LogistEC

Logistics for Energy Crops' Biomass

Grant agreement number: FP7-311858

Collaborative project (small or medium-scale focused research project targeted to SMEs)
SEVENTH FRAMEWORK PROGRAMME

Priority: Food, Agriculture and Fisheries, and Biotechnology

Deliverable D2.2

Internal report prepared and passed to WPs 1 and 4 detailing all data acquired during first winter of harvest system evaluations.

Due date: M10

Actual submission date: M19

Project start date: September 1st, 2012

Duration: 42 months

Workpackage concerned: Work Package 2

Concerned workpackage leader: RRes

Dissemination level: PU

Table of contents

Glossary and definitions

Partners;

CENER	National Renewable Energy Centre, Spanish partner.
CRL	Coppice Resources Ltd, UK partner.
RRES	Rothamsted Research, UK partner.
SSSA	Scuola Superiore di Studi Universitarie di Perfezionamento Sant'Anna, Italian partner.

Other:

DoW	Description of Work, as submitted to EU
REAB	Rosenhälls Gård Energi AB, Sweden (not a LogistEC partner).
SRC	Short Rotation Coppice

Summary

Objectives To generate data that will verify (or not) manufacturer / service operator claims regarding the suitability and financial and environmental performance of different options for harvesting energy crops.

Rationale: The original work plan was severely disrupted by the difficult ground conditions during winter 2012-13.
It had been planned that all machines would be transported to one site and work in one crop divided into plots in a randomised block design, thereby giving the most comparable performance data possible.
The first problem arose when Westcon (UK) returned the only bio-baler in the UK to Canada and ceased to represent the manufacturer / machine here.
This was followed by incessant rain falling on already saturated ground, which also caused problems for SSSA (Italy) and CENER (Spain) and their work plans.
Finally, one of the sugar cane harvesters operating in the UK suffered major mechanical failure leaving only one machine to cover the work of two. The owners of that machine were reluctant to move it to an experimental site when under so much pressure under difficult weather conditions.
Therefore the researchers involved in WP2 travelled to sites where the machines could be seen working and made measurements for comparison to manufacturers' claimed performance figures.
All data in this preliminary report are derived from Short Rotation Coppice Willow. More data will be collected during the winter harvesting season 2013-14, including harvesting of poplar, eucalyptus, miscanthus, sorghum and giant reed. Data will also be collected regarding any necessary secondary processing and drying of the biomass harvested so as to complete the assessment of the whole harvesting system.

Teams involved: RRes, CRL and REAB, Sweden (not a LogistEC partner).

Geographical areas covered: UK and Sweden

1. Methodology

1.1 Machine Observations and validation

The machines identified in the DoW for harvesting SRC willow and currently found working in the UK and Sweden were observed during the winter/spring of 2013.

Table 1. From the DoW, WP2, Task 2.1. Short Rotation Coppice Harvesting Systems to be evaluated.

Early generation technologies	More recent innovations
Forage harvester, wood chip dried outdoors in ambient conditions.	Smaller scale; Bio-baler, wood bales dried outside in ambient conditions (UK only).
Forage harvester, wood chip force dried in a continuous flow dryer.	
Smaller scale; forage harvester, wood chip force dried in a continuous flow dryer.	
Sugar cane harvester, wood billets dried outside in ambient conditions.	
Smaller scale; Whole rods, dried outside in ambient conditions.	

Not all machines were fully evaluated / manufacture's claims validated. The final line of Table 2. indicates the level of validation achieved in the first season of work. It was not possible to collect any data regarding harvest losses or post-harvest management in 2013, this will begin in 2014.

Measurements were taken during these observations with which to calculate; labour requirements, fuel usage and costs. Some machines were evaluated in greater detail and the degree of validation for each machine was recorded. All data collection followed the protocols presented as **Deliverable 2.1.** of the LogistEC project. Further observations and data validation of the SRC Willow machines will be carried out during the harvest season of 2013/14

The observations and data collection from the remaining crops (poplar, eucalyptus, miscanthus sorghum and giant reed) and machine types will use a similar approach and will be conducted by RRES, SSSA and FCBA during the 2013 /14 season.

1.2 Measurements

The measurements were taken as stated in **D2.1/ 1.3 Data validation from independent sites.** Only some of the measurements were carried out as the observations were conducted on private commercial fields and return site visits were not always possible, this prevented the post-harvest management aspects of the harvesting systems from being evaluated.

1.3 Performance Calculations

The data collected were used as input parameters in an Excel spreadsheet designed to calculate the performance indicators listed in the summary table (Table 2). There is a spreadsheet for each machine. The input parameters collected in the field were used to calculate the performance indicators assuming that each machine harvested the same willow field (described below).

Ultimately the input parameters may be lifted from WP2 work and presented in the format required for WP4. At the present time WP4 have seen the Excel spreadsheets referred to above.

1.3.1 The SRC willow field

The field selected is a typical commercial 11ha Willow field located in south Lincolnshire, UK (Figure 1). It is an established willow field currently in commercial production and managed by CRL. The layout (number of rows, distances and ride length) is known in detail and therefore comparisons between machines can be accurately calculated on and "field basis" rather than an area basis.

Figure 1. The aerial view of the CRL willow field, Lincs.

1.4 Harvest losses and Post-Harvest management

All harvesting methods listed in Table 1. were expected to result in some “in field” loss of otherwise usable crop. This has financial implications but may also have an environmental impact e.g. if the lost crop contributed to the replenishment of soil carbon pools. WP1 has an interest in such inputs to the soil system. Unfortunately no data on losses were collected in 2013 and any input to WP1 is delayed by one year.

The post-harvest management of all harvesting systems listed in Table 1. will require some further drying of the woodchip. In addition some systems will require secondary processing of the harvested material to produce a usable feedstock. It had been intended to collect energy, time and cost data on the secondary process during winter harvest season 2012-13, but this proved impossible. It will be done during 2013-14. The harvesting machine requirement for secondary processing has not been considered in detail in this report

For compatibility purposes all harvesting and post-harvest management systems will be taken to wood chips (a usable form of the wood) at 22% moisture content.

2. Results

2.1. Performance summary table

The observations and performance of the SRC Willow harvesting machines considered in the season 2012/13 are summarized in Table 2. The level of validation from all of the machines considered is presented at the base of the table. The Biobaler and medium scale forager were fully validated using a full range of measurements while the whole rod harvester has yet to be observed and will be investigated fully in 2013/14 season. Those labelled as “partially” validated are those where insufficient data has been collected, especially when a machine was observed and measured in atypical condition.

It should be noted that the calculations have not included any costs for repairs as the machines are considered to be purchased new and under warranty. However this

will change during the machines working life. Lost time due to breakdowns was also omitted as we cannot make predictions about machine reliability.

The data summarised in Table 2 were collated and further calculations made, in Excel spreadsheets. An example of which is available on the LogistEC web site and may be made available to others upon request.

Table 2. The performance summary of the selected SRC Willow harvesting machines 2012/2013

	Bio-baler	Small scale forage harvester	Medium scale forage harvester	Large scale forage harvester	Billet harvester	Whole rod harvester* plus bundler	Whole rod harvester* Loose rods / stems
Cost £ ha^{-1}	£417	£500	£340		£415	£424	£267
Fuel used l ha^{-1}	196	236	129		101	106	60
Time taken person h ha^{-1}	7.1	10.0	4.4		4.6	5.6	2.7
No people required	1	2	3	3	3	1	1
Capital invested [a] £ 000	£380	£249	£650		£510	£740	£365
Specific Capital investment [b] £ 000	£145	£23	£120		£240	£210	£210
Product	Round bale	Chips 50-75 mm	Chips 50-75 mm	Chips 50-75 mm	Billets 120 – 200 mm	Whole stems / rods Up to 8m, 2m when bundled	Whole stems / rods Up to 8m
Further processing required	In most cases	No	No	No	Yes	Yes	Yes
Verified	Yes	Partially	Yes	No	Partially	No	No

[a] irrespective of use elsewhere / in other crops (i.e. tractors, trailers, forage harvesters used for other crops)
[b] specific to energy cropping, no perceived use elsewhere
* Stemster III, not Mantis

3. Conclusion

An early, provisional assessment of the current technologies for harvesting SRC (specifically willow, but similar to other woody bio-energy crops) has been carried out. Forage harvesters producing wood chip directly, in the field, appear the most efficient technology at the present time. This is subject to evaluating the drying options for wet wood chips. The whole rod harvester (lose rods) and sugar cane harvester are also an efficient method for clearing the field, but account must be made for processing the material post-harvest.
The Bio-baler is the least attractive option and this may be reflected in the decline in interest in the machine since 2011.

An example of the spreadsheet based calculator for financial costs of harvesting is also available on the LogistEC collaborative workspace and upon request:
Harvesting model Bio-Baler.xls