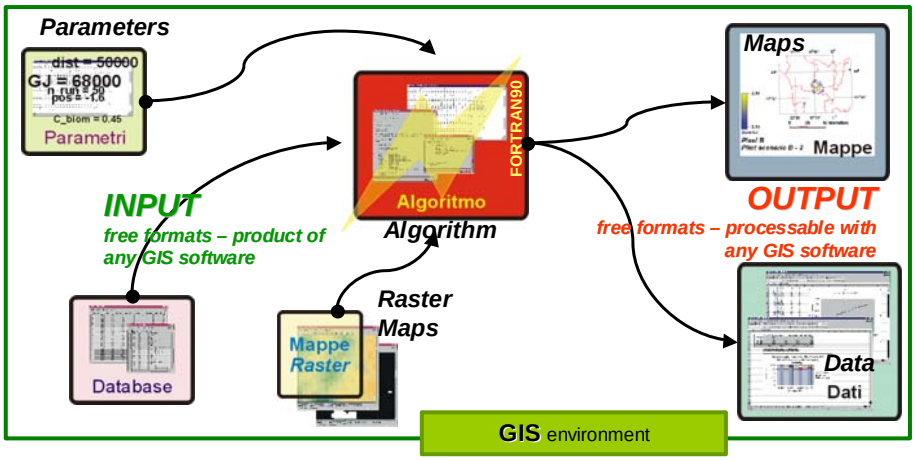
BIOSIT

LIFE00 ENV/IT/000054

GIS BASED METHODOLOGY AND ALGORITHM

RELEASE 1.0

THE HANDBOOK



1 INTRODUCTION 3

1.1 WHAT IS GIS 3
1.2 BIOMASS TO ENERGY CHAIN 3

2 GIS BASED ALGORITHM 5

2.1 DESCRIPTION OF THE ALGORITHM 5
2.1.1 POINTING OUT THE INPUT DATA 5
2.1.2 BIOMASS TRANSPORT 7
2.1.3 ENERGY COLLECTION TO THE PLANT 8
2.1.4 RESULTS 8
2.2 INPUT FILES 9
2.2.1 RASTER FORMAT DESCRIPTION 10
2.2.2 DATABASE FORMAT DESCRIPTION 11
2.2.3 PARAMETER FORMAT DESCRIPTION 12
2.2.4 SETTINGS FOR THE RUN 13
2.3 OUTPUT FILES 14
2.3.1 RUN CHECK UP 14
2.3.2 OUTPUT 14
2.3.3 OUTPUT EXAMPLES 16
2.3.4 RASTER FORMAT DESCRIPTION 17
2.3.5 VECTOR FORMAT DESCRIPTION 17
2.3.6 DATA FORMATS 17

3 REFERENCES 18

4 CONTACTS 18

5 ACKNOWLEDGEMENTS AND DISCLAIMER 18

Reproduction is authorised provided the source is acknowledged
© ETA Renewable Energies - September 2003

For contacts: leonardo.nibbi@etaflorence.it
BIOSIT on the web: http://www.etaflorence.it/biosit

The present handbook describes the methodology and the algorithm developed within the BIOSIT project. This document is intended for technicians and scientists with technical background on renewable energies and GIS wishing to deepen the knowledge on how the algorithm works; the handbook may also be used as a manual for the BIOSIT algorithm end user.

1 Introduction

The BIOSIT project is based on a partnership between the Department of Energetics (DE-Project coordinator) and the Department of Agricultural and Land Economy (DEART) of the University of Florence, and ETA Renewable Energies, a company skilled in research, design and carrying out renewable energy plants.
This working team integrates the necessary multi-disciplinary skills in environmental analysis and modelling, engineering, agro-forestry, dissemination and know-how transfer.
The aim of the BIOSIT project is to develop an efficient and sustainable strategy for the exploitation of biomass resources for energy use within specific applications.
To support the definition of the energy policy an innovative Geographical Information System based methodology and a GIS tool have been developed.

1.1 What is GIS

GIS is an acronym for Geographical Information Systems.
Information Systems (in general) were born to provide tools to collect and elaborate information in order to give to decision makers the widest and clearest possible set of information to operate onto, to perform the best possible choices.
An Information System is told to be Geographic when it is projected to operate on geographically referenced data. With simpler words we may say that a GIS is a set of computer tools able to visualise, treat and analyse geographical data and also link them to databases, in order to produce "dynamically intelligent maps" providing clear and easy to analyse information.
The main components of a GIS are:

- an user interface, to put the software in relationship with the operator;
- modules for the creation and management of databases, to manage the databases related to the geographic objects;
- modules for the management (creation, editing and exchange) and analysis of the geographic data and objects;
- tools for the visualisation of geodata and related databases.

1.2 Biomass to energy chain

Biomass supply, intermediate and final storage, biomass conversion in usable solid or liquid biofuels, delivery to the energy plant and energy production represent the biomass to energy service chain; each link of this chain is more or less directly dependant upon the geographical location of each process. It is widely assessed that if each step of the whole bioenergy chain is not optimised, the final cost of the produced energy (heat and/or electric) may result not competitive in comparison with energy from traditional fossil fuels.
The costs of the energy from biomass are mainly: biomass production, storage, transport and plant costs. Moreover, in some cases mechanical or thermo-chemical processes are required to transform the original biomass into the desired more practical fuel after the collection.
One of the most important problems in using biomass as a fuel in fact is the spreading out of supplies together with the low territorial density, in comparison with the traditional fossil fuels; the biomass supply is also in most of the cases seasonal, namely variable in time, thus creating the need of a temporarily stockpiling before and after the delivery to the power, heat or processing plant;

Reproduction is authorised provided the source is acknowledged
© ETA Renewable Energies - September 2003

For contacts: leonardo.nibbi@etaflorence.it
BIOSIT on the web: http://www.etaflorence.it/biosit

storage costs are mainly due to the management of great volumes of biomass, since its low specific weight and need to be stored in large quantities, to face the time difference between biomass and energy production. The biomass sources are mainly forestry residues, agricultural residues and dedicated cultures (energy crops); different typologies leads to different costs and energetic potentials of these sources thus affecting the choice of biomass supply. Transport costs are in general mainly dependent on geographic issues. The costs of the power or heat plant depend on plant size, components and technological level. For each type of plant the foreseen cost can be computed, independently from the biomass supply costs.

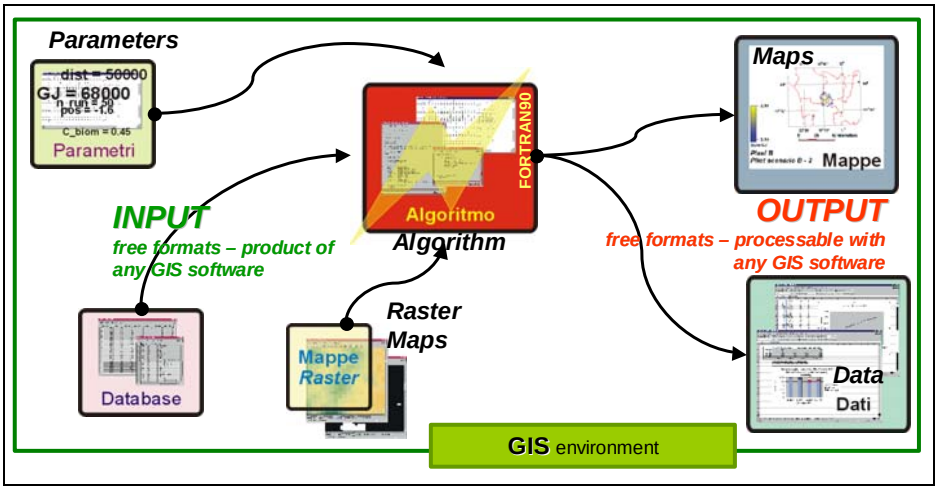
It is then evident that in order to reach a competitive feasibility of the use of biomass for energy production it is strictly necessary a detailed economic analysis; the use of the GIS tool may result in the identification of the best geographic position of each link of the biomass to energy chain, supporting also the choice of biomass resource, being able to evaluate and possibly minimise the effect of every factor on energy production final cost. The GIS-based methodology elaborated through the BIOSIT project aims at leading to a correct energy planning on the territory, giving its best results in the planning of endogenous resources exploitation.

Reproduction is authorised provided the source is acknowledged
© ETA Renewable Energies - September 2003

For contacts: leonardo.nibbi@etaflorence.it
BIOSIT on the web: http://www.etaflorence.it/biosit

2 GIS based algorithm

In order to perform a detailed analysis on the areas under investigation, a GIS-Based algorithm has been developed.



FIGURE[1]: THE CONCEPT OF "BLACK BOX" ALGORITHM

The algorithm, implemented as a stand-alone executable program that can be run outside any specific GIS application, works as a "Black Box" (see Figure[1]) operating on previously elaborated Input files and parameters, and produces a set of Output files representing the results of the computation.

GIS data, both in input and in output, are stored in free formats in order to allow the program to be used in association with any of the most common GIS Software environment.

The program analyses costs and emissions related to the biomass delivery from the collection location to the energy conversion plant, thus producing maps and spreadsheets indicating costs and pollutant emissions.

For each plant size under analysis and for each point of the potential location map, the cost of production and delivery of the necessary biomass supply to the plant is calculated, together with the emissions associated to the transportation. The emission results are available both as a numerical data and in terms of localisation of the emissions, since the algorithm produces as output a vector file representing the transport paths of biomass delivery and its associated pollutant emissions per path unit.

2.1 Description of the Algorithm

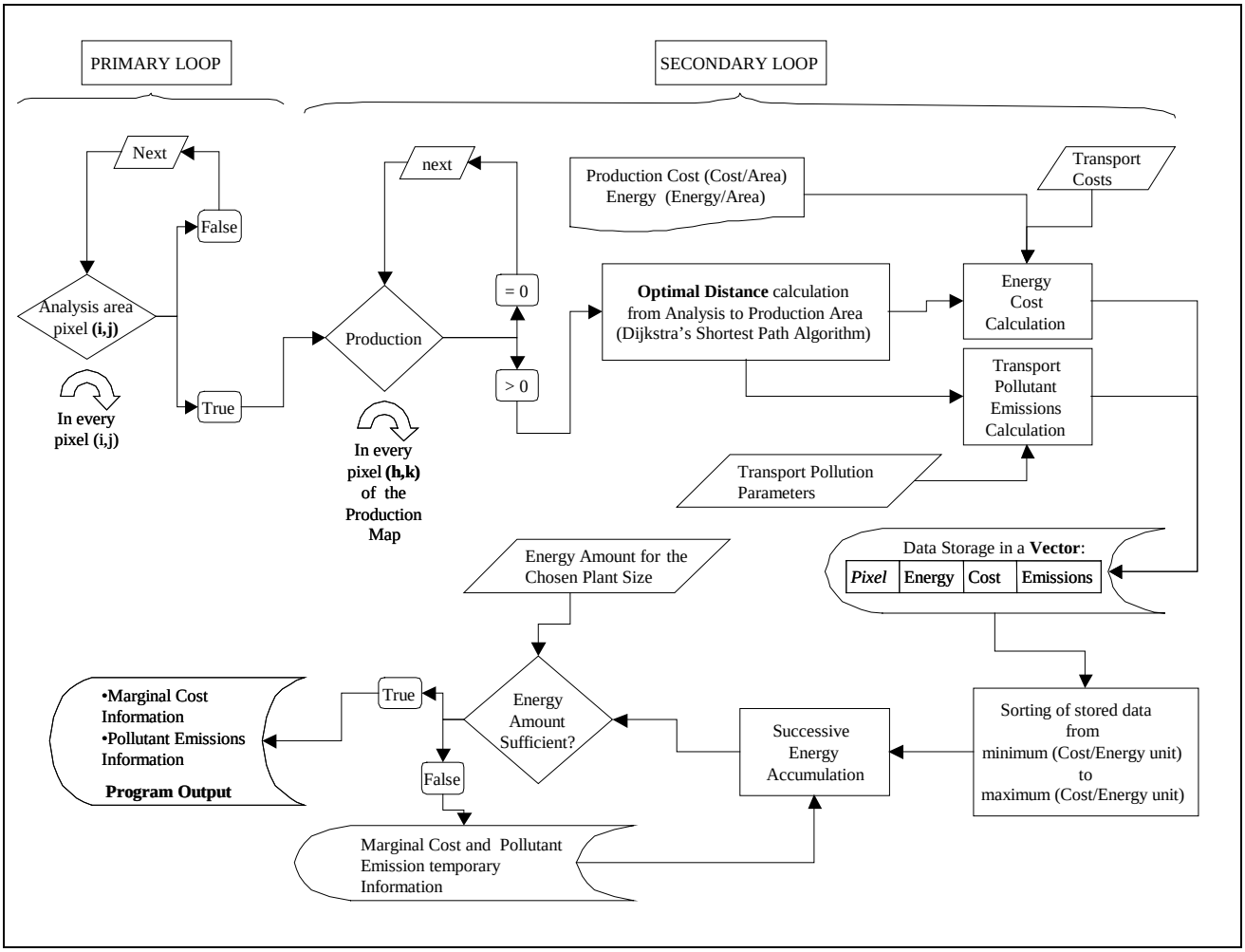
The objective of the algorithm (whose flow chart is presented within Figure[2]) is to execute a detailed analysis on the area under investigation with the aim to:

- compute the marginal cost of the biomass delivered to the plant;
- compute transport costs due to the delivery of biomass to the plant;
- point out the road network path concerned with the biomass transport;
- quantify and localise the emissions related to biomass transport.

2.1.1 Pointing out the Input data

The production of the input data for the algorithm may be achieved through the use of any of the most common GIS software available on the market. The only constraint is the format in which the elaborated maps must be provided as input to the algorithm (for major details on the format see

2.2). The different typologies of spatial analysis necessary to obtain these maps are easily performed within any standard GIS environment.



FIGURE[2]: ALGORITHM FLOW CHART

The first step of the GIS elaboration of the input files is to point out the area to be investigated (Figure [3]-a). The area is previously selected on the basis of a GIS analysis (i.e. the area may be homogeneous from the agronomic or forestry point of view) and its extension will represent the geographical boundaries of the problem.

The map of the potential locations where the bioenergy plant can be installed is produced (Figure [3]-b). Criteria and constraints supporting the choice of the locations may vary depending on the specific problem under examination. As a matter of example only industrial areas with easy road accessibility and not in the proximity of urban areas may be selected.

The biomass productivity concerning the area under investigation is examined and localised. The total yearly productivity associated to the area must be greater or equal to the biomass supply for the plant typology under examination. Information must be also provided regarding the energetic amount of the biomass and its production costs for each production location (Figure [3]-c); production costs summarise all the costs (farming, collection etc.) of the biomass before it is loaded onto the transport vector.

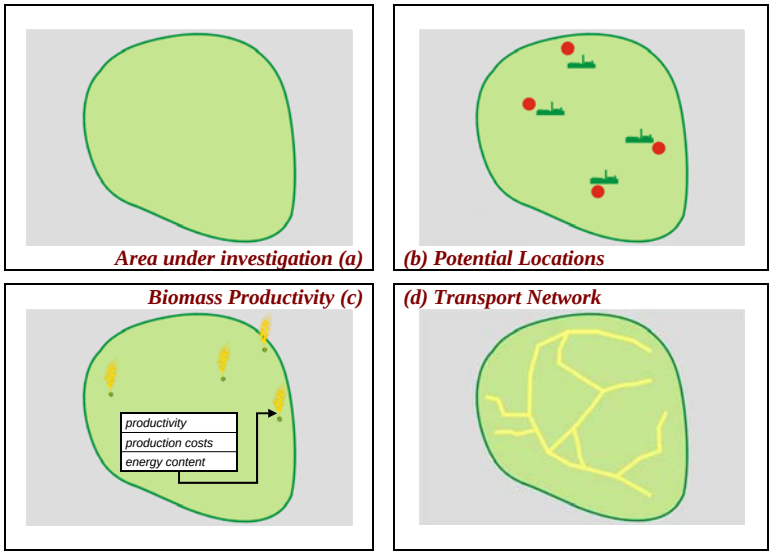
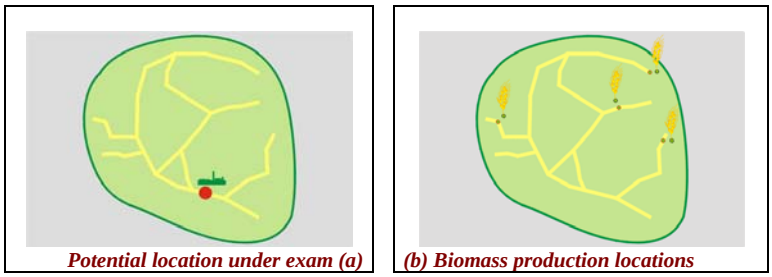


FIGURE [3]: DATA INPUT FOR THE ALGORITHM

Finally the transport network map must be produced (Figure [3]-d). No additional information must be provided on the road typology (i.e. road class etc.). The selected roads must be practicable by the transport vector chosen for the analysis.

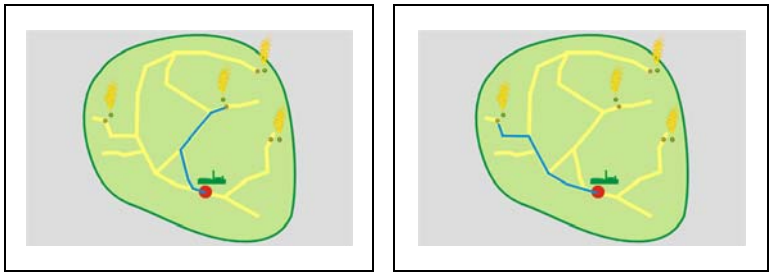
2.1.2 Biomass transport

The algorithm analysis is performed once per potential location.
First of all the point of access to the transport network is localised for the potential location (Figure[4]-a) and for each production point (Figure[4]-b); as a matter of example in Figure[4]-b the production location is the light green/dark green circle, while the related access is represented through the light green/red circle.



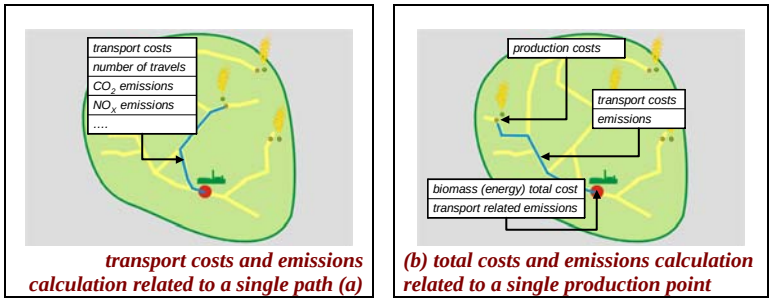
FIGURE[4]: ACCESS TO THE TRANSPORT NETWORK

The shortest path connecting to the potential location is calculated for each of the production point (two examples in Figure[5]); the program localises the optimal path through the use of Dijkstra's Shortest Path Algorithm.
Once the shortest path is determined, it is then possible to calculate the number of travels (depending on the truck capacity and on the production point biomass availability), transport costs and transport related emissions (Figure[6]-a).



FIGURE[5]: SHORTEST PATHS CONNECTING PRODUCTION LOCATIONS TO THE POTENTIAL LOCATION

Then it is possible to calculate the total cost of the biomass (or the corresponding energy amount) unit from the production to the delivery to the utilisation plant (Figure[6]-b).



transport costs and emissions calculation related to a single path (a)

(b) total costs and emissions calculation related to a single production point

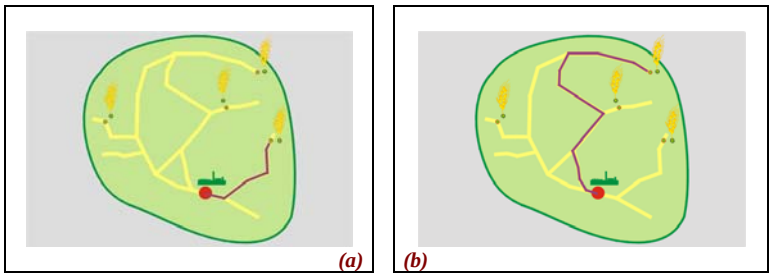
FIGURE[6]: EMISSIONS AND ENERGY/BIOMASS COST CALCULATION

2.1.3 Energy collection to the plant

The computed data, related to each production area, is stored in a vector that is sorted on the basis of the total cost per energy content unit.

The energy amount necessary to fuel the plant is then collected starting from the biomass with minimum total cost, until the total amount is reached. Information on the last collected biomass (energy) unit is stored; the total cost of this biomass amount (per weight unit) is the Marginal Cost of the biomass for the location under analysis.

Following this accumulation approach, some productivity areas will be excluded from the list of the supply areas for the plant. As a matter of example, some areas, even if not far from the potential location (Figure[7]-a) could be excluded due to excessive production costs (i.e. due to difficulties in the collection of the biomass). Other areas, too far from the potential location, (Figure[7]-b) could be excluded i.e. due to greater transport costs.



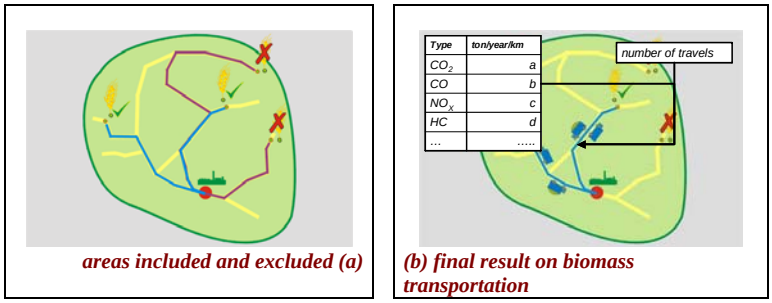
(a) *(b)*

FIGURE[7]: BIOMASS PRODUCTION EXCLUDED FROM PLANT SUPPLY

2.1.4 Results

At the end of the "energy content accumulation process" the areas included and excluded from the biomass supply to the potential location are pointed out (Figure[8]-a). Details on the emissions

related to biomass transportation are available for each of the production point chosen for the biomass supply (Figure[8]-b).

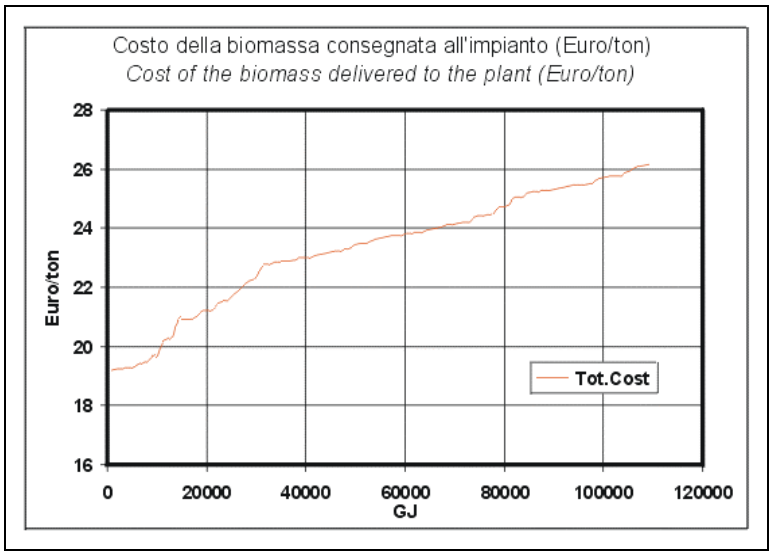


areas included and excluded (a)

(b) final result on biomass transportation

FIGURE[8]: RESULTS OF THE COMPUTATION

Wide details are also available for costs of biomass delivered to the potential location. An example of the computed trend of the cost during the successive energy accumulation is presented in Figure[9] for a 1*MW* size plant.The cost of the last biomass (that is energy) parcel delivered to the plant is the resulting Marginal Cost (in the example this cost, related to nearly 110*TJ* energy, is equal to 26.1*Euro*).



FIGURE[9]: TREND OF BIOMASS COST

2.2 INPUT files

The input **maps** for the algorithm, **all in raster format** (format discussed at point 2.2.1), are the following:

- Potential location map, indicating the zones where it is possible to install a bioenergy conversion plant. Datatype must be Integer. Values greater than zero indicate a potential location, zero indicates no potential location;
- transport network map. Datatype must be Integer. Values greater than zero indicate the presence of a road, zero indicates no road;
- biomass production map, where each pixel represents the productivity (weight) of biomass associated to the area of the cell. Any Datatype; the program converts it to DoublePrecision Floating point. Weight unit must be in accordance with the unit used for transportation load (see further, paragraph 2.2.2). Production cells' value must indicate the associated productivity. Non production cell value must be zero;

- bioenergy production map, with the corresponding productivity in terms of bioenergy associated to the area of the cell. Any Datatype; the program converts it to DoublePrecision Floating point. Bioenergy unit must be in accordance with the conversion plant fuel demand unit (see further, paragraph 2.2.3); this is the value used for successive energy accumulation (see paragraph 2.1.3). Accumulation can be performed directly on weight. In this case the map may coincide with the biomass production map. Bioenergy production cells' value must indicate the associated bioenergy value. Non production cell value must be zero;
- biomass production cost map, representing the cost to be associated to the productivity related to the area of the cell. Any Datatype; the program converts it to DoublePrecision Floating point. Cell value must indicate the associated cost value. Non production cell value must be zero.

The input **databases** for the algorithm, are the following:

- database including the main characteristics of the energy conversion plants (working hours, fuel demand); for major details see paragraph 2.2.3.
- database where the emissions due to transport are specified for any type of tractor, truck or lorry used; for major details see paragraph 2.2.2.

2.2.1 Raster format description

Input raster files format is the simple array format coupled with related georeference information. The most simple (and also storage space saving) way to represent a raster object is to store the values representing the pixel grid of the raster in a bi-dimensional binary array.
This format simply saves the raster as a stream of data written on a binary file containing the values associated to each cell of the raster.
Since this way to store the data does not allow defining the spatial structure of the raster in itself, the interpretation of these data may be achieved through the use of an attached ASCII file including a set of metadata describing the file structure. This file permits the interpretation of the array as it indicates the number of lines and columns in which the array is divided.
Since we refer to Geographically referenced objects, the metadata should also contain information able to univocally identify the geographic extensions and size of the raster. It is then sufficient to know, within a specified Geographic reference system, which are the co-ordinates of the extreme corners of the quadrilateral defined by the raster and the size of the raster cell, to spatially locate the raster.
In general, a raster map image consists of a defined count of rows and columns thus forming cells. These cells are stored as a sequence of numbers (byte, integer or real) representing values (i.e. vegetation classcodes, reflectance numbers, political units, z-values in a DEM, etc.).
Let us imagine a very simple image [2]:

	0	1	2	3	4
0	22	22	18	18	18
1	15	15	18	16	16
2	11	15	15	18	16
3	11	15	12	12	12

5 columns, 4 rows. The values may represent some code for land usage. The raster should be saved starting in the upper-left corner (row 0/column 0), then advancing column-by-column and row-by-row.
If saved as ASCII, the cellvalues would be stored as:
22 22 18 18 18 15 15 (...) 11 15 12 12 12

In our case the image is stored binary, one value after the other. Depending on the datatype a value occupies more or less of memory.
The table below shows the available datatypes for the raster format used by the code:

	MEMORY REQUIRED PER CELL VALUE	RANGE
BYTE	8 bit	0 to 255
INTEGER	32 bit	-32768 to +32767
REAL	IEEE 32 bit	±1*10^38, 7 significant figures precision
DOUBLE	IEEE 64 bit	±1*10^308, 15 significant figures precision

Evidently the image 'does not know' about its dimensions or about the area one cell covers in real. So we need a 'header file', with metadata describing the Geographical structure of the image and indicating the format used to save the data (byte, integer or real) corresponding to the image.
An example of the structure of this metadata file is presented below:

```
BYTES CELL ------ BYTES COLOUR
1                 1
COLUMNS --------  LINES
50                50
CELL WIDTH (m) -- CELL HEIGHT (m)
21.458340         21.458340
UPPER LEFT E ---- UPPER LEFT N
1600257.740322    4735500.567212 N
UPPER RIGHT E --- UPPER RIGHT N
1601328.778353    4735564.036939 N
LOWER LEFT E ---- LOWER LEFT N
1600321.210048    4734429.529181 N
LOWER RIGHT E --- LOWER RIGHT N
1601392.248080    4734492.998908 N
```

The example metadata indicates that the stream of data that are going to be read by the program represents a raster of 8 bit type, whose width is 50 pixel (column) and whose height is 50 pixel (lines); then information are available on the geographical structure of the raster (cell size and geographical location of the corner cells).
This metadata format has been chosen since it is simple to produce this kind of text data from any operator working within any other GIS environment.

2.2.2 Database format description

Input database information on transport should be saved as Borland dbIII dbf file format.
Since this format is free of use and widely described through a Borland Technical document [4], it has been decided to use this format for these input parameters of the algorithm.
Moreover, the dbf file can be easily imported, modified and exported with all the most diffused databases software and environments.
The structure of this database is presented within Figure[10].
Presently only one type of transport vector is considered in the computation, so only the first record of the database will be considered.

A brief comment on the database structure :

- the first field of the database is presently not used. It could be used for further implementations. In Figure[10] it is the field [CLASS]. The field name does not matter for the computation;
- The second field ([LOAD] in Figure[10]) represents the maximum load for the vector in weight units. The weight unit considered is the same used for the production Input raster map (i.e. if the values used for the map are expressed in tons, the example value means that the truck used loads 7.5 tons per travel). The field name does not matter for the computation;

the following fields (as many as the operator needs) represent the pollutant emissions (in unit weight **per travelled km**) due to transport. The field name will be the same used for the output. The measurement unit of the output will be the same used for the input data.

CLASS	LOAD	NOX	COVNM	CO	PM	CO2
0.00000	7.50000	3.55830	0.64039	1.11340	0.14239	629.59998

FIGURE[10]: TRANSPORT VECTOR INFORMATION

2.2.3 Parameter format description

Information regarding the plants taken into account are provided within a text file named GJ.dat. The file structure is presented within Figure[11].

```
NUMBER OF PLANTS TO BE CONSIDERED
5
SCALE FACTOR
1.0E-06
GJ YEARLY NECESSARY TO FEED THE PLANT

5.25_MW
80640000    7200

2.25_MW
30880000    7200

10.3_MW
133120000   7200

4.3_MW
52000000    7200

1_MW
15200000    7200
```

FIGURE[11]: INPUT DATA ON PLANT ENERGY CONSUMPTION

The first line is a comment. The second line indicates the number of different plants that will be considered (five in the example). The third line is a comment, while the fourth line indicates the scale factor (*SCF*) to be used to compute the energy need (see further). The fifth line is for comments. Then each plant is presented as:

- a blank line;
- a label line (the label will be used for identification of the results). No duplicate names are allowed, since this may cause a loss of result data;

- data line (2 parameters): the energy need per time unit (*EnU*) and the total working time units (*T*). The energy need (*E*) will be computed as energy need per time unit multiplied for the total working time, scaled on the basis of the scale factor. In formulas: *E=SCF*EnU*T*

As a matter of example, consider the 1MW plant in the file presented in Figure[11]; the energy need per hour is 15.2*GJ/h* corresponding to 15200000*J/h*; the working hours are 7200*h/year*. This will correspond to 109440000000*J/year*. But since the energy map is presented in terms of GJ, the energy need is scaled by a factor 1.0E-06. The energy need for the plant will finally be of 109440*GJ/year*.

2.2.4 settings for the run

An ASCII file Set.dat is used to set the parameters for the run. The file structure is presented within Figure [12].

```
NUMBER OF RUNS --------
1
NUMBER OF MAP/SET FILES
5
NAMES OF THE FILES (Roads; Potent.loc.; Prod. map; Cost map; Energy map)
RUN=2 rural area boschi prod roads 100*100
r_roads100.dat
r_roads100
loc_rural.dat
loc_rural
Rural_Boschi.dat
Rural_Boschi
cRural_Boschi.dat
cRural_Boschi
eRural_Boschi.dat
eRural_Boschi
*CREATE SHP FILE OUTPUT? 1=YES;0=NO
1
*CREATE RASTER ROAD FILE OUTPUT? 1=YES;0=NO
0
*CREATE csv TOTAL ACCUMULATION FILE OUTPUT? 1=YES;0=NO
1
*TRANSPORT COSTS COEFFICIENTS (Ct/WeightUn=A+B*km): A,B
7.88    0.205
```

FIGURE [12]: FILE SET.DAT

The first line is a comment. The second line indicates the number of different runs that will be performed by the algorithm. To each run a set of input files will correspond. The third line is a comment, while the fourth line indicates the number of maps to be used during each computation. Presently this number must be set to 5. The fifth line is for generic comments. Then each run is presented as:

- a comment line, useful to remember what does the run represent;
- five couples of file names, corresponding to the georeference file and the binary data file of each raster map: transport map, potential location map, productivity, bioenergy and cost maps.

This set of lines should be replicated as many times as many runs are going to be performed.
Then a comment line, followed by a parameter line:

```
*CREATE SHP FILE OUTPUT? 1=YES;0=NO
1
```

if 1 the output emission maps will be produced and saved as Shapefiles. If this parameter is set to 0, no file will be produced.

Then another comment line, followed by a parameter line:

```
*CREATE RASTER ROAD FILE OUTPUT? 1=YES;0=NO
0
```

if 1 the output emission maps will be produced and saved as Raster. If this parameter is set to 0, no file will be produced.

Then another comment line, followed by a parameter line:

```
*CREATE csv TOTAL ACCUMULATION FILE OUTPUT? 1=YES;0=NO
1
```

if 1 the output csv file will be produced and saved. If this parameter is set to 0, no file will be produced.

Then another comment line, followed by a two parameters line:

```
*TRANSPORT COSTS COEFFICIENTS (Ct/WeightUn=A+B*km): A,B
7.88    0.205
```

These two parameters will be used to compute transport cost *Ct* per Weight Unit following the expression *Ct=A+B*km* where *A* and *B* are the parameters to be read. The parameters are the result of previous investigation on the transport costs considered for the region under exam. The parameter *A* represents the fixed costs while the parameter *B* represents the variable costs depending on the transport covered distance. The currency unit used for costs is the same used for the Cost Raster Map.

2.3 OUTPUT files

The program produces a set of output files. Some of these files are written to check up if the performed runs encountered problems during the computation, while some other files are the output results of the algorithm.

2.3.1 Run Check up

During the run the algorithm produces two plain text ASCII files that allows to check if the computation was performed correctly and if all the Inputs were correctly interpreted:

- *prompt.txt* is a file that reproduces (with some additional information) the messages prompted to the command prompt shell during the run; it is useful, in case of a system crash during long time consuming runs, to check if the computation was performed entirely, and, in case this did not happen, it is possible to point out where the computation stopped;
- through the *vector.txt* file it is possible to check how the program reads the inputs. Within the file it is possible to find the values contained in the raster Input maps **as the program reads them**; comments are provided in the text thus allowing an easy interpretation of the content. With this file it is possible to check if the Input provided to the program do respect the defined standard format.

It is possible to read both files with a text editor also during the computation.

2.3.2 Output

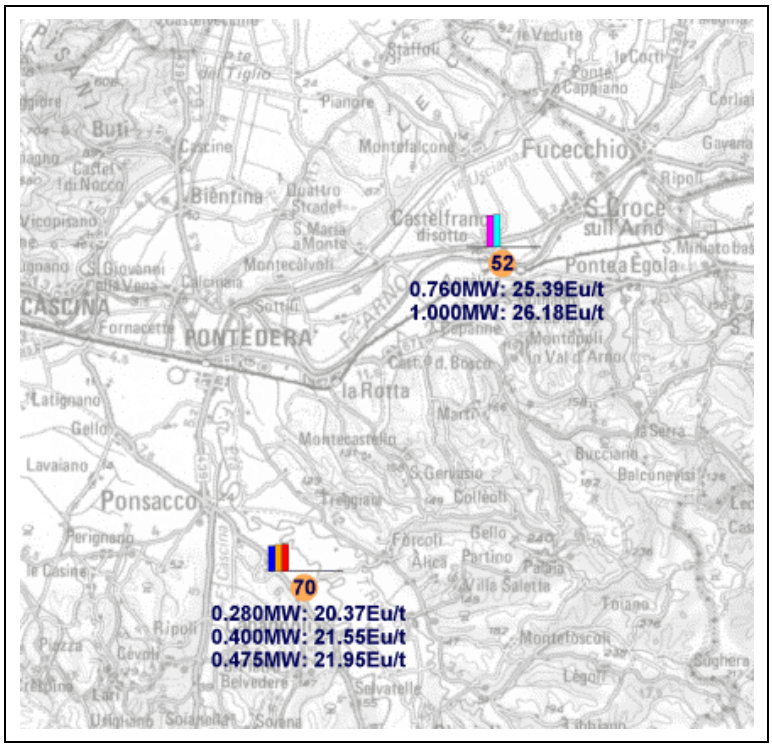
The algorithm produces output data and maps as result of the computation. The classification of the files is allowed through their names, automatically generated by the program itself on the basis of the input parameters. Results are available for each plant size and each potential location and for each run, thus producing a wide set of files. The results of each run are presented within a set of summary files.

2.3.2.1 File names

The distinction of the file output is due to the file name.

The run reference is indicated within the file name with the string "R_*N*" where *N* is the run number (i.e. the files pertaining to run four will have, within their name, the string "R_4").

The prefix "TOT_" to the file name indicates that the file is a summary file. Depending on the file name it may summarise the whole run or the results of the analysis on a potential location.
Each single result file name presents a couple of numbers indicating the line and the column (referred to the potential location input raster map) of the potential location to which the result is referred to; furthermore the last part of the name is the label indicating the plant size to which the result is referred to.
As a matter of example the file:
`ACC_R_1_010-301_0.28_MW.csv`
refers to Run number 1, for the potential location located at line 10 and column 301 cell on the potential location raster map, and refers to the plant labelled 0.28_MW.
The file:
`TOT_ACC_R_5_258-239.csv`
refers to Run number 5, for the potential location located at line 258 and column 239 cell on the potential location raster map, and summarises the results for all the plant types.



FIGURE[13]: MARGINAL COST RESULTS

2.3.2.2 Output contents

The output files represent the results of the computation. These are:

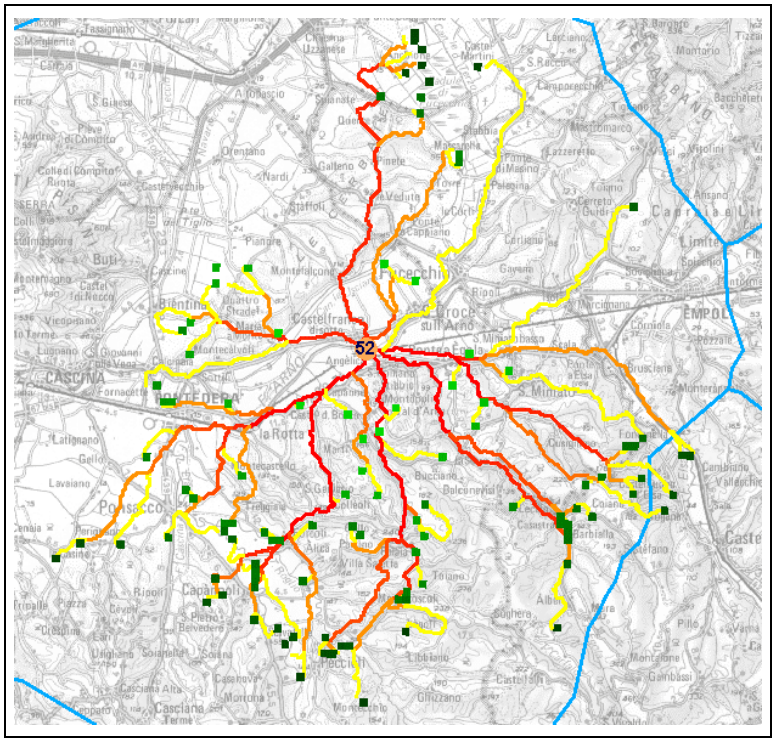
- **data** to build the accumulation curve; the successive energy accumulation is available as a csv file. The file is indicated by the presence of the "ACC" string in the name. The accumulation may be referred to the single potential location and plant size, but the accumulation of the whole biomass/energy quantity available to the potential location is saved within a summary file. This files' name prefix is "TOT_ACC". These data, post processed with graphic tools or spreadsheet programs (i.e. with MSOffice Excel) allow to obtain the curves like the one presented within Figure[9].
- point **vector** maps summarising the cost results. The file set (a shp, a shx and a dbf file) name contains the prefix "TOT_MC". Each point of the map is a potential location; attached

to this point a database with the marginal cost obtained for each of the plant size is available;

- **raster** maps for each plant type indicating the marginal cost of the biomass for each potential location. Each cell value, located at each potential location, indicates the marginal cost of the biomass for the plant size to which the file refers to.
- **raster** maps for each potential location and plant size indicating the production cells used; the cell value indicates the total cost of the biomass taken from that area. The file is characterized by the prefix "MCR".
- line **vector** maps containing the transport paths interested by the biomass transportation. Attached to each line of the path the emissions due to transport are available.

2.3.3 Output examples

As a matter of example, some pictures of results from a set of runs. The output results have been here elaborated and visualised through the use of Microimages TNTMips GIS software. The same maps, provided the same basis of data, may be obtained through the use of any other GIS software.



FIGURE[14]: TRANSPORT PATHS AND EMISSIONS

Within Figure[13] the results of the marginal cost for two potential locations referred to different plant types are presented. The map is obtained through the post processing of the "TOT_MC" point vector. The details of the transport impact on the road network for one of the potential locations are presented within Figure[14]. The emissions impact is put in evidence through the use of different colours: yellow paths have lower impact, red ones are the one with greater impact. The production location that provide biomass to the potential location are pointed out, their colour (light to dark green) depending on the marginal cost of the biomass delivered to the potential location. The map is obtained through the use of the line vector transport paths together with the "MCR" raster map.

2.3.4 Raster format description

Raster results are saved as GGR File Format. GGR is MicroImages' designation for its Generic Georeferenced Raster file format. It can support pixel depths from 1 to 64 bits, signed or unsigned integer and floating point values, and accompanying georeference information. This last feature, together with the ease of interpretation of the georeference data, led to the choice of the file format.

A GGR file can contain a single raster image or a multiraster set in which all rasters have the same line and column dimensions and the same bit-depth and data type. For multi-raster files, the raster value order can be band sequential, band-interleaved by line, or band-interleaved by pixel.

A GGR file consists of a header followed by the raster image data. The header is in ASCII text format, and contains the information required to correctly interpret the raster data, along with georeference information (if any). The raster data values are in binary form.

Detailed information on the format may be found within the microimages web site [3]. These pages provide all the technical information necessary for writing macros or libraries to import and export GGR files.

2.3.5 Vector format description

Output vectors are available as ESRI® Shapefiles. This is one of the most diffused GIS exchange file format and nearly every GIS environment has import/export libraries to manage this kind of file. Moreover its format is widely discussed and explained in [5]. This document provides all the technical information necessary for writing a computer program to create shapefiles without the use of ESRI® software for organizations that want to write their own data translators.

2.3.6 Data formats

Table results are saved as csv (Comma Separated Values) files. Csv is a file format used as a portable representation of a database. Each line is one entry or record and the fields in a record are separated by commas. Commas may be followed by arbitrary space and/or tab characters which are ignored. If field includes a comma, the whole field must be surrounded with double quotes [1]. The first line usually represents the field names, each name separated by commas.

Reproduction is authorised provided the source is acknowledged
© ETA Renewable Energies - September 2003

For contacts: leonardo.nibbi@etaflorence.it
BIOSIT on the web: http://www.etaflorence.it/biosit

3 References

[1] FOLDOC - Free On-Line Dictionary Of Computing: http://foldoc.doc.ic.ac.uk/
[2] IDRISI raster tutorial - http://www.sbg.ac.at/geo/idrisi/wwwtutor/raster.htm
[3] Microimages' Web site - http://www.microimages.com; GGR file format description is presented at http://www.microimages.com/refman/xhtml/YAPPE003.HTM
[4] AA.VV., "dBASE .DBF File Structure- Technical Information Database", Borland Developer Support Staff, 1998 Available for download on internet through search or at the following: http://www.vmlinux.org/jakov/community.borland.com/15838.html
[5] VV.AA. "ESRI Shapefile Technical Description; An ESRI White Paper", July 1998; document available for download at http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf or search for it within the ESRI® web site http://www.esri.com/

4 Contacts

For wider details on the methodology please contact Eng. Leonardo Nibbi:
Eng. Leonardo Nibbi
ETA - Renewable Energies
Piazza Savonarola 10,
I - 50132 Florence, Italy;
Tel. +39 055 5002174 - Fax +39 055 573425
e-mail: leonardo.nibbi@etaflorence.it
Visit the Biosit project Web Site at http://www.etaflorence.it/biosit

5 Acknowledgements and Disclaimer

The present publication is printed within the "BIOSIT" project (LIFE00 ENV/IT/000054) with the support of the European Commission through the LIFE III Environment financial instrument.
Neither the European Commission, nor any person acting on behalf of the Commission, is responsible for the use which might be made of the information contained in this publication.
The views given in this publication do not necessarily represent the views of the European Commission.