RENEWED
EuRopEan NEtWork of BioEnergy Districts

Intelligent Energy Europe

CRPV soc. coop.
CENTRO RICERCHE PRODUZIONI VEGETALI

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# 1. INTRODUCTION

## *1.1. AN "APPROACH" RATHER THAN A "MODEL"*

The heterogeneity of local conditions and of the quality, quantity and detail of available statistics precludes the design of a structured model based on predefined input parameters and imposes a great flexibility of analysis and adaptability to local conditions and available information. A flexible methodological approach, therefore, rather than a model appears best suited in Emilia-Romagna region to support the analysis, identification and delineation of bio-energy districts.

# 2. METHODOLOGICAL APPROACH AND PHASES OF ANALYSIS

## *2.1. PROPOSED APPROACH*

In agreement with partners, the approach applied in Emilia-Romagna has been based on a more flexible method. It is described in the deliverable D2.1 and its application is described following.

# 3. TEST CASE OF BIO-DISTRICT DEFINITION IN EMILIA-ROMAGNA – PROCEDURE OF ANALYSIS MAIN THEMATIC LAYERS AND PRELIMINARY RESULTS

## *3.1. SELECTION OF GEO-STATISTICAL AND SPATIAL BASE OF ANALYSIS*

The selection of the spatial base of analysis represents an important preliminary step as it influences all subsequent search for demand- and supply-related parameters. Two aspects should be considered: one referring to administrative territorial units and another one referring to the geospatial analysis.

### *3.1.1. Administrative level of analysis*

This may be defined as the lowest administrative level for which statistics (directly or indirectly related to supply and/or demand of biofuels) are normally produced. Key statistical categories to be considered are demography, industry, agricultural production.

In case of Emilia-Romagna the selected administrative unit is the *Comune* (municipality). The territory of Emilia-Romagna Region is subdivided into 9 Provinces and 341 municipalities. In addition, there are sub-provincial territorial units called *Regioni Agrarie* (agricultural regions) that group several municipalities of a given province (7 on average) to define somewhat homogenous regions from the agricultural perspectives and for which production statistics are normally published (http://rersas.regione.emilia-romagna.it/statexe/agricoltura.htm).

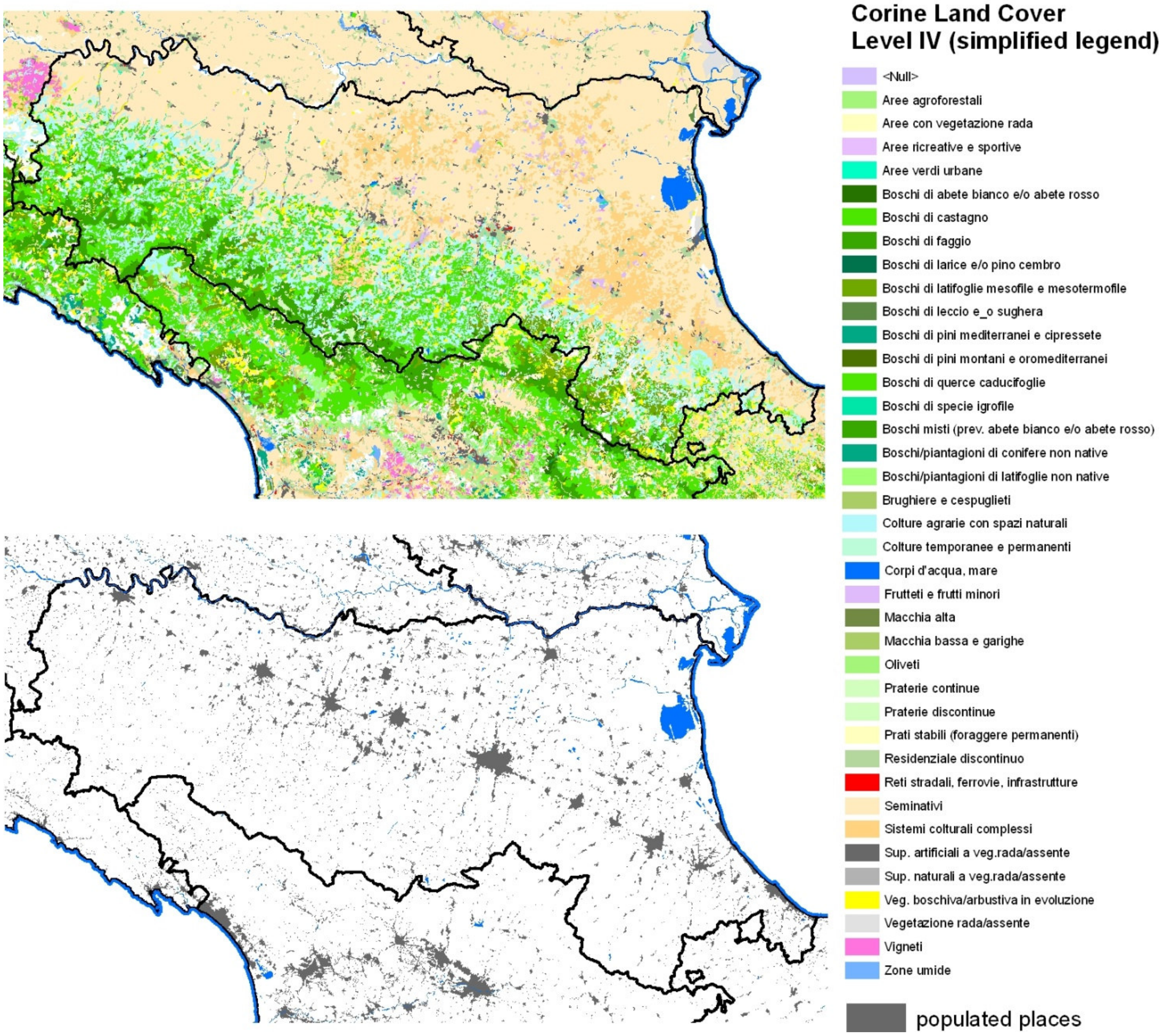
### *3.1.2. Spatial level of analysis*

This represents the basis of the true GIS-based spatial analysis and may be defined as the dimension of the pixel of the raster dataset to be developed. Scope of raster data is to support the best possible spatial representation of supply and demand-related parameters, the analysis of supply/demand balance and the definition of resource accessibility. Its dimension depends basically on the wanted resolution of analysis and on the spatial resolution of available cartographic references that cover the entire study area. The main cartographic layers to be considered are the available digital land cover / land use maps, forest maps, populated places, etc. In general, for regional and national analyses, cell size may vary between 100 and 1000 m., depending on the reference data available.

In case of Emilia-Romagna the selected pixel size of analysis is 300 m, for a raster dataset covering the region composed by 245,698 cells. Specifically, the raster dataset used for Emilia-Romagna (see Fig. 1) is part of a national-level WISDOM analysis recently conducted.

The map of populated places (centri_abitati_EmRom.shp), with its 6003 polygons of settlements of all sizes in Emilia-Romagna only, allows a very discrete spatial distribution of population and families as well as location of industries and biomass plants (when their location is known).

*Figure 1: Corine Land Cover – Emilia-Romagna*




### *3.2. DEMAND MODULE*

#### *3.2.1. Consumption in the residential sector*

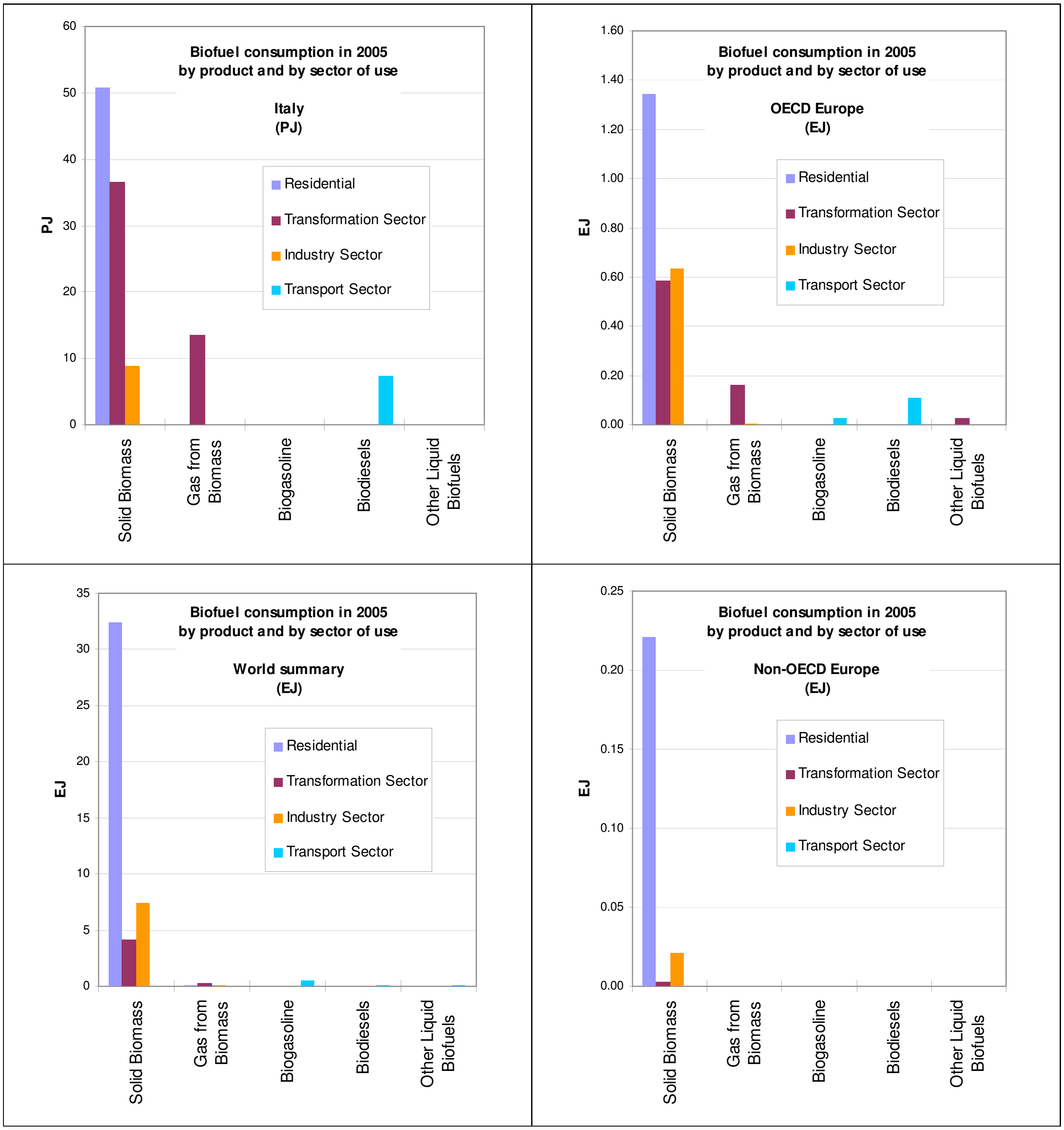
The residential sector is, traditionally, the one where bioenergy plays its most consistent role, as shown in the graphs in Fig. 2 that represent the energy contribution of main biofuel categories in the various sector in Italy, Europe (OECD and non-) and at global level (IEA 2007). It's diffuse and often informal character has generally concealed the importance of residential bioenergy (wood energy, mainly) and kept it off tracts of leading energy and forestry policies and statistics. Besides its historical and cultural role, in Europe the use of biomass in the residential sector is experiencing a strong revival "fueled" by soaring oil prices and increasing environmental concerns.

In Italy, in spite of the undeniable importance that woodfuels, and fuelwood in particular, continue to play for a significant fraction of Italian households, the available statistics appear grossly inadequate to quantify consumption levels and trends.

The official source of national statistics, ISTAT, produces forestry statistics that include fuelwood production that are sometimes erroneously equaled to consumption, thus significantly underestimating true consumption levels. In fact, it's likely that production values capture less than 1/3 of real consumption because they are limited to the formally recorded forest products from official felling data that underestimate actual felling for number, area and products of actual felling. Moreover, such statistics exclude the contribution in woody biomass from tree lots, orchards, pruning, et. as well as the fuelwood auto produced from forests and farmlands by the users. (Gerardi et al., 1998; Tomassetti, 2000; Gerardi e Perella, 2001).

More consistent information on the consumption in the residential sector have been produced on behalf of ENEA in two nation-wide investigations, in 1997 and in 1999, each based on some 6000 telephone interviews, with some 440 samples in Emilia-Romagna (Gerardi et al., 1998; Gerardi e Perella, 2001). These surveys revealed a consumption in the residential sector far greater than that derived from ISTAT (approximately 4.4 Mt in 1997), although the two survey presented significantly different estimates (21.6 Mt in 1997 vs 14.7 in 1999) due primarily to a different estimation of the fraction of the families using biomass at regional level. There is large variety of local situations ranging from the smaller mountain hamlets, where virtually all households use fuelwood, to the metropolitan areas where the use of biomass is limited to sporadic barbeques on charcoal or briquettes.

*Figure 2: Biofuel consumption by product and by sector use*




Since there is no clear evidence on which survey provides the most reliable estimate, and there is no reason to believe that both studies underestimate or overestimate actual consumption, it's reasonable to believe that the national annual consumption between 1997 and 1999 was between 16 and 20 Mt (Hellrigl, 2002).

Concerning Emilia-Romagna, the regional consumption was estimated at 1.3 Mt by the first survey (ENEA, 1997) and 0.98 Mt by the second (ENEA, 1999). Assuming stable saturation levels (as determined by the two ENEA surveys) and updating population data to year 2003, the biomass consumption in the residential sector in 2003 was estimated between 1.44 Mt (upper range) and 1.06 Mt (lower range), with a "mean" value of 1.27 Mt.

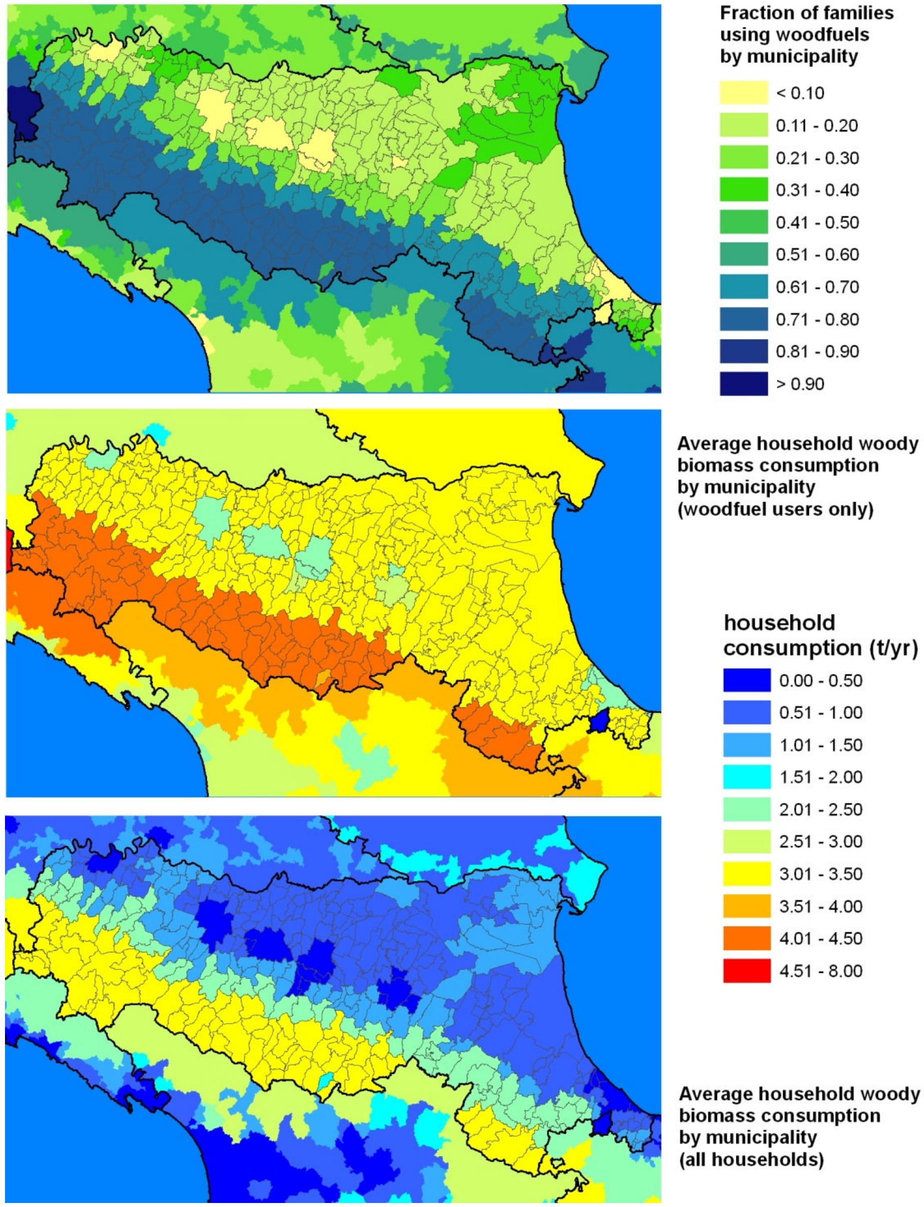
The fraction of families using woody biomass (including sporadic as well as regular users) was estimated by the 1997 and the 1999 surveys at 26.6 % and 17.4%, respectively, with a "mean" value of 22%.

### *3.2.2. Distribution of household consumption by admin unit and spatially*

Demographic statistics and the gradients of biomass consumption by degree of urbanization and by altimetry determined at national level by the 1999 ENEA study were used to distribute spatially the consumption of biomass in the residential sector. At first, these parameters were used to estimate the consumption at municipality level, and subsequently the consumption was associated to the populated places and rasterized to 300 m cells in order to reach a discreet spatial distribution of current biomass demand of the residential sector.

The influence determined by biomass demand (Fig. 3) is not affected by sub-national administrative boundaries because these pose no limitation to the flow of resources. Consequently, the analysis of household consumption was not limited to Emilia-Romagna alone, but considered as well surrounding areas of neighboring regions.

*Figure 3: Household woody biomass consumption in Emilia-Romagna*

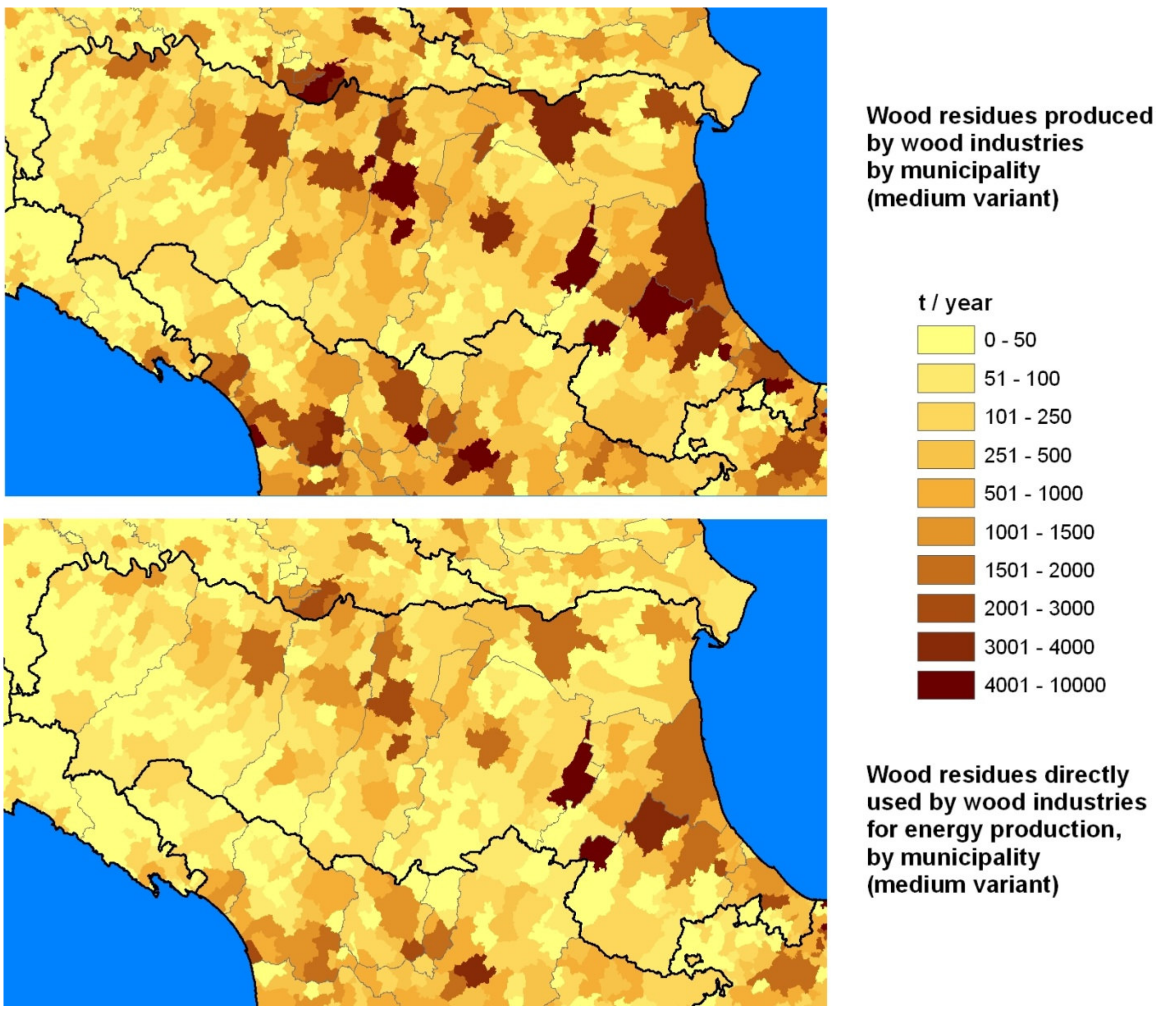



### *3.2.3. Consumption in the industrial and commercial sector*

The consumption of biomass for energy production in the industrial and in the commercial sector may be relevant and needs adequate investigation. Unfortunately structured data do not exist to assess such consumptions with acceptable precision.

The limited information available allowed a first tentative estimation of the share of woody biomass residues produced by wood industries that is used directly to produce heat for space heating, water heating and for specific industrial processes. Such estimation was based on the results of limited investigation conducted in North Italy where there is a high concentration of wood industries and reported in the APAT study of woody biomass available in Italy (APAT, 2003). Such studies determined the quantity of residues produced for each employee and then the fraction of these residues that is consumed directly in the same industry for energy purposes. These values, associated to ISTAT statistics on the number of employees of wood industries in each municipality allowed a first tentative estimation and spatial distribution of biomass consumption in this specific industrial sector. The maps in Figure 4 shows the estimated production of wood residues by wood industries and a very tentative estimation of the fraction of such residues that are used in the same industries.

*Figure 4: Estimated production of wood residues by wood industries and residues directly used.*




The pulp and paper industry that applies the chemical and semi-chemical process produce considerable amounts of black liquor. In general, this liquid biofuel is used directly to fuel internal processes or for heat and power production. These industries are at the same time producers and users of bioenergy and must be accounted in both Demand and Supply modules.

In Emilia-Romagna there is only one sizable paper pulp production unit located in Canossa that had 76 employees in 2001 (additional details are not available at present).

The assessment of biomass consumption by other categories of industries and in the commercial sector (*i.e.* restaurants, pizzeria, bakeries, etc.) requires further investigation as ready-to-use information could not be found as yet. An internet search with "Pagine Utili" on "pizzeria a legna" resulted in over 5000 hits. Assuming an average annual consumption per unit of 19,6 t of fuelwood (air dry, sd 10,8), as determined by a study in the province of Brescia (APAT 2003), the consumption of the of the 5000 pizzerias would add up to the sizeable amount of 100,000 t per year.

### *3.2.4. Consumption for heat and power production*

The creation of biomass plants for production of heat and/or power of medium and small scale is a recent and rapidly growing phenomenon.

The information about such plants is fragmented and incomplete, since this activity is not yet object of systematic statistical analyses.

In case of Emilia-Romagna the list and location of biomass plants was based on information extracted from media, specialized magazines and administrative references related to the granting of subsidies by the Regional Administration.

### *3.2.5. Spatial distribution of industrial and commercial woodfuel consumption and biomass plants*

The (limited) information on industrial consumption and biomass plants was spatially distributed according to the municipality and, when a more detailed address was available, associated to the specific town or village possible located. (Fig. 5)

*Figure 5: Biomass consumption in Emilia-Romagna*

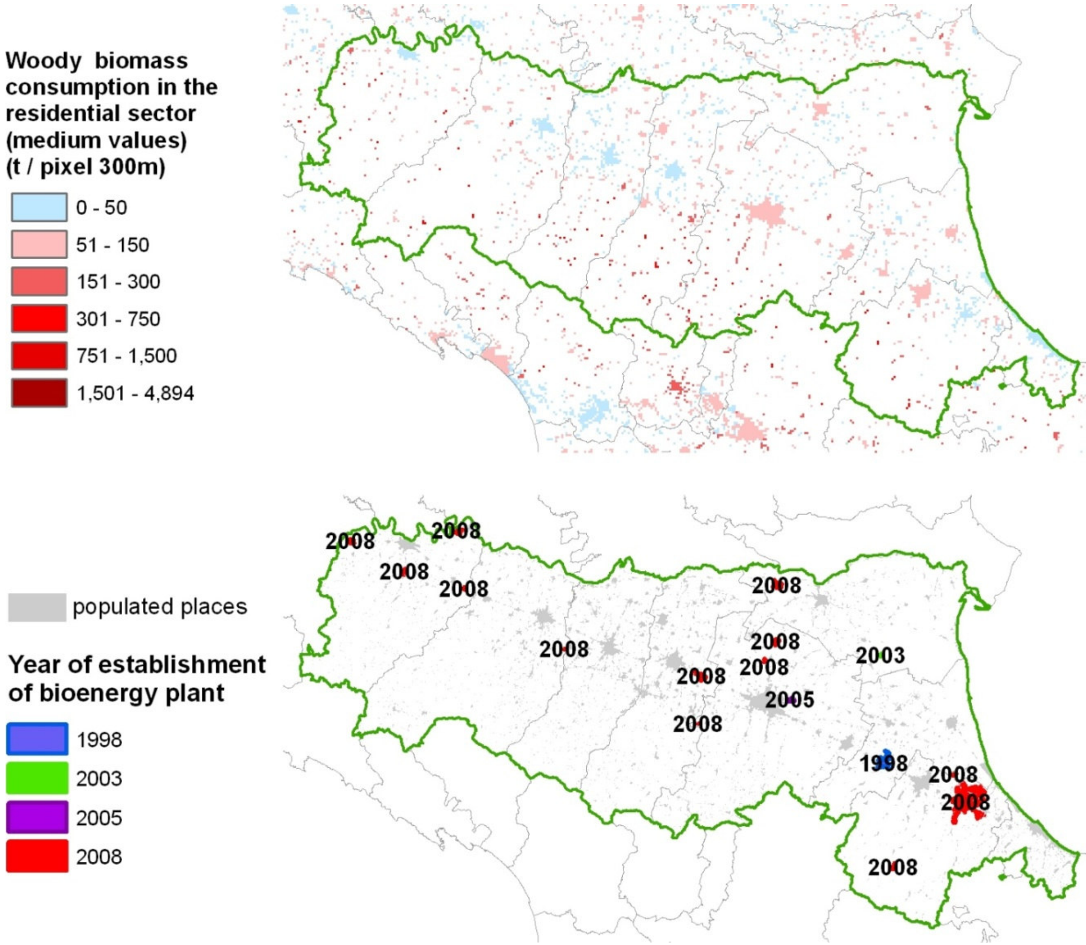
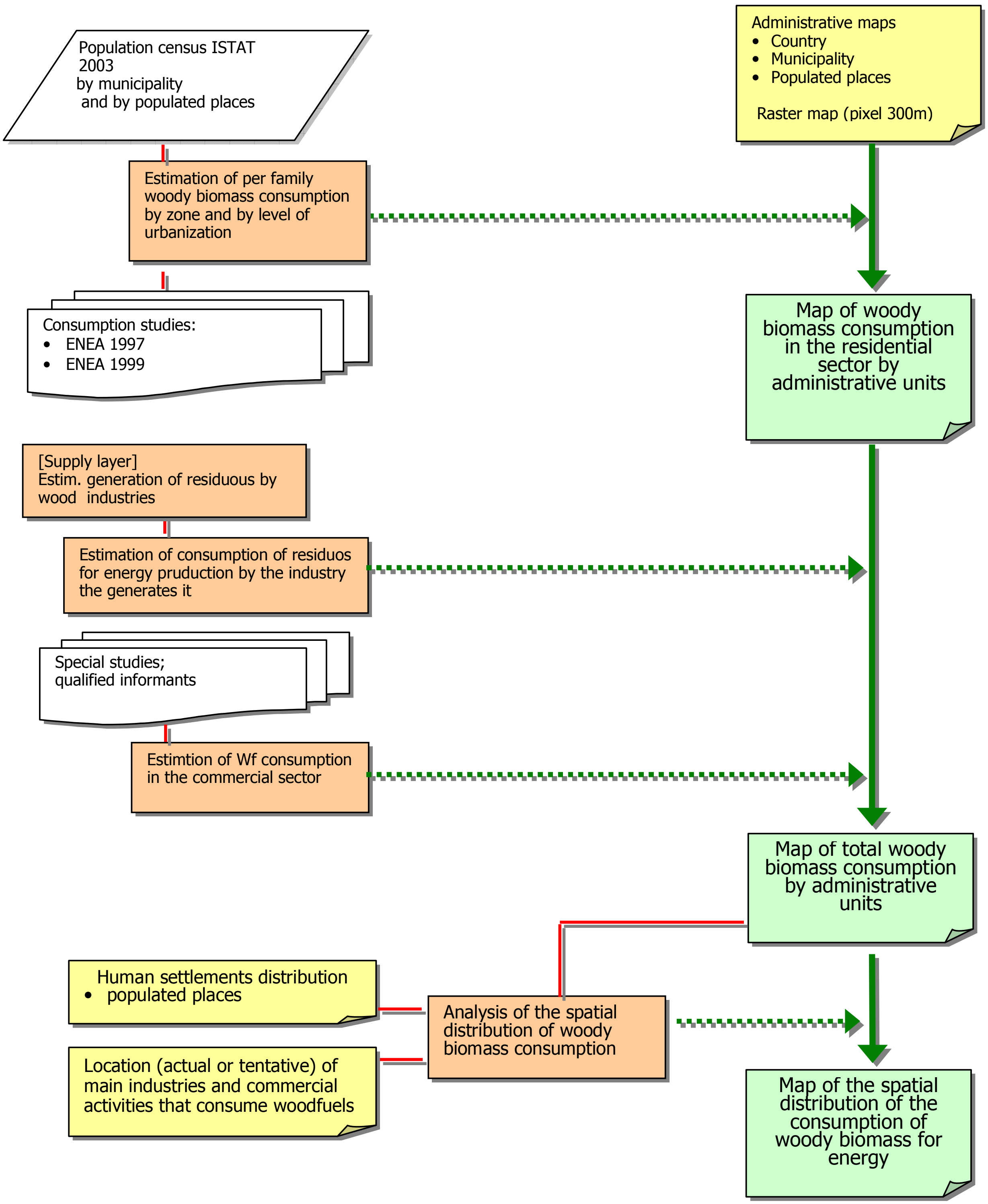



*Figure 6: Flowchart of main analytical steps*


Population census ISTAT 2003 by municipality and by populated places
Administrative maps
• Country
• Municipality
• Populated places
Raster map (pixel 300m)
Estimation of per family woody biomass consumption by zone and by level of urbanization
Consumption studies:
• ENEA 1997
• ENEA 1999
Map of woody biomass consumption in the residential sector by administrative units
[Supply layer] Estim. generation of residuous by wood industries
Estimation of consumption of residuos for energy pruduction by the industry the generates it
Special studies; qualified informants
Estimtion of Wf consumption in the commercial sector
Map of total woody biomass consumption by administrative units
Human settlements distribution
• populated places
Location (actual or tentative) of main industries and commercial activities that consume woodfuels
Analysis of the spatial distribution of woody biomass consumption
Map of the spatial distribution of the consumption of woody biomass for energy

### 3.3. SUPPLY MODULE

#### 3.3.1. Dry and wet biomass, a useful distinction

In consideration of the most common energy conversion processes used for biomass and to the fact that the relative moisture content is determinant for the selection of the process, it is useful to distinguish between "dry" biomasses that are more suitable to combustion and "moist" biomasses that are more suitable to anaerobic fermentation (source LEAP). Sixty percent of relative moisture content appears a useful threshold to distinguish between dry and moist biomasses (source LEAP). Moist biomasses include animal by-products and moist agro-industrial by-products from processing of beet, tomato, potato, etc. while the rest ( forest products and by-products, forest industries by-products, SRF, crop residues, energy crops) may be classified as dry biomass. See Table 1 for a comprehensive list of biomass supply sources (UBET, FAO, 2004) distinguished into dry and moist.

#### 3.3.2. Biomass characteristics and other useful categories

Table 1 proposes a scheme of classification of the most common sources of biomass potentially available for energy use (UBET, FAO, 2004).

*Table 1: Classification of Biofuel sources by different characteristics (adapted from UBET, FAO, 2004)*

*"Dry" biomass "Moist" biomass*

| | | woody biomass | herbaceous biomass | biomass from fruits and seeds | others (including mixtures) |
|---|---|---|---|---|---|
| **Energy crop** | | **WOODFUELS** | **AGROFUELS** | | |
| | direct | - energy forest trees<br>- energy plantation trees | - energy grass<br>- energy whole cereal crops | - energy grain | |
| **By-products*** | | - thinning by-products<br>- logging by-products<br>- landscape manag. by-products | - crop production by-products: | | - animal by-products<br>- horticultural by-products |
| | | | - straw | - stones, shells, husks | |
| | indirect | - wood processing industry by-pro-ducts<br>- black liquor | - fibre crop proces-sing by-products | - food processing industry by-products | - biosludge<br>- slaughterhouse by-products |
| **End use materials** | recovered | - used wood | - used fibre products | - used products of fruits and seeds | **MUNICIPAL BY-PRODUCTS** |
| | | | | | - kitchen waste<br>- sewage sludge |

*The term "by-products" includes the improperly called solid, liquid and gaseous residues and wastes derived from biomass processing activities.

#### 3.3.3. Dry biomass

WOODY BIOMASS

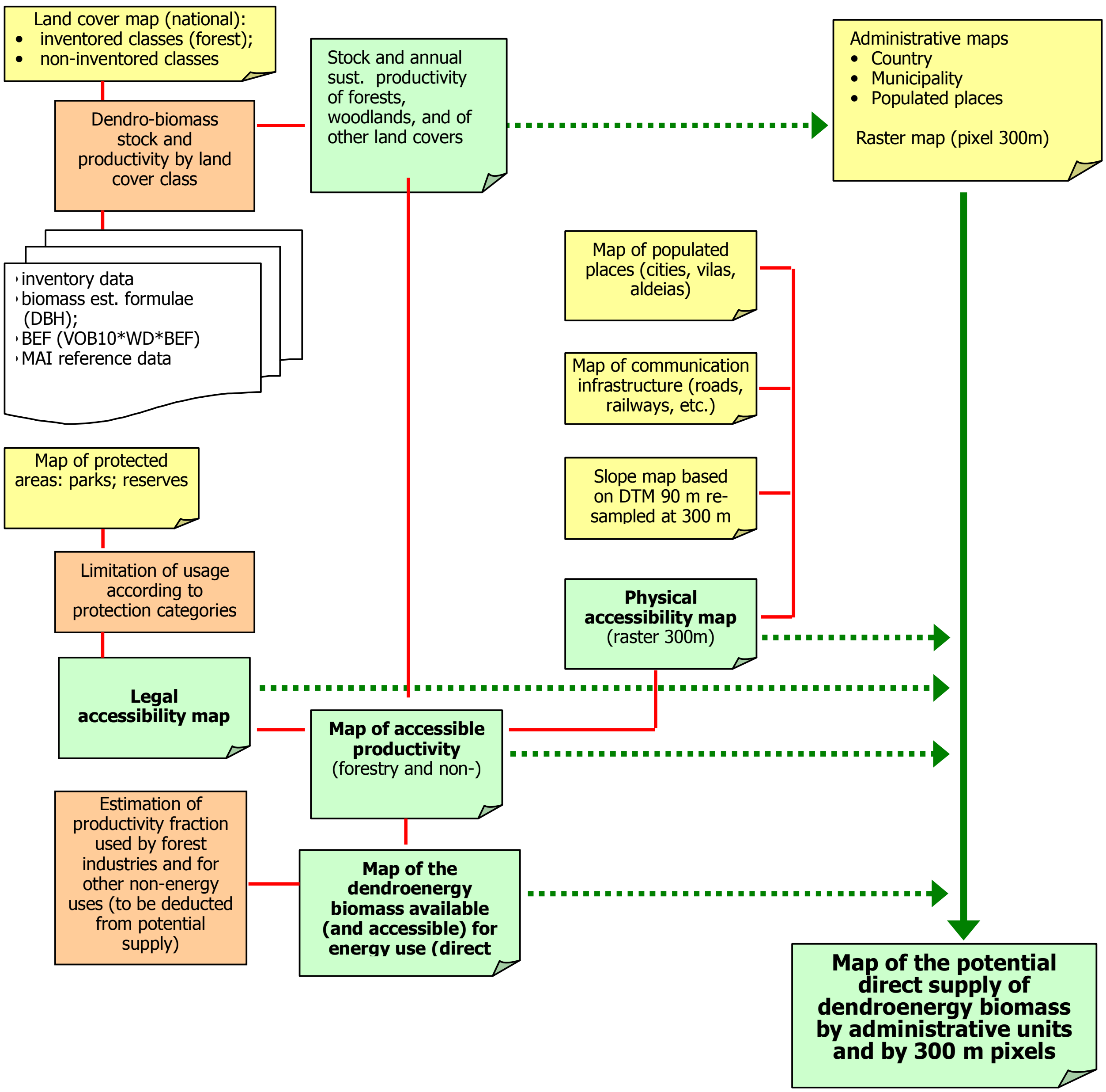
Direct supply sources (land covers / land uses)

The estimation of the potential woody biomass availability for energy purposes was based on available land use/land cover information, national forest inventory data and a variety of references on from regional, national and international literature on biomass productivity in forests and other landscapes (WISDOM Italy citation). Minimum, medium and maximum productivity level were estimated for all land cover classes of the Corine Land Cover (IV Level) and associated as attribute to class polygons (see Appendix 3 for the list of classes and the estimated productivity levels).

Concerning forest formations, the main references used for the definition of productivity levels were the National Forest Inventory of 1985 (IFNI, 1985) and the APAT study on woody biomass potential in Italy (APAT 2003). Given the old reference data used (IFNI, 1985) and the limited exploitation of regional studies, the values used for the analysis of Emilia-Romagna should be considered as indicative and preliminary only. The results and cartographic output of the new national inventory, when fully accessible, will provide substantial reference for a revision of forest productivity levels.

For many land cover classes the estimated potential productivity is tentative due to lack of reference data and therefore purely indicative. In time, the values proposed, which are based on some external reference and some educated guesswork should be verified and corrected on local reliable references.

Data on urban green management in the Province of Bologna (Barnabè, Agri 2000 Soc. Coop., pers. com.), for instance, allows a first check of the proposed values for the classes "continuous and discontinuous residential", which shows that the values assumed were reasonable. Provincial data indicate 2531 t for 2007 while the value estimated on Clc classes varies between 2092 t (minimum) and 3442 t (maximum), with a mean value of 2830 t*year$^{-1}$.

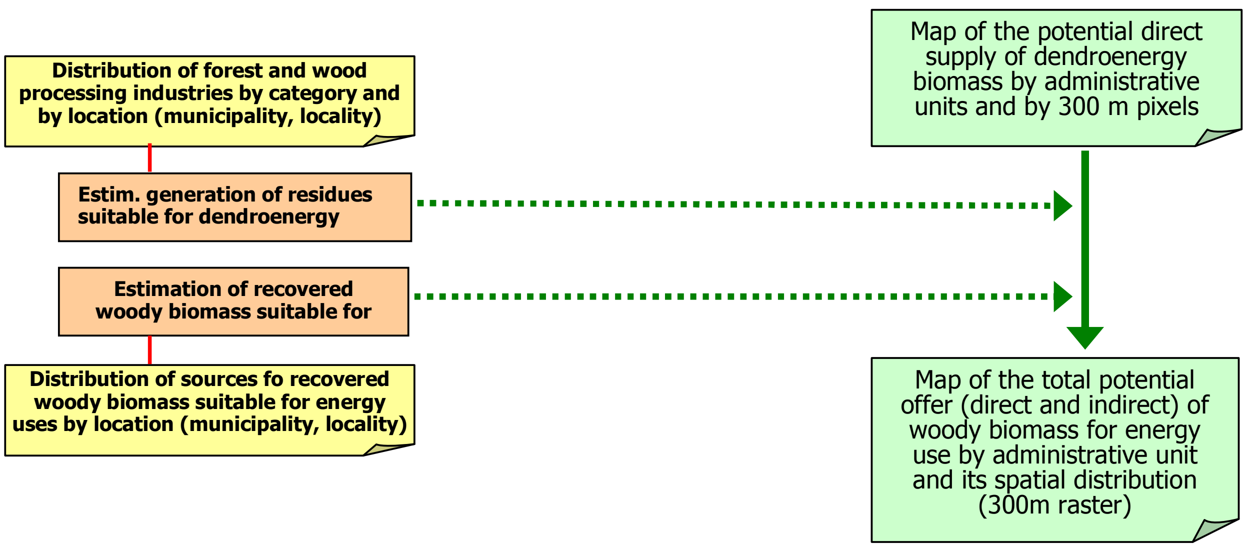

Land cover map (national):
inventored classes (forest);
non-inventored classes
Dendro-biomass stock and productivity by land cover class
Stock and annual sust. productivity of forests, woodlands, and of other land covers
Administrative maps
Country
Municipality
Populated places
Raster map (pixel 300m)
inventory data
biomass est. formulae (DBH);
BEF (VOB10*WD*BEF)
MAI reference data
Map of populated places (cities, vilas, aldeias)
Map of communication infrastructure (roads, railways, etc.)
Slope map based on DTM 90 m re-sampled at 300 m
Map of protected areas: parks; reserves
Limitation of usage according to protection categories
Physical accessibility map (raster 300m)
Legal accessibility map
Map of accessible productivity (forestry and non-)
Estimation of productivity fraction used by forest industries and for other non-energy uses (to be deducted from potential supply)
Map of the dendroenergy biomass available (and accessible) for energy use (direct
Map of the potential direct supply of dendroenergy biomass by administrative units and by 300 m pixels

Indirect supply sources

*Residues of forest industries*

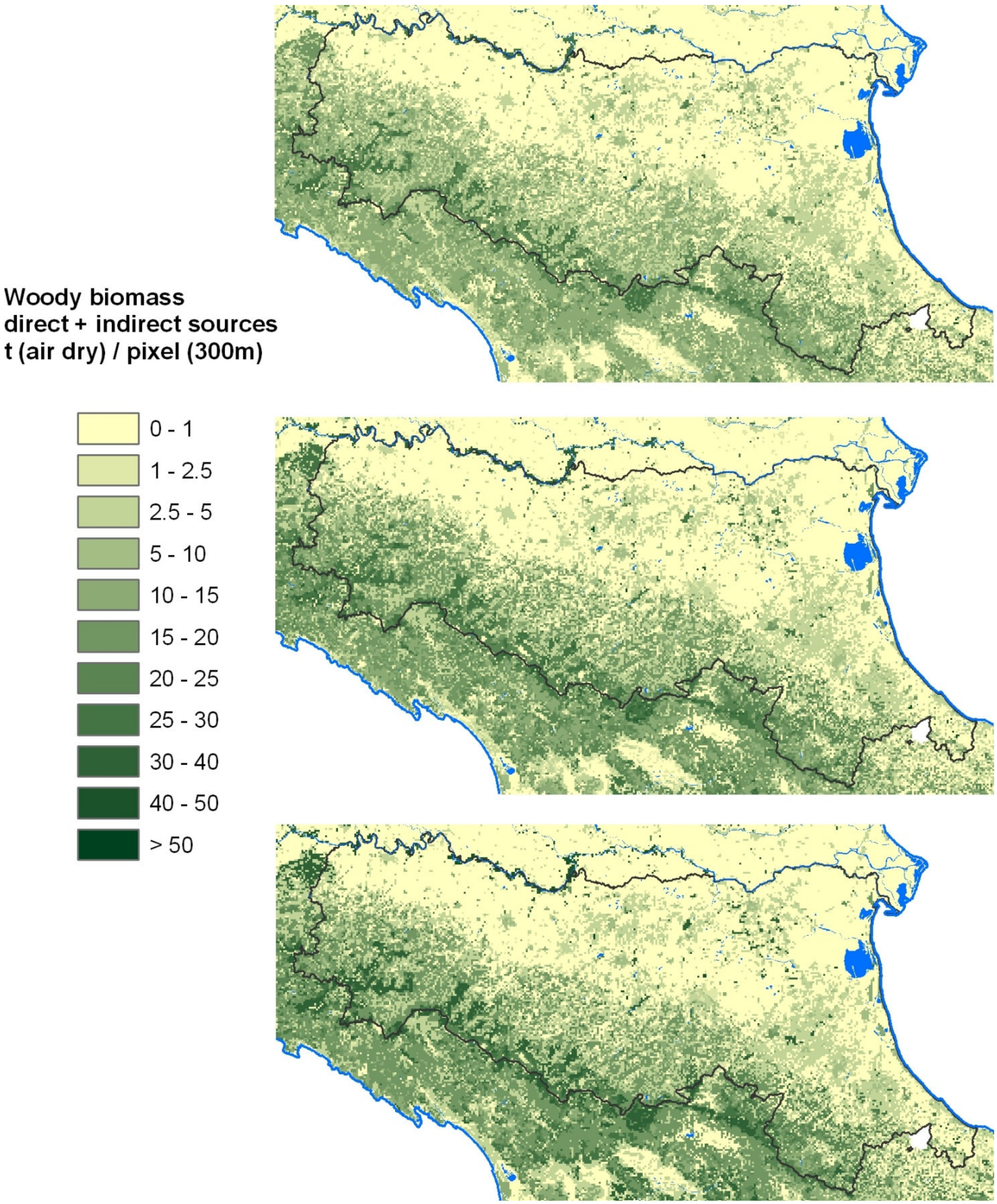
The available woody biomass residues of the wood industries available for energy use (in addition to the amount used in the same industries and to the amount sold out for other uses) was assessed on the basis of an estimated production average of 4.76 dry t per employee (LEAP, 2007) and the ISTAT statistics of number of employees by municipality (Census of industries and services 2001, ISTAT).

*Recovered wood*




The raster maps in Figure 7 shows the distribution of woody biomass annually accessible and available from direct and indirect sources with a pixel resolution of 300m. The total woody biomass by municipality is calculated by addition. The estimated regional total woody biomass from direct and indirect sources is over 1.2 $t*10^6*year^{-1}$.

*Figure 7: Estimated annual woody biomass potential currently available from direct and indirect sources. Minimum (top, medium (middle) and maximum (bottom) productivity levels.*



OTHER DRY BIOMASSES

Direct sources

*Dedicated crops*

If we exclude coppice forests, which are since centuries dedicated to fuelwood production, the dedicated bioenergy crops in the "modern" sense cover very small surfaces.

In fact, the dedicated bioenergy crops grown in 2007 are limited to experimental plots, rather than actual production areas, located mainly in the Province of Ravenna and covering an area of 265 ha (sorghum 124 ha, poplars 70 ha, rapeseed 40 ha, *cane* 29 ha and other SRF, 2.5 ha).

However, the sector is developing very fast and the plans for future years indicate a very substantial increase. Already planned surfaces add to some 3200 ha, almost entirely by SRF composed by poplar species (Canestrale, pers. comm..).

*Crop residues at harvesting sites*

Biomass residues of agricultural crops are estimated using per/ha production values derived from literature (Canestrale, CRPV; pers. com.) and applied to crop statistics of surfaces, which are available for Emilia-Romagna at the level of Agricultural Regions (AR) (*Regioni Agrarie*), which represent sub-provincial aggregations of municipalities (7, on average)[1].

Crop residues represent a very substantial source of biomass, with a total potential around 1.6 Mt of fresh biomass, corresponding to some 1.1 Mt of dry matter (assuming that approximately ¼ of the residues would remain on site for nutrients, structure or would simply be inaccessible).

In order to spatially distribute the residues at municipality level, AR totals should be associated to CLC classes where these crops are likely to occur. There are difficulties in the spatial distribution of these residues for individual classes because the relation between the Corine Land Cover classes and the statistics produced by AR is quite poor[2]. Finally, to solve at least in part the poor relation of individual classes the distribution was based on aggregated residues on one hand and group of classes on the other. The map in Figure 8 shows the result of the aggregation of the residues for cereal crops, corn, sunflower and grain sorghum by AR, distributed over the group of ClC classes where they are likely to occur[3]. The result of the analysis on the 300m raster map is not a reliable representation of the spatial distribution of available crop

[1] http://rersas.regione.emilia-romagna.it/statexe/index.htm

[2] For instance, AR statistics report some 60,000 ha of vineyards in the Region, but Clc only shows 2,200 ha under the vineyard class. Most likely, the majority of vineyards are included in the generic class "complex systems" (Sistemi colturali complessi), which covers approximately 220,000 ha. Nevertheless, it is encouraging to see that the aggregated estimation of available woody biomass from fruit orchards and vineyards based on Corine Land Cover classes and the one based on detailed statistics by Regioni Agrarie show a good match, indicating some 255,000 air-dry t the first and 269,000 the second (considering the entire residues).

[3] Intensive cropland (Colture Intensive); extensive cropland (Colture Estensive); temporary and permanent croplands (Colture Temporanee e Permanenti); complex farming systems (Sistemi Colturali Complessi), farmlands with natural vegetation (Colture Agrarie con Spazi Naturali) and paddy fields (Risaie).

residues, but it complements well the woody biomass dataset and thus it allows a first spatial overview of the distribution of dry biomass over the region (Figure 9).

*Figure 8*

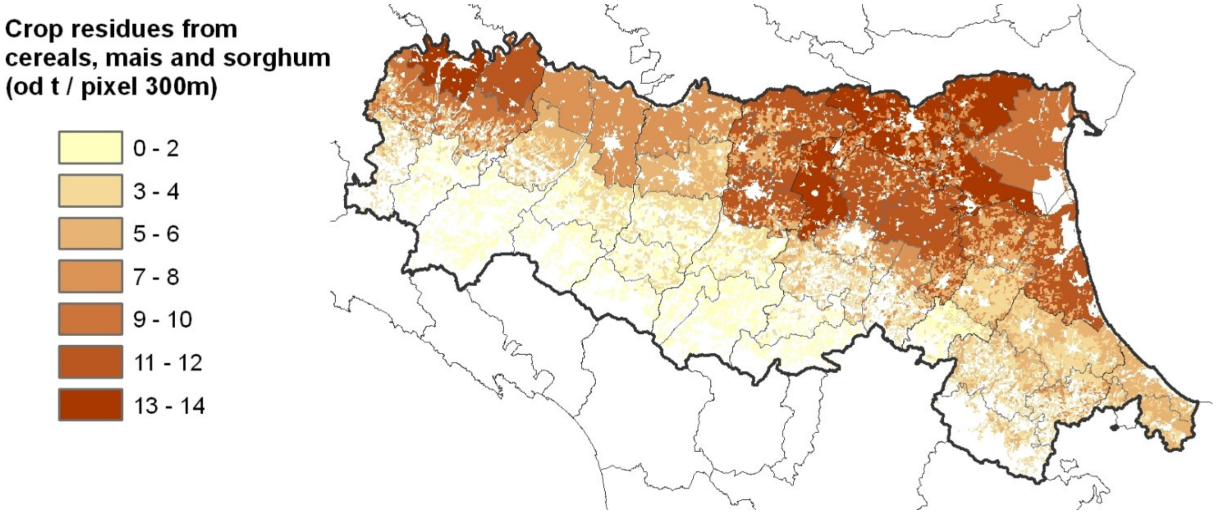
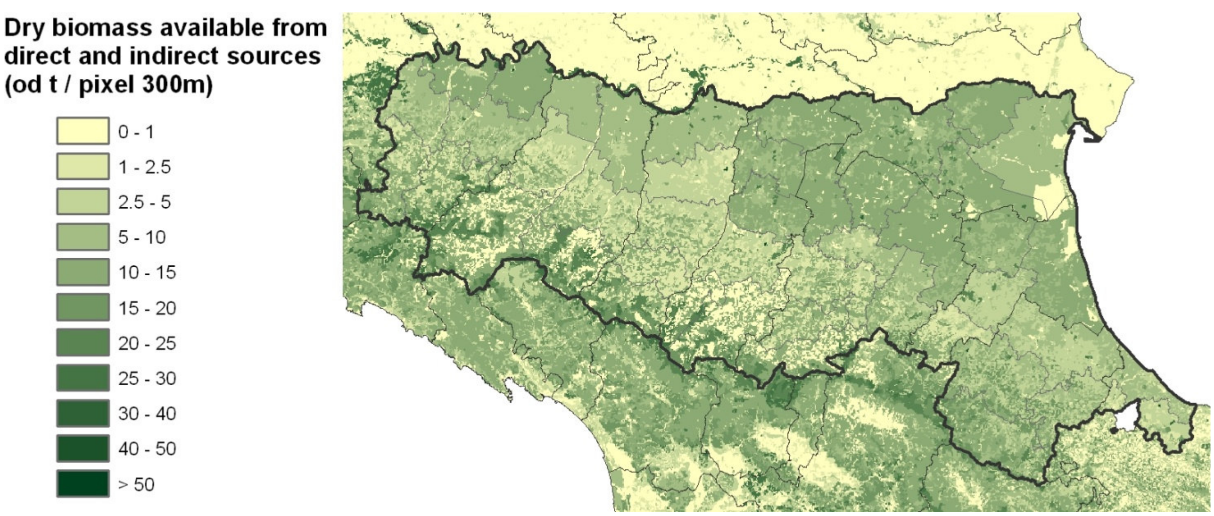



*Figure 9*



### *3.3.4. Wet biomass*

RESIDUES OF LIVESTOCK ACTIVITIES

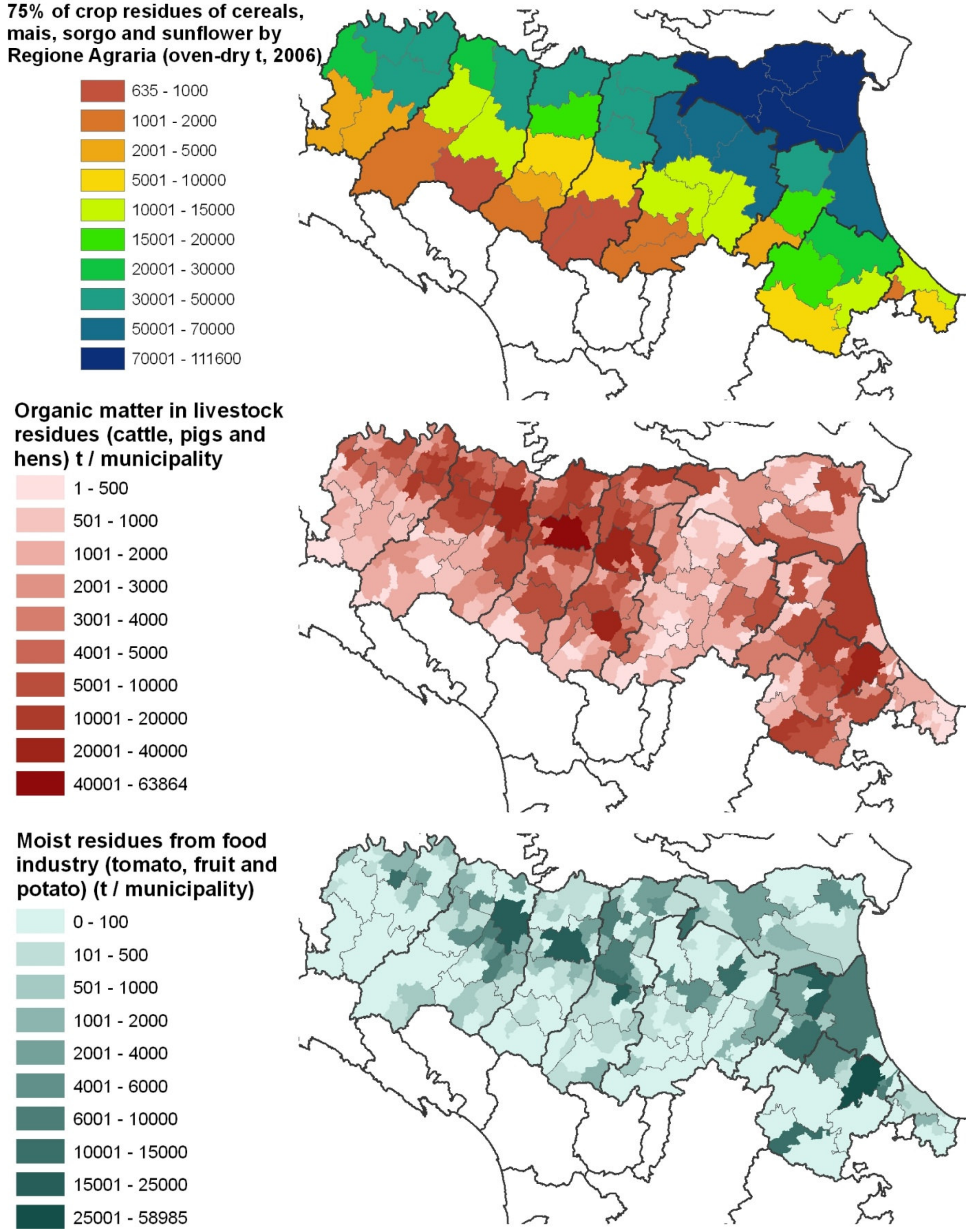
The annual production of livestock residues is very substantial, considering that each animal produces in one year approximately 24 times its own weight (original liquid state), 7.5 to 11.6 % of which in terms of organic matter (Table 2 and Fig. 10).

### *3.3.5. Summary of biomass productivity*

*Table 2: Summary table of biomass productivity by province and main biomass category ($t*10^3*year^{-1}$)*

| | direct woody biomass | indirect woody biomass | crop residues | **total dry biomass** | moist residues from food industry | Organic matter from livestock |
|---|---|---|---|---|---|---|
| Bologna | 182 | 9 | 212 | **403** | 33 | 77 |
| Ferrara | 43 | 3 | 266 | **312** | 23 | 48 |
| Forlì-Cesena | 181 | 9 | 62 | **252** | 105 | 134 |
| Modena | 150 | 10 | 131 | **291** | 100 | 272 |
| Parma | 280 | 4 | 84 | **368** | 62 | 249 |
| Piacenza | 161 | 3 | 141 | **304** | 27 | 150 |
| Ravenna | 55 | 4 | 120 | **179** | 77 | 46 |
| Reggio-Emilia | 127 | 9 | 65 | **201** | 35 | 315 |
| Rimini | 11 | 6 | 20 | **38** | 3 | 13 |
| Emilia-Romagna | 1190 | 57 | 1101 | **2348** | 466 | 1305 |

*Figure 10*

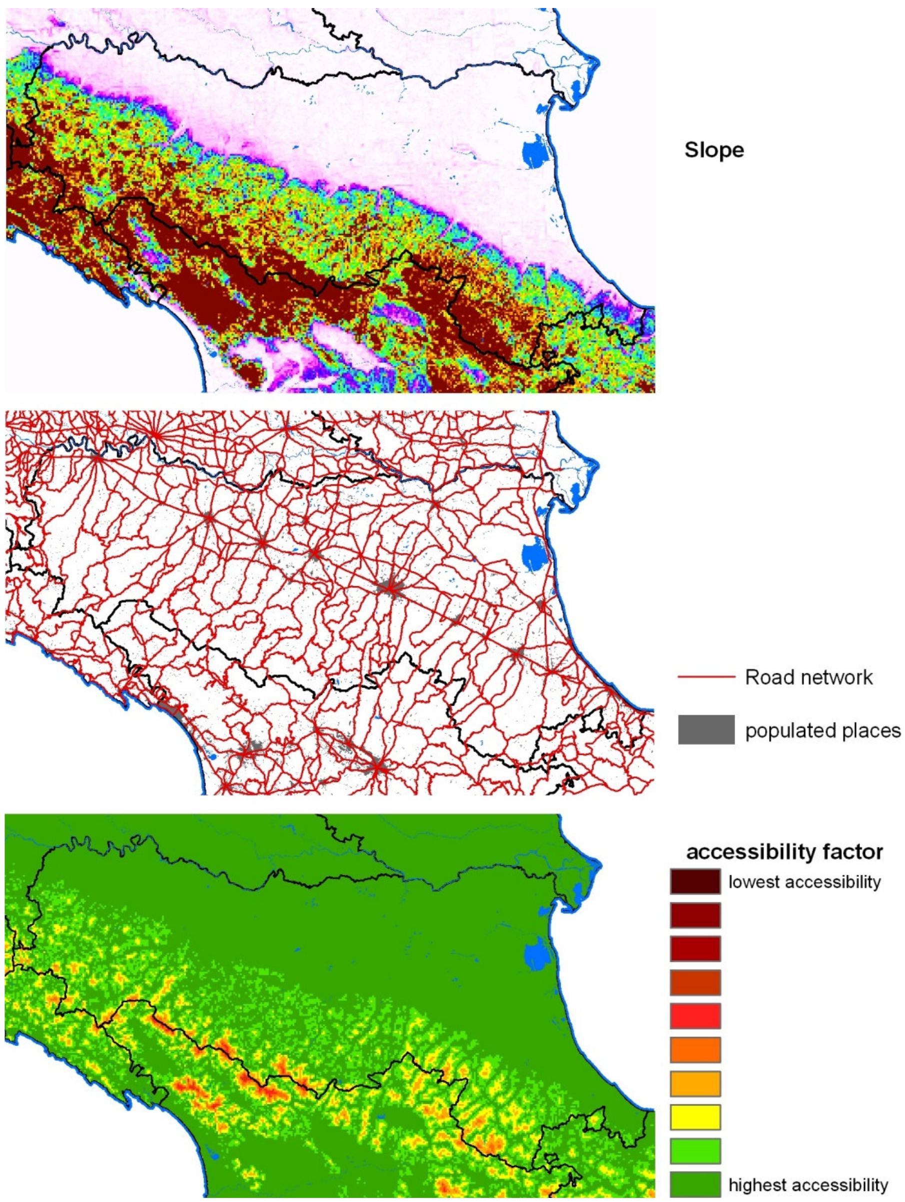

75% of crop residues of cereals, mais, sorgo and sunflower by Regione Agraria (oven-dry t, 2006)
635 - 1000
1001 - 2000
2001 - 5000
5001 - 10000
10001 - 15000
15001 - 20000
20001 - 30000
30001 - 50000
50001 - 70000
70001 - 111600
Organic matter in livestock residues (cattle, pigs and hens) t / municipality
1 - 500
501 - 1000
1001 - 2000
2001 - 3000
3001 - 4000
4001 - 5000
5001 - 10000
10001 - 20000
20001 - 40000
40001 - 63864
Moist residues from food industry (tomato, fruit and potato) (t / municipality)
0 - 100
101 - 500
501 - 1000
1001 - 2000
2001 - 4000
4001 - 6000
6001 - 10000
10001 - 15000
15001 - 25000
25001 - 58985

### 3.3.6. Accessibility

PHYSICAL ACCESSIBILITY

Mapping of the physical accessibility of biomass is here intended as assessing the limitations induced by slope and by distance from roads and populated places. The data used to assess accessibility limitations are the Digital Terrain Model, and the derived slope map, the road network and the map of populated places. These maps, as well as the final output, *i.e.* the physical accessibility map, are shown in Figure 11.

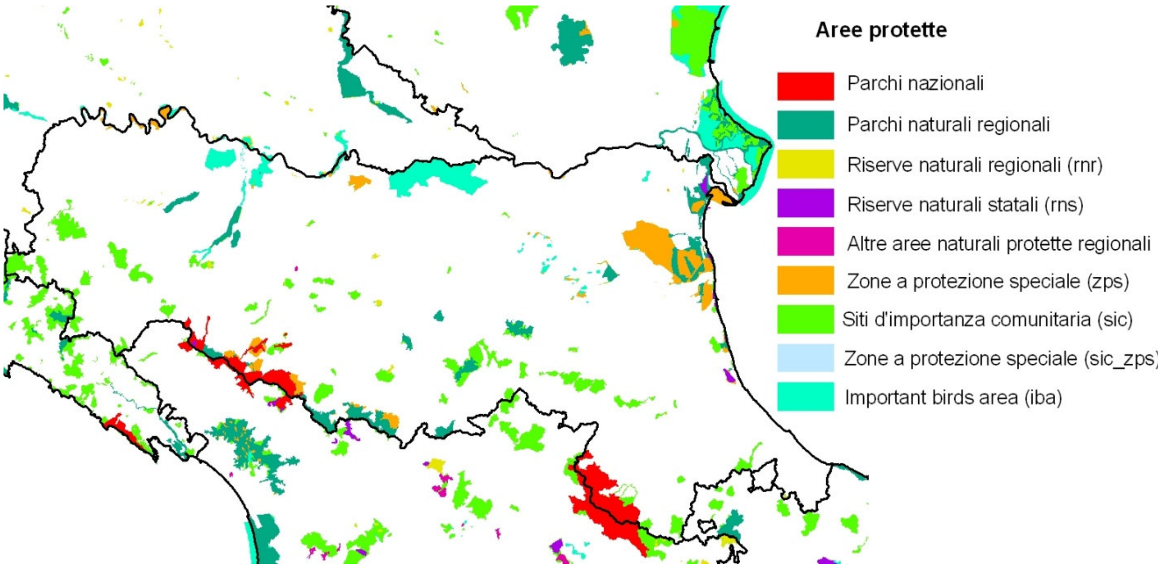
*Figure 11*



LEGAL ACCESSIBILITY

The legal accessibility refers to the limitations of resource exploitation induced or imposed by protected areas. Figure 12 shows the large variety of protection categories represented in the region. It is a rather complex situation, as many locations are under several protection categories at the same time.

*Figure 12*




ACCESSIBILITY FACTORS

None of the parameters and map features used can be directly converted into a quantitative accessibility factor. Forest management prescription raise the issue of the protective function of forests and the need to operate carefully in higher slope, but do not define a specific limit to a sustainable exploitation. The distance as well doesn't present clear thresholds between accessible and inaccessible locations, not to mention the fact that the available road map doesn't include forest tracts. Similarly, the protected areas never totally exclude the possibility of sustainable exploitation of forest resources, especially in presence of centuries' long coppicing practices. The limitation are very specific in location and in time and oriented to protect certain species in particularly vulnerable moments or places.

Under these considerations, the accessibility factors were defined (rather arbitrarily) to range between 0% (no limitations) and 50% (highest limitation) on account of physical constraints based on cost-distance analysis and to 80% on account of legal constraints within protected areas.

### *3.4. INTEGRATION MODULE*

Calculation of local supply/demand balance to determine the legally and physically accessible potential biomass surplus is shown in Table 3, where overall balance (total supply – total consumption) at regional level, municipality level balance (internal supply potential – internal consumption) and estimation of local balance are described.

*Table 3: Summary table of dry biomass supply/demand balance by (t*103*year-1)*

| | Total dry biomass supply potential | Total dry biomass consumption | Supply / demand balance |
|---|---|---|---|
| Bologna | 403 | 269 | **1,50** |
| Ferrara | 312 | 172 | **1,81** |
| Forli'-Cesena | 252 | 104 | **2,42** |
| Modena | 291 | 162 | **1,80** |
| Parma | 368 | 127 | **2,90** |
| Piacenza | 304 | 91 | **3,34** |
| Ravenna | 179 | 104 | **1,72** |
| Reggio-Emilia | 201 | 121 | **1,66** |
| Rimini | 38 | 35 | **1,08** |
| Emilia-Romagna | 2348 | 1185 | **2,02** |

### *3.5. ANALYSIS AND DELINEATION OF POTENTIAL BIO-DISTRICTS*

#### *3.5.1. Current supply/demand pattern*

The factors that determine the size and delineation of a bio-district, in its first-level definition, depend primarily on the geographic relation between potential sustainable biomass supply and current or projected biomass demand.

Under this general perspective, two main directions of analysis may be considered: (i) bio-district delineation aiming at the definition of the sustainable supply zone of a predefined center (or centers) of consumption or (ii) aiming at the definition of the most suitable location and size for a consumption unit such as biomass plant in relation to the geographic distribution and accessibility of biomass supply resources. In both cases the essential ingredients of analysis are the spatial distribution of biomass surplus determined by potential productivity and current consumption, and accessibility factors.

In order to exemplify the procedure of analysis, considering that the supply / demande balances are >1 in every province, the theoretical bio-district of the three major biomass plants planned for the near future in the region was delineated on the basis of the dataset available. The plants taken into consideration are briefly described in Table 4.

*Table 4: Description of individuated 3 Bio-Energy Districts*

| Region | BD name (Administrative district) | Locality | Type of energy chain (type of biomass) | Type of energy | Plant (MWe) | Involved Area (ha) |
|---|---|---|---|---|---|---|
| Emilia Romagna (I) | West Bologna | Zola Predosa (BO) | residues from public green, agriculture and wood | heat / electric | 1 MWt / 1MWe | 30.000 |
| Emilia Romagna (I) | North Modena | Finale Emilia (MO) | energy crops, residues from public green, agriculture and wood | electric | 12,50 | 45.000 |
| Emilia Romagna (I) | Ferrara | Bando di Argenta ( FE) | energy crops, residues from public green, agriculture and wood | electric | 20,00 | 90.000 |

The selection was based on the expected size of the plants and on the availability of quantitative details on the expected amounts of biomass utilized.
The supply / demand BDs biomass individuated are shown in table 5.

**DEMAND**

| | ***Corine Land Cover – Emilia-Romagna*** *(Figure 1)* | ***Household woody biomass consumption in Emilia-Romagna*** *(Figure 3)* | | | ***Estimated production of wood residues by wood industries and residues directly used*** *(Figure 4)* | | ***Biomass consumption in Emilia Romagna*** *(Figure 5)* | |
|---|---|---|---|---|---|---|---|---|
| **DISTRICT** | | Fraction of families using woodfuels by municipality | Average household woody biomass consumption by municipality (woodfuel users only) | Average household woody biomass consumption by municipality (all households)) | Wood residues produced by wood industries by municipality (medium variant) | Wood residues produced by wood industries for energy production, by municipality (medium variant) | Woody biomass consumption in the residential sector (medium values) - t/pixel 300m | Year of estabilishment of bioenergy plant |
| MODENA NORTH | Prevalent sowable land and complex coltural systems area | From 11 to 20% | 3,01-3,50 t/year | 0,51-1,00 t/year | 500-1500 t/year | 101-500 t/year | 51-150 | Energy plant is not present, but 30 km far there are 4 of them |
| BOLOGNA WEST | Forestry and woody areas | From 11 to 30%, except Marzabotto municipality 70% | 3,01-3,50 t/year | 1,01-1,50 t/year | 101-250 t/year | 51-250t/year | 51-150 | Energy plant is not present, but 30 km far there are 4 of them |
| FERRARA | Prevalent sowable land and complex coltural systems area | Form 31 to 40% | 3,01-3,50 t/year | Il range di valori va da 0,00-2,50 t/year | 101-500 t/year | 51-250t/year | 51-150 | There is an energetic plant since 2003 |

**SUPPLY**

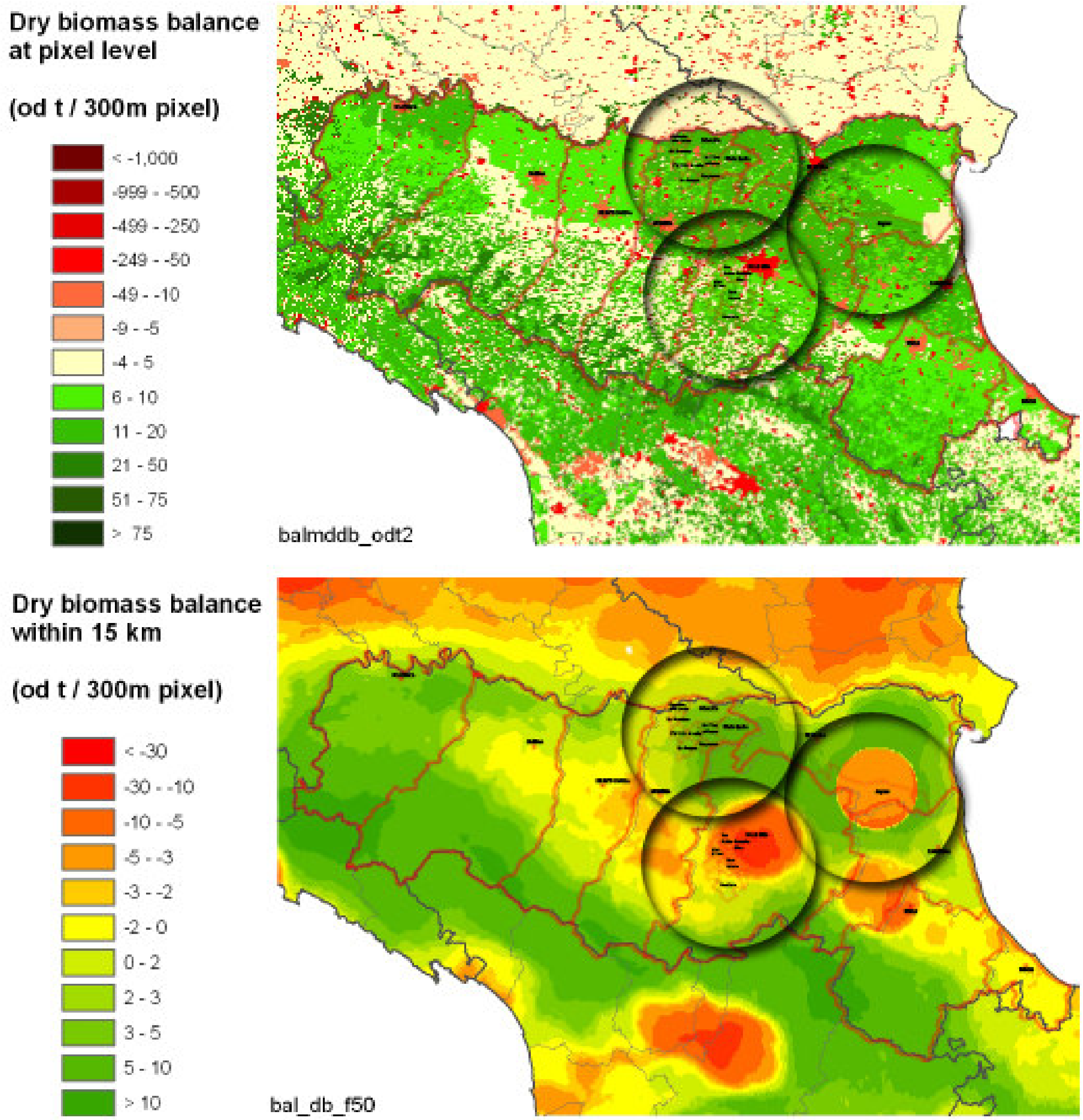
| | ***Estimated annual woody biomass potential currently available from direct and indirect sources. Medium (middle) productivity level.*** *(Figure 7)* | ***Figure 8*** | ***Figure 9*** | ***Figure 10*** | | |
|---|---|---|---|---|---|---|
| **DISTRICT** | Woody biomass direct + indirect sources - t(air dry)/pixel (300m) | Crops residues from cereals, mais and sorghum (od t/pixel 300m) | Dry biomass available from direct and indirect sources (od t / pixel 300m) | 75% of crops residues of cereals, mais, sorgo and sunflowers by Regione Agraria (oven-dry t,2006) | Organic matter in livestock residues (cattle, pigs and hens) t/mucipality | Moist residues from food industry (tomato, fruit and potato) t/municipality |
| MODENA NORTH | 0 -2,5 | 9-12 od t /pixel 300m | 5-20 od t /pixel 300m | 30001-50000 | 2001-20000 | 101-6000 |
| BOLOGNA WEST | 0 - 5 | 3-8 od t /pixel 300m | 2,5-15 od t /pixel 300m | 10001-15000 | 501-3000 | 101-1000 |
| FERRARA | 0 - 2,5 | 11-12 od t /pixel 300m | 5-20 od t /pixel 300m | 70001-111600 | 10001-20000 | 1001-2000 |

Figure 11 shows that all areas are highly accessible.
Figure 12 shows very small not usable areas due to:

| **DISTRICT** | ***Type of protected area*** |
|---|---|
| MODENA NORTH | Birds protection area |
| BOLOGNA WEST | Sites of Community Importance, Regional Natural Parks |
| FERRARA | Special Protection Area, Regional Natural Parks |

The supply area is determined by the portion territory in which the demand determined by the plants and the supply/demand balance of dry biomass achieves equilibrium (non negative total value).

*Figure 13*



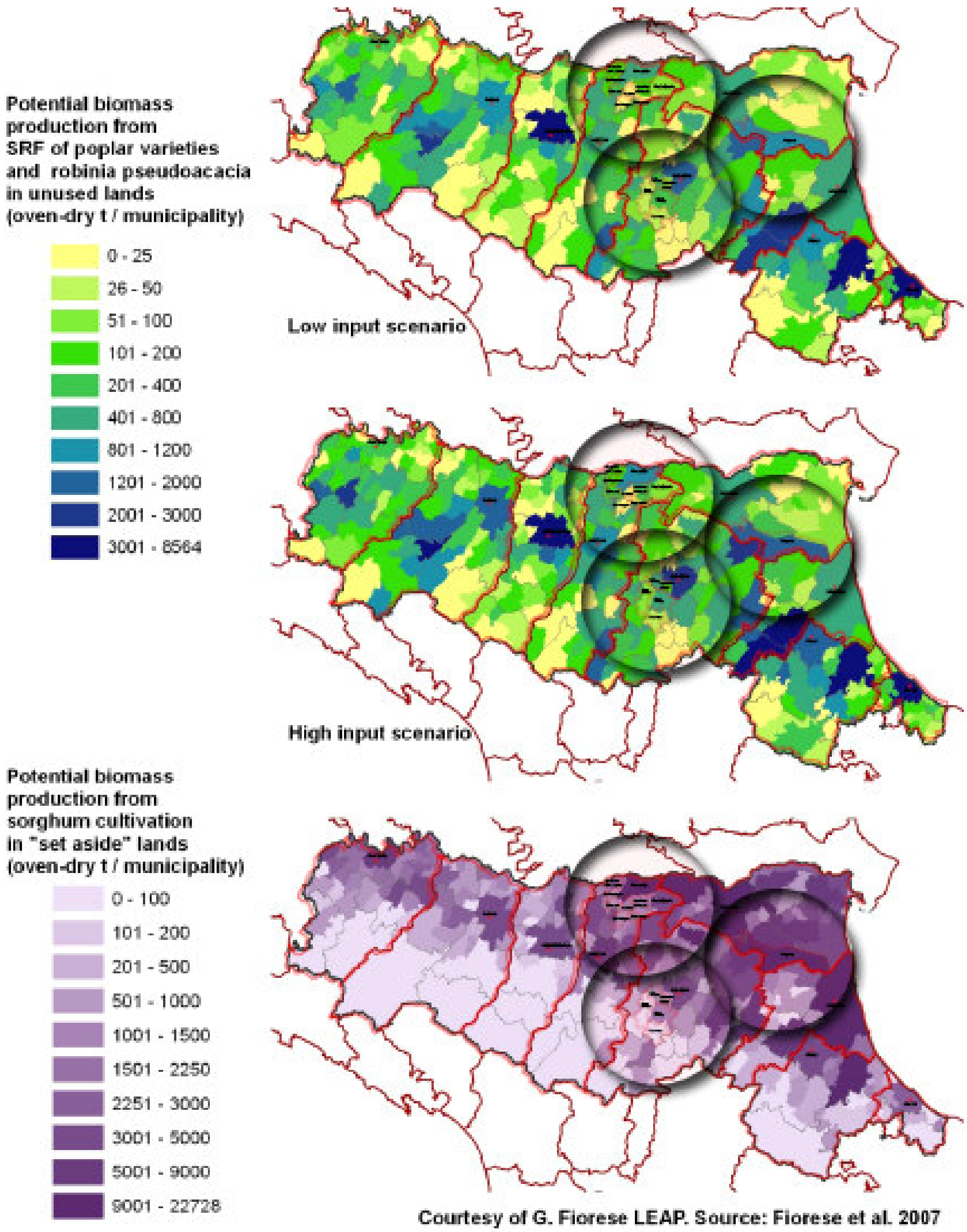

The important amounts of biomass that these plants are expected to use determine a very large supply area.

### *3.5.2. Possible supply scenarios of dedicated crops*

In addition to current situation concerning potential sustainable supply and consumption patterns, it's important to consider possible/likely changes in the availability of different types of biomass from dedicated crops. This requires the determination of the land areas potentially available for dedicated crops in addition to those presently used for conventional food crops, their location, their suitability to grow the most promising bioenergy crops and the spatial distribution of the additional biomass that could be grown under different investment scenarios.

A comprehensive analysis of the bioenergy crops potential for Emilia-Romagna was recently conducted by Fiorese et al. (2007) in the framework of the action supported by the consortium *Laboratorio Energia Ambiente Piacenza* (LEAP) and of the project "Efficienza e Compatibilità Ambientale delle Tecnologie Energetiche" (ECATE). In that study, the agricultural surface of each municipality that is classified (ISTAT) as unutilized (SANU) or that is set aside from food production was analyzed under multiple criteria to assess the suitability for dedicated bioenergy crops. The suitability was assessed for Short Rotation Forestry (SRF) of three poplars varieties and *Robinia pseudoacacia* in SANU areas and for sorghum cultivation in the "set aside" areas. The results of this analysis, which included the definition of the most promising combination of SRF species in each municipality, is shown in Figure 14. Two input levels were assumed for the poplars cultivation to determine a low- and a high- input scenarios.

*Figure 14*




Courtesy of G. Fiorese LEAP. Source: Fiorese et al. 2007

In order to assess and visualize the impact of new bioenergy crops on the overall supply/demand context and, specifically, on the provision of biomass to the present and future biomass plants, the potential biomass from such crops was integrated in the geodatabase created during the first phase. The result of these scenarios are described in table 6, showing that a significant potentiality in the described areas can be reached by additional bioenergy crops. In particular sorghum appears to be a good dedicated crop in Ferrara and Modena Nord areas, while SRF in Bologna Ovest area.

RESULTS

| | ***Figure 13*** | | ***Figure 14*** | | ***Supply zone of the four largest biomass plants planned in Emilia Romagna*** |
|---|---|---|---|---|---|
| **DISTRICT** | Dry biomass balance at pixel level (od t/pixel 300m) | Dry biomass balance within15 kml (od t/pixel 300m) | Potential biomass production from SRF of poplar varieties and robinia | Potential biomass production from surghum cultivation in set aside lands (oven-dry | Dry biomass balance at pixel level (od t/pixel) |
| MODENA NORTH | 6-50 | 3-10 | Low 0-400 High 0-1200 | 101-5000 | 11-25 |
| BOLOGNA WEST | 6-20 | -10-2 | Low 0-3000 High 0-3000 | 0-2250 | -9-10 |
| FERRARA | 11-50 | -5 - 5 | Low 0-2000 High 0-3000 | 0-9000 | 11-25 |

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## APPENDIX 1: SUMMARY OF MAIN LAYERS, VARIABLE AND DATA SOURCES OF WISDOM MODULES

| Module /phase | Layer/ parameter | | Main Variables | Source de information | Comments |
|---|---|---|---|---|---|
| **Spatial base** | **Map administrative (vector)** | | | | |
| | **Land cover** | | | | |
| **Spatial analysis (pix. 250m?)** | **DTM** | | | | |
| | **Protected areas** | | | | |
| | **Roads, railways** | | | | |
| | **Accessibility** | | | | |
| **Supply Module** | **Direct sources** | | | | |
| | **Stock and productivity of Forest lands** | | | | |
| | **NON-energy use** | | | | |
| | **Spatial proxy for values distribution within the classes** | | | | |
| **Cont./ Supply Module** | **Stock and productivity of NON-Forest lands** | | | | |
| | **Indirect sources** | | | | |
| | **Residues from forest industries** | | | | |
| | **Recovered woody biomass** | Oven-dry t of biomass/year | Waste pallets;<br>Exhausted construction wood; | ?? | |
| | **Residues from Agroindustries** | | Regional agro-industrial biomass residues by category:<br>◦ Fruit and vegetable processing; Potatoes processing; Meat processing (beef and pork);<br>◦ Meat processing (poultry-white meat);<br>◦ Olive oil; Other vegetable oil;<br>Employees by category by municipality (proxy variable for spatial distribution | CRPA 2004;<br>ISTAT Census of industries 2001;<br><br>File: Tabella Industrie Alimentari ER 02.xls | The total amount of residues fro the first 4 categories was assessed by CRPA for year 2004.<br>Verify if the residues are humid or dry!!<br>The estimation of olive and other vegetable oil residues was based on ....<br><br>Missing specific data, the residues availability was distributed by municipality in proportion of the number of employees. |

| | | | | | |
|---|---|---|---|---|---|
| | **Residues from livestock** | | Breeding/farming units and number of heads by municipality | ISTAT Census 2000; | |
| **Demand Module** | **Household consumption** | | | | |
| **Cont./ Demand Module** | **Consumed by industrial processes** | | | | |
| | **Consumption in the Commercial sector** | | | | |

## APPENDIX 2: RESIDENTIAL CONSUMPTION IN EMILIA-ROMAGNA

Estimate based on the fraction of the families using biomass (%) and on the average consumption (t*year $^{-1}$) indicated by ENEA 1997 and ENEA 1999. Distribution by degree of urbanization and by elevation zones was based on the national values indicated by the same studies. Mean values are made by the average of the two studies, except for Valle d'Aosta, Molise e Basilicata for which only ENEA 1999, with higher sampling intensity, was used as reference.

| | Family users | | Cons. / Fam. users | Total consumption | | Low inhabitant level | | | | | Medium inhabitant level | | | | | High inhabitant level | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (%) | No (2003) | (t) | (t) | | Internal mountain | Littoral mountain | Internal hill | Littoral hill | Plain | Internal mountain | Littoral mountain | Internal hill | Littoral hill | Plain | Internal mountain | Littoral mountain | Internal hill | Littoral hill | Plain |
| Mean (average ENEA 97 ENEA 99) | 22.0 | 384,639 | 3.3 | 1,271,400 | Family users | 65,876 | | 41,435 | 1,069 | 24,453 | 914 | | 51,018 | 2,346 | 122,556 | | | 41,209 | | 33,763 |
| | | | | | Total consumpt | 275,740 | | 144,531 | 3,356 | 76,765 | 3,507 | | 177,958 | 7,366 | 384,743 | | | 114,995 | | 82,439 |
| | | | | | t/fam users | 4.2 | | 3.5 | 3.1 | 3.1 | 3.8 | | 3.5 | 3.1 | 3.1 | | | 2.8 | | 2.4 |
| Lower values (ENEA 1999) | 17.4 | 304,214 | 3.50 | 1,065,710 | Family users | 52,102 | | 32,771 | 846 | 19,340 | 723 | | 40,351 | 1,856 | 96,931 | | | 32,593 | | 26,704 |
| | | | | | Total consumpt | 231,131 | | 121,148 | 2,813 | 64,346 | 2,940 | | 149,167 | 6,174 | 322,498 | | | 96,391 | | 69,102 |
| | | | | | t/fam users | 4.4 | | 3.7 | 3.3 | 3.3 | 4.1 | | 3.7 | 3.3 | 3.3 | | | 3.0 | | 2.6 |
| Higher values (ENEA 1997) | 26.6 | 465,063 | 3.11 | 1,445,287 | Family users | 79,650 | | 50,099 | 1,293 | 29,566 | 1,105 | | 61,685 | 2,837 | 148,181 | | | 49,826 | | 40,823 |
| | | | | | Total consumpt | 313,453 | | 164,298 | 3,816 | 87,264 | 3,987 | | 202,297 | 8,373 | 437,363 | | | 130,722 | | 93,714 |
| | | | | | t/fam users | 3.9 | | 3.3 | 3.0 | 3.0 | 3.6 | | 3.3 | 3.0 | 3.0 | | | 2.6 | | 2.3 |

| Italy | 60.9 | | | 27.4 | | | 13.8 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mountain | Hill | Plain | Mountain | Hill | Plain | Mountain | Hill | Plain |
| % users | 73.3 | 56.3 | 39.7 | 47.8 | 29.8 | 20.3 | 22.1 | 18.7 | 10.5 |
| Mean consumption/Family users | 4.0 | 3.3 | 3.0 | 3.5 | 3.1 | 2.9 | 2.9 | 2.6 | 2.2 |

## APPENDIX 3: PRODUCTIVITY OF WOODY BIOMASS POTENTIALLY AVAILABLE FOR ENERGY USE BY CORINE LAND COVER CLASSES

| CLC_4 | Clc_IV class name | MIN_t_ha | MED_t_ha | MAX_t_ha | Riferimento di stima IFNI o altro |
|---|---|---|---|---|---|
| 3121 | Boschi di pini mediterranei e cipressete | 0.80 | 1.33 | 1.86 | vedi fustaie pinete mediterranee /altre conifere |
| 3122 | Boschi di pini montani e oromediterranei | 0.90 | 1.50 | 2.10 | vedi fustaie pinete montane |
| 3123 | Boschi di abete bianco e/o abete rosso | 1.05 | 1.74 | 2.44 | vedi fustaie leccete /abetine |
| 3124 | Boschi di larice e/o pino cembro | 0.64 | 1.07 | 1.50 | vedi fustaie larice |
| 3125 | Boschi/piantagioni di conifere non native | 1.53 | 2.55 | 3.57 | vedi altre fustaie dominanza conefere |
| 31311 | Boschi misti (prev. leccio e/o sughera) | 1.98 | 2.24 | 2.50 | 80% ceduo (leccio, sughera) e fustaia (altre latifoglie) + 20% fustaia (pini mediterranei) |
| 31312 | Boschi misti (prev. querce caducifoglie) | 1.50 | 1.80 | 2.09 | 80% ceduo (altre querce) e fustaia (misto querce) + 20% fustaia (misto conifere) |
| 31313 | Boschi misti (prev. latifoglie mesofile e mesotermofile) | 1.98 | 2.35 | 2.71 | 80% ceduo (altre latifoglie) e fustaia (altre latifoglie) + 20% fustaia (misto conifere) |
| 31314 | Boschi misti (prev. castagno) | 1.41 | 1.71 | 2.00 | 80% ceduo (castagno) e fustaia (altre latifoglie) + 20% fustaia (misto conifere) |
| 31315 | Boschi misti (prev. faggio) | 2.55 | 2.99 | 3.43 | 80% ceduo (faggio) e fustaia (faggio) + 20% fustaia (misto conifere) |
| 31316 | Boschi misti (prev. specie igrofile) | 1.98 | 2.35 | 2.71 | 80% ceduo (altre latifoglie) e fustaia (altre latifoglie) + 20% fustaia (misto conifere) |
| 31317 | Boschi misti (prev. Spp. esotiche) | 2.11 | 2.56 | 3.01 | 80% ceduo (altre latifoglie) e fustaia (altre latifoglie) + 20% fustaie (altre conifere) |
| 31321 | Boschi misti (prev. pini mediterranei) | 0.84 | 1.41 | 1.97 | media fustaie pinete mediterranee /generale fustaie |
| 31322 | Boschi misti (prev. pini montani e oromediterranei) | 0.89 | 1.49 | 2.09 | vedi fustaie pinete montane /generale fustaie |
| 31323 | Boschi misti (prev. abete bianco e/o abete rosso) | 0.97 | 1.61 | 2.26 | vedi fustaie peccete /abetine /generale fustaie |
| 31324 | Boschi misti (prev. larice e/o pino cembro) | 0.77 | 1.28 | 1.79 | vedi fustaie larice /generale fustaie |
| 31325 | Boschi misti (prev. conifere non native) | 1.21 | 2.02 | 2.82 | vedi altre fustaie dominanza conifere /generale fustaie |
| 3111 | Boschi di leccio e_o sughera | 2.27 | 2.47 | 2.66 | ceduo (leccio, sughera) e fustaia (altre latifoglie) |
| 3112 | Boschi di querce caducifoglie | 1.65 | 1.87 | 2.10 | ceduo (altre querce) e fustaia (misto querce) |
| 3113 | Boschi di latifoglie mesofile e mesotermofile | 2.25 | 2.56 | 2.88 | ceduo (altre latifoglie) e fustaia (altre latifoglie) |
| 3114 | Boschi di castagno | 1.54 | 1.76 | 1.99 | ceduo (castagno) e fustaia (altre latifoglie) (-% paleria) |
| 3115 | Boschi di faggio | 2.97 | 3.37 | 3.77 | ceduo (faggio) e fustaia (faggio) |
| 3116 | Boschi di specie igrofile | 2.25 | 2.56 | 2.88 | ceduo (altre latifoglie) e fustaia (altre latifoglie) |
| 3117 | Boschi/piantagioni di latifoglie non native | 2.25 | 2.56 | 2.88 | ceduo (altre latifoglie) e fustaia (altre latifoglie) |
| 324 | Veg. boschiva/arbustiva in evoluzione | 1.08 | 1.23 | 1.37 | Study in Slovenia indica 2.2m3/ha/a circa. Qui definito a 1/2 del ceduo |
| 222 | Frutteti e frutti minori | 2.25 | 3.00 | 3.78 | APAT 30/2003 indica valori tra 3 e 6.3 t ha/anno secondo spp. |

| | | | | | |
|---|---|---|---|---|---|
| 223 | Oliveti | 1.50 | 2.25 | 3.00 | APAT 30/2003 indica 3 t ha (4 m3). Usato come valore massimo |
| 2241 | Pioppicoltura | 3.00 | 3.90 | 4.80 | APAT 30/2003 indica 4 m3 /ha/anno solo potature e 6.4 incluso potature e ceppaie |
| 2242 | Latifoglie pregiate (quali ciliegio e noce) | 0.99 | 1.65 | 2.31 | Simile alle fustaie naturali (rami e cimali solamente) |
| 2243 | Eucalitteti | 0.99 | 1.65 | 2.31 | Simile alle fustaie naturali (rami e cimali solamente) |
| 2245 | Impianti misti di latifoglie e conifere | 0.99 | 1.65 | 2.31 | Simile alle fustaie naturali (rami e cimali solamente) |
| 244 | Aree agroforestali | 0.72 | 0.82 | 0.91 | Biomassa legnosa a fini preval. Energetici. 1/3 del ceduo |
| 243 | Colture agrarie con spazi naturali | 0.36 | 0.41 | 0.46 | Biomassa legnosa a fini preval. Energetici. 1/6 del ceduo |
| 141 | Aree verdi urbane | 0.72 | 0.82 | 0.91 | Biomassa legnosa a fini preval. Energetici. 1/3del ceduo |
| 241 | Colture temporanee e permanenti | 0.36 | 0.41 | 0.46 | Biomassa legnosa a fini preval. Energetici. 1/6 del ceduo |
| 242 | Sistemi colturali complessi | 0.36 | 0.41 | 0.46 | Biomassa legnosa a fini preval. Energetici. 1/6 del ceduo |
| 221 | Vigneti | 2.20 | 3.30 | 4.40 | APAT 30/2003 indica 4.4 t ha (5.9 m3). Posto come valore massimo |
| 142 | Aree ricreative e sportive | 0.28 | 0.38 | 0.47 | |
| 322 | Brughiere e cespuglieti | 0.28 | 0.38 | 0.47 | |
| 3211 | Praterie continue | 0.11 | 0.15 | 0.19 | Studio in Slovenia indica 0.28 m3/ha/a circa. Qui definito a 0.2 |
| 3212 | Praterie discontinue | 0.23 | 0.30 | 0.38 | Studio in Slovenia indica valori tra 0.28 e 0.67 m3/ha/a. Qui definito a 0.4 |
| 231 | Prati stabili (foraggere permanenti) | 0.28 | 0.38 | 0.47 | Studio in Slovenia indica 0.67 m3/ha/a circa. Qui definito a 0.5 |
| 3231 | Macchia alta | | | | Aree a funzione protettiva. Non è previsto sfruttamento. Da confermare per macchia alta |
| 3232 | Macchia bassa e garighe | | | | Aree a funzione protettiva. Non è previsto sfruttamento |
| 112 | Residenziale discontinuo | 0.17 | 0.23 | 0.28 | Studio in Slovenia indica 0.5 m3/ha/a circa. Qui definito a 0.3 per mggiore intensità abitativa |
| 333 | Aree con vegetazione rada | 0.11 | 0.15 | 0.19 | Tipologia poco chiara |
| 122 | Reti stradali, ferrovie, infrastrutture | | | | Potenzialmente interessante per le pendici a robinia (o altro) di molte autostrade e ferrovie |
| 212 | Seminativi in aree irrigue | 0.03 | 0.04 | 0.05 | |
| 213 | Risaie | 0 | 0 | 0 | |
| 2111 | Colture intensive | 0.03 | 0.04 | 0.05 | |
| 2112 | Colture estensive | 0.06 | 0.08 | 0.09 | |
| 411 | Paludi interne | 0.06 | 0.08 | 0.09 | |
| 412 | Torbiere | 0.06 | 0.08 | 0.09 | |
| 111 | Residenziale continuo | 0.06 | 0.08 | 0.09 | |
| 121 | Industriali | 0.06 | 0.08 | 0.09 | |
| 123 | Aree portuali | 0 | 0 | 0 | |
| 124 | Aeroporti | 0 | 0 | 0 | |
| 131 | Aree estrattive | 0.11 | 0.15 | 0.19 | |
| 132 | Discariche | 0.11 | 0.15 | 0.19 | |

| | | | | | |
|---|---|---|---|---|---|
| **133** | **Cantieri** | **0.11** | **0.15** | **0.19** | |
| **331** | **Spiagge, dune e sabbie** | **0** | **0** | **0** | |
| **332** | **Rocce nude, falesie, rupi, affioramenti** | **0** | **0** | **0** | |
| **335** | **Ghiacciai e nevi perenni** | **0** | **0** | **0** | |
| **421** | **Paludi salmastre** | **0** | **0** | **0** | |
| **422** | **Saline** | **0** | **0** | **0** | |
| **511** | **Corsi d'acqua, canali e idrovie** | **0** | **0** | **0** | |
| **512** | **Bacini d'acqua** | **0** | **0** | **0** | |
| **521** | **Lagune** | **0** | **0** | **0** | |
| **522** | **Estuari** | **0** | **0** | **0** | |
| **523** | **Mari e oceani** | **0** | **0** | **0** | |

..

## APPENDIX 4: STRUCTURE OF MUNICIPALITY GEODATABASE

| | |
|---|---|
| **Shape** | |
| **ISTAT** | |
| **ISTAT_txt** | |
| **NOME** | |
| **N_ISTAT** | |
| **SIGLAPROV** | |
| **PROVINCIA** | |
| **SIGLAREG** | |
| **COD_REGION** | |
| **REGIONE** | |
| **OLD_ISTAT** | |
| **NAZIONE** | |
| **ZONA_ALT** | **1 = montagna interna; 2 = montagna litoranea; 3 = collina interna; 4 = collina litoranea; 5 = pianura** |
| **Morfo_ER** | **Aree morfologiche regionali: p=pianura; ap=alta pianura; marap=margine appenninico; bap=basso Appennino; map=medio App.; aap=alto App.** |
| **DEGREEURB** | **1 = basso; 2 = intermedio; 3 = elevato** |
| **FAM_2003** | **Numero di famiglie 2003** |
| **FAM_U_99** | **Frazione famiglie utilizzatrici di biomassa per energia al 2003 basato su ENEA99** |
| **FAM_U_97** | **Frazione famiglie utilizzatrici di biomassa per energia al 2003 basato su ENEA97** |
| **F_U_97_99** | **Frazione famiglie utilizzatrici di biomassa per energia al 2003 basato su media ENEA97-99** |
| **CONS_FAM99** | **Consumo medio annuo per famiglia (utilizzatrice e non) al 2003 basato su ENEA99 (t/a) - combustibili vegetali** |
| **CONS_FAM97** | **Consumo medio annuo per famiglia (utilizzatrice e non) al 2003 basato su ENEA97 (t/a) - combustibili vegetali** |
| **C_F_MEDIO** | **Consumo medio annuo per famiglia (utilizzatrice e non) al 2003 basato su media ENEA97-99 (t/a) - combustibili** |
| **CON_F_UT99** | **Consumo annuo per famiglia utilizzatrice al 2003 basato su ENEA99 (t/a) - combustibili vegetali** |
| **CON_F_UT97** | **Consumo annuo per famiglia utilizzatrice al 2003 basato su ENEA97 (t/a) - combustibili vegetali** |
| **CON_F_U_ME** | **Consumo annuo per famiglia utilizzatrice al 2003 basato su media ENEA97-99 (t/a) - combustibili vegetali** |
| **CONS_T_97** | **Consumo domestico totale al 2003 basato su ENEA97(t/a) - combustibili vegetali** |
| **CONS_T_99** | **Consumo domestico totale al 2003 basato su ENEA99 (t/a) - combustibili vegetali** |
| **CONS_T_MED** | **Consumo domestico totale al 2003 basato su media ENEA97-99 (t/a) - combustibili vegetali** |
| **CON_L_F_99** | **Consumo medio annuo per famiglia (utilizzatrice e non) al 2003 basato su ENEA99 (t/a) - legna** |
| **CON_L_F_97** | **Consumo medio annuo per famiglia (utilizzatrice e non) al 2003 basato su ENEA97 (t/a) - legna** |
| **C_L_F_MED** | **Consumo medio annuo per famiglia (utilizzatrice e non) al 2003 basato su media ENEA97-99 (t/a) - legna** |
| **C_L_F_UT99** | **Consumo annuo per famiglia utilizzatrice al 2003 basato su ENEA99 (t/a) - legna** |
| **C_L_F_UT97** | **Consumo annuo per famiglia utilizzatrice al 2003 basato su ENEA97 (t/a) - legna** |
| **C_L_F_U_ME** | **Consumo annuo per famiglia utilizzatrice al 2003 basato su media ENEA97-99 (t/a) - legna** |
| **C_L_T_97** | **Consumo domestico totale al 2003 basato su ENEA97(t/a) - legna** |
| **C_L_T_99** | **Consumo domestico totale al 2003 basato su ENEA99 (t/a) - legna** |
| **C_L_T_MED** | **Consumo domestico totale al 2003 basato su media ENEA97-99 (t/a) - legna** |
| **ab_cen_ab** | **abitanti dei centri abitati (centri_abitati_wgs.shp, anno di rif. non disponibile) usati per spazializzare i consumi** |
| **pix_ab_0** | **Numero pixels di centri urbani (expanded 2) nei comuni senza abitanti nel raster a 300 usati per spazializzare i** |
| **Cons_proxy** | **Proxy di spazializzazione (numero abitanti centri abitati o numero pixels di centri abitati o numero pixels dei 2 comuni** |
| **con_min_prx** | **consumo MINIMO per proxy value [abitante et al] (C_L_T_99/cons_proxy) al 2003, valore usato per spazializzare i** |
| **con_med_prx** | **consumo MEDIO per proxy value [abitante et al] (C_L_T_med/cons_proxy) al 2003, valore usato per spazializzare i** |
| **con_max_prx** | **consumo MASSIMO per proxy value [abitante et al] (C_L_T_97/cons_proxy) al 2003, valore usato per spazializzare i** |
| **MIN_prod_t** | **Produttività di biomassa legnosa disp. ad usi energetici - somma classi Clc4 nel comune (solo fonti dirette) - valori** |
| **MED_prod_t** | **Produttività di biomassa legnosa disp. ad usi energetici - somma classi Clc4 nel comune (solo fonti dirette) - valori** |
| **MAX_prod_t** | **Produttività di biomassa legnosa disp. ad usi energetici - somma classi Clc4 nel comune (solo fonti dirette) - valori** |
| **MIN_ac_p_t** | **Produttività ACCESSIBILE di biomassa legnosa disp. ad usi energetici - somma classi Clc4 nel comune - valori minimi** |
| **MED_ac_p_t** | **Produttività ACCESSIBILE di biomassa legnosa disp. ad usi energetici - somma classi Clc4 nel comune - valori medi** |
| **MAX_ac_p_t** | **Produttività ACCESSIBILE di biomassa legnosa disp. ad usi energetici - somma classi Clc4 nel comune - valori massimi** |
| **Bal_med_med** | **Bilancio produttività accessibile MEDIA (MED_ac_p_t) - consumi domestici di legna MEDI (C_L_T_MED) - Accessibilità** |
| **Bal_max_min** | **Bilancio produttività accessibile MASSIMA (MAX_ac_p_t) - consumi domestici di legna MINIMI (C_L_T_99) -** |
| **Bal_min_max** | **Bilancio produttività accessibile MINIMA (MIN_ac_p_t) - consumi domestici di legna MASSIMI (C_L_T_97) -** |
| **TOT_IMP_L** | **Numero industrie di lavorazione del legno (ISTAT cens 2001)** |
| **ADDET_I_L** | **Numero addetti nelle industrie di lavorazione del legno (ISTAT cens 2001)** |
| **RESID_MIN** | **Stima minima residui dell'industria del legno al 2001 a 13.2 t /addetto/anno (APAT 30/2003)** |
| **RESID_MAX** | **Stima massima residui dell'industria del legno al 2001 a 20.6 t /addetto/anno (APAT 30/2003)** |
| **RESID_MED** | **Stima media residui dell'industria del legno al 2001 a 16.9 t /addetto/anno (derivato da APAT 30/2003)** |
| **RES_EN_Min** | **Stima minima residui utilizzati per energia nell'industria del legno al 2001 (17% Resid_min) (APAT 30/2003)** |
| **RES_EN_MAx** | **Stima massima residui utilizzati per energia nell'industria del legno al 2001 (65% Resid_max) (APAT 30/2003)** |
| **RES_EN_MEd** | **Stima media residui utilizzati per energia nell'industria del legno al 2001 (41% Resid_med) (derivato da APAT** |
| **Energy_crop** | **Colture energetiche dedicate t.s.s.** |

| | |
|---|---|
| **Res_agro** | **Residui agricoli sui siti di coltivazione e raccolta t.s.s.** |
| **Res_agrind** | **Residui delle industrie agroalimentari t.s.s.** |
| **Res_zootec** | **Produzione di liquami zootecnici (m3)** |
| **Cons_Ind** | **Consumo biomasse nel settore industriale (escluse industrie del legno)** |
| **Cons_Comm** | **Consumo biomasse nel settore commerciale** |
| **Cons_CHP** | **Consumo biomasse nel settore energetico per produzione e vendita di energia elettrica e termica** |
| **p_lux** | **Attitudine dei comuni alla produzione di PIOPPO LUX in aree SANU 0=neglig.;1=bassa; 2=medio-bassa; 3=medio-** |
| **p_I_214** | **Attitudine dei comuni alla produzione di PIOPPO I-214 in aree SANU 0=neglig.;1=bassa; 2=medio-bassa; 3=medio-** |
| **p_BL_C** | **Attitudine dei comuni alla produzione di PIOPPO BL-C in aree SANU 0=neglig.;1=bassa; 2=medio-bassa; 3=medio-** |
| **Robinia** | **Attitudine dei comuni alla produzione di ROBINIA in aree SANU 0=neglig.;1=bassa; 2=medio-bassa; 3=medio-alta;** |
| **Proposed_BD** | **Impianti proposti/offerti come possibili centri di biodistretti** |

**Shape_Length**
**Shape_Area**

## APPENDIX 5: BIOENERGY TERMS AND DEFINITIONS

Selection of most relevant terms from the Unified Bioenergy Terminology (FAO, 2005)

| | |
|---|---|
| **agrofuels** | biofuels obtained as a product of energy crops and/or agricultural by-products (including agro-industrial by-products and animal by-products) |
| **bioenergy** | energy from biofuels |
| **biofuel** | fuel produced directly or indirectly from biomass |
| **biomass** | material of biological origin excluding material embedded in geological formations and transformed to fossil |
| **black liquor** | alkaline spent liquor obtained from digesters in the production of sulphate or soda pulp during the process of paper production, in which the energy content is mainly originating from the content of lignin removed from the wood in the pulping process |
| **densified biofuel, compressed biofuel** | solid biofuel made by mechanically compressing biomass to increase its density and to mould the fuel into a specific size and shape such as cubes, pressed logs, biofuel pellets or biofuel briquettes |
| **energy crops, fuel crops** | woody or herbaceous crops grown specifically for their fuel value |
| **fuel** | energy carrier intended for energy conversion |
| **fuelwood** | woodfuel where the original composition of the wood is preserved |
| **gross calorific value (qgr)** | absolute value of the specific energy of combustion, in joules, for unit mass of a solid fuel burned in oxygen in calorimetric bomb under the conditions specified. The result of combustion are assumed to consist of gaseous, oxygen, nitrogen, carbon dioxide and sulphur dioxide, of liquid water (in equilibrium with its vapour) saturated with carbon dioxide under conditions of the bomb reaction, and of solid ash, all at the reference temperature and at constant volume. Old term is higher heating value. |
| **net calorific value (qnet)** | under such conditions that all the water of the reaction products remains as water vapour (at 0.1 MPa), the other products being as for the gross calorific value, all at the reference temperature. The net calorific value can be determined at constant pressure or at constant volume. Old term is lower heating value. Net calorific value as received (qnet,ar) is calculated by the net calorific value from dry matter (qnet,d) and the total moisture as received. |
| **renewable energy** | consists of energy produced and/or derived from sources infinitely renovated (hydro, solar, wind) or generated by combustible renewables (sustainably produced biomass); usually expressed in energy units and, in the case of fuels, based on net calorific values. |
| **wood energy, forest energy** | energy derived from woodfuels corresponding to the net calorific value of the fuel |
| **wood energy systems** | All the (steps and/or) unit processes and operations involved for the production, preparation, transportation, marketing, trade and conversion of woodfuels into energy |
| **woodfuels, wood based fuels, wood-derived biofuels** | all types of biofuels originating directly or indirectly from woody biomass |

## APPENDIX 6: OVERVIEW ON THE MOST IMPORTANT BIOMASS SUPPLY SOURCES

### "Dry" biomass "Moist" biomass

| Material classes | Sources | Examples |
|---|---|---|
| **woody biomass** | forest and plantation wood | energy forest trees |
| | | energy plantation trees |
| | | short rotation trees |
| | | thinning by-products |
| | | logging by-products |
| | | complete tree |
| | | whole tree |
| | | tree section |
| | | slabs |
| | | shrubs |
| | | stumps |
| | | bark |
| | wood processing industry by-products | edgings |
| | | cross-cut ends |
| | | wood shavings |
| | | grinding dust |
| | | saw dust |
| | | particle/fibre board by-products |
| | | plywood by-products |
| | | cork production by-products |
| | | viscose by-products |
| | | fibre sludge |
| | | black liquor |
| | used wood | demolition wood |
| | | recovered construction wood |
| | | woody bulk waste |
| | | used paper |
| **herbaceous biomass** | energy crops | energy grass |
| | | energy whole cereal crops |
| | agricultural by-products | straw |
| | agro-industrial by-products | bagasse |
| | | textile industry by-products |
| | end use material | used clothes |
| | | used insulation material |
| **biomass from fruits and seeds** | energy crops | energy grain |
| | agricultural by-products | stones |
| | | shells |
| | | husks |
| | agro-industrial by-products | oil extraction meal |
| | | brewery by-products |
| | | starch processing industry by-products |
| | | Vegetables and fruit processing |
| | end use material | used vegetable oil |
| **others /mixtures** | animal by-products | dung |
| | | manure |
| | | poultry waste |
| | horticultural by-products | bushes |
| | landscape management by-products | road side green |
| | | protected areas management by-products |
| | agro-industrial by-products | slaughterhouse by-products |
| | | bio-sludge |
| | end use material | kitchen waste |
| | | sewage sludge |
| | | bone meal |