NEWE – LOCATION PROBLEMS FOR BIOMASS FACILITIES

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Abstract: The use of plant biomass as energy source requires the rise of an ecological and economic logistic chain. Because of the smaller energy density in contrast to fossil energy sources the transport to energy changing facilities must be as short as possible. Basis of this is the search for locations to achieve these requirements. Following work will describe different ways to allocate the facilities and building up an economic and ecological biomass supply chain. This research work is advanced by the Ministry of Education of Saxony Anhalt.

Keywords: biomass, logistics, location problem, transport, gasification and fuel cell

1. Introduction

It is obvious that an ecological and economic use of biomass in Germany could not be handled from one single biomass facility. The creation of electricity from biomass is explored in a joint project at the University of Magdeburg, the Fraunhofer Institute and the Max-Planck-Institute. Experts of process and systems engineering, electric nets and logistics work in this case together.

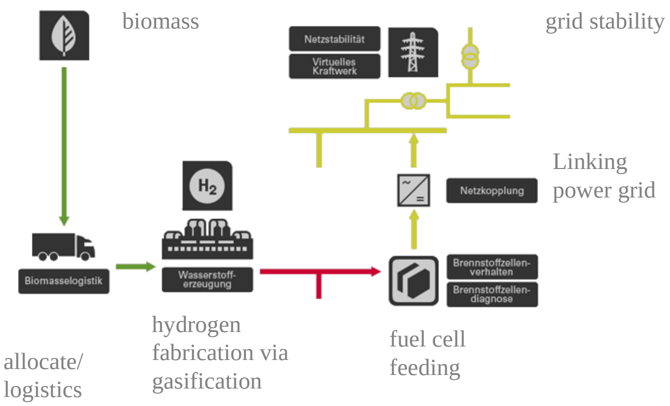

Figure 1. Selection of topics in NEWE project

Aim of the NEWE (networks of electric converter in the energy production) project is the supply of electricity into the public electricity grid (see Figure 1). The electricity is produced in special fuel cells which are fed by a biogenic gas. This low gas is assembled by the gasification of biomass. This kind of fluidized bed gasification under the special restriction of suitable biomass goods (pellets, roadside greenery, hay, straw) are expored in the Otto-von-Guericke University Magdeburg and the Fraunhofer Institute for Factory Operation and Automation. The choice of biomass facilities locations demands models, which determine possible sites under the restriction of prices, seasonality, energy density of the biomass goods and the driveways to collect the biomass and consolidate it. These models have to compare different sites to choose the best ecological and economical one. On one hand, it could be economic to transport biomass over long distances because of preferable prices but on the other hand, the transport could exhaust more energy than what can be produced from the transported goods.

Based on the problem models have to be described and tested for the allocation of biomass under the restricted appearance of different biomass goods, size of the gasification facilities. Due to the fact that biomass has a smaller energy-density than oil and coal other consolidating ways need to be found. Similarly, the question if central or local biomass facilities are suitable, and the question where to build up the fuel cells (near to the gasification facilities or not) have to be answered. The activity of biomass logistics in this chapter discusses the problems of different goods, their seasonality, potential and their characteristics regarding density, energy-density and prices.

Furthermore the functional and operational processes have to be created and configured. For this purpose the in- and outgoing logistics at each facility have to be described.

Currently, different ecological models (which can be combined) have been created and maximal material handling distances for every biomass good calculated. *For instance it is not economically efficient to transport none compressed hay more than 30km via lorry. At this point more energy would be used for rising and handling it, than energy would be created out of it.* These consolidated findings could be used and linked with the models which are described in a later chapter.

Besides the validation of the existing models the influence of seasonality must be reviewed and the effects to the logistic solution needs be calculated. Furthermore, the forecast of biomass appearance needs to be investigated to implement these technical expertises in the models.

2. Economic model

The following model for the allocation of any kind of goods is based on geo positions considering the degree of longitude and latitude, in order to have the flexibility for the model to be adjusted to calculate and show very detailed problems (every tree could be a biomass appearance) and very abstract calculation (i.e. for rough calculation or in the absence of detailed data). The model is also available on the internet and calculates effective facilities at which a benefit could be created. The model calculates for every geo position the costs that are created to deliver the biomass and the benefit it has generated. So it is possible that near biomass offers are not included because of the high biomass price, the seasonality or the low energy-density. The method of operation of this model is shown in Figure 2.

3. Ecologic models

Besides the optimization of the financial profit the exploitation of the output from a region could be improved. For this purpose a model was build up. It is an imitation of an alignment problem [3.] to decrease the waste between different facilities. The same problem occurs at the fabrication of shafts out of cuboids. The waste between the shafts should be minimized. The collection from biomass around the facility itself must be taken within a circle (it is the shortest way around a facility). The circles must be so large that the demand of every facility is guaranteed. For up to 20 circles the location and the radius is mathematical evidenced. Figure 3. shows the location of the circles.

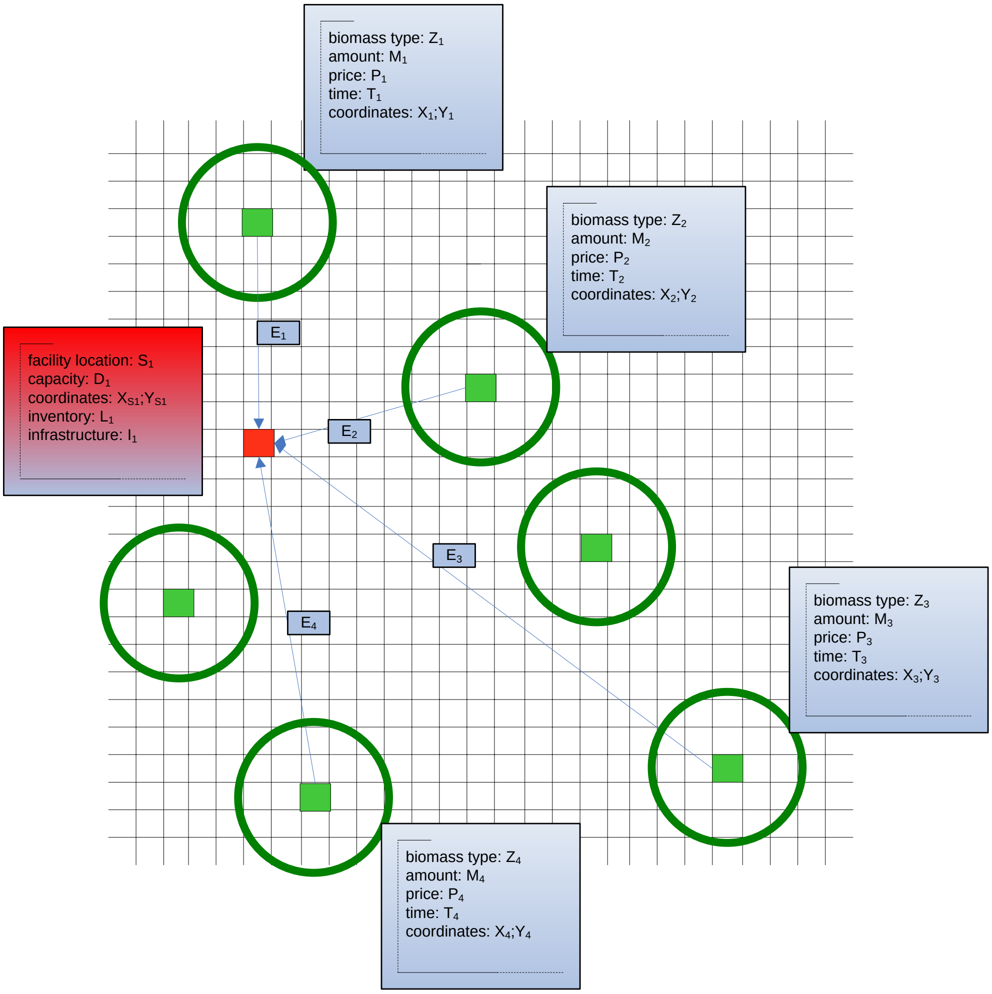

Figure 2. Functionality of the economic model

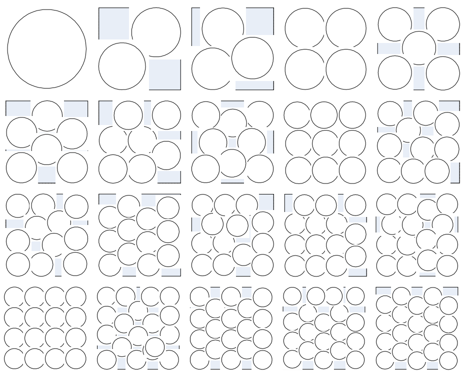

Figure 3. Location of circles in trivial square [3.]

First calculations show that around 13 facilities could be raised in Saarland (area of 50 x 50 km). The calculation is based on the assumption that 25% of the biomass available in 2007 in Saarland is accessible for this non-food use in gasification facilities. Every facility has a feeder radius of around 6,7km and these thirteen 1MW arrangements could deliver the electricity for 26.000 households.
Another arranged location decision method works with efficiency criteria. Special scenarios were created here for (near term economic, long term ecological, only regional biomass, etc.). With these it is possible to find corresponding locations to the investor's intention. At this point this should not be explained in detail.
An additional ecological method, which was set up, is a heuristic search with the aim to minimize the search radius. The theoretical function is shown in Figure 4. The basis is a scenario region in which the offer of biomass is allocated heterogeneous. Background of the location search is the minimization of the transport disbursement. As described above the circle search offers the best ecological search around a facility location. The smaller the search radius is to supply the biomass facility, the less transport disbursement accrues. Deductive the location with the smallest search radius must be chosen. After a heuristic procedure all possible locations (depending on infrastructure, availability of area, political assistance, etc.) must be considered and the search radius must be calculated. As described the model offers an ecological comparison of different locations.

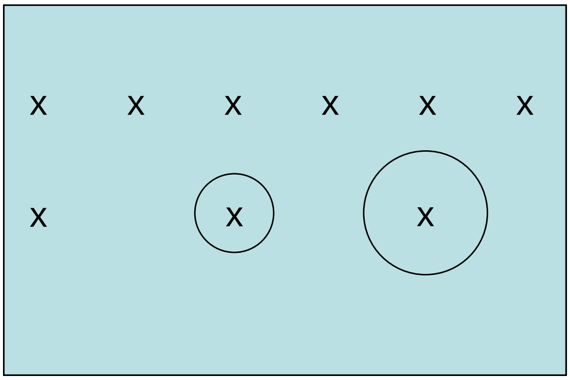

Figure 4. Heuristic search to minimize the search radius

The economic model describes a practical solution for the search of locations for every kind of consolidation problems. It can be applied across the globe to all accommodation and removal problems. The other ecological models which were described are very theoretical. Of course all described models can be combined with each other and can be incorporated into the calculation of maximal transport kilometers of every kind of biomass.
For a better practical adaptability another graphical model considering efficiency criteria, biomass appearance, seasonality and infrastructure was designed. In reality the knowledge about the infrastructure is mostly more exact than the data about the regional biomass. Infrastructure data can be taken from GPS and navigation equipment. Biomass data appearance must be taken from forest and regional institutions. Figure 5 shows a typical aerial photo which is the basis for the model which is based on the criteria of infrastructure, seasonality and biomass appearance.
This real photo is transferred in schemata. All possible locations (where infrastructure is available) are marked by bars. At these points the efficiency criteria for the biomass output for every season must be calculated. High efficiency criteria show high biomass availability at this location in the considered season. When exact data for seasons are available, the

values of benefit could be calculated for instance for every week or day. Due to the fact that the infrastructure does not change over the seasons all seasonal values could be added at every location. Figure 6. shows this procedure. The location with the highest value is chosen under these restrictions.

Figure 5. Aerial photo as basis for the location search model

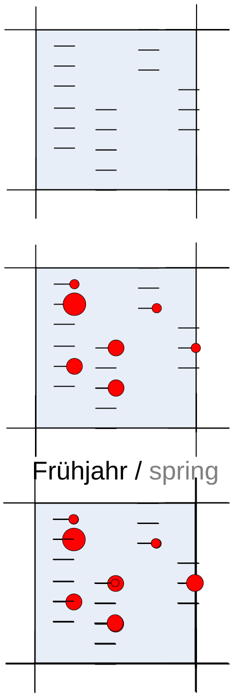

Figure 6. Calculation of efficiency criteria in different seasons

4. Conclusion

Different intentions for positioning and construction consolidation facilities (in this example plant biomass) require different approaches to solve the location problem. Furthermore are mostly not all relevant and exact data available. Under these conditions different models are necessary. Of course the models could be completed by each other and consolidated.
Further cases regarding different distances to feed-in facilities of the biomass gas were reviewed. Because of the small energy density of this special gas, restocking and shipping of the gas via truck have not been considered. That is the reason why the fuel cell has to be situated at the gasification facilities if no gas pipeline is available.
Furthermore functional and operational processes have to be created and configured. For this purpose the in- and outgoing logistics at each facility have to be described in the next steps.
The results show that the use of biomass can have a share to the electricity problem. The advised use and transport can raise the biomass to clean and CO_2 neutral or positive energy.

References

[1.] BIOLY, A. (2002): **Standortfaktoren im Einzelhandel - Methoden der Standortbewertung**, IHK, http://www.wertvmg.de/IHK/Kurs_7/Standortanalyse_Einzelh.pdf; 24.04.2009

[2.] FLAIG, H. (1998): **Biomasse – Nachwachsende Energie**, Expert Verlag, Renningen-Malmsheim

[3.] GOLDBERG, M. (1970): **The packing of equal circles in a square**, Math. Magazine 43, S. 24-30

[4.] HOFFMANN, V. (1994): **Wasserstoff- Energie mit Zukunft**, Teubner, Stuttgart

[5.] KALTSCHMITT, M., HARTMANN, H. (2009): **Energie aus Biomasse**, Grundlagen, Techniken und Verfahren, Springer, Berlin

[6.] KARAFYLLIS, N. (2000): **Nachwachsende Rohstoffe** (Technikbewertung), Leske und Budrich, Opaden

[7.] REINHART, ZEMANEK (2000): **Ökobilanz Bionergieträger**, Erich Schmidt Verlag, Berlin