GLOBAL POSITIONING SYSTEM UTILIZATION FOR MONITORING OF ENERGETIC BIOMASS LOGISTIC PROCESSES

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Abstract. Utilization of biomass for energetic purposes is continuously growing during recent years. This situation brings higher demand for analysis of particular operational indicators, such as time and energetic intensity of various processes. The data presented in the proceedings were collected during maize harvesting. Maize silage is used for a biogas station located in Central Bohemia. The station uses a cogeneration unit for electricity and heat production with 526 kilowatt total electric and 566 kilowatt total heat output. The indicated consumption of the maize silage for this station is 27 tons per day. Two Garmin GPS modules (76CS and 76CSx) were used during the monitoring process of maize harvest at the beginning of October. 76CS was installed in the Claas Jaguar 870 forage harvester with a 4.5 meters working width. 76CSx was used in the Case Puma 140 tractor with the ZDT Mega 20 trailer attached. Both modules collected data about latitude and longitude, distances, altitude, time and velocity. These data were downloaded to Garmin MapSource 6.13.7 software which allowed data transfer to Microsoft Excel 2007 for further analysis and also projection of track points to the map. The calculations based on the data analysis provided the values of operating parameters, e.g., average velocities during various operations on different surfaces, transportation distances, working time, loading time, transportation time and distance, and course of the transport corridor altitude. The calculated values are important for determining basic dependences during harvest and transportation processes. They also provide the initial point for operational indicators estimation for other transportation vehicles. Identification of all these factors may present a significant contribution to the energetic biomass logistics optimization.

Keywords: maize harvest, energetic biomass, biomass transportation, GPS monitoring, biogas.

Introduction

Biogas plants represent a very important part of systems using renewable energy sources in Czech Republic as well as in the European Union. Their importance lies in the energetic potential that can be fast mobilized, biological waste utilization and the creation of alternative business opportunities for local farms [1].

The number of facilities registered a sharp increase between 2002 and 2009, which reached nearly 50 % in average annually. At present, we can notice a slowdown, but not stagnation. According to the report of the licenses granted by The Energy Regulatory Office, there were 188 facilities operating with a total installed capacity of 111.68 MW on 1.3.2011. [2]. Detailed data are shown in the Figure 1. Development of individual regions can be described as balanced, except the Liberec and Usti nad Labem regions.

According to this trend, the importance of material transportation and biogas production work stages detailed analysis significantly increases. Careful analysis of certain indicators resulting in effective optimization measures can lead to a very important reduction in the costs of individual operations.

The important parameters of the maize harvest and chopped shredding transportation from the field to the silage trough were measured. Silage is used for the operating purposes of the agricultural biogas plant in Drahobudice with the installed power output of 526 kW. The heat output is 566 kW [3]. The plant belongs to the ZAS Becvary farm.

Considering the agricultural character of this production with all its typical characteristics, considerable differentiation of the transport system, a significant proportion of traffic in the field and low achieved speeds (compared to other sectors) can be expected [4].

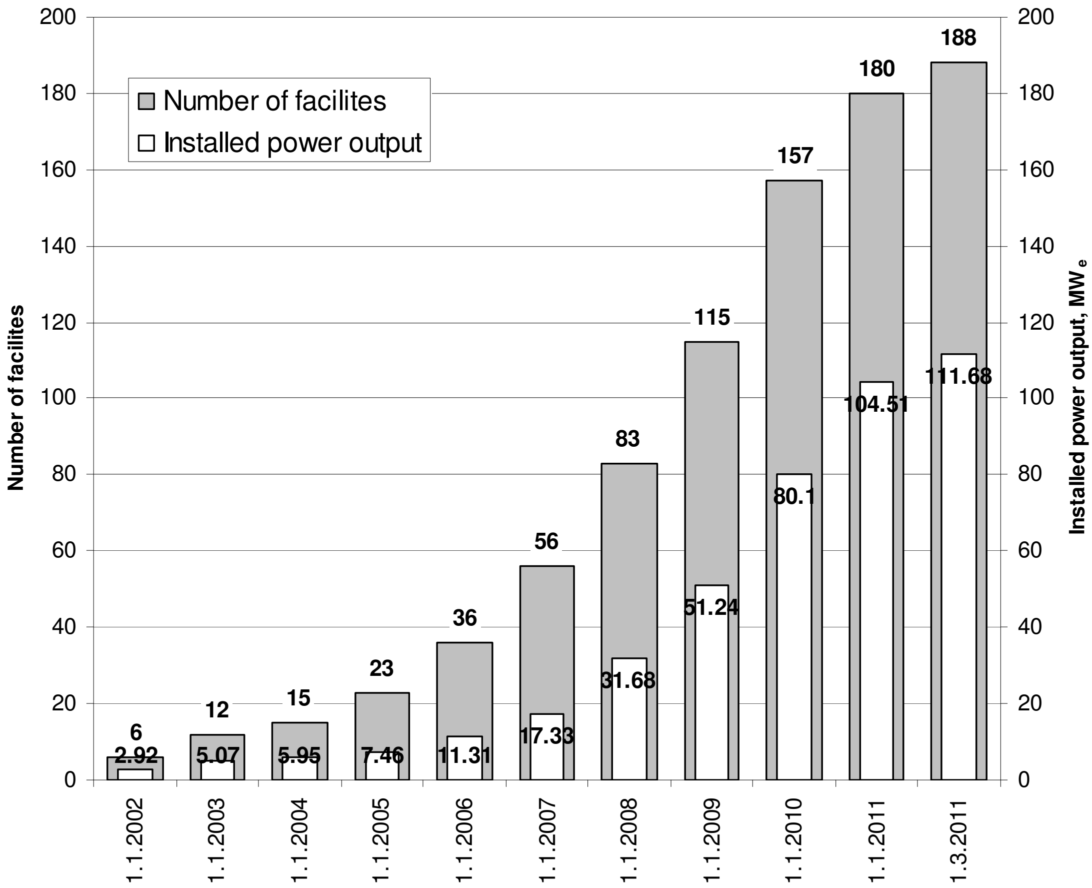

Fig. 1. **Number of biogas plants installations and total installed power output [2]**

Materials and methods

The farm ZAS Becvary is located in the Central Bohemia near the city Kolin. The field is located about 5 km (road with asphalt surface) from the premises, where the silage trough is located. Harvesting of maize provides the forage harvester Claas Jaguar 870 with a working width 4.5 m (equivalent to 6 lines). For monitoring the routes of material transport a Case Puma 140 + ZDT Mega 20 was chosen, due to best meeting the needs of analysis. The measured parameters were as follows:

- Location – latitude, longitude
- Altitude
- Distance
- Time
- Vehicle speed
- Total fuel consumption

GPS modules Garmin 76CSx (Transport vehicle) and 76CS (forage harvester) were used to obtain the data 1-5. No.6 – Fuel consumption was measured at the end of the day. Garmin MapSource application (version 6.13.7) was used for obtaining and basic processing of the data from the GPS. All the required data can be easily viewed and exported for further elaboration in an external application – Microsoft Excel 2007 in this case. Based on the analysis of the coordinates and vehicle speeds, different operations were set:

- Field – traffic
- Harvest
- Traffic – road (with load/empty)
- Loading and unloading
- Idle time

Results and discussion

Monitoring of the vehicles was carried out between 5:56 till 18:34. The actual harvest started at 6:51 and ended at 18:04. During this time, the area 24.46 ha was harvested. The fuel consumption of forage harvester within one working day was 508 l. For details of the operating parameters see Table 1.

Table 1

Class Jaguar 870 overall operating parameters

Operation	Total time	Avg. speed, km·h^{-1}	Distance, km
Harvest	10:02:34	5.83	55.58
Traffic – field	0:14:14	14.35	3.55
Traffic – road	0:47:06	17.79	10.36
Idle time	1:33:02	-	-

One transfer cycle consists of field traffic (approx. 1 km), road traffic (with load and empty, approx. 10 km) and processes of loading and unloading. Monitored Case Puma 140 + ZDT Mega 20 performed 15 normal traffic cycles during the day plus 1 traffic cycle which consists of vehicle transfer from the farm premises to the field in the morning and the last half traffic cycle in the evening. This additional combined cycle (cycle 1) had a slightly different traffic route. This fact had to be taken into account in some detailed calculations, therefore it is marked with *. Average parameters per cycle are shown in the Table 2. During one traffic cycle, relatively small fluctuations in altitude were experienced, as can be seen in the Figure 2.

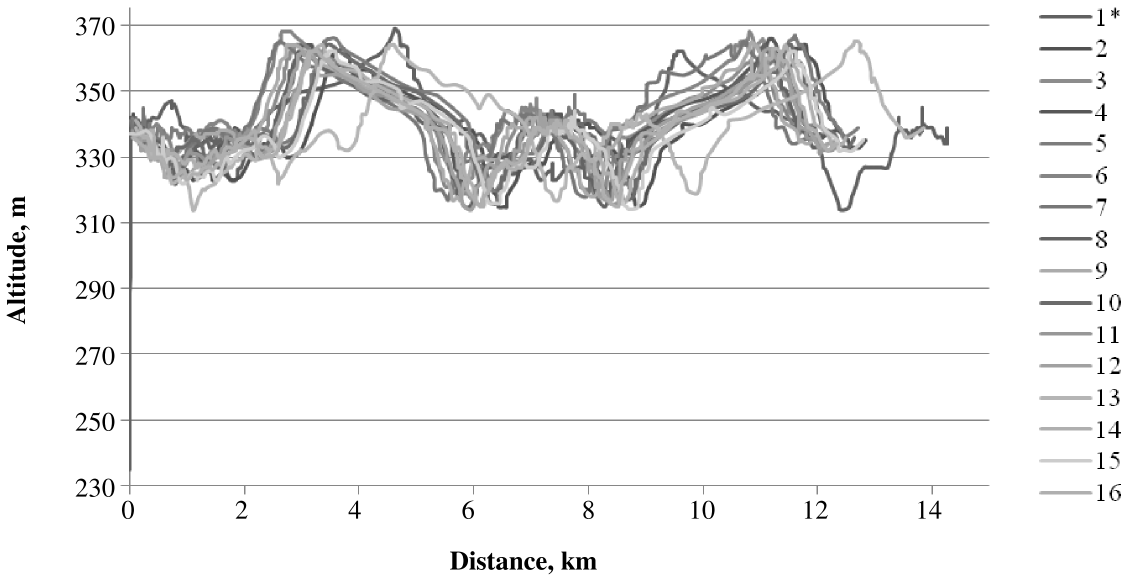

Fig. 2. **Altitude changes during traffic cycles**

Table 2

Case Puma 140 + ZDT Mega 20 average operating parameters per cycle

Operation	Avg. time	Avg. speed, km·h^{-1}	Distance, km
Traffic – road – load	0:11:19	32.34	5.26
Traffic – road – empty	0:09:23	26.97	5.04
Traffic – field	0:03:29	19.94	1.12
Loading	0:11:46	6.16	1.07
Unloading	0:02:34	0.97	0.04
Idle time	0:08:16	-	-

Detailed results of the most important traffic parameters for each cycle are shown in Table 3. Due to very high terrain humidity, relatively small amount of relevant data about the field traffic and big differences between them, it was not possible to determine a significant difference between field traffic with and without load. A significant difference had been found between the road traffic speeds with load and without load – 5.37 km·h^{-1}, or 5.95 km·h^{-1} when excluding the combined cycle. The difference between the travelled distances (approx. 220 m per cycle) was caused by a slightly different route with and without load through the farm premises. Projection of the traffic cycles to the map is shown in Figure 3.

Table 3

Case Puma 140 + ZDT Mega 20 detailed parameters for individual cycles

Cycle	Distance, km	Time	Avg. speed, km·h^{-1}	Avg. speed – road – load, km·h^{-1}	Avg. speed – road – empty, km·h^{-1}
1*	14.26	1:10:34	15.87	21.77	18.28
2	12.84	1:04:43	19.81	27.12	30.70
3	12.17	0:36:41	23.47	27.31	31.71
4	12.32	0:36:08	25.01	27.90	34.96
5	12.71	0:44:42	19.73	24.21	35.00
6	11.95	0:30:48	27.09	28.46	33.83
7	11.86	0:37:21	25.19	27.56	34.95
8	12.19	0:42:19	25.15	27.86	34.24
9	11.99	0:36:33	25.44	28.01	31.49
10	12.65	0:47:05	23.59	27.18	33.78
11	12.38	0:53:33	22.62	27.41	31.71
12	12.33	1:10:11	22.97	25.07	33.97
13	13.86	0:41:36	25.25	28.54	32.66
14	12.49	0:43:18	22.84	26.76	31.66
15	12.79	0:49:36	25.58	28.97	36.95
16	12.35	0:49:41	24.08	27.41	31.48
AVG	12.57	0:47:11	23.36	26.97	32.34
SD	0.63	707 s	2.73	1.78	4.00
AVG (2-16)	12.46	0:45:37	23.85	27.32	33.27
SD (2-16)	0.47	627 s	2.00	1.20	1.73

Fig. 3. **Traffic cycles projection on the map**

Case Puma 140 + ZDT Mega 20 transported 12 t of material during one cycle which gives us the total amount of 192 t. The total measured fuel consumption was 120 l in this case.

Conclusions

Utilization of sensitive global positioning system modules provides information about parameters distribution during the whole traffic cycle, which is important for detailed processes planning. This can bring significant improvement to the cost-saving politics of farming companies, especially when considering very small first cost (approx. 350 EUR incl. VAT per module with all necessary accessories). In this case, more efficient operations can result into cheaper energy production.

Constant monitoring of operating parameters during several hours helped to calculate the time and the travelled distance required to perform individual operations. It also revealed the influence of the terrain and operation characteristics on the vehicle performance, as well as the difference between loaded and empty vehicle speeds, times and routes.

Projecting acquired traffic points to the map is a powerful instrument for controlled traffic farming, where minimal soil compaction is required to increase the yields. This can be also used for determining optimal traffic routes.

Acknowledgements

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