Biomass Supply chain Feasibility Study by Means of Web Application: Technical, Economic and Energetic Aspects

Remigio Berruto[1], Patrizia Busato[2]
[1]DEIAFA – University of Turin, Via L. Da Vinci, 44. 10095 – Grugliasco (TO) , Italy, remigio.berruto@unito.it
[2]DEIAFA – University of Turin, Via L. Da Vinci, 44. 10095 – Grugliasco (TO) , Italy, patrizia.busato@unito.it

ABSTRACT

One of the main difficulties in the development of biomass supply chains is the lack of reliable and complete information, which is needed to carry out a correct analysis. In this context, it is very important to have a reference application in order to compare biomass production systems. With the aim to bridge this information gap has been implemented by DEIAFA a web application - www.EnergyFarm.unito.it - to investigate the biomass supply chains under the technical, economic and energetic aspects. Functionalities offered by this advanced application include the evaluation of field and logistic operations related to biomass cultivation, harvest and transport to the point of use. All procedures share a common database, ensuring their proper integration. Following the data insertion the user could compute its own crop cultivation costs and margins both on the economic and energetic point of view. The tool was used in combination with discrete event simulation model to assess in detail the logistic operation costs of biomass supply chain. EnergyFarm® represents the first step toward the standardization of data and calculation procedures. In the future it will be possible to foresee also in the same application the computing of the results with different standards (ASAE, EU, etc.). The interface to the application is provided in English and Italian languages.

1. INTRODUCTION

Producing and selling energy is a brand new scenario for farmers. In the simplest case, the agricultural firm must simply redirect its output to another supply chain. In the worst case, it must change type of production. In both cases, the firm finds itself in a different supply chain with possibly new rules and there are several difficulties in its exploitation because of the extent of the single supply chains, which consist of different phases. Often the lack of reliable and complete information on this new activity, which is needed to carry out a correct economic and energetic analysis, tends to hinder the development and exploitation of biomass supply chain. Farm managers, consultants, and other working with machinery management use equipment capacity information to estimate costs and select machinery to complete field operations within

Remigio Berruto, Patrizia Busato. “Biomass Supply chain Feasibility Study by Means of Web Application: Technical, Economic and Energetic Aspects”. International Commission of Agricultural and Biological Engineers, Section V. Conference “Technology and Management to Increase the Efficiency in Sustainable Agricultural Systems”, Rosario, Argentina, 1-4 September 2009. The authors are solely responsible for the content of this technical presentation. The technical presentation does not necessarily reflect the official position of the International Commission of Agricultural and Biosystems Engineering (CIGR), and its printing and distribution does not constitute an endorsement of views which may be expressed. Technical presentations are not subject to the formal peer review process by CIGR editorial committees; therefore, they are not to be presented as refereed publications.

the time available. As new technology and information become available, a periodic study of on farm activities is required to maintain current and useful information (Harrigan, 2003).
The biomass logistic costs could be very important, due to distance and low energy density/value of the product. These costs are often not computed when the biomass supply is performed by the farmers. Data are written in publications not easy to access outside of the academic and research domain. Hence, there is a need of a standardized tool to assess the feasibility study, with the use of common input data and evaluation procedures in order to ensure uniformity, which in turn is a guarantee of the quality of the assessment.
The aim of the research is contributing to knowledge which can be exploited in designing and evaluating biomass supply chains, within a standardized system approach. The implementation of a web application that allows to compute technical, economic and energetic indexes related to biomass supply chains is a step toward this objective.

EnergyFarm overall view
The multilanguage web-based application (www.EnergyFarm.unito.it), developed with ASP® technology, allows the user to compare different farming systems and to evaluate biomass supply chains. The idea beyond the tool is to provide a simple way to compute crop costs and energetic balance without the insertion of the whole farm business plan. All the coefficient related to tractor and machinery use are already in the database (e.g. maintenance, fuel consumption, machinery lifetime, machinery depreciation rate, etc.). Also the energetic coefficients, for both technical meanings and biomass products are provided by the system.
The web application is made up of data insertion procedures and output forms to visualize the results. The interface is already provided in English and Italian and the access to the database is guaranteed in anonymous way. Once the insertion of the farm parameters, machinery and operations is completed, the tool calculate:

- working times of the equipment;
- costs of mechanization of every operation and each crop;
- costs of the technical means and the extra-farm services;
- revenues and the profits of management;
- energy balance for the crops.

Use of machines is computed just for the operative time. The hourly use of equipment does not consider the waiting times, like in Busato et al. (2005). Manpower costs are not considered by the application. They can be inserted as extra costs, otherwise are incorporated into the farmer profit. The inserted data are relative to a single farm and they constitute a scenario. The user could manage many scenarios.

Forms Data Insertion
Some data are common for the entire farm (general parameters, technical means, tractors and equipment) while others (operations, use of technical means, extra costs and revenues) are inserted for each crop.
Particularly, among the common data, the application require the average field size, field distance from the farm, interest rate and fuel price. These parameters will be used consistently through the evaluation of different crops and operations.

The crops have to be inserted with definition of the area cultivated within the farm since this datum is used as reference for all the calculations. The amounts of the factors used or the products obtained have to be inserted as totals for the crop area and not per hectare. The application deals just with annual crops. For this reason, multi-year crops have to be inserted as many annual crops. This allow great detail in cost and revenue evaluation year by year.
The technical means are inserted previously of their use, or can taken from a list provided by the application. For each product there is a description, price, and measure unit. The units for the distributed resource (fertilizer, herbicide, fungicide, etc.) and the capacity of the equipment' tank should be consistent. Also the energetic coefficients are required in order to compute the energy balance.
The tractors and equipment owned by the farm are required previously to the insertion of the field and logistic operations. For the tractors the year of purchase and the purchase value have to be inserted. For the equipment are required also the working width and the turning time. For the machines that distribute or collect product from the field the user has to insert the tank capacity and the time required to load or unload it.
The main step are related to the insertion of field and logistic operation.
The field operation require to specify the working width, the working speed, the tractor and the equipment used. By default is proposed the whole area of the crop as specified in the crop section. Additional information is the crop area on which is carried the operation. For what concern the insertion of the product used or retrieved from the field within the operation the quantity inserted refers to the total surface of the crop and not to the hectare (Figure 1).

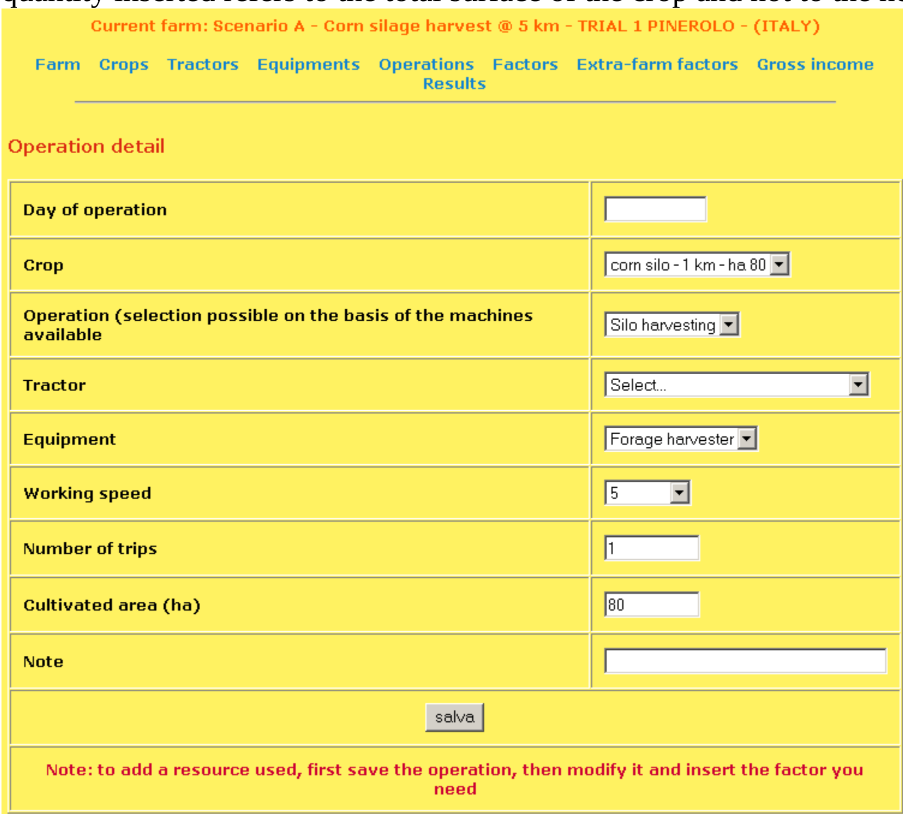

Figure 1. Form for the insertion of field operation data.

The logistic operations, such the transfer of fertilizers and manure to the field, and harvested product or biomass to the farm or to the point of use, are considered separately from the traditional field work. The required data are the followings: total amount carried by the operation (e.g. total corn silo produced in the farm), quantity carried per cycle, tractor and equipment used. All the working times are referred to quantity for each cycle: loading/unloading time in the field, loading/unloading time at the farm and transport time. Detailed machinery use for logistic operations could be computed with cycle time analysis (Buckmaster, 2006), analytical formulas (Piccarolo et al., 2006) or in a more detailed way with simulation models (Busato et al., 2005; Busato and Berruto, 2007; Busato and Berruto, 2008).
Other cost like rent of the land, water irrigation, taxes and services (harvesting, drying operation, accounting, etc.) have to be inserted separately for each crop and refers to the whole crop area.
At last the farm revenue are calculated, by inserting the total quantity sold for each product separately (e.g. grain and straw from wheat). It is also possible to specify cultivation contributions (e.g. EU contribution, national and regional contribution and so on).
The data insertion could be partial if the user is interested into partial results. For example, if just the mechanic costs have to be assessed, the insertion could be limited to these aspect.

Equipment Working Times and Mechanical Operations Costs

The variation of mechanical operations cost is strong dependent from farm size, field size, distance from the farm, and other factors like yield and timeliness. The summation of in-field operations and logistic operation give an exact figure of machinery and tractor use per year. This number allow to determine the duration of the tractor and equipment and to compute detailed fixed costs. Following the pattern described in Figure 2, the web application compute in a detailed way the operation cost on a farm basis.
The equipment unitary working times are function of:

- working width and the working speed of the operations;
- surface and shape of the field;
- tractor used to pull the equipment, for non self-propelled machines.

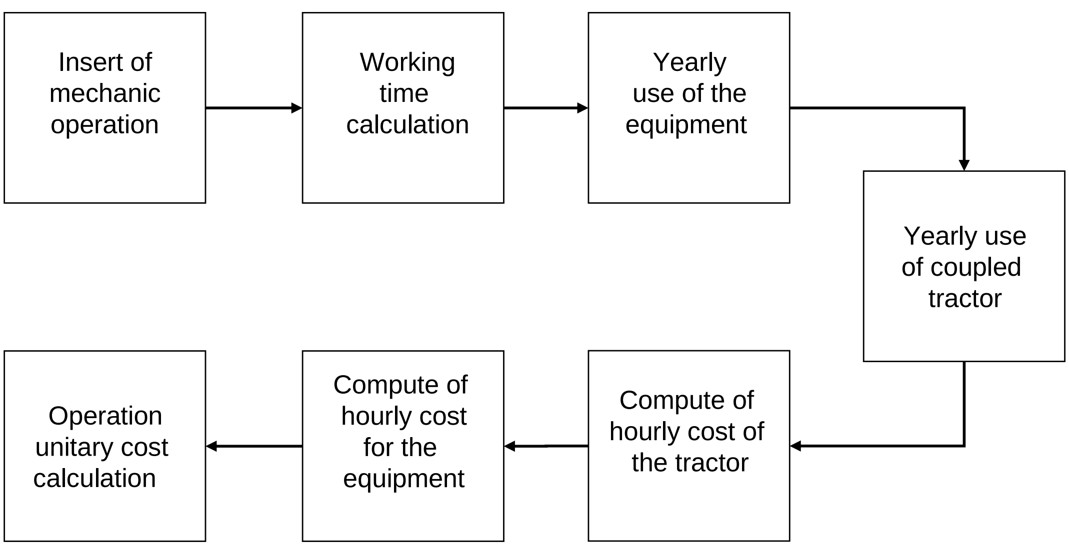

Figure 2. Sequence of computation used to calculate the operation costs.

The summation of machinery working times gives an exact figure of machinery and tractor use per year. The introduction of a new crop or the use of new equipment, involves the calculation of the unitary cost of all the operations that have some link with the changed parameter, following recursively the pattern in Figure 2. The working times have been calculated following the standard CIOSTA, while for the fuel consumptions the formulas from Piccarolo are being used (Piccarolo et al., 1989). Depreciation and maintenance were taken from Hunt (2001).

Energy Coefficients

For the energy balance have been considered both direct and indirect consumptions.
The energy coefficients have been taken from different sources (Kitani et al, 1999; Pimentel et al., 1999 and Nagy, 1996). These were inserted in the database, and then the application calculates all the inputs and the relative outputs for each crop, without asking for the manual insertion of such coefficients by the operator. However, the user can provide or change them for products or equipments not already in the database.
The energy expense related to the equipments and tractors is calculated as a function of their usable machine life (hours) and yearly use of the equipment, following the same pattern described for cost calculation (Berruto and Busato, 2006).

Application Results: Economic and Energetic Aspects

The results are showed both for single operation and for the crop.
An example of the single operation results is presented in Figure 3. These are related to a transport operation of the corn silage carried out by a tractor of 140 hp pulling a 30 m3 wagon, that brings to a biogas plant the product from a 10 km distance, as depicted in the scenario C presented in Busato and Berruto (2008).
The outputs for the operation shows in detail:

- working times for tractors and equipment;
- fuel consumption;
- hourly cost (€.hour-1) for tractors and equipment;
- unitary cost for the operation (€.ha-1);
- unitary energy consumptions (MJ.ha-1) both direct and indirect. The energy consumptions are visualized by the model divided for categories and added in order to compute the total energy inputs.

Figure 3. Detailed result of the computed calculation on a single operation.
An example of the crop cultivation result can be seen in Figure 4. It refers to a corn grain production cultivated over 15 ha. The results related to the crop are presented in the following categories:

- cost of equipment use and fuel consumption;
- cost of use of fertilizers, herbicides, and so on;
- other cost, including extra-farm costs (e.g. contractors, irrigation costs, lease of land and so on);
- sales of product (corn grain, wheat, straw, etc.);
- net income for the crop;

- energy balance for each crop. The outputs are added and presented in one row in the table. Finally, the ratio output / input is showed at the bottom of the page for the crop. The energetic indexes could be used in other parts of the web application that refers to the evaluation of power plants for biomass energy production (Berruto and Busato, 2007).

Current farm: LOMBRIASCO - BI 2005 - LOMBRIASCO - ()

Farm Crops Tractors Equipments Operations Factors Extra-farm factors Gross income Results

Cost and benefit analysis for:
Corn cultivated on ha 15,00

Mechanical cost of the operation	**€/ha**	**€/crop**	**MJ/ha**
Fertilization su 15 ha - Tractor 2WD 70 cv (2000) - Fertilizer, broadcaster	-23,15	-347,23	-378
Fertilization su 15 ha - Tractor 2WD 70 cv (2000) - Fertilizer, broadcaster	-21,75	-326,31	-356
Fertilization su 15 ha - Tractor 2WD 70 cv (2000) - Fertilizer, broadcaster	-26,50	-397,43	-433
Hoeing su 15 ha - Tractor 4WD 100 cv (2000) - Row-crop cultivator+fertilizer	-71,92	-1.078,80	-785
Seeding su 15 ha - Tractor 2WD 70 cv (2000) - Corn planter	-76,45	-1.146,78	-1.099
Spraying su 15 ha - Tractor 2WD 70 cv (2000) - Sprayer, hitched 3 points	-21,36	-320,46	-276
Chopping residues su 15 ha - Tractor 4WD 100 cv (2000) - Rotary cutter, vertical plane	-76,51	-1.147,62	-1.105
Cost for resources			
Fertilizer - Cloruro Potassico	-35,70	-535,50	-887
Fertilizer - Urea	-117,26	-1.758,92	-12.890
Herbicide - Acqua	0,00	0,00	0
Herbicide - Ghibli	-33,47	-502,05	-188
Herbicide - Mikado	-39,00	-585,00	-188
Seed - Mais Goldelen	-135,00	-2.025,00	-210
Cost for extra-farm factors			
Rent of Land	-356,00	-5.340,00	0,00
Taxes	-116,00	-1.740,00	0,00
Service for combine harvesting	-122,00	-1.830,00	-2.666,67
General Expences	-96,00	-1.440,00	0,00
Water for Irrigation	-80,00	-1.200,00	0,00
Drying Costs	-164,44	-2.466,56	-10.000,00
Crop income			
Sell of Corn Grain	1.538,33	23.075,00	188.032
EU and Regional Contributions	292,57	4.388,55	0
Total mechanical cost	**-317,64**	**-4.764,63**	**-4.432**
Fuel	-62,71	-940,69	-2.997
Tractors	-178,39	-2.675,84	-1.188
Equipments	-76,54	-1.148,10	-246
Total resource costs	**-360,43**	**-5.406,47**	**-14.364**
Total extra-farm costs	**-934,44**	**-14.016,56**	**-12.666,67**
Total gross income	**1.830,90**	**27.463,55**	**188.032**
Total Profit	**218,39**	**3.275,89**	**156.569**
Ratio Output / Input			**5,98**
Rapporto Output / Input (just direct consumptions)			**6,26**

Figure 4. Output of the application: economic and energetic cost for corn crop.

Farm Comparison
The tool helps the farmers to assess the convenience of the adoption of biomass crops. The inserted data are relative to a single farm and constitute a scenario. The new farm can be inserted ex-novo or, through a hierarchical command of copy, duplicated from the farm being inserted, and modified in the parameters that define the new scenario. The application allows in this way to compare biomass versus traditional crops, short rotation forestry versus annual crop (e.g. corn silo), or different years within the same crops rotation.

Case Study
The case study refers to the use of the application in conjunction with the simulation model in order to determine harvesting and transport costs of the corn silo. The three scenarios (5 km, 10 km and 20 km biomass collection radius) presented in Busato and Berruto (2008), characterized with different transport distances of corn silo (Table 1), were investigated. The results of the simulation were uploaded on the application database with a custom procedure made by the authors, and were used as input data for the definition of logistic operations.

Table 1. Areas to be harvested (ha) and field distance (km) for the three scenarios.

	Field distance																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	80	80	80	80	80															
B	40	40	40	40	40	40	40	40	40	40										
C	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

The three farms scenarios were inserted in the web application, one for each biomass collection radius. The application deals just with field situated at the same distance for all the fields. For this reason, multi-distance crop has to be inserted as many one-distance crops. The area of 400 ha was so divided in many different crops.
In order to assess the costs of the operations, for each crop distance the working chains suggested by the linear programming model were uploaded on the web application with a customized procedure in VBA Access®, along with working times computed by the simulation model. Direct comparison with the cost used for the linear programming model in Busato and Berruto (2008) could not be performed because the labor is not computed by the application, however the results have a good level of details and provide some insight of how the application works.

RESULTS

The cost of the harvest operation for the corn silo at 5 km was taken as an example. The comparison refers to the costs found in scenario A versus scenarios B and C.
The higher the use of the machinery, the lower the operation cost, because of less incidence of the fixed costs. In table 2 are presented the hours of use of the equipment for the three scenarios, taken from the EnergyFarm® web application.

Table 2. Hours of use of equipment for the harvest of corn silage, for the logistic scenarios presented in table 1.

	FH([1])	PACK	W1 & T1	W2 & T2	W3 & T3	W4 & T4	W5 & T5	W6 & T6	Total transport
A	298	310	279	279	222	--	--	--	779
B	307	307	268	268	239	129	101	50	1056
C	326	306	283	283	283	274	274	250	1648

(1) FH stands for forage harvester, W stands for wagon and T for tractors, PACK for compacter

Model description	Year of purchase	Purchase value (€)	Working width (m)	Working speed (km/h)	Yearly use (h/year)	Fixed hourly cost (€/h)	Energetic hourly cost (MJ/h)
Silage leveller	2000	8.000,00	2,50	0,00	309,94	33,30	121,96
Wagon	2000	16.720,00	0,00	0,00	0,00	0,00	0,00
Wagon	2000	16.720,00	0,00	0,00	0,00	0,00	0,00
Wagon	2000	16.720,00	0,00	0,00	0,00	0,00	0,00
Wagon	2000	16.720,00	0,00	0,00	221,52	6,14	195,14
Wagon	2000	16.720,00	0,00	0,00	278,84	5,40	195,14
Wagon	2000	16.720,00	0,00	0,00	278,84	5,40	195,14
Forage harvester	2006	250.000,00	4,50	8,00	297,60	102,72	390,28

Figure 5. Equipment use for the scenario A, with biomass collection radius of 5 km

Model description	Year of purchase	Purchase value (€)	Working width (m)	Working speed (km/h)	Yearly use (h/year)	Fixed hourly cost (€/h)	Energetic hourly cost (MJ/h)
Silage leveller	2000	8.000,00	2,50	0,00	307,01	33,31	121,96
Wagon	2000	16.720,00	0,00	0,00	50,31	18,52	387,88
Wagon	2000	16.720,00	0,00	0,00	101,12	10,47	195,14
Wagon	2000	16.720,00	0,00	0,00	128,66	8,77	195,14
Wagon	2000	16.720,00	0,00	0,00	239,42	5,87	195,14
Wagon	2000	16.720,00	0,00	0,00	268,08	5,51	195,14
Wagon	2000	16.720,00	0,00	0,00	268,08	5,51	195,14
Forage harvester	2006	250.000,00	4,50	8,00	307,20	101,46	390,28

Figure 6. Equipment use for the scenario A, with biomass collection radius of 10 km

Model description	Year of purchase	Purchase value (€)	Working width (m)	Working speed (km/h)	Yearly use (h/year)	Fixed hourly cost (€/h)	Energetic hourly cost (MJ/h)
Silage leveller	2000	8.000,00	2,50	0,00	305,77	33,31	121,96
Wagon	2000	16.720,00	0,00	0,00	250,24	5,73	195,14
Wagon	2000	16.720,00	0,00	0,00	273,73	5,45	195,14
Wagon	2000	16.720,00	0,00	0,00	273,73	5,45	195,14
Wagon	2000	16.720,00	0,00	0,00	283,30	5,35	195,14
Wagon	2000	16.720,00	0,00	0,00	283,30	5,35	195,14
Wagon	2000	16.720,00	0,00	0,00	283,30	5,35	195,14
Forage harvester	2006	250.000,00	4,50	8,00	326,40	99,17	390,28

Figure 7. Equipment use for the scenario A, with biomass collection radius of 20 km

The operation costs taken from the web application, are presented in Figure 4 for the scenario A, Figure 5 for the scenario B and Figure 6 for the scenario C.
The cost of transport is directly related to the time the single wagon spend to transport the biomass produced over one hectare. This increase with the distance, and when the number of trailers available is less. The higher the wagons are used, the lower will be the transport cost. At the same distance (5 km) the differences are very little. Still the scenario A present lower cost than B and C because it use just three wagon over the whole farm, with high equipment use and little decrease in costs of transport compared to the other scenarios.

Current farm: Scenario A - Corn silage harvest @ 5 km - TRIAL 1 PINEROLO - (ITALY)

Farm Crops Tractors Equipments Operations Factors Extra-farm factors Gross income Results

Cost and benefit analysis for: corn silo - 5 km cultivated on ha 80,00

Mechanical cost of the operation	€/ha	€/crop	MJ/ha
Transportation su 80 ha - Tractor 4WD 140 cv (2000) - Wagon	-28,94	-2.315,42	-797
Transportation su 80 ha - Tractor 4WD 140 cv (2000) - Wagon	-28,94	-2.315,42	-797
Transportation su 80 ha - Tractor 4WD 140 cv (2000) - Wagon	-31,63	-2.530,70	-815
Silo harvesting su 80 ha - () - Forage harvester	-137,73	-11.018,30	-3.238
Silo harvesting su 80 ha - Tractor 4WD 180 cv (2000) - Silage leveller	-45,55	-3.644,26	-451
Cost for resources			
Cost for extra-farm factors			
Crop income			
Total mechanical cost	**-272,79**	**-21.824,10**	**-6.096**
Fuel	-100,65	-8.052,07	-4.809
Tractors	-56,20	-4.496,36	-416
Equipments	-115,95	-9.275,67	-873

Figure 8. Cost of harvest, transport and compaction of corn silo at 5 km distance, for the scenario with biomass collection radius of 5 km

Current farm: Scenario B - corn silage harvest @ 10 km - TRIAL 2 PINEROLO - (ITALY)

Farm Crops Tractors Equipments Operations Factors Extra-farm factors Gross income Results

Cost and benefit analysis for:
corn silo - 5 km cultivated on ha 40,00

Mechanical cost of the operation	€/ha	€/crop	MJ/ha
Transportation su 40 ha - Tractor 4WD 140 cv (2000) - Wagon	-29,36	-1.174,55	-799
Transportation su 40 ha - Tractor 4WD 140 cv (2000) - Wagon	-29,36	-1.174,55	-799
Transportation su 40 ha - Tractor 4WD 140 cv (2000) - Wagon	-30,66	-1.226,54	-808
Silo harvesting su 40 ha - () - Forage harvester	-142,34	-5.693,69	-3.369
Silo harvesting su 40 ha - Tractor 4WD 180 cv (2000) - Silage leveller	-45,63	-1.825,25	-452
Cost for resources			
Cost for extra-farm factors			
Crop income			
Total mechanical cost	**-277,35**	**-11.094,58**	**-6.227**
Fuel	-103,16	-4.126,28	-4.928
Tractors	-56,19	-2.247,45	-417
Equipments	-118,02	-4.720,86	-885

Figure 9. Cost of harvest, transport and compaction of corn silo at 10 km distance, for the scenario with biomass collection radius of 10 km

Current farm: Scenario C - corn silage harvest @ 20 km - TRIAL 3 PINEROLO - (ITALY)

Farm Crops Tractors Equipments Operations Factors Extra-farm factors Gross income Results

Cost and benefit analysis for:
corn silo - 5 km cultivated on ha 20,00

Mechanical cost of the operation	€/ha	€/crop	MJ/ha
Transportation su 20 ha - Tractor 4WD 140 cv (2000) - Wagon	-14,58	-291,52	-403
Transportation su 20 ha - Tractor 4WD 140 cv (2000) - Wagon	-14,58	-291,52	-403
Transportation su 20 ha - Tractor 4WD 140 cv (2000) - Wagon	-14,58	-291,52	-403
Transportation su 20 ha - Tractor 4WD 140 cv (2000) - Wagon	-14,76	-295,15	-404
Transportation su 20 ha - Tractor 4WD 140 cv (2000) - Wagon	-14,76	-295,15	-404
Transportation su 20 ha - Tractor 4WD 140 cv (2000) - Wagon	-15,27	-305,36	-408
Silo harvesting su 20 ha - () - Forage harvester	-149,71	-2.994,15	-3.588
Silo harvesting su 20 ha - Tractor 4WD 180 cv (2000) - Silage leveller	-45,21	-904,27	-448
Cost for resources			
Cost for extra-farm factors			
Crop income			
Total mechanical cost	**-283,45**	**-5.668,64**	**-6.461**
Fuel	-107,71	-2.154,23	-5.147
Tractors	-55,04	-1.100,90	-407
Equipments	-120,68	-2.413,51	-906

Figure 10. Cost of harvest, transport and compaction of corn silo at 5 km distance, for the scenario with biomass collection radius of 20 km

CONCLUSION

The web-based application, named EnergyFarm, developed with ASP.NET® technology, allows the user to compare different farming systems, under economic and energy point of view, taking into account in-field and logistic operations.
The Authors used the application to compute the harvest cost of corn silo for biogas production, starting from the results of the discrete event simulation model (Busato and Berruto, 2008) that were uploaded into the web application database. The web application was able to compute detailed harvest and transport operation cost, for each field distance from the farm, for three scenarios characterized by biomass collection radius of 5, 10 and 20 km.
Especially for the biomass, the logistic cost could be very important, due to distance and low energy density/value of the product.
The application outputs detail results useful for a feasibility study of the biomass supply chain, with technical, economic and energetic indicators.
The use of the web to run the application has the following advantages:

- Standardization of the results gotten with the same method of calculation and with the same biomass characteristics, that allows the comparison of the results produced by different users, and different scenarios;
- Free availability of standard data on biomass characteristics (Low Heating Value, moisture content, density, etc.) for non-expert users;
- Absence of installation and costs of distribution of the software and of the updates, since the application resides only in one server;
- Safe storage of the user feasibility studies and possibility to retrieve them, in presence of Internet connection;
- Summarized and grouped results for classes of plant sizes that produce energy from biomass sources;
- Possibility for every single user to compare his own results with those from other users, for farm of homogeneous classes of cultivated area;
- Automatic save of all the technical, economic and energy data of the single farm, in anonymous way;
- Possibility to upload results coming from research into the database, thus allowing immediate transfer of the results to the community of experts that use the web application;
- Statistics updated in real time on the data inserted by the users, since all the files are saved in the same database on one server.

From a more general point of view, the most important result is the widespread diffusion of culture, among professionals, public and private stakeholders, and possibly students. A Web application providing free access to sophisticated and otherwise quite costly software is the only way to achieve this significant result.
The way with which the technical, economic and energy parameters are computed can vary in fact from country to country, as the unities of measure. Nevertheless, an application distributed on the web represents a first step toward the standardization of the data and the methodologies of calculation, within EU countries. In the future it will be possible to foresee also in the same application the computing of the results with different standards (ASAE, EU, etc.).

REFERENCES

Berruto, R. Busato, P. 2006. EnergyFarm: Web Application to Compare Crop Systems Under Technical, economic and Energetic Aspects. Computers in Agriculture 2006. Lake Buena Vista, Florida, 24-26 July, pp 481-487.

Berruto, R. Busato, P. 2007. WEB Decision Support System for Biomass Plant Feasibility Study. 5th Efita-WCCA Conference. Electronic proceedings.

Buckmaster, D. R. 2006. Systems Approach to Forage Harvest Operations. 2006 ASAE Annual Meeting. Paper n. 061087.

Busato, P., Berruto, R., and Piccarolo, P. 2005. Modeling of Rice Harvesting Chains: Technical and Logistic Aspects. XXXI Ciosta - CIGR V Conference, Hohenheim, 18-20 September, vol. 1: pp. 168-176.

Busato, P., Berruto R. 2007. Advanced logistic design and management of biomass supply chain by simulation toolbox. 15th Biomass Conference, , Berlin. 1:597-603.

Busato, P., Berruto R. 2008. Logistics Design Process of Biomass Supply Chain: Simulation and Optimization Models. Ageng 2008 conference, Hernissons, Crete, 23-25 June (In press).

Harrigan, T. M. 2003. Time–motion analysis of corn silage harvest systems. Applied Engineering in Agriculture. Vol. 19(4): 389–395.

Hunt, D., 2001. Farm power and machinery management. Iowa State University Press, 1:77-93.

Kitani, O., T. Jungbluth, R. M. Peart, A. Ramdani. 1999. CIGR Handbook of Agricultural Engineers, Vol. V:13-39.

Nagy, C., 1999. Energy coefficient for agriculture inputs in Western Canada. CAEEDAC report.

Piccarolo, P. 1989. Criteria to choose and manage agricultural equipments. M&ma-IMA, , 12:37-57.

Piccarolo, P., et al., 2006. Meccanica agraria, volume II: la meccanizzazione. Edagricole, Bologna.

Pimentel, D., Pimentel, M. and Karpenstein, M.. Energy use in agriculture: an overview. CIGR E-journal, 1999, Vol 1.