Biomass sources in Parkstad

– Research on conditions as a renewable energy

Yixin Lyu

Faculty of Architecture & the Built Environment, Delft University of Technology

Julianalaan 134, 2628BL Delft

Y.Lyu-1@student.tudelft.nl

ABSTRACT

The energy potential for biomass energy in Parkstad Linburg is assessed. Netherlands has an ambition to replace 30% of the fossil energy carries by biomass till 2030 (Rabou. Etc. 2006). Situations and potentials in Parkstad are reviewed. The analysis explores accessible amount of waste produced in Parkstad a year according to the categories accepted by various biomass conversion. The energy that could be gained from each kind of waste is roughly calculated with a case study as a reference. Statistics are collected from CBS and official website of Dutch government. This paper also has an argument about the feasibility of a satellite system model with multiple small-scale biomass power plant in context. Transport cost, energy consumption and facility efficiency are concerned and discussed. Pros and cons are discussed, and a neutral but possible scenario is pointed out.

KEYWORDS: *Parkstad, biomass energy, waste, satellite system model*

1 INTRODUCTION

Parkstad is an administrative parternship located in Southeast of Limuburg, consisting of 8 municipalities of Heerlen, Kerkard, Landgraaf, Brunssum, Nuth, Voerendaal, Simpelveld and Onderbanken. Parkstad occupies a total area of 211.10 km2, with measures approximately 15 by 20 km. It is close to borders of Germany on two sides. There are around 255,000 inhabitants living in this plain. The environment has a great characteristic of the interwoveness between urban and countryside. The urban development mainly radiates around the higher parts of the stream valley landscape. Brunssum, Heerlen, Landgraaf and Kerkrade are four centres where urban structure formed. Towns and cities there are surrounded by green areas and islands.

In the period from 1900 to 1960, coal extraction was the support of the economy in Parkstad where was also called Oostelijke Mihnstreek, the Eastern Mining Region in English. At that time, the four largest municipalities (Heerlen, Kerkrade, Brunssum and Landgraaf) were the regions where had the highest number of high incomes among other municipalities in Netherlands. However, after 1960 coal mine industry gained a hard shock from other sources of energy such as oil and gas. As a result, mining industries were closed in the end of 20th century due to unprofitable exploitation. On December 31, 1974, the last coal mine, The Oranie Nassau I, was closed. With the declination of coal mine industry, unemployment rate boomed up and many highly-educated employees move away from this region (Elzerman and Bontje, 2015). All coal mines and mine sites were dismantled and rebuilt as residential areas, recreational space and industrial estates as a well-known event as ‘From black to green’. Although the measures of the reconstruction have been produced by governments and municipalities since then, unfortunately

Partstad is no longer prosperous but as the lowest in the high-income rankings. As accompanied effects, labour participation and the level of education is reducing in a negative situation. Young people and high-educated graduates leave for work in other cities (Elzerman and Bontje, 2015). All these changes have caused urban shrinkage in Parkstad.

Governments in Parkstad has formulated a series of strategies including energy, micro economy, Governance coalition and so on. SMART (Brightlands Smart Service campus) is proposed to build a more sustainable environment and services Leisure (Tourism and Recreation), Care, and urban development. The Regional Program is set with new and innovative employment to create a more adoptive environment for investments in a sustainable and vital region. This brings a vision for the future (Parkstad 2040) and strategies up to 2020. Remarkable success has been achieved in the tourism as part of economic development. Parkstad has won the highest tourist award in the world. The result is a turnover of € 368 million in 2015 and 5,800 new full-time jobs in the last fifteen years. Renewable energy is also one of these plans. Energy transition is also one ambition in developing strategy of Parkstad in the framework of the EU Poly-SUMP project to be energy neutral in 2040（Interregeurope, 2017). In Parkstad Limburg, wind, solar. Hydropower, biomass and heat-cold storage are five main renewable energy sources. Biomass energy comes a third position among them. A study is executed by the Netherlands Energy Research Centre and Wageningen University & Research Centre. They have evaluated an ambition to replace 30% of the fossil energy carries by biomass in 2030. There are a number of biomass companies studying on this renewable energy, however limitations are there as a barrier for common application in regions. And in Parkstad, there has not been a biomass power plant. A big potential for biomass energy can been seen in the future.

1.1.1 Thematic research question

1. Whether a satellite plant system will have a potential to exist in the region of Parkstad?

2. How could a biomass conversion flow permeate in a design of a bath centre?

1.1.2 Sub-question

1. What are the conversions used by biomass energy?
2. How much waste could be collected in Parkstad? And what categories do they belongs to?
3. What aspects should be thought about to illustrate about the size and location of plants?
4. Will a satellite model with multiple small-scale biomass energy plants be feasible in the context of Parkstad or not?

2 METHODS

The methods used for this research are mainly up on literature and case studies. Published scientific literatures in recent decades provide rich and professional information and knowledge on waste-to-energy system and biomass energy. Some governmental documents and website are also referred to know about existing flow system and future strategies of sustainable energy application. Local statistics are also collected from official website. Case studies are analysed as comparative projects to make approximate assumptions regarding to waste energy. Some interviews published online are also referred to know about different views about a topic.

The results of this research will be illustrated in the following three parts. The existing biomass conversions will be evaluated and compared with each other about pros and cons. Combined with the situation in Parkstad, energy power network will also be analysed. The second part will look into a case study. The scale of building and energy achievement will be analysis and learnt from. Then the last part will point out a guess of satellite system with small-scale power plants. This scenario will be tested and evaluated with situations in Parkstad and theories from experts.

3 RESULTS

3.1 Existing waste source and biomass energy conversion

3.1.1 Waste sources

Waste that can be used for energy could be classified into categories, Lignocellulose, sugar & starches (agricultural corps) and landfill gas & biogas. And all these feedstocks could be divided into first-generation biofuels and second-generation biofuels. First-generation biofuels basically use sugar to produce bioethanol by fermentation. Sources are mainly from food-based resources such as sugarcane and corn starch. However, food shortage might be a side effect. Second-generation biofuels are produced from non-food-based biomass sources such as agriculture and municipal waste. These biofuels are non-edible and from low-value wastes from some industries including agriculture and municipal waste. Following is the amount of five types of waste in Parkstad.

Wood resources

Wood is the most popular biomass energy source so far including forest residues (dead trees, branches and tree stumps), yard clippings, wood chips and municipal solid waste. Lignocellulosic biomass is the element used in wood source as second-generation biofuels. Parkstad has a large area of 17.8 km2 (10%) for forest and nature. Total energy that could be produced by wood waste will approximately be 0.07TWh/year.

Agricultural resources and livestock

Second-generation biofuels from Agriculture are wastes in agricultural production processes, such as crop stalks. Waste from agricultural processing are part of resources such as rice husks left over from agricultural production. In Parkstad, there is 42% of area used for agriculture with area of 74.96km2. Annual energy from crops is about 0.025TWh/year.

Manure is the general term for livestock and poultry excrement. It is a form of transformation of other forms of biomass (mainly foodstuffs, crop, stalks, pastures, etc.), including excrement from livestock and poultry, urine and its mixture with grass. In Parkstad, grassland has around 7,960,000m2. Bovine, pigs and poultry are main animals for manure. The weight of manure we could get is about 4,667,844t. Total energy from manure waste is about 0.32TWh a year.

Energy crop

Energy plants generally refer to various types of plants that are used to provide energy, and generally include herbaceous energy crops, oil crops, and the production of hydrocarbon plants and aquatic plants. Annually there are 137,176 tonnes of energy crops available in this region, and it could produce about 0.6TWh a year.

Urban waste

Urban solid waste is mainly composed of solid waste such as urban residents' living garbage, commercial and service industry garbage, and construction industry garbage. Its composition is relatively complex and affected by the average living standards of local residents, energy consumption structure, urban construction, natural conditions, traditional habits, and seasonal changes. According to the statistics from CBS, there is be an amount of urban waste with 68,130t in Parkstad a year, including 22,950t organic waste. By a rough calculation, energy of 0.036TWh could be produced a year.

According to the data from CBS, energy consumption of household, commercial service and public service in Parksatd is approximately 888 million KWh a year. Energy supply from waste would be 675 million KWh/ year which could cover 67% of energy consumption.

3.1.2 Biomass conversion

Biomass is an industry term transferring plants or plant-based material but not used for food or feed. Generally, it is a renewable energy sources producing heat energy or electricity directly by combustion or bio fuel indirectly by other forms of conversion. Biomass energy is a renewable energy significantly for reduction of greenhouse gas emissions and moderation of climate change. There are basically three conversion methods widely used among countries, thermo-chemical conversion, biochemical conversion and Physio-chemical conversion (Figure.1). Combustion is one of the main thermal technologies used today or developed for the future (Luo & Zhou, 2012). Biomass conversion applies the use of heat as its primary mechanism to transfer biomass into other forms. Some biomass plants will collaborate with combined heat and power (CHP) in a typically smaller size which can convert about 85% of potential energy in biomass into useful energy.

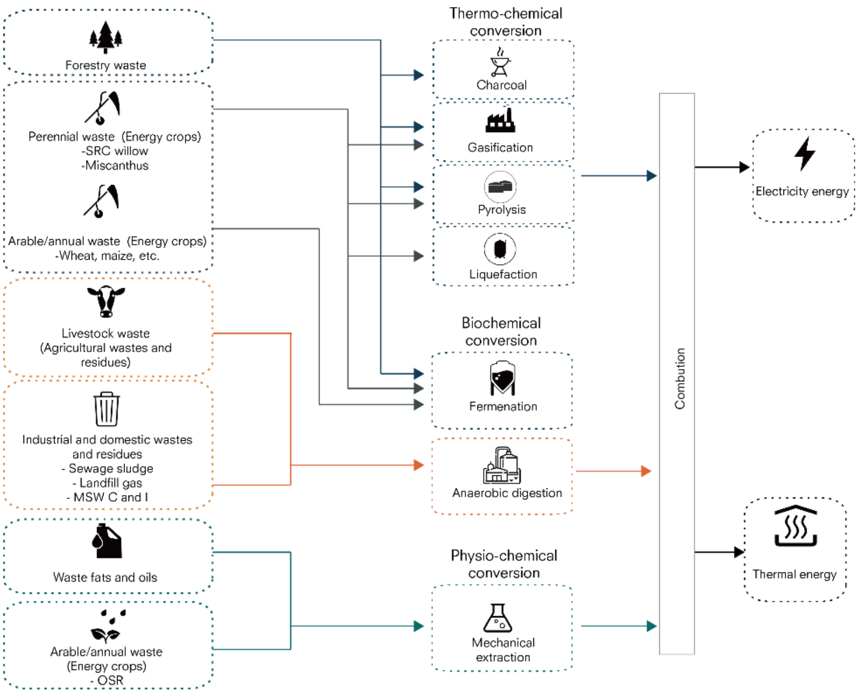


Figure 1Biomass energy conversion

Thermo-chemical conversion processes include four subcategories: pyrolysis, gasification, charcoal and Liquefaction (Adams. Ect., 2017). Pyrolysis is a process subjecting biomass feedstock under environment with high temperature of above 430°C, high pressure and low oxygen levels producing liquid fuels and biochar which is a solid residue like charcoal and rich in carbon. Gasification is the latest generation of the development of biomass technology having higher efficiency and lower the investment costs. It requires temperature of around 800°C. Gas turbine technology is used in this flow. However, gasification is only carried in a few locations in Netherlands.

Biochemical conversion is a process to break down the molecules by enzymes of bacteria and other microorganisms. It can produce gaseous or liquid fuels. Biogas and bioethanol are the most well-known products. Anaerobic digestion and fermentation are main two key technologies. Fermentation technologies are guiding a breakthrough for producing fuels, fertilizer and some other products for agriculture. (Satyawali, Ehimen and Dejonghe, 2016)

Chemical interactions are used for chemical conversion to transform feedstock into other forms of energy. Transesterification is the most common chemical reaction to biomass with oils, fats and greases to alcohol. A common end-product is created in this process as biodiesel.

3.2 Proposed biomass plant system

For biomass energy, sourcing, transporting and storing biomass are issues that necessarily has to been considered (Suurs, 2002). As a result, logistics is important in the system. Production systems, pretreatment operations and transport options are all aspects that should be taken into account. Costs and energy consumption are related to transport chains. Factors including transport distance, fuel prices and equipment operation times are associated with model and system design. Suurs (2002) pointed in his paper that if a transport chain is based on the high-density energy carriers, such as logs and pellets, it will be attractive for all scenarios.

In Netherlands, more biomass power plants are in south-Holland and north part. It is close to costal as a convenient location for import waste. However, there is no biomass power plant in Parkstad now. The closest one shown in Figure 5 is in Sittard, Biomassa Energiecentrale Sittard (BES). The longest distance from somewhere in Parkstad to the plant in Sittard is approximately 26km. In other words, long-distance logistics could not be avoided if biomass energy is wanted from waste from Parkstad. It will cost 0.2-0.35L/km oil by a typical 18-tonne heavy duty vehicle and release 1800-5400 gCO_2/t-km. If it is delivered by railway which uses gasoil and energy mix, 1 kWh/t-km of electricity is required and releases 45 gCO_2/t-km (IES-ETSAP, 2013). If it is assumed to multiple distance and time, the result of cost for logistics will still be huge.

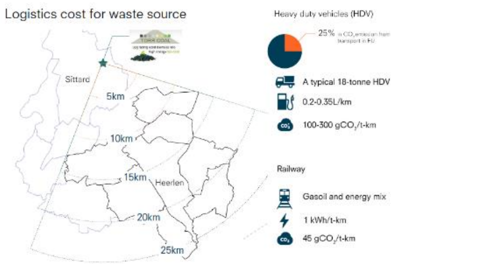


Figure 2 Location of biomass power plant around parkstad

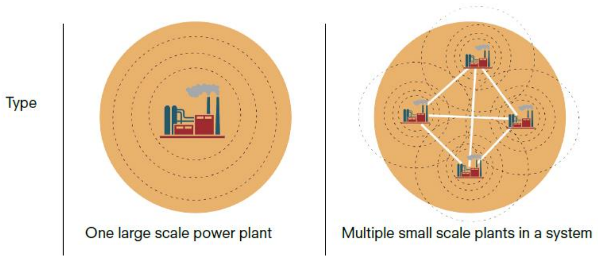


Figure 3 Proposed satellite system

If a system is built in system and has a radiated area of ca. 4-5km, then the fuels used could be reduced as well as CO2 emission reduction. Because of a closer distance for transportation, the cost of storage in total can also decrease for less area required. The cost for the construction for energy grid could also be lower. There was an interview by Biomass Magazine talking to industry experts about the perfect size for biomass-fired power plant (Austin, 2012). A group of 25 small 4-MW wood and agricultural-waste-fired plants will be built in two regions in Italy. This is an agreement by Denmark-based Babcock & Wilcox Vølund, a subsidiary of U.S.-based Babcock and Wilcox Power Generation Group Inc. and Italy-based Advanced Renewable Energy Ltd. There are two voices about this decision.

Ryan Cornell, company spokesman believes small-scale plants will be more suitable for local contexts with a town of only 1,000 to 5,000 inhabitants. It will be more economical asking for lower transportation cost and higher the demand of workers. It also makes sense to avoid taxing the grid of power output from one large plant in terms of the grid infrastructure (Austin, 2012). However, Peter Flynn, pool chair in Management for the Engineers Department of Mechanical Engineering University of Alberta at Edmonton, Canada defends for an opposite opinion. Small power plants are not thermally efficient that it will lose more heat per unit of capacity. The bigger the plant is, the cheaper the power output will be. Research conducted by Patricia Thornley of the Tyndall Centre for Climate Change Research at the University of Manchester, United Kingdom, shows that higher levels of emissions per unit of electrical output will be produced by smaller facilities (Austin, 2012).

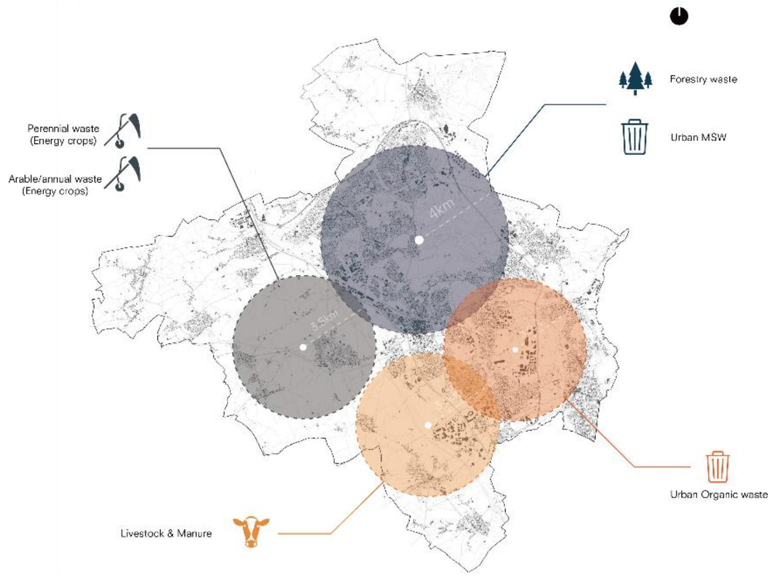


Figure 4 Proposed network of biomass energy plant

For Partsad, cost and energy consumption of feedstock transportation are considerable due to a low urban density if it has to rely on long-distance logistics. Considering the situation and conditions there, Heerlen, Brunssum, Landgraaf and Kerkrade have much higher urban densities while other areas have more natural views. Different conversions could be applied in specific plants depending on where waste sources are and what end-products will be produced. Concentrations for similar type of feedstock could also increase energy produced efficiency. In this case, the working load of logistics could be reduced. And for a specific waste source, one plant is serving for whole area of the region while it is still part of biomass energy system.

3.3 CASE STUDY

3.3.1 Copenhill / Amager Bakke,

Copenhill / Amager Bakke, a waste-to-enegy plant, designed by BIG is studied as a reference. It is located in an industrial area near city centre in Copenhagen (Babcock & Wilcox Vølund A/S). This plant replaces a 45-year-old plant with four furnace lines. The new plant will be equipped with two furnace lines burning 2 x 35 tonnes of waste per hour. A joint turbine- and generator system will be applied in this plant. According Lars Juel Rasmussen, this plant can utilize more than 100% of the fuel's energy content. This waste-to-energy plant will collect and treat waste of 400,000 tonnes from 500,000-700,000 citizens and at least 46,000 companies. Energy produced, then, can supply more than 50,000 households with electricity and 120,000 housed holds with district heating. It could create steam up to 440 ^{0}C. There will be 70 bars doubling the electrical efficiency than that of the former plant.

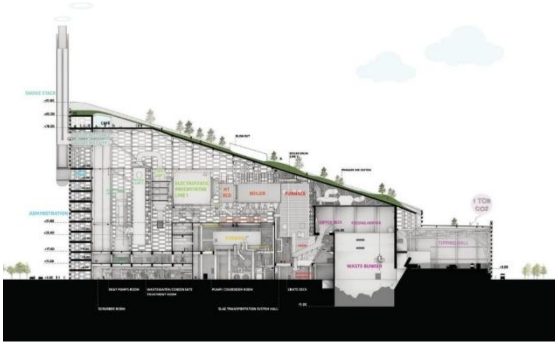


Figure 3 Section of Copenhill / Amager Bakke

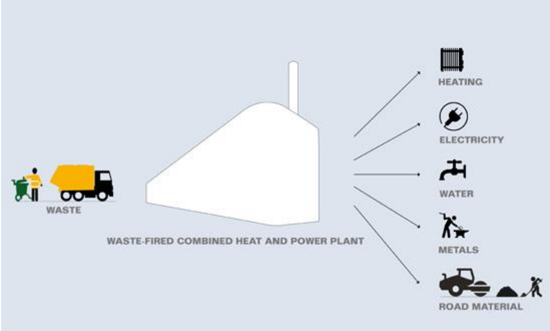
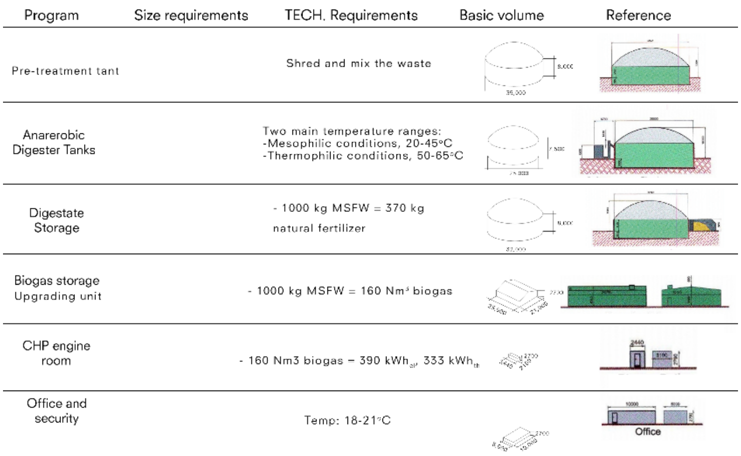


Figure 2 Diagram of Copenhill / Amager Bakke

3.3.2 EcoTricity Anaerobic Digestion Plant

There is an anaerobic digestion plant located in England. It can provide enough green gas to power nealy 3,500 typical UK homes and save over 2,500 tonnes of carbon dioxide each year. 1 tone urban organic waste could produce 390 kWh for electricity and 333 kWh for heating. This will be referred to the project. In Parkstad, the amount of organic waste is about 22,950t, producing 8,950,890kWh for electricity and 7,642,350kWh for heating.



Program	Size requirements	TECH. Requirements	Basic volume	Reference
Pre-treatment tant		Shred and mix the waste		
Anaerobic Digester Tanks		Two main temperature ranges: -Mesophilic conditions, 20-45°C -Thermophilic conditions, 50-65°C		
Digestate Storage		- 1000 kg MSFW = 370 kg natural fertilizer		
Biogas storage Upgrading unit		- 1000 kg MSFW = 160 Nm³ biogas		
CHP engine room		- 160 Nm3 biogas – 390 kWh$_{el}$, 333 kWh$_{th}$		
Office and security		Temp: 18-21°C		Office

Figure 4 Producing Efficiency of EcoTricity Anaerobic Digestion Plant

4 CONCLUSION AND EVELUATION

This research is mainly depending on literature reviews and assisted with analyzation of data. It evaluates the waste from local that is possible to satisfy a great demand of energy consumption in Parkstad. However, the logistics cost for biomass sources is one issue for the development of this renewable energy. The potential of a satellite system with multiply smaller biomass power station in Parkstad is discussed. If it is acceptable, plants could be located in several locations and concentrate on different biomass conversions responding to local waste sources with larger percentage in Parkstad. Possibilities of satellite system needs a more accurate formula to get a more detailed result about the balance of gas emission and energy consumption. Meanwhile it is hard to calculate how much emission will increase when the scale of plant is getting smaller.

With the technologies of biomass energy improved, the cost of a plant will decrease, and the efficiency will increase. It is possible that the number of energy plants increases. They will also be possible to be closer to citizens' daily life and even become part of urban environment. A research on how to integrate a power plant in a public project in urban landscape will be the next topic. So, the consumption of a bathhouse will be selected as an example and applied in the energy system connecting with contexts around to have a test of the cooperation between facilities and recreation activities.

5 References

1. Adams, P., Bridgwater, T., Lea-Langton, A., Ross, A. and Watson, I., 2017. Biomass conversion technologies.

2. Austin, A. (2012). Size Matters. Journal of Biomassmagazine, [online]. Available at: http://biomassmagazine.com/articles/2309/size-matters [Accessed 29 May. 2018].

3. Babcock & Wilcox Vølund A/S, ARC, Copenhill / Amager Bakke, Copenhagen, Denmark. [online] Available at: http://www.volund.dk/Waste_to_Energy/References/ARC_Amager_Bakke_Copenhagen[Accessed 29 May 2018]

4. Banks, C. (2009) Optimising anaerobic digestion. Evaluating the Potential for Anaerobic Digestion to 4rovide Energy and Soil amendment. Lecture delivered on 25th March 2009 at University of Reading

5. CBS (2016) Dierlijk mest en mineralen 2016, Den Haag/Heerlen

6. CL Williams, after Baye, (2010). Bioenergy? Conversion Technologies. [image] Available at: http://www.wgbn.wisc.edu/conversion [Accessed 29,May,2018].

7. Demirbas, A., 2009. Thermochemical conversion processes. Biofuels: Securing the Planet's Future Energy Needs, pp.261-304.

8. Elzerman, K. and Bontje, M., 2015. Urban shrinkage in parkstad limburg. European Planning Studies, 23(1), pp.87-103.

9. Interregeurope.eu, (2017). Region in the spotlight: Parkstad Limburg. [online] Available at: https://www.interregeurope.eu/reform/news/news-article/1349/region-in-the-spotlight-parkstad-limburg/ [Accessed 29.05.2018].

10. IEA-ETSAP, (2013). Biomass Production and Logistics. [online] Available at: https://iea-etsap.org/E-TechDS/PDF/P09_Biomass%20prod&log_ML_Dec2013_GSOK.pdf [Accessed 29.05.2018].

11. Luo, Z. and Zhou, J., 2012. Thermal conversion of biomass. In Handbook of Climate Change Mitigation (pp. 1001-1042). Springer US.

12.Rabou, L.P.L.M., Deurwaarder, E.P., Elbersen, H.W. and Scott, E.L., 2006. Biomass in the Dutch energy infrastructure in 2030. Wageningen UR.

13. Regional Atelier (2007) ReEnergize South Limburg. Designing sustainable energy landscapes, Van Etteger, R and Stremke, S. editors, Landscape Architecture Chairgroup, Wageningen University and Research, The Netherlands

14. Roxana, F. and Lucia, P., Wageningen University-Landscape Architecture and Planning.(statistic)

15. Wisconsin Grasslands Bioenergy Network. Bioenergy Conversion Technologies. [online] Available at: http://www.wgbn.wisc.edu/conversion/bioenergy-conversion-technologies [Accessed 29/05.2018].

16. Satyawali Y., Ehimen E.A., Dejonghe W. (2016) Biochemical Conversion. In: Drioli E., Giorno L. (eds) Encyclopedia of Membranes. Springer, Berlin, Heidelberg

17. Suurs, R., 2002. Long distance bioenergy logistics. An assessment of costs and energy consumption for various biomass energy transport chains (No. NWS-E--2002-01). Department of Science. (

Appendix 1

Energy from all kinds of waste in Parkstad

	Wood waste	Household waste	Agricultural crops	Livestock and manure	Energy Crops
Waste	17.80 km²	68,129.64t (organic waste: 22,950t)	74.96 km²	7,960,000m² Grassland	137,176,8t
Energy from cleanrance kWh/year	7,712,740	35,966,876	2,517,621	32,134,032	617,295,600

	Household	Commercial service	Public service	Total
Energy consumption million kWh	500	216	172	888
Energy Supply from waste million kWh				675
Ratio				76%

Energy from forest waste clearance

forest wood production	1 ton/ha (1780t)
gas/heat production	3000 KWh/ton
electricity production	1333 KWh/ton
total energy supply	4333 KWh/ton
TOTAL ENERGY FROM FORESTS CLEARANCE	7,129,330 KWh/year

Energy from for agriculture waste clearance

capacity	0,02 W/m2
	0,00002 KW/m2
efficiency	30 %
energy	0,05 KWh/m2
TOTAL ENERGY FROM AGRICULTURAL WASTES	2,519,600 kWh/year

Energy from forest waste clearance

urban waste production per capita/year	0,27 ton/year
	270 Kg/year

energy content	2,5 KWh/kg
efficiency	21 %
energy net	0,525 KWh/kg
population	252,332
TOTAL ENERGY FROM urban wastes	35,634,480 KWh/year

Energy from manure

		Manure production (kg/year/animal) [1]	m3 biogas/ton manure[2]
cows	solid	7000	24
	liquid	31193	10
pigs	solid	0	0
	liquid	2400	11
total poultry	solid	13	96
	liquid	38	23

Biogas energy content: 23 MJ/m3 6,39 KWh/m3

Number of animals	bovine	pigs	poultry
kg manure/animal	solid 711.970.000	0	2.574.130
	liquid 3.172.640.030	773.136.000	7.524.380
m3 biogas/kg	solid 17.087.280	0	247.116
	liquid 31.726.400	8.504.496	173.061

Parkstad

total biogas (m3)	54,851,436
Parkstad grassland (m2)	17,960,000
biogas (m3/m2)	3,5
biogas in Parkstad (m3)	63,404,766
biogas energy (KWh/m3)	6,39
biogas efficiency %	35
KWh gross	403,805,933
KWh net	141,332,076
TOTAL ENERGY FROM MANURE (TWh/year)	0.54TWh

Reference:

Rijkswaterstraat, Ministerie van Infrastructuur en Milieu, 2013 Rijkswaterstraat, Ministerie van Infrastructuur en Milieu, viewed 23 march 2012, < Klimaatmonitor.databank.nl >

McKendry, P. (2002) 'Energy production from biomass (part 1): overview of biomass', Bioresource Technology , 83 : 37–46

CBS (2016) Dierlijk mest en mineralen 2010, Den Haag/Heerlen

Banks, C. (2009) Optimising anaerobic digestion. Evaluating the Potential for Anaerobic Digestion to provide Energy and Soil amendment. Lecture delivered on 25th March 2009 at University of Reading

Appendix 2

Plant design data (per line)

Process parameters	Guaranteed values*	Unit
Waste capacity	35	t/h
Heat value, lower	11.5	MJ/kg
Steam output	141.1	t/h
Steam temperature	440	°C
Steam pressure	70	bar
Boiler outlet flue gas temp.	160	°C
Feed water temperature	130	°C

Flue gas out of boiler:	Guaranteed values*	Unit
NOx**	15	mg/Nm³
CO***	50	mg/Nm³
NH3**	3	mg/Nm³
TOC	5	mg/Nm³

* All values refer to 11% O_2 dry gas

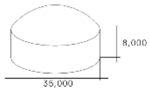
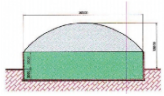
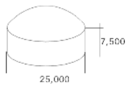
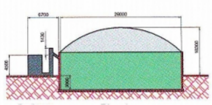
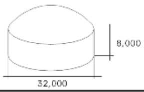
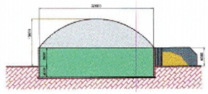
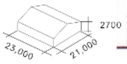
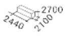
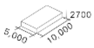
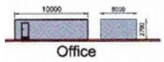
** 24-hour average

*** Half-hour average

Plant design data of Copenhill / Amager Bakke waste-to-energy plant

Accessible at: http://www.volund.dk/Waste_to_Energy/References/ARC_Amager_Bakke_Copenhagen

Appendix 3

Program	Size requirements	TECH. Requirements	Basic volume	Reference
Pre-treatment tant		Shred and mix the waste		
Anarerobic Digester Tanks		Two main temperature ranges: -Mesophilic conditions, 20-45°C -Thermophilic conditions, 50-65°C		
Digestate Storage		- 1000 kg MSFW = 370 kg natural fertilizer		
Biogas storage Upgrading unit		- 1000 kg MSFW = 160 Nm^3 biogas		
CHP engine room		- 160 Nm3 biogas = 390 kWh$_{el}$, 333 kWh$_{th}$		
Office and security		Temp: 18-21°C		

Plant design data of EcoTricity Anaerobic Digestion Plant

Accessible at:

http://www.stokeandtredington.co.uk/ecotricity/

https://www.theguardian.com/environment/2016/nov/18/could-gas-from-grass-rival-fracking-to-heat-uk-homes

https://www.ecotricity.co.uk/news/news-archive/2017/ecotricity-proposes-much-smaller-green-gasmill-beside-m5-near-fiddington