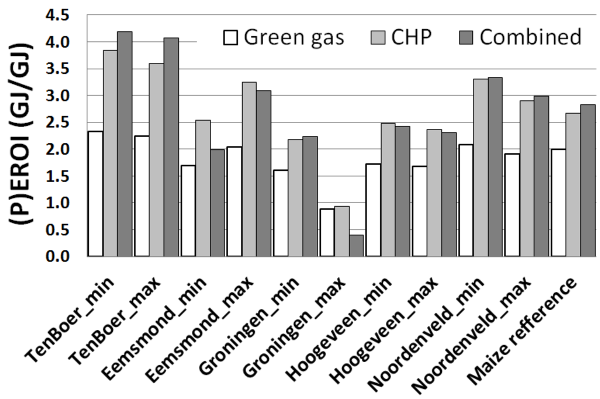


Fig 3: The energy efficiency of the AD system per municipality

4) The emissions and environmental impacts

The emissions and environmental impact is calculated through the use of aLCA with the SimaPro 7 model. The results are compared to the reference of maize used as a feedstock and natural gas

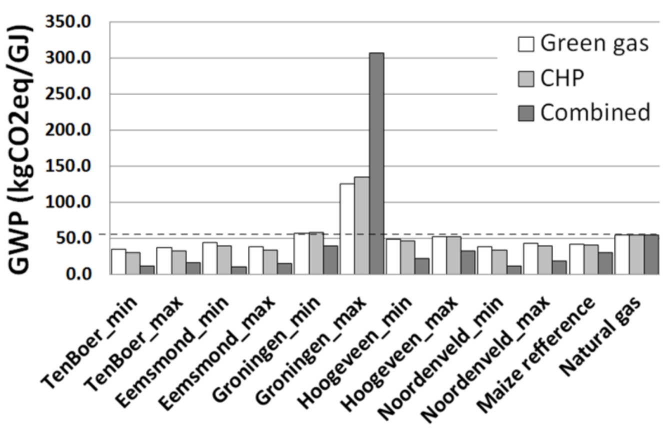


Fig 4: The emissions per municipality

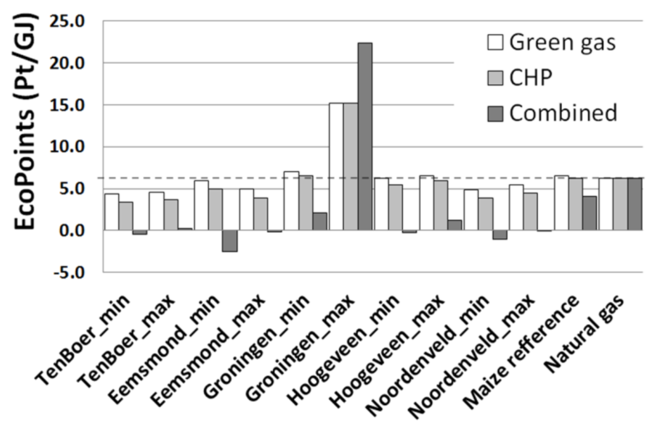


Fig 5: Environmental impact per municipality