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# Removing barriers to Biomass District Heating Projects in Slovenia

## Analysis of Wood Biomass Potential in Slovenia

**FINAL REPORT**

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# CONTENCE

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# 1 PROBLEM DEFINITION

## 1.1 Introduction

Slovenia is a country poor in fossil fuels, in particular those of high-quality. The existing energy system based on hydroelectric stations is largely exploited, and, for various reasons, the Krško nuclear power plant is posing problems either. Due to Slovenia's specific natural conditions in the Alpine and Sub-alpine area, the environment is very vulnerable, which makes the construction of new power plants both a demanding and costly intervention. Slovenia's dependency on imported energy has reached as much as 75%, although it should not exceed 65 %. The use of energy per inhabitant is within the average in the European Union, while the consumption per unit of GNP is 2,5 times higher, which means that energy is not used as efficiently as in the EU. With respect to this situation, it is understandable that the Resolution on Efficient Energy Supply and Use in Slovenia (1996) gives special emphases to the improvement of efficiency, and to the increase of consumption through renewable energy sources. Among the renewable and alternative sources, particular attention is made of wood biomass, which is, in fact, the only natural source of energy in which Slovenia abounds. The important advantages of this energy source are traditional use, general and scattered occurrence, private ownership, as well as the possibility of ecologically acceptable use. Therefore, the Resolution anticipates in its guidelines that its present share of 4 to 5% in primary energy should double by the year 2010. Beside an increased efficiency in the use of wood biomass in many small private fireplaces, this should be reached through the construction of thermal power plants for local district heating, which would produce heating and electrical energy at the same time.

Key components for planning and realising the increased use of wood biomass on different levels are the qualitative and quantitative analyses of the available sources. Such analyses are necessary both in establishing the national energy balance and in planning and constructing the relevant thermal power plants. The sources, quantities, structures and kinds of the biomass potential must be assessed and analysed in time and space, and so must the parameters which are important for the actual planning, and the permanent, reliable and high-quality operation of the planned power plant. In Slovenia, the four main groups of biomass sources for energy purposes are: residues from industrial (mechanical and chemical) completion and treatment of wood; forests; abandoned and overgrown agriculture land; and used wood and wood products. In planning the exploitation of biomass in thermal power plants for local district heating, the most important factor are residues from the wood processing industry. These residues are obtained locally in large quantities, and do not need to be collected and transported over long distances. As they mostly represent waste at the place of production, they represent the least expensive energy source at the place of production. The remaining three biomass source groups should guarantee the operational stability of power plants although they are dispersed and require additional inputs in work and/or time hence they are more expesive.

## 1.2 Project goals

Several studies have been conducted in the area of the wood biomass potential in Slovenia. For the time being, however, an extensive and planned introduction of local district heating systems based on wood biomass has not been carried out. One of the reasons for this is the

absence of knowledge and incorrect estimation of barriers in wood biomass supply, and of the processes for their removal. The goals of the present project are as follows:

1 **Analysis of the available databases regarding biomass potential appropriate for the local district heating plants in Slovenia.**
2 **Determination of the prospective regions in Slovenia appropriate for sustainable supply of the wood biomass.**
3 **Identification of the major barriers from the forestry and wood industry with the proposals for their removal.**

# 2 PROJECT SCOPE AND METHODS

The project scope comprises the analysis of residues from industrial (mechanical and chemical) completion and treatment of wood, available sources of wood biomass from forests, and wood biomass from abandoned and overgrown agricultural areas (brushwood). Due to close project deadlines it does, however, not comprise an analysis of quantities and locations of waste from used wood and wood products, or (considerable) amounts of wood waste from other sectors (railway, mail, construction industry), although the quantities of this energy source may account for an essential contribution to the supply of heating plants with wood biomass.

## 2.1 Industrial sector

The available potential of wood biomass involve, in particular, most important enterprises which engage in primary, secondary and tertiary wood treatment. In the primary, secondary and tertiary treatment of wood, waste is produced of which the value of use varies a great deal. As we were interested in the amount of available residues from the wood processing industry, we tried to collect all possible data on the quantities of input primary material and of wood residues obtained in the production process. With respect to the project's deadlines, we chose the method of collecting and analysing the available databases which contained data on business subjects engaging in wood processing. For this purpose, we turned to the Statistics Office of the Republic of Slovenia, as well as to other organisations which collect data. Unfortunately, we soon had to realise that, in Slovenia:

- There is no database which offers satisfactory information on the wood processing industry,
- No detailed register on the quantities of wood resources entering production processes is administered, nor a register of output residues or waste quantities,
- The quantity of input raw materials is surveyed only for companies or enterprises engaging in processing, and employing 10 or more persons; according to data from the Statistics Office of the Republic of Slovenia, there are only 171 such enterprises in Slovenia.

Residues which occur in production are surveyed only for certain companies which were chosen as samples. The register of companies engaging in the primary processing of wood is

administered by a private company. The database has, therefore, the inconvenience of being established for the companies' commercial presentation to the public, and not for surveying production quantities, so that it contains only data on the capacities of the individual companies, and not on their actual production.

## 2.2 Forestry sector

The goals of our forestry analysis were as follows:

- Analysing data on forest areas in municipalities,
- Studying the forestry potential in these municipalities (wood stock, wood stock incrementation and balance),
- Studying the realisation of fellings, and the analytical processing of this data according to population density.

Data on the forestry sector was obtained at the Slovenia Forest Service, from the following data bases:
1 - forest register,
2 - register of cuttings for 1995, 1996 and 1997.

All data was compiled at the level of cadastral communities. For the project's final report, the data was assembled at a municipality level (147 municipalities). It is important to know that, at the time of the project's emergence, Slovenia was split into new municipalities, and there will be 39 more municipalities. With regard to the fact that we have data bases for every cadastral municipality, we could prepare additional analyses for possible new projects.


## 2.3 Abandoned agricultural land

### 2.3.1 Causes and processes of overgrowing agricultural land

The territory of Slovenia belongs to the moderate climate zone. Without anthropogenic influences, more than 90% of Slovenia would be covered by forests. The emergence and existence of agricultural ecosystems is subject to a permanent input of energy through animals, humans or machines. If the source of additional energy dries up, all of these artificial ecosystems, in the process of natural succession, gradually change into natural ecosystems, or - in our climate conditions - into forests. A characteristic intermediate step in this succession process is the different development phases of tree and brushwood vegetation on abandoned agricultural land; this is normally called the "*overgrowing of agricultural land*".

Various factors have an impact on the manner, composition and intensity of the overgrowing of agricultural land which is (being) abandoned: the previous use; the manner of abandoning (sudden, gradual); natural conditions; the proximity and type of a source for possible natural seeding; wind forces and directions; presence of animals; etc. The speed of overgrowing is greater, with more variety, on fertile locations than on dry and shallow soil. Under favourable conditions, this process evolves very quickly and lasts less than a decade; it may, on the other hand, last several decades under less favourable conditions. In Slovenia most overgrown areas used to be pastures and meadows, and not so much grassland or fields.

### 2.3.2 Methods of determination wood potentials from abandoned agricultural land

As a logical consequence of the incomplete policy regarding the use of abandoned and overgrown agricultural areas, data for assessing the potential - especially updated data - is incomplete and insufficient. This holds true for brushwood both on agricultural land and in forests, the only difference being that, for brushwood in forests, surfaces are known as they are registered in the forestry plans as a special economic forest category. However, here also the remaining necessary indicators, such as wood stock, increment and structure do not exist. The bases for an actual assessment of the biomass potential in brushwood here are: wood stock; increment; location; present and planned use; with the appropriate measures. We could only receive partial data from different specialist and scientific sources, established according to different methods, with varying purposes and goals, and on different levels (national, regional, local) for different periods.

Among the existing sources which directly or indirectly treat the issue of overgrowing agricultural areas, we chose the data from the '**Agromap**' project as the basis of our analysis. The Agromap project is an extensive and demanding project which was performed under the technical guidance of the Agricultural Institute of Slovenia from 1985 to 1990. With respect to the high professional qualification of the specialists who established the methodology and technical instructions of the project (Agricultural Institute, 1987), and to the experience of the operative co-operators, we believe the project to be an appropriate basis for our analysis, despite some deficiencies, such as a lack of updated data. We verified all data anew, and eliminated the established data in most cases, together with the former project leader.

The necessary data selected for our analyses from the Agromap was compared to the relevant data from some other sources. For different reasons (use of different methods, different goals and purposes, obsolete data, different levels of treatment - according to forestry areas, or in total for the state), comparisons were possible mostly for information, and could only partially be used as an auxiliary basis for the assessment of average values of some parameters. Among the existing and accessible databases and written sources which served comparative purposes, we used the following:

**BOŽIČ, J. / KOŠIR, Ž., 1978. Malodonosni gozdovi, grmišča in kmetijska zemljišča določena za gozd ter recentne regresije v gozdovih - Preglednice. Inštitut za gozdno in lesno gospodarstvo, Ljubljana. (Forests yielding little profit, brushwood, agricultural plots intended for forestry and timber economy, and recent regressions in forests - tables. Institute for Forestry and Wood Economy, Ljubljana)** The goal of this study was to allow for a planned access to activating the natural potential of forests, from the viewpoints of forest biology and the economy. The areas, wood stocks in ha and the increment, was established for the individual categories mentioned in the title, separately for conifers and deciduous trees, according to forestry areas, ownership, and in total for Slovenia. 33,724 ha of brushwood were established, with an average wood stock of about 61 $m^3$/ha, and an increment of 2 $m^3$/ha. We must point out here that only stocks and increments of trees above the measurement threshold have been considered (more than 10 cm in breast-height diameter), signifying that these numbers do not include one third of stocks and increments, at least. The area covered by brushwood on abandoned agricultural surfaces amounted to 2,354 ha, and its stock and increment have not been assessed. Considering outdated data from this study (20 years old), the dynamism of brushwood development, the difference in social and forestry conditions, as well as different methods, interests and goals of both sectors (forestry - agriculture), the discrepancy in surfaces

between the two compared databases becomes transparent. For our analysis, data on stocks and increments in ha are useful.

---------, **Kategorizacija kmetijskih zemljišč v Sloveniji. (Classification of agricultural plots in Slovenia)** At the beginning of the eighties, the agricultural plots of Slovenia were classified, and 127.418 ha of agricultural plots were entered in the 6th category (comprising plots where the possibility of agricultural use is much reduced due to soil inclination, and overgrowing plots).

**ŽONTA, I., 1982. Opuščanje in zaraščanje kmetijskih zemljišč ter spreminjanje namembnosti rabe plodnih zemljišč. Elaborat. Inštitut za gozdno in lesno gospodarstvo, Ljubljana. (The process of abandoning and overgrowing of agricultural plots, and change of use of fertile plots. Expert's report. Institute for Forestry and Wood Economy, Ljubljana)** According to this study, 70.101 ha of agricultural plots were established as (being) abandoned, 50.302 ha showed an initial phase of overgrowing, and 40.136 ha were fully overgrown agricultural areas. The total of overgrowing and overgrown areas, i.e. 90.438 ha comes fairly close to the relevant area from the Agromap (95.119 ha), which was considered in our analysis.

**AZAROV, E. / ČAMPA, L., 1990. Prostorska analiza negozdnih površin. Raziskovalna naloga. Inštitut za gozdno in lesno gospodarstvo, Ljubljana. (Spatial analysis of non-forest areas. Research work. Institute for Forestry and Wood Economy, Ljubljana)** According to this study, in 1990, there were between 130 thousand and 160 thousand ha of overgrown agricultural area in Slovenia. The assessment was made on the basis of a sample of 14 municipalities from the Agromap, and corrected with data from the Žonta study (1982). Considering the medium of mentioned surface intervals, and subtracting the non-respected protective areas (barrier woodland) from the Agromap (64.000 ha) in our analyses, we are again approaching our findings.

**UN - ECE /FAO, 1997. Temperate and Boreal Forest Resources Assessment 2000. Country Slovenia. Slovenian Forestry Institute, Ljubljana.** In this study, the area covered by non-forest brushwood was assessed to 67.000 ha, the biomass above ground to 6.380 mill. tons, with an annual increment of above 46,000 tons. If we add forest brushwood (15.654 ha) to this area, we receive a total area which is 12.000 ha smaller than in our analyses. The difference may be explained by an entirely different method of assessment dictated by the customer.

---------, **1997. Vzorčni popis osnovnih zmogljivosti kmetij, 1997 - Predhodni podatki. Zemljišča po zemljiških kategorijah v uporabi družinskih kmetij in kmetijskih podjetij. Statistične informacije št. 298 / 1997. Statistični urad RS, Ljubljana. (1997 Sample census of basic capacities of farms - Previous data. Land plots according to land categories used by family farms and agricultural enterprises. Statistical information No. 298 / 1997. Statistics Office of the Republic of Slovenia, Ljubljana).** On the basis of a sample census of family farms and agricultural enterprises, of the 466.589 ha of used agricultural plots 59.882 ha (13%) of agricultural plots are overgrowing. If we apply the same share to all tilled plots in Slovenia (614.692 ha - Statistical annual report of the Republic of Slovenia for 1997, group of plot categories and field crops, p. 258), we receive an area of 79.910 ha of overgrowing plots. Adding forest brushwood (15.600 ha) to this number, we get close to our estimation of relevant areas.

---------, **Analiza grmišč. Strokovna naloga. Gozdno gospodarstvo Kočevje, Kočevje. (Analysis of brushwood. Expert's report. Forestry of Kočevje)** The study shows the methods and conclusions of research of biomass quantity and structure in different kinds and developmental phases of brushwood. Measurements of the entire tree mass above ground, including brushwood, were performed by sampling on 22 permanent experimental

plots. The established wood mass quantities varied between 17,5 $m^3$/ha (initial phase of brushwood - pastures starting to overgrow), and 363,2 $m^3$/ha in brushwood turning to wood. We utilised the conclusions for our assessment of the biomass potential in brushwood.

**ŽGAJNAR, L / KOŠIR, B. / GREGORIČ, T., 1992. Količinski, tehnološki in ekonomski vidiki ter možnosti izboljšanja oskrbe z lesno surovino za iverne plošče v podjetju BREST Cerknica. (Quantitative, technological and economic viewpoints, and possibilities of improving the supply with wood resources for chipboards in the BREST Cerknica company.)**

**ŽGAJNAR, L. / BITENC, B., 1994. Količinska, strukturna, prostorska in energijska ocena stanja rabe lesne biomase v slovenski energetiki. Elaborat. Gozdarski inštitut Slovenije, Ljubljana. (Assessment of present situation of use of wood biomass in the Slovenian energy economy, regarding quantities, areas and structure)**

**ŽGAJNAR, L. / BITENC, B., 1996. Količinska, strukturna, prostorska in energijska ocena potencialov lesne biomase za energijske namene v Sloveniji. Elaborat. Gozdarski inštitut Slovenije, Ljubljana. (Assessment of the wood biomass potential for energy purposes in Slovenia, regarding quantities, areas and structure)**

In all three above-mentioned studies, the conclusions of research in quantities and structure of the wood biomass potential from 1992 - established through measurements on experimental plots, in different developmental phases of brushwood, and in different regions of Slovenia - were used. In the early developmental phases (10 to 20 years) of brushwood, we established an average of 68,1 $m^3$/ ha including the total potential, and 36,8 $m^3$/ha biomass with more than 5 cm in diameter (exploitable). In relatively old brushwood (20 to 40 years), the overall potential was 172,3 $m^3$/ha, with 123,9 $m^3$/ha being exploitable. These conclusions served as a basis for comparisons in the our research work.

## 2.4 Data verification

The fundamental database on primary and secondary wood processing, including the obtained residues, used in our analysis, was provided by the Statistics Office of the Republic of Slovenia (data from 1995). We are dealing with data which the companies and independent enterprises with more than 10 employees are obliged to send in their annual report to the Statistics Office.

To assess the value or reliability of such data, we conducted a survey in the area of the municipalities of Nova Gorica, Kanal, Bovec and Tolmin, involving 9 wood processing companies (5 companies with primary processing, 4 companies with secondary processing) where we questioned the leading personnel. For this purpose, we had prepared a questionnaire where we entered general data and data on the quantity and structure of wood production, including the use of wood resources and the obtained wood residues in 1997. We were particularly interested in an assessment of the company's performance in the last 5 years, and the planned development for the future. The leading personnel also consented to give us insight into the data on the quantities of used wood resources and wood production for 1992, 1995 and 1996, which was sent in their yearly report to the Statistics Office of the Republic of Slovenia. For additional comparisons, the results of the BIZJAK 1998 (graduation thesis) were included, involving the same 9 wood processing companies in the survey (data are valid for 1996).

## 2.5 Integral data evaluation

The synthesis of the collected data was planned, according to their anticipated quality, in three phases:

1 Selection of key indicators, calibration of indicators respecting the characteristics of municipalities (size, forest area, etc.), classification of indicators.
2 Comparison of place of origin and of consumption of wood biomass, well as assessment of the net (i.e. not exploited) potential in municipalities.
3 Establishment of the net potential with respect to the programmed changes in the exploitation of the sources.

The actual quantity and quality of, as well as access to the necessary data effectively prevented our evaluation of point 3, and, to some extent, also of point 2. We therefore focused on different levels of data compilation, as well as on a presentation of the collected data by area. The basic level of compilation was set by the municipalities, from 1/1/1995 to 1/8/1998, when the then 147 communities were split into 186 communities. The next level of compilation was the statistical regions, and the final level the state.

The selected parameters for a synthesis of the potential were as follows:

1 **Number of business entities from the area of wood processing in the municipality,**
2 **Documented quantities of wood residues (based on accessible data) in the municipality,**
3 **Forest in ha per inhabitant in the municipality,**
4 **Quantity ($m^3$)of documented cuttings per inhabitant in the municipality, as well as**
5 **Agricultural and forest brushwood area in ha per inhabitant in the municipality.**

Every listed indicator was classified according to a uniform scale between 1 and 6 (in 6 classes), the average class was calculated, and later the municipalities were reclassified into the 6 classes. In this manner, we were able to keep the demanded secrecy of individual data according to the municipalities, while we could perform a quantitative and spatial comparison between the municipalities. As a rule, absolute values of parameters were shown collectively according to statistical regions.

In the following, we present a table with the municipalities (1995) including general data used in our analyses and graphs.

Table 1: Municipalities (1995) and general data used in our research work

| Munic. Code | Name of Municipality | Regional code | No. of Settlements | Surface of Municip. | No. of inhabitants | % of farming population | No. of Subjects from the area of wood processing |
|---|---|---|---|---|---|---|---|
| 1 | AJDOVŠČINA | 11 | 45 | 24523 | 17500 | 8,3 | 53 |
| 2 | BELTINCI | 1 | 8 | 6225 | 8655 | 21,6 | 26 |
| 3 | BLED | 9 | 22 | 18851 | 10986 | 4,1 | 45 |
| 4 | BOHINJ | 9 | 23 | 33373 | 5195 | 7,9 | 16 |
| 5 | BOROVNICA | 8 | 12 | 4232 | 3694 | 4,4 | 5 |
| 6 | BOVEC | 11 | 13 | 36732 | 3358 | 6,8 | 11 |
| 7 | BRDA | 11 | 45 | 7197 | 5798 | 23,6 | 11 |
| 8 | BREZOVICA | 8 | 16 | 9117 | 8481 | 4 | 28 |
| 9 | BREŽICE | 6 | 109 | 26811 | 24456 | 14,9 | 50 |
| 10 | CANKOVA-TIŠINA | 1 | 20 | 6940 | 6604 | 26,2 | 7 |
| 11 | CELJE | 4 | 39 | 9490 | 50023 | 1,7 | 89 |
| 12 | CERKLJE NA GORENJSKEM | 9 | 30 | 7804 | 6079 | 13,3 | 22 |
| 13 | CERKNICA | 10 | 65 | 24131 | 10184 | 6,9 | 41 |
| 14 | CERKNO | 11 | 28 | 13159 | 5197 | 9 | 30 |
| 15 | ČRENŠOVCI | 1 | 9 | 5236 | 6124 | 21,5 | 21 |
| 16 | ČRNA NA KOROŠKEM | 3 | 9 | 15596 | 3856 | 5,4 | 10 |
| 17 | ČRNOMELJ | 7 | 118 | 33966 | 14673 | 11,3 | 13 |
| 18 | DESTRNIK-TRNOVSKA VAS | 2 | 31 | 7485 | 5061 | 29,2 | 36 |
| 19 | DIVAČA | 12 | 32 | 14778 | 3767 | 4,6 | 4 |
| 20 | DOBREPOLJE | 8 | 27 | 11816 | 3535 | 11,3 | 35 |
| 21 | DOBROVA-HORJUL-POLHOV | 8 | 42 | 15003 | 8687 | 11,4 | 29 |
| 22 | DOL PRI LJUBLJANI | 8 | 19 | 3328 | 3981 | 6,2 | 15 |
| 23 | DOMŽALE | 8 | 49 | 8119 | 31583 | 2,3 | 84 |
| 24 | DORNAVA | 2 | 12 | 2840 | 2640 | 17,6 | 3 |
| 25 | DRAVOGRAD | 3 | 24 | 10500 | 8644 | 7 | 36 |
| 26 | DUPLEK | 2 | 10 | 3998 | 5972 | 10,2 | 9 |
| 27 | GORENJA VAS-POLJANE | 9 | 72 | 14913 | 6488 | 14,2 | 27 |
| 28 | GORIŠNICA | 2 | 24 | 6117 | 6076 | 21,5 | 6 |
| 29 | GORNJA RADGONA | 1 | 51 | 12810 | 13179 | 15,4 | 27 |
| 30 | GORNJI GRAD | 4 | 7 | 9010 | 2732 | 19,9 | 19 |
| 31 | GORNJI PETROVCI | 1 | 14 | 6684 | 2529 | 44,3 | 5 |
| 32 | GROSUPLJE | 8 | 66 | 13379 | 14427 | 7,7 | 61 |
| 33 | HODOŠ-ŠALOVCI - HODOS- | 1 | 8 | 7628 | 2433 | 40,9 | 3 |
| 34 | HRASTNIK | 5 | 19 | 5858 | 10686 | 0,9 | 13 |
| 35 | HRPELJE-KOZINA | 12 | 38 | 19220 | 4039 | 7,5 | 10 |
| 36 | IDRIJA | 11 | 35 | 29370 | 11924 | 5,9 | 51 |
| 37 | IG | 8 | 21 | 9876 | 4839 | 8,5 | 10 |
| 38 | ILIRSKA BISTRICA | 10 | 63 | 48001 | 14467 | 8,3 | 39 |
| 39 | IVANČNA GORICA | 8 | 137 | 22701 | 12644 | 13,2 | 35 |
| 40 | IZOLA - ISOLA | 12 | 8 | 2856 | 14111 | 1,4 | 34 |
| 41 | JESENICE | 9 | 21 | 11842 | 26208 | 0,4 | 33 |
| 42 | JURŠINCI | 2 | 13 | 3626 | 2393 | 27,7 | 1 |
| 43 | KAMNIK | 8 | 116 | 28970 | 29421 | 5 | 99 |
| 44 | KANAL | 11 | 19 | 14653 | 6347 | 5,3 | 14 |
| 45 | KIDRIČEVO | 2 | 18 | 7150 | 6723 | 15,8 | 10 |
| 46 | KOBARID | 11 | 32 | 19273 | 4726 | 7,3 | 8 |
| 47 | KOBILJE | 1 | 1 | 1974 | 651 | 28 | 5 |
| 48 | KOČEVJE | 8 | 135 | 59646 | 17294 | 3,1 | 53 |

Table 1(continued) : Municipalities (1995) and general data used in our research work

| Munic. Code | Name of Municipality | Regional code | No. of Settlements | Surface of Municip. | No. of inhabitants | % of farming population | No. of Subjects from the area of wood processing |
|---|---|---|---|---|---|---|---|
| 49 | KOMEN | 12 | 35 | 10272 | 3671 | 6,5 | 6 |
| 50 | KOPER - CAPODISTRIA | 12 | 104 | 31120 | 46777 | 3,8 | 62 |
| 51 | KOZJE | 4 | 23 | 8969 | 3665 | 28 | 3 |
| 52 | KRANJ | 9 | 48 | 14798 | 51761 | 2,3 | 92 |
| 53 | KRANJSKA GORA | 9 | 10 | 25631 | 5542 | 1,9 | 13 |
| 54 | KRŠKO | 6 | 185 | 34486 | 28582 | 12,2 | 48 |
| 55 | KUNGOTA | 2 | 19 | 4899 | 4433 | 15,4 | 5 |
| 56 | KUZMA | 1 | 12 | 6024 | 4515 | 37,9 | 8 |
| 57 | LAŠKO | 4 | 86 | 19908 | 14411 | 9,4 | 16 |
| 58 | LENART | 2 | 79 | 20455 | 17685 | 21,7 | 18 |
| 59 | LENDAVA - LENDVA | 1 | 26 | 15407 | 13661 | 13,3 | 25 |
| 60 | LITIJA | 8 | 153 | 32081 | 18734 | 9,9 | 38 |
| 61 | LJUBLJANA | 8 | 42 | 27499 | 269296 | 0,6 | 439 |
| 62 | LJUBNO | 4 | 9 | 7891 | 2809 | 19,2 | 25 |
| 63 | LJUTOMER | 1 | 69 | 17532 | 18756 | 19,8 | 39 |
| 64 | LOGATEC | 8 | 19 | 17311 | 10319 | 6,5 | 70 |
| 65 | LOŠKA DOLINA | 10 | 65 | 24190 | 5277 | 12,8 | 18 |
| 66 | LOŠKI POTOK | 8 | 17 | 13450 | 2166 | 11,6 | 10 |
| 67 | LUČE | 4 | 11 | 21221 | 2287 | 26,3 | 17 |
| 68 | LUKOVICA | 8 | 66 | 7490 | 4633 | 12,4 | 13 |
| 69 | MAJŠPERK | 2 | 30 | 10885 | 5583 | 19,4 | 8 |
| 70 | MARIBOR | 2 | 50 | 21372 | 134195 | 1,5 | 140 |
| 71 | MEDVODE | 8 | 31 | 7759 | 13279 | 1,8 | 63 |
| 72 | MENGEŠ | 8 | 4 | 2223 | 6603 | 2,4 | 29 |
| 73 | METLIKA | 7 | 59 | 10887 | 8246 | 11,5 | 14 |
| 74 | MEŽICA | 3 | 6 | 2645 | 4151 | 2,5 | 11 |
| 75 | MIREN-KOSTANJEVICA | 11 | 15 | 6278 | 4766 | 6,1 | 23 |
| 76 | MISLINJA | 3 | 11 | 11217 | 4528 | 14,7 | 16 |
| 77 | MORAVČE | 8 | 51 | 6257 | 4353 | 9,8 | 7 |
| 78 | MORAVSKE TOPLICE | 1 | 28 | 14446 | 6555 | 30,8 | 11 |
| 79 | MOZIRJE | 4 | 21 | 8568 | 6336 | 13,9 | 49 |
| 80 | MURSKA SOBOTA | 1 | 11 | 6443 | 21102 | 5,2 | 33 |
| 81 | MUTA | 3 | 6 | 3877 | 3770 | 7,9 | 6 |
| 82 | NAKLO | 9 | 13 | 2829 | 4768 | 6,2 | 24 |
| 83 | NAZARJE | 4 | 14 | 4137 | 2583 | 11,3 | 19 |
| 84 | NOVA GORICA | 11 | 55 | 32391 | 42241 | 4,1 | 147 |
| 85 | NOVO MESTO | 7 | 241 | 62292 | 51232 | 8,3 | 149 |
| 86 | ODRANCI | 1 | 1 | 693 | 1791 | 25,6 | 6 |
| 87 | ORMOŽ | 2 | 81 | 21239 | 17775 | 26,6 | 12 |
| 88 | OSILNICA | 8 | 19 | 3622 | 408 | 5,5 | 1 |
| 89 | PESNICA | 2 | 31 | 7584 | 7223 | 16,3 | 5 |
| 90 | PIRAN - PIRANO | 12 | 11 | 4445 | 17375 | 2,8 | 18 |
| 91 | PIVKA | 10 | 29 | 22325 | 5899 | 8,2 | 37 |
| 92 | PODČETRTEK | 4 | 38 | 9170 | 4906 | 33,2 | 9 |
| 93 | PODVELKA-RIBNICA | 3 | 17 | 16298 | 4276 | 13,6 | 21 |
| 94 | POSTOJNA | 10 | 40 | 26987 | 13635 | 4 | 44 |
| 95 | PREDDVOR | 9 | 16 | 15577 | 3594 | 7 | 15 |
| 96 | PTUJ | 2 | 26 | 11812 | 32031 | 8,2 | 45 |
| 97 | PUCONCI | 1 | 23 | 10766 | 6556 | 33,7 | 8 |

Table 1 (continued) : Municipalities (1995) and general data used in our research work

| Munic. Code | Name of Municipality | Regional code | No. of Settlements | Surface of Municip. | No. of inhabitants | % of farming population | No. of Subjects from the area of wood processing |
|---|---|---|---|---|---|---|---|
| 98 | RAČE-FRAM | 2 | 13 | 5124 | 5912 | 9,4 | 7 |
| 99 | RADEČE | 4 | 22 | 5035 | 4649 | 5 | 1 |
| 100 | RADENCI | 1 | 22 | 3412 | 5466 | 9,8 | 7 |
| 101 | RADLJE OB DRAVI | 3 | 14 | 9415 | 6228 | 11,5 | 27 |
| 102 | RADOVLJICA | 9 | 52 | 11871 | 18229 | 2,6 | 48 |
| 103 | RAVNE-PREVALJE | 3 | 28 | 12152 | 19102 | 3,5 | 32 |
| 104 | RIBNICA | 8 | 85 | 20311 | 11300 | 7,1 | 118 |
| 105 | ROGAŠEVCI | 1 | 11 | 4015 | 3849 | 40,1 | 5 |
| 106 | ROGAŠKA SLATINA | 4 | 41 | 7155 | 10664 | 10,1 | 17 |
| 107 | ROGATEC | 4 | 9 | 3956 | 3132 | 12,3 | 2 |
| 108 | RUŠE | 2 | 28 | 20971 | 15546 | 3,2 | 48 |
| 109 | SEMIČ | 7 | 56 | 14666 | 3830 | 10,9 | 11 |
| 110 | SEVNICA | 6 | 113 | 27217 | 18011 | 11,2 | 97 |
| 111 | SEŽANA | 12 | 64 | 21740 | 11605 | 3,7 | 17 |
| 112 | SLOVENJ GRADEC | 3 | 22 | 17369 | 16858 | 8,1 | 57 |
| 113 | SLOVENSKA BISTRICA | 2 | 129 | 36767 | 33529 | 9,7 | 60 |
| 114 | SLOVENSKE KONJICE | 4 | 57 | 9784 | 13638 | 11 | 34 |
| 115 | STARŠE | 2 | 8 | 3397 | 4062 | 12 | 2 |
| 116 | SVETI JURIJ | 1 | 27 | 5132 | 3036 | 32,5 | 3 |
| 117 | ŠENČUR | 9 | 13 | 4321 | 7968 | 7,4 | 18 |
| 118 | ŠENTILJ | 2 | 22 | 6501 | 8361 | 8 | 7 |
| 119 | ŠENTJERNEJ | 7 | 58 | 9599 | 6627 | 16,6 | 15 |
| 120 | ŠENTJUR PRI CELJU | 4 | 121 | 23975 | 19673 | 16,4 | 44 |
| 121 | ŠKOCJAN | 7 | 38 | 5858 | 3017 | 20,1 | 7 |
| 122 | ŠKOFJA LOKA | 9 | 62 | 14915 | 21556 | 4,3 | 62 |
| 123 | ŠKOFLJICA | 8 | 18 | 4331 | 5720 | 4,1 | 19 |
| 124 | ŠMARJE PRI JELŠAH | 4 | 77 | 10770 | 9713 | 21,7 | 21 |
| 125 | ŠMARTNO OB PAKI | 4 | 10 | 1815 | 2816 | 4,2 | 6 |
| 126 | ŠOŠTANJ | 4 | 11 | 9559 | 8144 | 5,8 | 27 |
| 127 | ŠTORE | 4 | 12 | 2815 | 4175 | 5,4 | 9 |
| 128 | TOLMIN | 11 | 72 | 38154 | 12425 | 7,7 | 39 |
| 129 | TRBOVLJE | 5 | 17 | 5782 | 18536 | 0,7 | 23 |
| 130 | TREBNJE | 7 | 218 | 31149 | 18012 | 17,3 | 57 |
| 131 | TRŽIČ | 9 | 35 | 15537 | 15138 | 2,5 | 26 |
| 132 | TURNIŠČE | 1 | 4 | 2384 | 3676 | 20,8 | 10 |
| 133 | VELENJE | 4 | 25 | 8350 | 33591 | 1,8 | 37 |
| 134 | VELIKE LAŠČE | 8 | 88 | 10318 | 3467 | 13,6 | 87 |
| 135 | VIDEM | 2 | 44 | 12812 | 7713 | 21 | 7 |
| 136 | VIPAVA | 11 | 20 | 10741 | 5135 | 13,7 | 23 |
| 137 | VITANJE | 4 | 8 | 5938 | 2497 | 24,9 | 9 |
| 138 | VODICE | 8 | 16 | 3138 | 3655 | 5,8 | 15 |
| 139 | VOJNIK | 4 | 66 | 10693 | 10047 | 9,5 | 43 |
| 140 | VRHNIKA | 8 | 21 | 12626 | 16200 | 4 | 65 |
| 141 | VUZENICA | 3 | 5 | 5010 | 2877 | 8,6 | 19 |
| 142 | ZAGORJE OB SAVI | 5 | 72 | 14714 | 17065 | 5,7 | 20 |
| 143 | ZAVRČ | 2 | 9 | 1933 | 1433 | 22,9 | 1 |
| 144 | ZREČE | 4 | 20 | 6704 | 6289 | 12,5 | 28 |
| 145 | ŽALEC | 4 | 100 | 33509 | 38755 | 9,4 | 87 |
| 146 | ŽELEZNIKI | 9 | 29 | 16478 | 6675 | 9 | 40 |
| 147 | ŽIRI | 9 | 18 | 4921 | 4853 | 5,6 | 17 |
| **SLO** | **SLOVENIJA** | | **5961** | **2027305** | **1982265** | **7,4** | **4755** |

# 3 ANALYSIS OF THE AVAILABLE DATABASES REGARDING BIOMASS POTENTIALS APPROPRIATE FOR THE LOCAL DISTRICT HEATING PLANTS IN SLOVENIA

## 3.1 Industrial sector

### 3.1.1 List of available databases

We received and studied the following data sources which contain relevant data for the analysis of the wood biomass potential for energy purposes in projects of local district heating:

1. **List of sawmills - INTERNOVA**
2. **Statistical report on waste material from the industry, agriculture, the construction sector and hospitals - ODP1 (Statistics Office of RS)**
3. **Register of medium-sized heating installations with a rated power above 1 MW (RACI)**
4. **Data from the Statistics Office of RS on industrial production**
5. **Trade and commerce register (Chamber of Trade and Commerce), and the business directory of the Republic of Slovenia**
6. **Individual data (chemical wood processing, as well as chipboard and fiberboard industries)**

#### 1 List of sawmills - INTERNOVA

The list has been administered by the private Internova Ltd. company for several years. Internova collects data on sawmills from owners on a voluntary basis. The data is regularly published in the Lesarski Utrip magazine. As the database is intended for the promotion of individual companies, it does not include some key data on production quantities. It contains the annual capacity of sawmills, which, however, is not useful for calculating wood residue. Besides, wood residues (saw dust, side trimmings, slabs and offcuts) which occur with cutting log-timber, can be used for producing panels and cellulose, and therefore rarely accumulate on dumps. In the mentioned database, 402 sawmills are registered at present, which, according to the Chamber of Commerce, represents 45% of all registered sawmills. The yearly capacity of sawmills from the database amount to 1,961.810 $m^3$ of log-timber. By dividing the sawmills with respect to their capacity into five classes and respecting the established wood exploitation in the size classes of sawmills (MRZELJ 1993), we find that sawmills are left with a yearly amount of about **640,000 $m^3$**. This is not the actual annual production, but their capacity which is normally not exploited at 100%, so that the amount of residues is actually lower. According to the data of a study where the wood residues in the sawmill industry were analysed (MRZELJ 1993), wood exploitation and the connected quantity of residues differs depending on the size class of the sawmill. The quantity of residues is also dependant on the kind of wood and the thickness of log-timber. As the available database does not include all necessary information, it cannot serve as a basis for establishing the residues of sawmill production at the municipality level.

## 2 Statistical report on waste from industry, agriculture, the construction sector and hospitals ODP1 (Statistics Office of RS)

The statistical reports of 1992 and 1995 on waste from the industry, agriculture, the construction sector and hospitals (ODP-1 form) comprised data on waste produced by some companies and organisations, and their respective branches. Data on waste quantities collected with the ODP-1 form, was processed and is available in two units of measurement, i.e. in tons and $m^3$. Waste of under 0,1 ton or 1 $m^3$ produced in an individual reporting branch are not included.

Waste - according to the definition also used by the Statistics Office of RS - is material which the owners cannot or do not want to exploit themselves, and intend to dispose of, or have disposed of, without it being produced for selling. Waste also comprises material which occurred as waste, and was sold because of premeditated treatment to others as exploitable raw material. However, waste is not material which is processed anew by the owners, or used in their own production process - except on waste processing machinery. Waste is also not material which is directly released into the environment, e.g. into the air, water or sewage system. This definition treats wood residues as waste what is an example how state miss-understand their potentials.

Of approximately 1.600 companies which were selected for a statistical report on waste material in 1992, only 230 produced wood residues. Considering data from the Chamber of Commerce on all registered companies which engage in primary and secondary wood processing (4.755 companies), the mentioned report comprises less than 5% of these companies. Moreover, wood residues (packaging of wood, pallets) may also occur in other companies which are otherwise registered with completely different activities. According to the data from the report on waste in 1992 (data collected in 1995 have not been processed and are not available to the public), there are only 303.117,5 $m^3$ of wood residues in Slovenia. Wood residues or classified in 9 groups, according to the international classification of waste (table 2).

Table 2: Classification of wood residues according to the international classification of waste

| Code | Waste type | Quantity-$m^3$ |
|---|---|---|
| 17101 | Bark | 26.330,5 |
| 17102 | Slabs, off-cuts | 109.788,9 |
| 17103 | Saw dust, shavings | 144.439,0 |
| 17104 | Dust and residues from grinding wood | 8.979,6 |
| 17106 | Construction wood residues | 3.234,7 |
| 17114 | Dust and residues from the production of sandwich panels | 600,5 |
| 17115 | Chipboard residues | 607,2 |
| 17201 | Wood packaging, pallets, wood residues – clean | 8.533,1 |
| 17211 | Saw dust, shavings - polluted with organic substances | 604,0 |
| Total | | 303.117,5 |

Source: Statistics Office of RS

Due to the protection of individual data, we were able to show the data only summarily at the municipal level. In municipalities with just one relevant subject, the data was added to the nearest municipality having data on wood residues, thus avoiding revealing confidential data.

Table 3: Quantity of waste classified according to waste codes, and some municipalities (with more than 2 subjects)

| Community | Waste code | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 17101 | 17102 | 17103 | 17104 | 17106 | 17201 | 17115 | 17211 | Total ($m^3$) |
| ROGAŠKA SLATINA | | 24.060,0 | 4.360,0 | 960,0 | | | | | 29.380 |
| MARIBOR | 5.116,9 | 12.029,5 | 7.638,9 | | 1.408,4 | | 12,0 | | 26.206 |
| LOGATEC | 1140,0 | 12.490,0 | 6.332,0 | | | 1.100,0 | | | 21.062 |
| RADLJE OB DRAVI | | 708,6 | 16.418,1 | 300,0 | 70 | | | 231,0 | 17.728 |
| NOVO MESTO | | 5.671,4 | 12.013,0 | | | | 22,5 | | 17.706 |

Source: Statistics Office of RS (ODP1)

Due to the small sample selected for establishing the statistical report, data on wood residues is not reliable enough at the municipal level, and, in particular, does not show actual quantities of waste produced.

## 3 Register of medium-sized heating installations with a rated power of above 1 MW - RACI

The existing heating installations using wood biomass represent places of consumption of wood residues, and have been analysed separately for this reason. We were able to use the only existing database - with data collected and processed by a private company, and the customer being the Chamber of Commerce of Slovenia, Timber Industry Association. This report will only provide some important data from the report for 1997 (ČRETNIK / ŠLIBAR / TORNIČ / SMRDELJ 1998).

The RACI Ltd. company has been following the conditions in medium-sized heating installations in the Republic of Slovenia for several years. It has paid special attention to boilers heating with wood residues - biomass. The database comprises 52 companies owning 84 large energy (boiler) installations where biomass, i.e. wood residue, is used. 78 medium-sized heating installation are registered which operate at least on a seasonal basis. The mentioned register was established on the basis of a survey conducted with 55 industrial companies. 40 companies filled in the relevant questionnaire, and the result was that the average age of installations was 24 years. In Slovenia, the average rated heating power of the boilers and heating places fuelled by wood residues is 4,4 MW, and the average input heating power is 4,8 MW. The total rated heating power of boilers is 340 MW. On average, the installations operate between 5.500 and 6.000 hours per year. The installations mostly operate only on wood residues, and mixed heating is rather the exception than the rule. The estimated total use of wood residues in medium-sized heating installations amounts to 313.000 tons for 1997, which corresponds to 4.127 TJ heating power (ČRETNIK / ŠLIBAR / TORNIČ / SMRDELJ 1998). After consultations with the authors of the report we found that calculated owen-dry mass of the above quantity correspond to about **230.000 tons**. If we assess this estimated quantity of wood residues with that from the data of the Slovenian Statistics Office, we can see that the existing heating installations exploit 63,7% of all registered wood residues.

## 4 Data from the Statistics Office of RS on industrial production

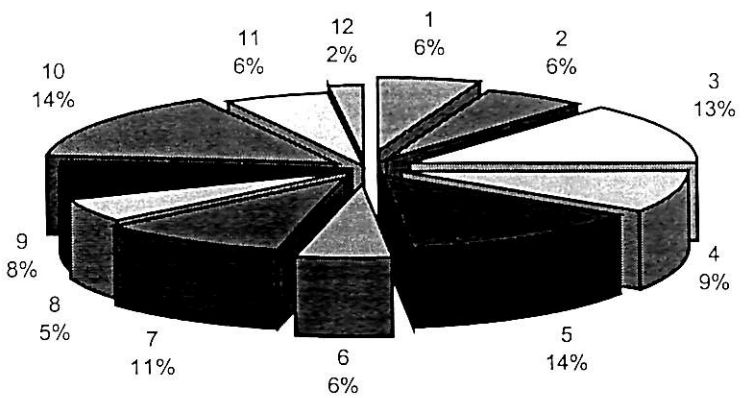
We received data on the quantities of input raw material for 171 companies, or reporting entities, which are registered for the following activities (according to the standard classification of activities):

**20** wood processing and treatment; manufacture of products of wood, cork, straw and twigs, except furniture

**36.1** manufacture of furniture

The number of companies for which we received data represents only 4% of all companies which are registered with the Chamber of Trade and Commerce for the mentioned activities. If we add the data collected in the list of sawmills to this number, the percentage increases to 12%, which is still not sufficient for drawing conclusions about the potential of wood biomass residues at the municipal level. If we combine the data at the level of statistical regions, the situation is somewhat improved (see graph 1), but does not allow serious comparisons. The fact is that the 171 subjects are distributed in 107 municipalities only, while we do not have any data on the wood processing industry for the remaining municipalities. As we are interested in overall quantities of wood biomass residues, and not just in those obtained from large plants, in order to evaluate the potential of wood biomass residues exploitable for energy purposes, the base of collected data is almost irrelevant.

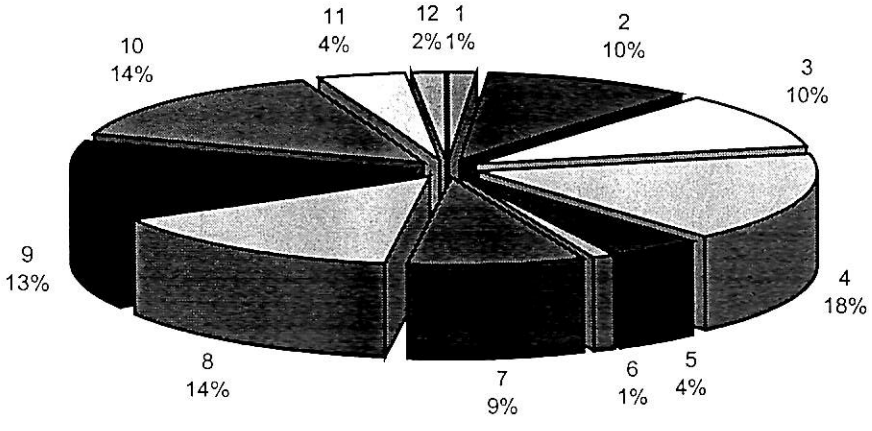
Graph 1: Share of subjects in statistical regions for which data on industrial production was available (activities 20 and 36.1; companies with more than 10 employees) - (name of regions see table 4)



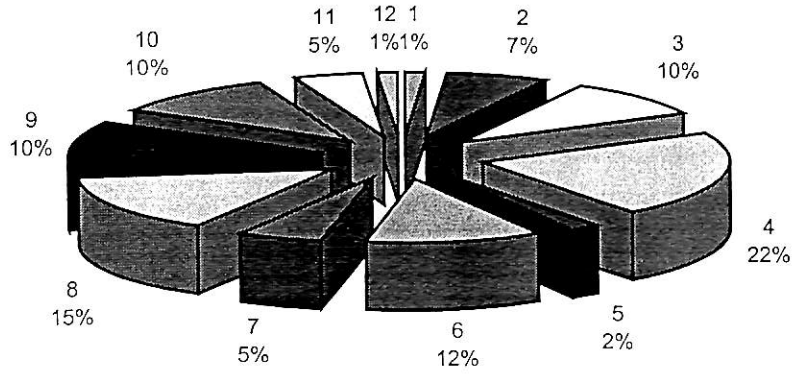

Apart from the quantities of raw material for 1992 and 1995, we also received data on the kind and quantities of products. The companies were classified according to municipalities, and the wood residues were calculated from the input raw material by means of known - and often tested - quotients. According to the data provided, these 171 reporting entities use a yearly amount of 2,487.812 $m^3$ of input raw material. It must be said that raw material does not exclusively represent log-timber, but also sawn wood, different forms of veneer, hardboards, chipboard, fiberboards, sandwich panels and other panels. Log-timber accounts for only 32,7% of all raw material. The quantities of input log-timber are very unevenly spread over the statistical region (graph 2). A further problem is posed by the fact that we do

not know the place of origin of this raw material; therefore, it is not sensible to compare used quantities of log-timber with the fellings in the same region. Moreover, the residues calculated from the input raw material represent only a part of the wood residues actually obtained.

Graph 2: Share of used log-timber according to the statistical regions (for names of regions refer to table 4)




Wood residues do not only occur in the wood processing industry, but also in other branches of industry (packaging, pallets, etc.). A part of all wood residues or waste is included in the ODP 1 statistical report. This statistical report lists 230 subjects which produce wood waste. To obtain the most complete data possible on the obtained quantities of wood residues, we combined both bases respecting the higher figure of the two bases for waste in the same municipality. Even after both bases had been merged, we did not have data for 50 municipalities regarding the wood residues produced. The combined quantity of wood residues amounts to **721.940 m$^3$**. Its regional division is shown in graph 3.




Graph 3: Part of the obtained wood residues according to statistical regions

As data is insufficient, and only refers to the largest producers, any conclusions drawn from this graph are not well-founded, and may lead to serious mistakes. It is true that these producers account for the largest and most concentrated sources of wood residues, but a large

number of small subjects has been neglected in the analysis, and their production may be such as to produce large quantities of exploitable wood residues, from the viewpoint of the exploitation of wood biomass for energy purposes. Small subjects normally represent a deconcentration of producers of wood residues, causing more problems in collecting and exploiting the latter, but are still important for the potential of wood residues. Because we do not know exact activities and quantities of production for this small subjects we can only estimate amount of wood residues. According to our estimate annual amount of wood residues from this small timber companies is from 200.000 $m^3$ up to 300.000 $m^3$. To show the obtained quantities in the different regions, the quantities of obtained wood residues were classified in 6 classes (see map 1).

## 5 Trade and commerce register (Chamber of Trade and Commerce), and the business directory of the Republic of Slovenia

The trade and commerce register was established by the Chamber of Trade and Commerce of the Republic of Slovenia in co-operation with the Statistics Office of the Republic of Slovenia. The resulting base contains data on more than 110.000 private companies. Data on companies was collected on the basis of data from the business register of Slovenia, which is administered by the Slovenian Statistics Office utilising the register of members of the Slovenian Chamber of Commerce, final reports and additional surveys. Beside the company name and address, the base contains also data on the activity for which the company is registered, as well as data on the number of employees. Being aware that the data on production collected at the Slovenian Statistics Office is limited to companies employing more than 10 persons, we decided to find the actual number of companies from the mentioned database. According to data from this register, almost 95% of companies engaging in primary or secondary wood processing employ less than 10 persons. The number of subjects of a community which are registered for the mentioned activity does not directly show the quantity of disposable wood residues, but still represents the only indicator comprising all registered companies, from the smallest to the largest.

**In actual fact, we do not have data on the total quantity of processed wood, nor of data on the quantity of wood processed by forest owners on their farms.** There are estimations of the total quantity of processed wood, but only at a national level are they more or less accurate, while they are completely useless at a municipal level.

Table 4: Number of private companies in the statistical regions

| Region | Total | Activity No. 20 | Activity No. 36.1 |
|---|---|---|---|
| Total number of companies | 4.708 | 3.263 | 1.445 |
| 1. Pomurje | 249 | 159 | 90 |
| 2. Posavje | 396 | 314 | 82 |
| 3. Koroška | 235 | 199 | 36 |
| 4. Savinjska | 611 | 470 | 141 |
| 5. Zasavje | 56 | 34 | 22 |
| 6. Spodnje posavska | 195 | 142 | 53 |
| 7. Dolenjska | 300 | 201 | 99 |
| 8. Osrednjeslovenska | 1.428 | 942 | 486 |
| 9. Gorenjska | 498 | 299 | 199 |
| 10. Notranjsko-kraška | 179 | 140 | 39 |
| 11. Goriška | 410 | 268 | 142 |
| 12. Obalno-kraška | 151 | 95 | 56 |

Source: Trade and commerce register of 1997

As we estimated that small companies employing less than 10 persons were also important for wood residues, we were interested in the share of those companies which do not send an annual report on their production. Small companies take the largest share in the Drava region (67 %) and the Savinja region (64%), and the smallest share in Notranjsko-kraška region (45 %), as well as in Koroška (50 %). The number of subjects engaging in the chosen activities shows the number of potential sources of wood residues, but does not say anything on quantity, type or concentration. We can presume that a large number of small sources is less favourable for collection and exploiting wood residues, because the deconcentration of sources has a strong impact on the costs for collection and transportation costs of wood residues.

In the initial phase of data collection, we focused on data registered in the business directory of the Republic of Slovenia. Subsequent data comparisons have shown that the register of trade and commerce is far more detailed, and contains much more data on private companies. A further advantage is that data at the municipal or regional level can be collected more easily. However, the drawback with the register of trade and commerce is that not every company has its total number of employees registered - these take a share of 65 % - which leads to less accuracy, and it is doubtful whether such data are useful.

For a presentation of the number of subjects by area in the municipalities, we classified the total number of subjects in a municipality in 6 classes (see map 2)

## 6 Individual data (chemical wood processing, and chipboard and hardboard industries)

As we wanted to become familiar with some of the largest sources of wood residues, we conducted a brief survey of some companies by telephone. We focused on central mechanised storerooms, of which there are currently 6 in Slovenia, because in central mechanised storage facilities, large quantities of wood residues fit for energy production are obtained. According to the data obtained through our brief survey, the majority of mentioned companies sell their residues for energy purposes, and only some kinds of waste are dumped on municipal or "wild" disposal sights.

### 3.1.2 Presentation of relevant parameters

Chosen parameters:
1. Number of subjects engaging in primary or secondary wood processing in the municipalities
2. Quantities of wood residues calculated from production (Slovenian Statistics Office)
3. Currently existing and operating sources producing wood residues (RACI)

Data on quantities of wood residues are shown on map 2. The positions of wood residue sinkholes are presented on map 3. The comparation of the map 2 and the map 3 reveals that the areas with the most concentrated and the most abundant wood biomas potentials in Slovenia have their potential already significantly exploited. In the most cases for energy supplies for technological processes and on some locations for cellulose/board industry.

## 3.2 Forestry sector

Slovenia has more than 1,1 mill. ha of forests, which is over half of Slovenia's surface (54%). Among the countries of the European Union, only Finland (66%) and Sweden (60%) have a larger share in forests. Austria is covered with forests by 47%, while the remaining countries lag behind. With 0,56 ha/inhabitant, also the forest density per inhabitant is higher than in Austria (0,50 ha/inhabitant), while Finland and Sweden have the leading position (4,03 and 2,85 ha/inhabitant respectively) - (POGAČNIK 1997). The remaining EU countries have less than 0.30 ha per inhabitant. Slovenia is comparatively rich in forests.

According to the Slovenian Forest Institute, two thirds of the forests are privately owned, the rest is owned by the state and institutions. Considering the fact that privatisation has not been concluded, and that data on ownership structure is being completed, we may expect a final relationship of 3 : 1 in favour of private forests. This relationship will place us on the same level as Finland, France, Denmark and Sweden. Within the European Union, only in Austria and Portugal are forests privately owned by more than 80%. According to these criteria, Slovenia is perfectly comparable to countries where the exploitation of biomass for heating is well-developed (Sweden, Finland, Austria). In Slovenia, 80 municipalities are covered by forests by more than 50%, and 23 municipalities by less than 30%. 49 municipalities are covered with forests by more than 60%, of which 21 by more than 70%. Forest density in municipalities is shown in table 5.

Table 5: Forest density in municipalities

| Class | Percentage of forests (%) | Number of municipalities | % |
|---|---|---|---|
| 1 | <= 30 | 23 | 15,65 |
| 2 | > 30 in <= 40 | 18 | 12,24 |
| 3 | > 40 in <= 50 | 26 | 17,69 |
| 4 | > 50 in <= 60 | 31 | 21,09 |
| 5 | > 60 in <= 70 | 28 | 19,05 |
| 6 | > 70 | 21 | 14,29 |
| | Total | 147 | 100,00 |

Map 4 shows a more accurate picture of the forest density, revealing that, in Slovenia, the least forests are found in the Pomurje and Podravje regions. Relatively low forest density of less than 40 % is also found in some municipalities in the Southeast of Slovenia near the border with Croatia, and in the Ljubljana basin. The most forests are present in municipalities which reach out into the hilly and mountainous part of Slovenia, in the South at the border with Croatia, and in the North, where many municipalities border on Austria.

The population density is in inverse proportion to the forest density (see table 6, map 5). 18 municipalities have less than 50 inhabitants/km$^2$, in particular in the Southwest and the Northwest of Slovenia at the borders with Croatia and Austria. In 32 municipalities, found in particular in the hilly parts of Slovenia's West, on the Pohorje and Kozjak hill chains, and in some municipalities near the border with Hungary and Croatia, the population density is between 50 and 100 inhabitants/km$^2$. The highest population density (over 500 inhabitants per km$^2$) is found in the area of the urban municipalities (Ljubljana, Celje, Maribor, Koper and Kranj), and in the surroundings of other major towns. The municipalities in the lowland are

also rather densely populated, especially in the Northeast of Slovenia, and in the Ljubljana and Celje basins, as well as in agriculturally exploited areas.

Table 6: Population density with respect to total area

| Class | Inhabitants / km$^2$ | Number of municipalities | % |
|---|---|---|---|
| 1 | <= 50 | 18 | 12,24 |
| 2 | > 50 in <= 100 | 32 | 21,77 |
| 3 | > 100 in <= 200 | 38 | 25,85 |
| 4 | > 200 in <= 300 | 20 | 13,61 |
| 5 | > 300 in <= 500 | 22 | 14,97 |
| 6 | > 500 | 17 | 11,56 |
| | Total | 147 | 100,00 |

The synthesis of both data results in the forest surface per inhabitant (see table 7, map 6). With the data on the forest surface per inhabitant, we find that half of the municipalities have more forests than the Slovenian average of 0,56 ha/inhabitant. There is a positive correlation between the forest surface and the forest surface per inhabitant, which is logical, as the population density is lower where there is more forest. 54 municipalities have more than 0.9 ha of forests per inhabitant. Here, we believe, wood plays or could play an important role as a strategic raw material and as a renewable energy source.

Table 7: Surface of all forests per inhabitant

| Class | Forest surface (ha) | Number of municipalities | % |
|---|---|---|---|
| 1 | <= 0,3 | 35 | 23,81 |
| 2 | > 0,3 in <= 0,6 | 41 | 27,89 |
| 3 | > 0,6 in <= 0,9 | 17 | 11,56 |
| 4 | > 0,9 in <= 1,2 | 18 | 12,24 |
| 5 | > 1,2 in <= 2,0 | 18 | 12,24 |
| 6 | > 2,0 | 18 | 12,24 |
| | Total | 147 | 100,00 |

From the classification of municipalities in the tables 5 and 7, we have extracted those municipalities with more than 60% of forests, and over 0,9 ha forest surface per inhabitant. Both criteria are met by the following 37 municipalities:
**Bled, Bohinj, Cerknica, Cerkno, Črna na Koroškem, Črnomelj, Dobrova-Horjul-Polhov gradec, Dobrepolje, Gorenja Vas-Poljane, Gornji grad, Hrpelje-Kozina, Idrija, Ilirska Bistrica, Kanal, Kočevje, Litija, Logatec, Ljubno, Loška dolina, Loški potok, Luče, Mislinja, Nazarje, Osilnica, Pivka, Podvelka-Ribnica na Poh., Preddvor, Radlje ob Dravi, Ribnica, Ruše, Semič, Tolmin, Velike Lašče, Vipava, Vitanje, Vuzenica in Železniki.**

There are 17 more municipalities which fulfil only the criterion of having more than 0,9 ha forest surface per inhabitant:
Bovec, Divača, Gornji Petrovci, Hodoš-Šalovci, Ig, Ivančna gorica, Kobarid, Kobilje, Komen, Kozje, Kranjska gora, Lukovica, Majnšperk, Postojna, Sežana, Škocjan, in Trebnje.

A common characteristic of these municipalities is that they are mostly situated in the hilly area of Slovenia in the Dinaric Alps, in the range of hills of Škofja Loka and Cerklje, in the northern part of Štajerska region and in Koroška.

The forest surface comprises also protective areas (barrier woodland), and other surfaces which are unexploitable for various reasons. For this reason, data on increment, planned annual cut and performed cuttings is essential for our analysis. We analysed data on performed cuttings for the years 1995, 1996 and 1997 (table 8, map 7). We took the average long-term value, because cuttings fluctuate a great deal in the case of bad weather conditions. In the winters of 1995/96 and 1996/97, for example, our forests were severely damaged through snow- and ice-break.

Table 8: Average annual cut in all forests per inhabitant.

| Class | **Annual wood cut** ($m^3$/inhabitant) | **Number of municipalities** | % |
|---|---|---|---|
| 1 | <= 0,5 | 40 | 27,21 |
| 2 | >0,5 in <= 1,0 | 31 | 21,09 |
| 3 | >1,0 in <= 1,5 | 21 | 14,29 |
| 4 | >1,5 in <= 2,5 | 20 | 13,61 |
| 5 | >2,5 in <= 4,0 | 16 | 10,88 |
| 6 | >4,0 | 19 | 12,93 |
| | Total | 147 | 100,00 |

Cuttings of up to 1 $m^3$ per inhabitant predominate in 71 - almost half of - Slovenian municipalities. More than 1 $m^3$ per inhabitant is cut in 55 municipalities. We were interested in to what extent the list of these municipalities corresponded to the municipalities with more than 0,9 ha of forest surface per inhabitant.

Quantities of above 1,5 $m^3$ per inhabitant are not reached by the following municipalities (14): Bovec, Cerkno, Hrpelje-Kozina, Ivančna gorica, Kobarid, Kobilje, Komen, Kranjska gora, Sežana, Škocjan, Trebnje, Tolmin and Vipava. Most of these municipalities have forests with a limited wood stock, few farmers and forests on rough terrain.

The following municipalities have more than 1,5 $m^3$ of fellings per inhabitant: **Borovnica, Cerklje na Gorenjskem, Dravograd, Mozirje, Muta, Novo mesto, Podčetrtek, Ruše, Sevnica, Slovenska Bistrica, Slovenj Gradec, Škofja Loka, Šoštanj, Vrhnika, Tržič.** These municipalities have forests with relatively large much wood stock on smooth terrain.

Over the last decades, wood stocks in the Slovenian forests have increased, i.e. increment exceeded fellings. This is also the future directive for forest management, stipulated in the Strategy of forest development (Ministry of Agriculture, 1994). In the last few years, the planned cut has reached a little over half of increment, and the official percentage of realised cut compared to increment for 1996 is as low as 38%. The relationship between the planned annual cut and increment has also been calculated for the municipalities, and is shown in table 9 and map 8. On average, the annual cut does not exceed increment in any municipality, and is in excess of 65% in only 20 municipalities, while in 58 municipalities, the planned annual cut amounts to less than half of the yearly increment.

**This data points to the possibility that in the forest management concept, there may hidden barriers for more extensive exploitation of the biomass if the market in forest biomass should develop to a larger extent.**

Table 9: Relationship between the annual cut and increment in all forests

| Class | Annual cut / increment (%) | Number of municipalities | % |
|---|---|---|---|
| 1 | <= 40 | 24 | 16,33 |
| 2 | > 40 in <= 50 | 34 | 23,13 |
| 3 | > 50 in <= 55 | 28 | 19,05 |
| 4 | > 55 in <= 60 | 23 | 15,65 |
| 5 | > 60 in <= 65 | 18 | 12,24 |
| 6 | > 65 | 20 | 13,61 |
| | Total | 147 | 100,00 |

**A stricter barrier than the stipulated annual cut is the actual cut in our forests**, which may - to be honest - also be the result of incomplete registers. Irrespective of this, we can infer from the table 10 and map 9 that the actual realisation of the annual cut is very low. **It appears that the forest owners are not sufficiently interested in exploiting forest wood. For this reason, the exploitation conditions (economical, technical, environmental) in private forests represent an important barrier in forest biomass potential exploitation.**

Table 10: Realisation of fellings with respect to the anticipated annual cut in all forests

| Class | Annual cut / increment (%) | Number of municipalities | % |
|---|---|---|---|
| 1 | <= 40 | 18 | 12,24 |
| 2 | > 40 in <= 60 | 35 | 23,81 |
| 3 | > 60 in <= 70 | 27 | 18,37 |
| 4 | > 70 in <= 80 | 20 | 13,61 |
| 5 | > 80 in <= 100 | 28 | 19,05 |
| 6 | > 100 | 19 | 12,93 |
| | Total | 147 | 100,00 |

In more than a third of municipalities, less than 60% of the annual cut is performed. Admittedly, in places, the annual cut has been exceeded, but this is due to the terrible weather conditions in the winters of 1995/96 and 1996/97. Bad weather conditions in forests always yield a great biomass potential which are never used, because adequate processing and end-users are missing. For some data from the Prekmurje region, the cadastral municipalities were not known. This data was divided proportionally among the relevant municipalities with respect to the stipulated annual cut, which, to some extent, has distorted the results for these municipalities.

## 3.3 Abandoned agricultural land

### 3.3.1 Data procesing procedures

For the assessment of the biomass potential in brushwood, we proceded in the following order:

- A computer protocol with all data registered for establishing the Agromap was obtained. The data was supplied by the Agricultural Institute of Slovenia, which had led the Agromap project.
- We checked the supplied data, and harmonised it in co-operation with the Agromap project leader, correcting the established mistakes. These analyses were performed according to cadastral municipalities, thanks to which we were able to adapt the necessary data for the assessment of the biomass potential to the new local communities (municipalities) which were founded after 1994. All data and analyses from the Agromap are subject to the old administrative units (municipalities). Their number was 68, according to the division which we used there are 147 municipalities.
- Input data was processed by computer for a relative assessment of the biomass potential from brushwood according to individual new municipalities. All analyses were performed for individual cadastral municipalities, according to areas of production (territorial units with homogenous natural conditions, and characteristic cultivation and settlements), as well as for administrative political municipalities. Special attention was paid to agricultural plots overgrown with forest trees and brushwood. The actual situation was that those plots were split into more or less overgrown land. From the total surface of both categories, brushwood which already figured as forest surface in forest management plans was excluded. The remaining brushwood surface was divided into different functional groups for the future, on the basis of the natural conditions and an evaluation of the technological and socio-economic possibilities. Of the total surface (142.000 ha), 75% was brushwood intended for forests, of which 64% had a protective function. The remaining surfaces (25%) were intended for agricultural and other use.
- The selected database from the Agromap (total surface of agricultural plots, surface of exploitable brushwood) was adapted to the new municipalities, and merged with the relevant database of the official statistics (code, name of municipality, surface, statistical region, number of settlements, population, share of farmers). To this, we added the database on the surface of forest plots (taken from forestry registers).
- From the resulting database, we calculated the shares of brushwood surface (in percent) in individual municipalities with respect to the total surface of the relevant municipality. These percentages, i.e. the relevant municipalities, were classified in six different classes (see table 11). The same method was applied for calculating the share of brushwood on the surfaces of agricultural plots in individual municipalities.
- We aggregated the data on brushwood surfaces in the relevant municipalities according to the statistical regions of Slovenia.
- We calculated and showed the absolute value of the wood biomass potential in the statistical regions on the basis of surfaces and average annual increments.
- We performed an assessment of the energy potential, and showed the potential in the statistical regions, as well as summarily for Slovenia.
- We formed a synthesis of the quantity and energy values of the wood biomass potential from all treated sources (forests, brushwood, residues from the wood industry), for the statistical regions, as well as summarily for Slovenia.

Table 11: Partition of municipalities according to their share in brushwood surfaces with respect to the total municipal surface, and to the share of all agricultural surfaces.

| **Brushwood surfaces in municipality (%)** | | **Brushwood in relation to agricultural area (%)** | |
|---|---|---|---|
| Class | No. of municipalities (n) | Class | No. of municipalities (n) |
| 0 | 6 | 0 | 4 |
| between 0,1 and 6,7% | 114 | between 0,1 and 13,7% | 97 |
| between 6,8 and 13,5% | 21 | between 13,8 and 27,5% | 39 |
| between 13,6 and 20,3% | 3 | between 27,6 and 41,3% | 2 |
| between 20,4 and 27,1% | 1 | between 41,4 and 55,1% | 2 |
| between 27,2 and 33,9% | 2 | between 55,2 and 68,9%* | 3 |
| Total | 147 | | 147 |

***Note:** In the 6th class, we also included the municipality of Osilnica, whose 615,6% share in brushwood in relation to agricultural plots stands out markedly among all Slovenian municipalities. Of a total surface of 3.622 ha, this municipality has as little as 199 ha of agricultural plots, only 408 inhabitants and no more than 5,5% farmers, but as much as 1.225 ha brushwood. The forest density has reached 97%. All mentioned parameters prove that this is the most demographically jeopardised region, with a degree of de-agriculturing beyond all standards. (i.e. an excessive percentage of people turning away from farming)

With respect to the fact that the Agromap excludes brushwood in bad or extreme ecological conditions for protection, i.e. these surfaces will be, sooner or later, included in the barrier woodland, they have not been considered for our assessment of the potential. We considered exclusively brushwood, which was classified as forest (forest brushwood), namely with a surface of 15.654 ha (special extract from the database of the Slovenia Forest Service, 1998), and brushwood intended for forests or future agricultural use. These surfaces amount to 79.465 ha. **Hence, the total surface of "exploitable" surfaces which are considered in our assessment is 95.119 ha.** Irrespective of the type of actual use in the future, and the appropriate measures for this use (clearing, land amelioration, direct or indirect conversion into forests), we are dealing with a marked potential of wood biomass for energy purposes which should not be neglected. Another issue is the realisation of this potential, in particular, from an economic perspective.

### 3.3.2 Global determination of the energy wood biomass potential from abandoned agricultural land in Slovenia

The variety of natural conditions in Slovenia, the historical development of different regions, the differences of socio-economic conditions and of developmental possibilities pressed man to use the primary environment in many ways, which is noticeable in the marked differences in brushwood as a wood biomass potential, both between individual municipalities and between larger areas - the regions of Slovenia. With respect to the brushwood surface, i.e. the estimated quantity of the biomass potential, the municipalities can be classified in several groups (the results of this partition was shown on map 10, where one group was split into two subcategories.):

**1st group:** It comprises the municipalities with a very important brushwood biomass potential. They are mostly found in the South, Southwest and West of Slovenia. We are dealing with orographically varied areas of the Dinaric Alps, the Prealpine and Karst regions, with a high forest density, unfavourable conditions for intensive agricultural production, low population density - with areas which are also demographically jeopardised. We estimate these areas to have between 3.300 and 20.800 $m^3$ of annual brushwood biomass potential.

**2nd group:** In this group, we classified municipalities with an important potential. We are dealing with municipalities in hilly areas of central, eastern and north-western Slovenia. Here, agricultural production is concentrated in valleys and on Karst fields., and the population density is greater in the highlands and lowlands. Extreme locations of grassland have been abandoned, and are now overgrown with brushwood to a large extent. The quantity of annual potential in individual municipalities ranges from 1.700 to 3.300 $m^3$.

**3rd group:** Municipalities with a less important, but not negligible potential. They are scattered, in particular, in the central and north-eastern parts of Slovenia. Orographically speaking, these are hilly areas and foothills with no extreme slopes, where agriculture is developed and the population density relatively high. The potential in the municipalities is in the interval from 400 to 1.700 $m^3$ per year.

**4th group:** Municipalities with a low, unimportant potential, and municipalities with no potential from brushwood. The majority are found in the extreme Northeast of Slovenia. Here, lowland to slightly hilly areas predominate, allowing intensive agricultural and winegrowing production. Some of these municipalities are also in the extreme North of Slovenia. Coniferous forests cover the major part of surfaces, while on limited lowland and highland, meadows and pastures have been preserved. Four municipalities have no brushwood potential whatsoever, in the remaining municipalities, quantities are not in excess of 400 $m^3$ per year.

### 3.3.3 Energy equivalent of determined wood boimass potentials from abandoned agricultural land

For planning and using wood biomass in the energy economy, it is important to know both quantitative potential indicators and available as well as necessary energy values of the wood biomass. This is why we also assessed the quantity of potential energy for the established brushwood biomass potential (table 12). We can infer from the shown assessments that we are dealing with a relatively large energy potential which is important in the Slovenian context. Compared to the overall annual consumption of energy in Slovenia, in the order of 170 PJ, the share of this potential is 1,3%. If this potential was to be realised, the annual consumption of other energy sources could be reduced by approx. 80.000 tons of heating oil, or 230.000 tons of brown coal, or 120.000 $m^3$ of natural gas, or 618 GWh of electrical energy.

Table 12: Quantities of potential energy from wood biomass in brushwood in regions

| No. of region | Name of region | Biomass potential ($m^3$) | Energy potential | | |
|---|---|---|---|---|---|
| | | | TJ | GWh | % |
| 1 | Pomurje | 2.895 | 27,10 | 7,53 | 1,22 |
| 2 | Posavje | 11.072 | 103,63 | 28,77 | 4,65 |
| 3 | Koroška | 6.005 | 56,21 | 15,61 | 2,52 |
| 4 | Savinjska | 21.707 | 203,17 | 56,44 | 9,13 |
| 5 | Zasavje | 2.737 | 25,62 | 7,12 | 1,15 |
| 6 | Spodnje-posavska | 8.503 | 79,61 | 22,11 | 3,58 |
| 7 | Dolenjska | 21.853 | 204,54 | 56,82 | 9,19 |
| 8 | Osrednje-slovenska | 43.376 | 406,00 | 112,78 | 18,24 |
| 9 | Gorenjska | 16.207 | 151,70 | 42,14 | 6,81 |
| 10 | Notranjsko-kraška | 34.302 | 321,07 | 89,19 | 14,42 |
| 11 | Goriška | 47.892 | 448,27 | 124,52 | 20,14 |
| 12 | Obalno-kraška | 21.247 | 198,87 | 55,24 | 8,93 |
| | Total | **237.797** | **2.225,78** | **618,27** | **100,00** |

In this assessment, the following average values for wood biomass were respected:
- Mass per volume: 1.000 kg/m$^3$ of fresh wood;
- Water content: 42%;
- Nominal wood density: 580 kg/m$^3$;
- Content of primary energy (upper calorific value): 18 MJ/kg of absolutely dry wood (oven dry) ;
- Calorific value of wood/kg: 9,36 MJ = 2,6 kWh;
- Calorific value of wood/m$^3$: 9,36 GJ = 2,6 MWh;

As can be seen from table 13, an important reduction in emissions could be reached by replacing fossil fuel, in particular, by exploiting the existing potential with modern technologies.

Table 13: Effects of replacing fossil fuels by the biomass potential utilising modern technologies for a reduction in emissions (in tons)

| | **Replaced fossil fuel** | | | | | |
|---|---|---|---|---|---|---|
| **Type of** | Brown coal | | Heating oil | | Natural gas | |
| **emission** | A | B | A | B | A | B |
| $SO_2$ | - 735 | - 735 | - 290 | - 290 | + 22 | + 22 |
| NOx | - 45 | - 55 | + 22 | 0 | + 22 | + 22 |
| CxHy | + 2.200 | - 7 | + 2.200 | - 7 | + 2.215 | 0 |
| CO | + 3.300 | - 231.000 | + 13.300 | + 312 | + 13.250 | + 312 |
| $CO_2$ | - 231.500 | - 231.000 | - 173.600 | - 173.600 | - 115.700 | - 115.700 |
| Dust particles | + 22 | - 115 | + 145 | + 9 | + 156 | + 20 |

**Note:**
A = Change in emissions by replacing fossil fuels with wood biomass, utilising existing (outdated) heating technology;
B = Change in emissions by replacing fossil fuels with wood biomass, utilising modern (automatic) technology for central heating;
- = Reduction of emissions (in tons per year);
+ = Increase of emissions (in tons per year).

By replacing fossil fuels with wood biomass, major effects would be reached in the reduction of emissions in $CO_2$, with both outdated and modern technology, and with all three types of fossil fuels. With the exception of natural gas, emissions in $SO_2$ would also be reduced markedly, and, in particular, quantities in CO if coal was replaced by wood, and appropriate heating installations were used. Generally speaking, it is obvious that the influence of technology used for heating is equally as important as the influence of different fuel types. The introduction of modern technological solutions is therefore a precondition for an economically and ecologically acceptable exploitation of wood biomass - also in relation to fossil fuels.

## 3.4 Data verification

Data on the size and variation of production, and assessed quantities of wood residues for the analysed pattern of companies is shown in table 14. The collected data is partially incomplete, because the Slovenian Statistics Office did not supply data on the production in sawmills over the last few years - data had simply not been collected in this period, and one sawmill stopped production in 1997. Among other data, the data on quantities of wood raw material in the company engaging in secondary wood processing (No. 3) stands out strikingly. In this company, beside quantities used for the production of furniture, the wood quantities are also considered which are involved in direct trade with wood (purchase - cutting - selling). We are dealing with a developing company which is finding its position in the market, and has extended its activity by purchasing a major sawmill.

Table 14: Comparison of data from 9 selected companies regarding their production in the last 5 years (in $m^2$)

| No. | Activity | Dissertation | | Survey | | Data from Slovenian Statistics Office | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1996 | | 1997 | | 1992 | | 1995 | | 1996 | |
| | | Raw material | Residues | Raw material | Residues | Raw material | Residues | Raw material | Residues | Raw material | Residues |
| 1 | Home furniture | 8.200 | 3.200 | 8.000 | 3.000 | 10.190 | 4.070 | 8.578 | 3.345 | 7.107 | 2.770 |
| 2 | Office furniture | 456 | 81 | 600 | 180 | 952 | 285 | 1.169 | 350 | 750 | 225 |
| 3 | Trade and furniture | 70.000 | 12.000 | 40.580 | 11.460 | 0 | 0 | 570 | 246 | 460 | 199 |
| 4 | Production of toys | 56 | 3 | 180 | 2 | 0 | 0 | 49 | 2 | 55 | 3 |
| 5 | Sawmill | 3.200 | 1.600 | 1.200 | 285 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | Sawmill | 14.000 | 4.200 | 15.000 | 4.000 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | Sawmill | 600 | 174 | 800 | 240 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | Sawmill | 8.000 | 2.000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | Sawmill | 12.000 | 3.460 | 10.000 | 3.000 | 0 | 0 | 0 | 0 | 0 | 0 |

We established that the data obtained from the Slovenian Statistics Office on primary and secondary wood processing (used wood resources, production and residues) represented an adequate basis for a statistical evaluation of the gross potential in wood biomass appropriate for energy purposes. **However, this database refers only to companies registered at the Statistics Office (with more than 10 persons).** Major differences appear in the chronological analysis of quantities of wood residues within an individual company, which means that a periodic survey of the situation in the area of the processing of raw wood material is necessary, because the relevant data are quickly out of date. The quantities of wood residues depend on production quantities, which are changing with time. This is a fact which should be considered in long-term plans for wood biomass exploitation. For the actual planning of local district heating based on wood biomass, we must take into consideration the developmental strategies of the companies engaging in primary, secondary or tertiary wood processing, because a technological modernisation may completely change and undermine the main planned wood biomass resource. In wood processing companies with a long-standing tradition, an attractive production programme, mass production, and, above all, a clear strategy for the future development of the company, we may anticipate a certain quantity of wood residues for the future in spite of a gradual reduction in wood raw material and better exploitation.

On the basis of the data collected and the surveys conducted, we may give a general evaluation on the quality of the data on industrial production in the area of industrial wood processing:

1. The quality of data is largely dependant on the purpose for which the data was collected and used:
   - statistical data does have a stipulated and given content (questionnaire), but with small companies, in particular, data is mostly not classified in detail;
   - data for analysing a company's performance contains very detailed analyses, but certain data represents a business secret;
   - data from surveys is mostly useful for rough comparisons only.

2. The quality of data depends on a company's organisation:
   - companies with a long-standing tradition, an attractive basic production programme, mass production for their most important products adaptable to market demands, a guaranteed market, exact administration and data processing, are able to supply the Slovenian Statistics Office with exact data obtained on the basis of permanently surveying production;
   - relatively small companies - especially those developing, which still have to make a name for themselves, with a very broad spectre of activities (production, trade, agency, etc.), an unclear basic activity, mostly do not provide exact data, but a more or less adequate assessments of quantities;

3. The quality of data depends on the personnel's seriousness and legal obligations:
   - the reports must be established by the director or an authorised representative, and they represent factual data;
   - the reports are often established due to a legal obligation, and data are often unrealistic.

# 4 DETERMINATION OF THE PROSPECTIVE REGIONS IN SLOVENIA APROPRIATE FOR SUSTAINABLE SUPPLY OF THE WOOD BIOMASS

## 4.1 Industrial sector

As data on wood residues is very insufficient, and for most subjects engaging in primary, secondary and tertiary wood processing there is no data whatsoever, a classification of municipalities according to prospects appears to be very risky and unfounded. Relatively exact data is available only for the number of subjects engaging in the mentioned activities. On the basis of data which was accessible to us, we may conclude that, from the viewpoint of the wood processing industry, the following municipalities have best prospects: **Kočevje, Novo Mesto, Logatec, Sevnica, Krško, Kamnik and Maribor.**

All the above-mentioned municipalities have **more than 45 subjects the registered activity of which is primary, secondary or tertiary wood processing, and which have more than 15.000 $m^3$ of documented wood residues per year.**

## 4.2 Forestry and agriculture

The exploitation of the forest wood biomass potential for energy purposes has already been shown in chapter 3.2. For a demonstration and analysis of the biomass potential from brushwood and the total potential from all treated sources, we shall utilise the regional partition of Slovenia according to statistical regions. We are dealing here with geographic, orographical and gravitational areas which are sufficiently homogenous for the natural conditions and socio-economic parameters, and differ from one another because of individual characteristics.

The basic data for calculating the energy potential of brushwood in the statistical regions was obtained by merging the data for the municipalities belonging to the specific regions. On the basis of different scientific and specialists' measurements and assessments (of stock and increment), combined with experience, we evaluated the hypothetical biomass potential in brushwood to be of the order of 2,5 $m^3$ per ha and year. Hypothetical, because the realisation of this potential is subject to a number of factors. It will depend on the classification for a permanent or provisional use of surfaces, and on the speed and intensity of implementing appropriate measures in order to realise this use, such as clearing, direct and indirect transformations, cleaning, thinning and other interventions. Respecting surfaces, real physical possibilities, and disregarding the dynamism of brushwood transformation, we believe that all work could be performed within a period of 25 to 30 years. These statements are, of course, dependant on the disposable financial resources, i.e. on the market value (the price) of biomass in the energy sector. This potential will, in fact, remain hypothetical in the future, unless appropriate and efficient financial stimulation is presented at all levels (governmental, local, sectorial). The assessed annual potential in wood biomass from brushwood in the individual statistical regions of Slovenia is shown in table 15.

Table 15: Annual potential in wood biomass from brushwood in the individual statistical regions

| No. of region | Name of region | Number of municipalities | Surface of brushwood in regions (ha) | Wood biomass ($m^3$) |
|---|---|---|---|---|
| 1 | Pomurje | 18 | 1.158 | 2.895 |
| 2 | Posavje | 20 | 4.429 | 11.072 |
| 3 | Koroška | 10 | 2.402 | 6.005 |
| 4 | Savinjska | 23 | 8.623 | 21.707 |
| 5 | Zasavje | 3 | 1.095 | 2.737 |
| 6 | Spodnje-posavska | 3 | 3.401 | 8.503 |
| 7 | Dolenjska | 7 | 8.741 | 21.853 |
| 8 | Osrednje-slovenska | 25 | 17.353 | 43.376 |
| 9 | Gorenjska | 15 | 6.483 | 16.207 |
| 10 | Notranjsko-kraška | 5 | 13.721 | 34.302 |
| 11 | Goriška | 11 | 19.156 | 47.892 |
| 12 | Obalno-kraška | 7 | 8.500 | 21.247 |
| | Total | 147 | 95.119 | 237.797 |

The table shows major differences in the potential of individual regions. A great concentration of potential in brushwood biomass is found in the western part of Slovenia, namely in the Goriška region (20% of total potential), in Osrednje-slovenska (18%) and Notranjsko-kraška

region (14%). In total, these three regions account for as much as 53% of all potential in Slovenia. There is also an important potential in the Savinjska region (9%), Dolenjska (9%), the Obalno-kraška region (9%), and Gorenjska (7%). The smallest potential - which is unimportant in the regional context – is found in the Zasavska region (1,1%), Pomurska region (1,2%) and Koroška (2,5%).

On average, every municipality has 1.618 $m^3$ of brushwood, which represents 0,7% of the total brushwood potential in Slovenia. However, the distribution is largely uneven, and the municipalities in Notranjsko-kraška region have an average of 43-fold that of those in the Pomurje region, and 4,2-fold the average of all municipalities. Other areas which show a marked discrepancy with respect to the average for all municipalities are the Goriška region (2,7-fold), Dolenjska (1,9-fold), and the Obalno-kraška region (1.9-fold). In general, the potential in brushwood biomass is large enough in all regions to be worthy of our attention. In particular, if we consider that this is only a part of the total potential, i.e. excludes the potential from forests and different wood processing and wood consuming activities.

## 4.3 Integration of analysed wood biomass potentials

When planning local district heating plants based on biomass, we should not limit our feasibility study to an analysis of the potential in the local (municipal) context, or to one single source. For a reliable, permanent and economical supply, an analysis of all potential in biomass sources, including a larger area, must be performed. However, this area must not be too large, as transportation costs for the biomass represent an important factor of whether the use of this energy source is economic. In our estimation, the distance from the heating plant should normally not exceed 30 km.

The actual picture of exploitable biomass potential, both from forests and from wood residues of industry, has been processed by cross-sectioning upon the selected parameters. On the basis of a calibration of the key indicators of the potentials and their classification, we determined the average classes for the municipalities. The average class represents an assessment of the gross potential for permanent wood biomass provision in a defined area. The quantitative distribution of the gross potential is shown in table 16 and its spatial distribution on the map 11. As we were unable to perform an analysis of places of consumption (due to insufficient and not existing data), no balance could be established.

Table 15: Distribution of the communities according to the suitability of the local wood biomass potentials for district heating projects

| Class | Average rank of suitability | Number of municipalities | % |
|---|---|---|---|
| 1 | 1,00-1,49 | 20 | 13,6 |
| 2 | 1,50-2,49 | 33 | 22,4 |
| 3 | 2,50-3,49 | 23 | 15,6 |
| 4 | 3,50-4,49 | 20 | 13,6 |
| 5 | 4,50-5,49 | 24 | 16,3 |
| 6 | 5,50-6,00 | 27 | 18,4 |
| | Total | 147 | 100,0 |

The highest two ranks gained 51 communities. The majority of them have all indicators above median. This communities are mostly located in rural environment with forests as prevailing land use and tradition in utilisation of wood as an energy source. The real challenge is that in such communities the balance between communal and individual wood biomass energy utilisation will have to occur in future.

# 5 IDENTIFICATION OF THE MAJOR BARRIERS FROM THE FORESTRY AND WOOD INDUSTRY WITH PROPOSALS FOR THEIR REMOVAL

## 5.1 General barriers

The main barriers against the exploitation of biomass for local district heating can be divided into two groups:

1 General and systemic, which are applied generally for the use of wood biomass in the energy economy,
2 Specific barriers set by natural, socio-economic, technical, technological and ecological characteristics of the treated potential in wood biomass sources.

The main barriers from the first group include:

1 Undefined strategies for the development of the energy economy at the local, regional, and national level. The adopted Resolution on energy supply and use, and the national energy programme, serve as guidelines and are not binding. There is no authorised body having the competence and the obligation to implement the national programme;
2 A lack of vision, stimulation and common focus at the state (governmental) level, with no clear goals and implementing instruments;
3 Incompatible financial instruments among the individual state institutions (Budget - Ministry of Trade and Commerce; Fund for efficient energy use (AURE) - Ministry of Trade and Commerce; Ecological development fund – Ministry of the Environment; tax on $CO_2$ - Ministry of Finance; Funds for demographically endangered regions; Funds for agricultural development - Ministry of Agriculture and other institutions).
4 Direct or indirect subvention of fossil fuel exploitation, non-transparent costs which do not allow orientation on the basis of market criteria for both investors and consumer. Price surveillance for energy sources and energy is a governmental instrument for balancing inflationary fluctuations and keeping social peace;
5 Inadequate price and tax policy in the energy sector. Prices do not comprise direct benefit, or external costs with the individual energy sources and types (environmental costs - emissions). Natural gas competing with biomass as energy source has the support of several state institutions. The financial means from the $CO_2$ tax are not used to reduce emissions by renovating energy plants;
6 Traditional vision of energy being produced in large central plants, thus guaranteeing the technological and economic development of society;

7 General ignorance of environmental, social and cultural consequences of one's own energy consumption and consumer customs, and of the possibilities and consequences of choosing a certain energy source or type;
8 Inadequate specialised knowledge and unawareness on the part of project teams, governmental and local administration, and political bodies regarding energy supply, energy services and the consequences of using different sources in different geographic and climatic conditions;
9 Unplanned and economically and ecologically unfounded decisions taken by local communities regarding long-term supply with energy. Local energy plans do not consider the possibility of exploiting renewable local energy sources;
10 Relatively high investment costs for projects involving local district heating based on biomass;
11 Lack of modern domestic technology and equipment for economical and ecologically acceptable extraction, preparation and exploitation of wood biomass;
12 Lack of relevant regional registers and information on the local wood biomass potential according to sources, quantities and types;
13 Much restricted financial resources for research and development in the area of identification, extraction and exploitation of wood biomass in the energy sector.
14 Mistaken idea of heating with wood as an outdated energy source, both in lay and some professional circles, resulting from traditional types of exploitation, and from ignorance of modern technology of heating with wood biomass. The ecologically aware and economically developed world understands this renewable energy source as the energy source of the future.

Likewise, the measures for eliminating these barriers are general, systemic and specific for a treated potential source. Among the general measures, we believe the following to be most important:

1 Systematic focusing of national, regional and local energy policies;
2 Accelerated impartion of knowledge, professional, organisational and administrative training, environmental and ethical awareness (going beyond tradition) having the goal of exploiting wood biomass, with more efficiency and environmental awareness, as a source of energy;
3 Creation of market conditions which will stimulate the use of ecologically acceptable sources;
4 Different measures taken through loan, tax and customs policies (loans, taxes, customs, ecological taxes, subventions) for increasing the competitiveness of wood biomass versus fossil fuels (inclusion of external costs into energy price);
5 More guaranteed financial resources for research and development in the area of identification, extraction and use of biomass in the energy economy (foundation of a special development fund);
6 Accelerated research and development in technologies and in the production of domestic equipment;
7 Subvention of project plans, pre-studies and studies;
8 Local communities should be obliged to first establish energy plans with an analysis of the biomass potential and their possible exploitation, also communities where a gas supply system is being introduced;

9 Consequent implementation of the Decree on emissions into the air from heating installations, and the direct material liability of the responsible party;
10 Foundation and permanent updating of a database on key parameters for potential biomass sources for energy purposes (sources, sort, quantity, structure, exploitability);
11 Sanctions for dumping and burning residues from wood production and processing, as well as used wood products, in the natural environment.

## 5.2 Industrial barriers

1 The first and foremost barrier is set by the fact that, in Slovenia, there is no overall database including all subjects which engage in primary and secondary wood processing. Data on waste and residues is not being collected, neither at the state nor the local level. It is true that, in 1992 and 1995, the Statistics Office of the Republic of Slovenia performed research on waste, but the research was restricted to some selected subjects. The Statistics Office of the Republic of Slovenia collects only data for those companies employing more than 10 persons - according to the Chamber of Commerce, in Slovenia, only little over 30% of all companies registered for the mentioned activities (the working and processing of wood) belong to this category, and the Statistics Office surveys the operations of just 4% of the above-mentioned companies. Data accessibility for data collected and administered by the Statistics Office is problematic, not least due to data protection for individuals. At the municipal level, data on primary and secondary wood processing is insufficient, and does not contain the majority share of primary wood processing which is done in private sawmills - beside the registered sawmills, there are a large number of unregistered sawmills in Slovenia belonging to forest owners. According to estimates from the survey of forest owners conducted in 1995, we can say that there are at least 8.000 sawmills cutting log-timber which belong to forest owners.
2 The issue of the biomass potential disposability for energy purposes is largely dependant on data on wood residues, but the usability of available data is very low, because the companies report only on production. A simple calculation of residue quantities based on coefficients and production quantities and types cannot be completely accepted, because we do not know the share of residues used for different purposes. Also data on wood residue concentration is important, because a large number of small sawmills in a municipality means a relatively large amount of exploitable wood residues, which are, however, scattered, so transportation costs are high. On the other hand, large companies producing furniture have large wood residue quantities concentrated in one place; here, the problem is posed by the type of wood residues, e.g. ground wood pulp, which may require a specially adapted technology, or the fact that wood residues are polluted (glues, colours).
3 It is necessary to know not only the sources of wood residues but also the places of consumption, but the latter are also not observed in a planned and systematic manner by anybody. Only by considering the sources and the existing places of consumption can we establish the actual disposable biomass - everything else is unfounded speculation.
4 There is no data on the quantity of exploited wood products on dumps and disposal sights, and nor we do not know the quantity of wood residues obtained in the construction industry and in major national companies, e.g. electric power stations, the mails, etc.

Proposals for removing barriers from the area of wood processing and finishing:

1 Companies should include in their regular annual reports for the Statistics Office of the Republic of Slovenia the quantities of produced waste. The Statistics Office should adapt more data, and present it at a municipal level, not only at the national level as it does now.
2 Data necessary for treating project drafts should be more easily accessible to the public and/or to investors.
3 An integral programme of periodic survey of the main wood biomass sources for energy purposes should be charted, and an appropriate institution should be selected for the implementation of such a programme.

## 5.3 Forestry barriers

On the basis of the analysed data on forests, we may conclude that the forests by themselves do not represent any barrier against the potential exploitation of biomass for local district heating. Barriers are set mainly by:

1 The forest management mode.
2 Technological immaturity for a rational preparation of biomass directly from the forests.
3 A vicious circle between the consumers, who are not equipped for exploiting biomass, and the potential suppliers, who do not have consumers. For this reason, it is necessary to stimulate the potential consumers in order to break this vicious circle. If this can be achieved, sustainable development in this sector, with increasing supply and demand will be created.

In extracting biomass directly from the forests, transportation costs play an important part. Transportation costs and wood extraction costs (felling, stocking) are included in all other forest products. In processing, these costs are passed on to the intermediate and final product, so that wood residues do not contain any production costs at the place of their occurrence. The fact that, in local district heating, biomass is used directly from the forests must be respected for further analyses.

## 5.4 Land use barriers

There are also numerous specific barriers hindering the exploitation of the wood biomass potential for local district heating based on brushwood. We believe the most important to be the following:

1 The long-term purpose and use of this category of plots is not defined, and the interests of potential beneficiaries (agriculture, forestry, other sectors) are not harmonised.
2 The economic interest shown by all mentioned potential subjects for this category is limited.
3 Registers are insufficient, and the important parameters of this potential is not known well enough (surfaces, stocks, structure, exploitability). A special problem is also posed by outdated and incompatible data regarding the actual and the registered (cadastral) situation.

4 Resources for taking measures (thinning, transformation, maintenance) essential for an economic exploitation (different purposes) are insufficient.
5 The bulk of wood produced in necessary measures is of low quality, and unfit for technological exploitation. Extraction costs by far exceed market prices for wood assortments of low quality.
6 A large share of brushwood is found on difficult terrain, which increases the costs of any intervention;
7 As real estate is scattered and the potential per surface unit are relatively low, sufficient biomass concentration for economic exploitation is impossible.
8 Many brushwood owners are not farmers, do not depend on supplementary income, and do not have the necessary specialist knowledge and experience, nor the ecological awareness, and are therefore completely uninterested in this potential.
9 Among owners of brushwood biomass potential, there is a general lack of knowledge and experience, and of appropriate equipment (chopping machinery). Purchase prices and costs for imported technology of this type are too high for Slovenian standards.

The following are major efficiency measures which are specific for the wood potentials on abandoned agricultural areas and other brushwood wood potential:

1 Abandoned and overgrown agricultural surfaces should be classified systematically for their long-turn exploitation, in co-operation with all potential beneficiaries.
2 Interest in appropriate management of these surfaces should be stimulated and positively sanctioned .
3 Necessary operative interventions in the sense of agreed purposes (thinning, cleaning, clearing, indirect and direct transformation into forests) must be performed.
4 Direct and indirect financial and other stimulation must be offered for the implementation of necessary interventions, in particular, in the private ownership sector.
5 A market for energy from wood biomass should be organised, with competitive purchase prices stimulating relevant measures and the exploitation of the brushwood biomass.
6 Modern technological solutions in extracting, preparing and exploiting wood biomass should be popularised and propagated - even for small private heating installations.
7 Various forms of ownership associations (co-operatives, technical associations) aiming at rationalising the extraction, preparation and exploitation of the potential should be stimulated.
8 The foundation of private enterprises should be assisted (with the inclusion of private capital, simplifying the procedure in obtaining concessions) in extracting, preparing, and exploiting wood biomass (in small private heating installations), as well as in supplying the market.

# 6 CONCLUSIONS AND FINAL RECOMENDATIONS

1 The documented quantity of wood residues in the industrial sector (about 200 enterprises with more than 10 employees) amounts annually to about 361000 tons (oven dry substance - average density: 500 kg/m$^3$) (722000 m$^3$). About 230000 tons is already used for energetic purposes in existing medium sized boilers. Beside larger enterprises there are over 4.000 small companies with at least 150000 tons of dispersed wood residues. **The additional/untapped biomass potential in industrial sector is estimated to be at least 280,000 tons.**

2 The programmed potentials from forests, according to the National forest development programme, amounts annually up to about 250000 tons (500.000 m$^3$) of wood biomass for energy, but this quantity is already used in existing individual - technological unsuitable - biomass heating systems. The annual increment of wood biomass in forests in Slovenia is 6,127000 m$^3$, average annual planned cut is 3,128000 m$^3$ and the annual cut (average of 1995-1997) is 2,332000 m$^3$. **We estimate that 50% of the difference between planned and realised cuts (400000 m$^3$) may be utilised in energetic purpose in the future, what makes the biomass potential from forests about 200000 tons.**

3 **The estimated total potential in brushwood in Slovenia amounts annually to about 120000 tons.** Uncontrolled overgrowing and uneconomic use of abandoned agricultural areas remains an open issue in environmental management, and, it appears, that in the foreseeable future there will not be any increased interest in a more intensive exploitation of these areas. Exploitation may be accelerated and directed for energy purposes, but the economic exploitation of this wood biomass source will have still to be developed. The same applies to the exploitation of wood residues on disposal sights, but here, emission standards will have to be much more respected in the future.

4 It is necessary to begin creating the conditions for a market of raw materials i.e. wood biomass. The market in wood biomass will have to comprise several sources, and measures should be adapted to this situation. For local district heating projects, concentrated potential is of crucial importance, i.e. companies obtaining major quantities of unpolluted wood residues. The latter are relatively well exploited in Slovenia, so that, for any new project, analyses of accessibility to wood biomass and forests, overgrowing areas, and wood residues are very important. Likewise, a thorough analysis and sensible connection has to be carved out in the wood production and processing industry (changes are very dynamic here), and in the agricultural sector.

5 Due to poor information support in the area of wood biomass potential, and the quality of the collected data, we are not able to establish a nation-wide, high-quality estimation of the sum of available wood biomass. On the other side the analysis of the major groups of the potentials have shown that there are over 500000 tons of unused potentials of wood biomass. There are many barriers hindering the realisation of the assessed potential. We belive that they can be removed and we have shown some possible major measures for their removal. With a systematic and organised approach involving adequate financial support, it is possible to fulfil the national program for doubling the share of energy from wood biomass by the year 2010 in Slovenia.

6 It is unrealistic and uneconomic to stimulate the establishment of additional information system in this field. However, the energy projects of local communities and the relevant documentation for particular project phases will have to contain requirements regarding an integral analysis of the biomass potential. The methods should be adapted to the Slovenian specificity's, and thus guarantee adequate auditing with the authorised institutions.

# 7 REFERENCES

AZAROV, E. / ČAMPA, L., 1990. Prostorska analiza negozdnih površin. Raziskovalna naloga. Inštitut za gozdno in lesno gospodarstvo, Ljubljana.

Bizjak, S.,1998. Les kot vir toplotne energije na severnem Primorskem.- Višješolska diplomska naloga, BF odd. za lesarstvo, Ljubljana, 41 s.

BOŽIČ, J. / KOŠIR, Ž., 1978. Malodonosni gozdovi, grmišča in kmetijska zemljišča določena za gozd ter recentne regresije v gozdovih. Preglednice. Inštitut za gozdno in lesno gospodarstvo, Ljubljana.

ČOKL, M., 1975. Gozdarski in lesnoindustrijski priročnik. Sestojne tablice - tablice donosov, st. 224 - 291. Strokovna in znanstvena dela. BF v Ljubljani, Inštitut za gozdno in lesno gospodarstvo, Ljubljana.

ČRETNIK / ŠLIBAR /TORNIČ / SMRDELJ, 1998. Stanje srednjih kurilnih naprav v R Sloveniji. Letno poročilo. RACI d.o.o. Ljubljana. 26 s.

GERMEK, V. / REDNAK, M. / CUNDER, T. / LUKAČIČ, M., 1987. Tehnična navodila za izdelavo agrokarte. Elaborat. SRS Republiški komite za kmetijstvo, gozdarstvo in prehrano. Zveza kmetijskih zemljiških skupnosti Slovenije, Ljubljana.

GOLOB, S. / HRUSTEL - MAJCEN, M. / CUNDER, T., 1994. Raba zemljišč v zaraščanju v Sloveniji. Zbornik. IX. tradicionalni posvet kmetijske svetovalne službe "Kako izboljšati posestno strukturo v Sloveniji, Bled, november 1994.

MERZELJ, F., 1993. Lesni ostanki v žagarski proizvodnji. -Les, 45, 1 - 2. s. 5-9

POGAČNIK, N. 1998. Nekatere značilnosti gozdov in gozdarstva v Evropski uniji. GozdV, 56, 2, s. 97-103.

SVETLIČIČ, A., 1977. Industrijski lesni ostanki v Sloveniji. Inštitut za gozdno in lesno gospodarstvo pri Biotehniški fakulteti v Ljubljani. Ljubljana. 61 s.

ŽGAJNAR, L. / BITENC, B. 1995. Količinska, strukturna, prostorska in energijska ocena stanja rabe lesne biomase za energijske namene v Sloveniji. Elaborat. Inštitut za gozdno in lesno gospodarstvo, Ljubljana.

ŽGAJNAR, L. / BITENC, B., 1993. Analiza potencialov biomase v grmiščih. Manuscript. Inštitut za gozdno in lesno gospodarstvo, Ljubljana.

ŽGAJNAR, L. / BITENC, B., 1996. Količinska, strukturna, prostorska in energijska ocena potencialov lesne biomase za energijske namene v Sloveniji. Elaborat. Gozdarski inštitut Slovenije, Ljubljana.

ŽGAJNAR, L. / KOŠIR, B. / GREGORIČ, T., 1992. Količinski, tehnološki in ekonomski vidiki ter možnosti izboljšanja oskrbe z lesno surovino za iverne plošče v podjetju BREST Cerknica. Elaborat. Inštitut za gozdno in lesno gospodarstvo, Ljubljana.

ŽONTA, I., 1982. Opuščanje in zaraščanje kmetijskih zemljišč ter spreminjanje namembnosti rabe plodnih zemljišč. Elaborat. Inštitut za gozdno in lesno gospodarstvo, Ljubljana.

---, 1988. Heizen mit Holz. Emissionen - Holz ist umweltfreudlich und $CO_2$ neutral - im Vergleich zu fossilen Brennstoffen. Gemeinschaft Südtiroler Sägewerker Gen. M. b. h.

---, 1991. Stanje in možna raba zemljiških kultur. Originalni podatki za agrokarto. Računalniška disketa. Kmetijski inštitut Slovenije, Ljubljana.

---, 1993. Analiza grmišč. Strokovna naloga. Polikopija. Gozdno gospodarstvo Kočevje, Kočevje.

---, 1994. Program razvoja gozdov. MKGP, , Ljubljana.

---, 1996. Poročilo o delu Zavoda za gozdove Slovenije. Ljubljana, Zavod za gozdove Slovenije, 62 s.

---, 1997. Statistični letopis 1997. Statistični urad R Slovenije. Ljubljana s. 486-489.

---, 1997. UN - ECE / FAO. Temperate and Boreal Forest Resources Assessment 2000. Country Slovenia. Elaborat. Gozdarski inštitut Slovenije, Ljubljana.

---, 1997. Vzorčni popis osnovnih zmogljivosti kmetij, 1997 - Predhodni podatki. Zemljišča po zemljiških kategorijah v uporabi družinskih kmetij in kmetijskih podjetij. Statistične informacije št. 298 / 1997. Statistični urad RS, Ljubljana.

---, 1998. Popis gozdov. Računalniški izpis površin gozdnih grmišč. Zavod za gozdove Slovenije, Ljubljana.

# 8 LIST OF MAPS



**ANALYSIS OF WOOD BIOMASS POTENTIAL IN SLOVENIA, FINAL REPORT**

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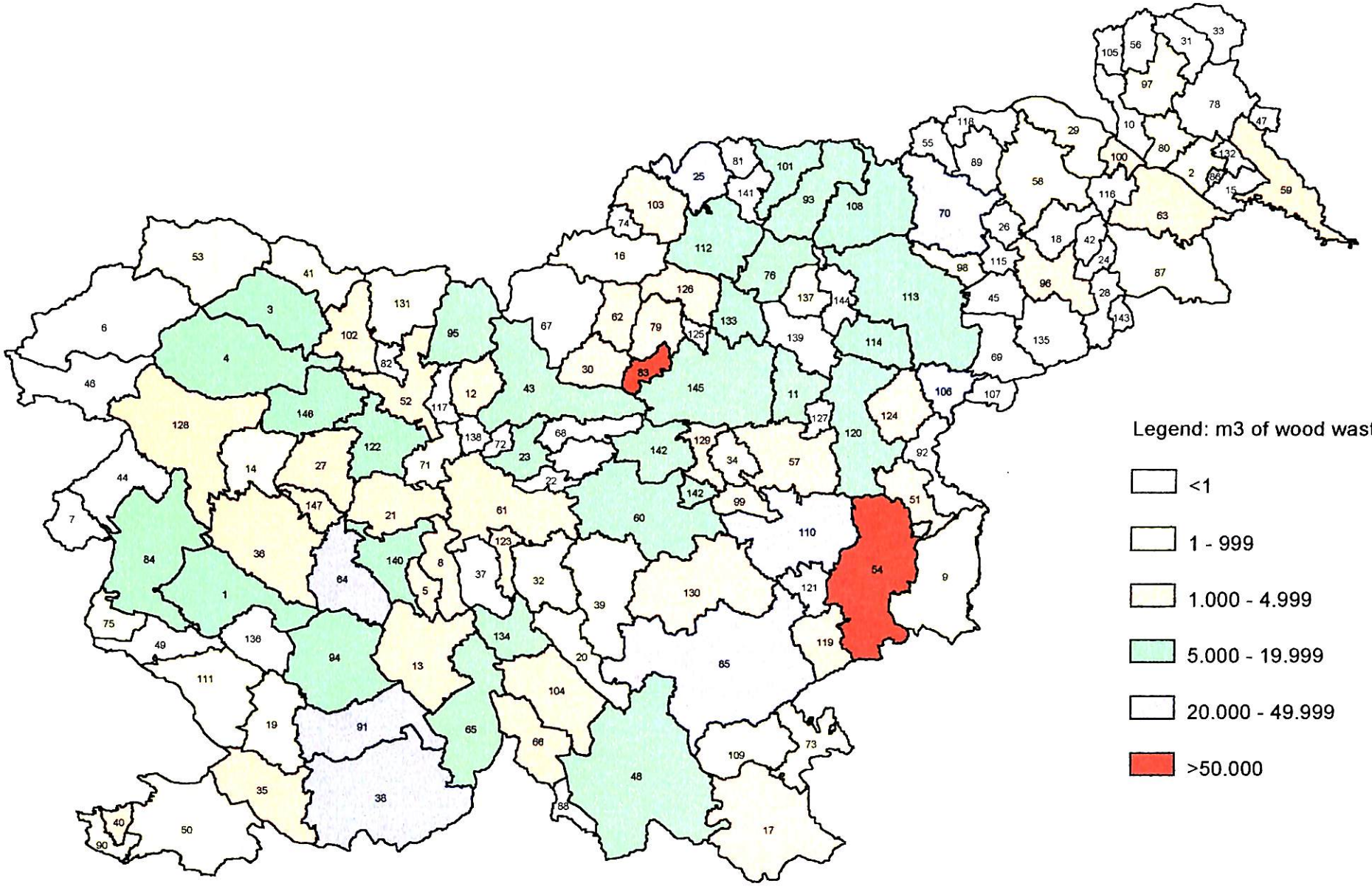
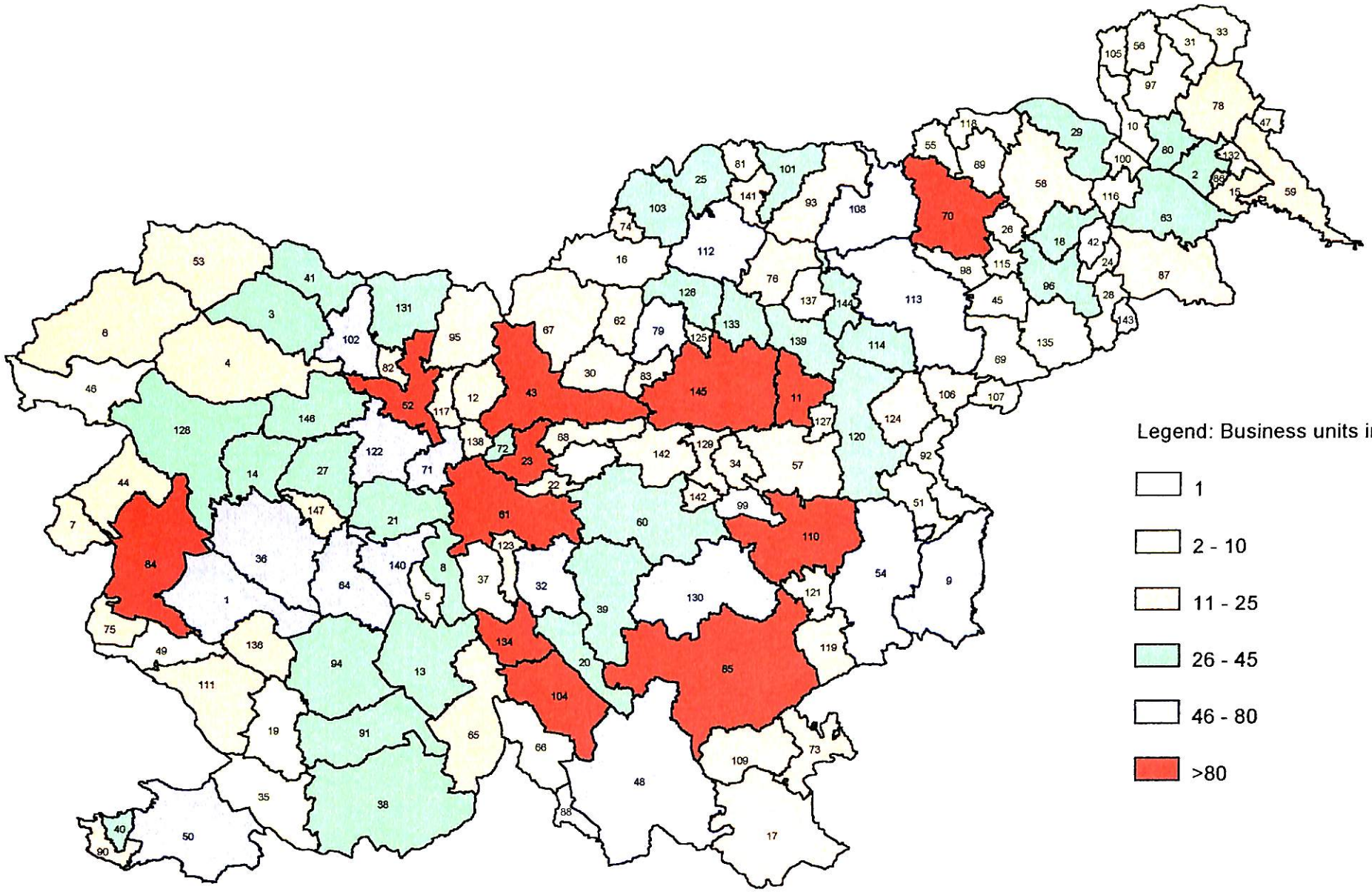
Prevodi / *Translation by*: Janez Špendor

# Documented annual wood residue quantities




MAP 1

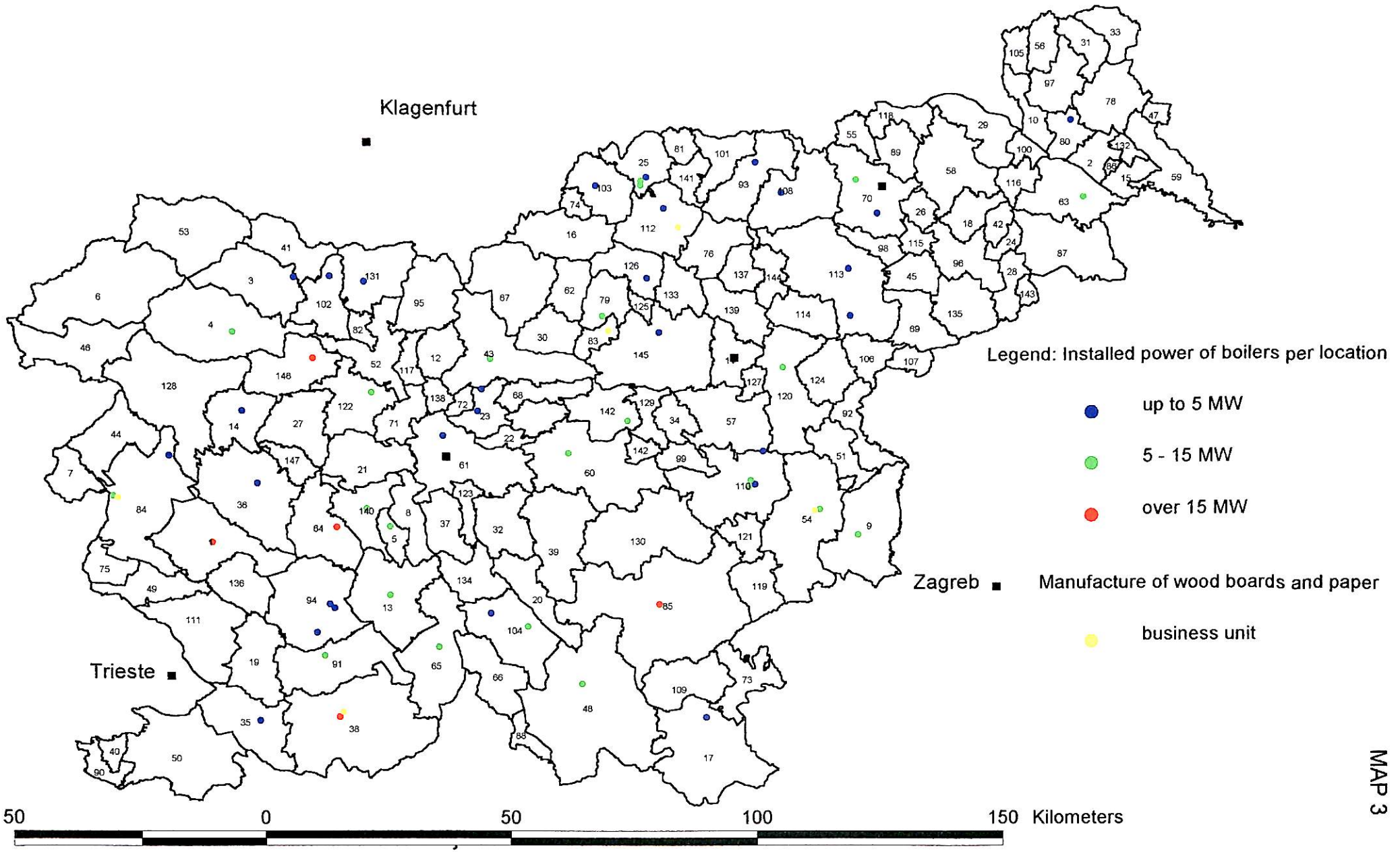
# Number of business units in timber industry




MAP 2

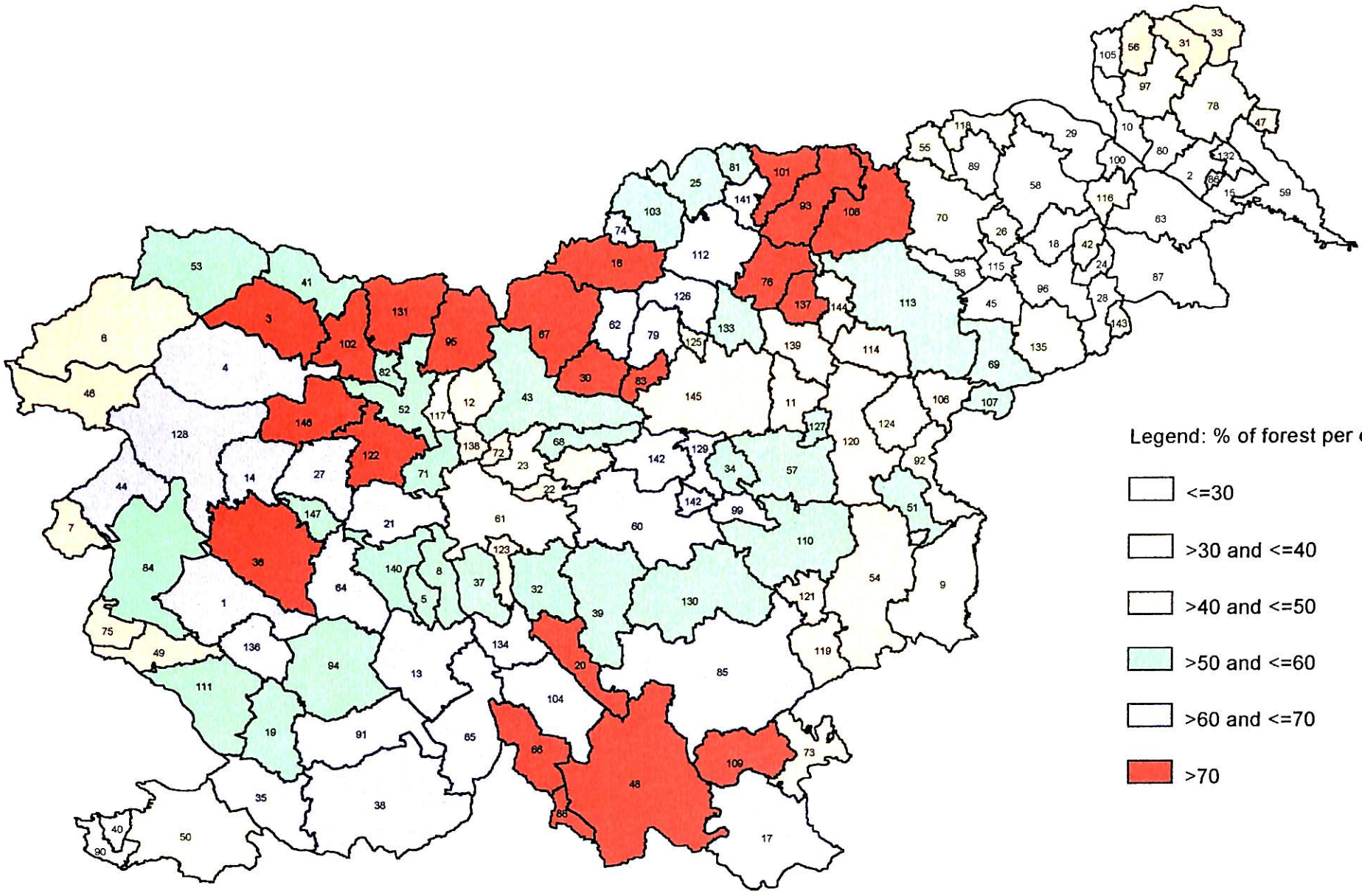
# Sinkholes of wood biomass (without chemical industry)





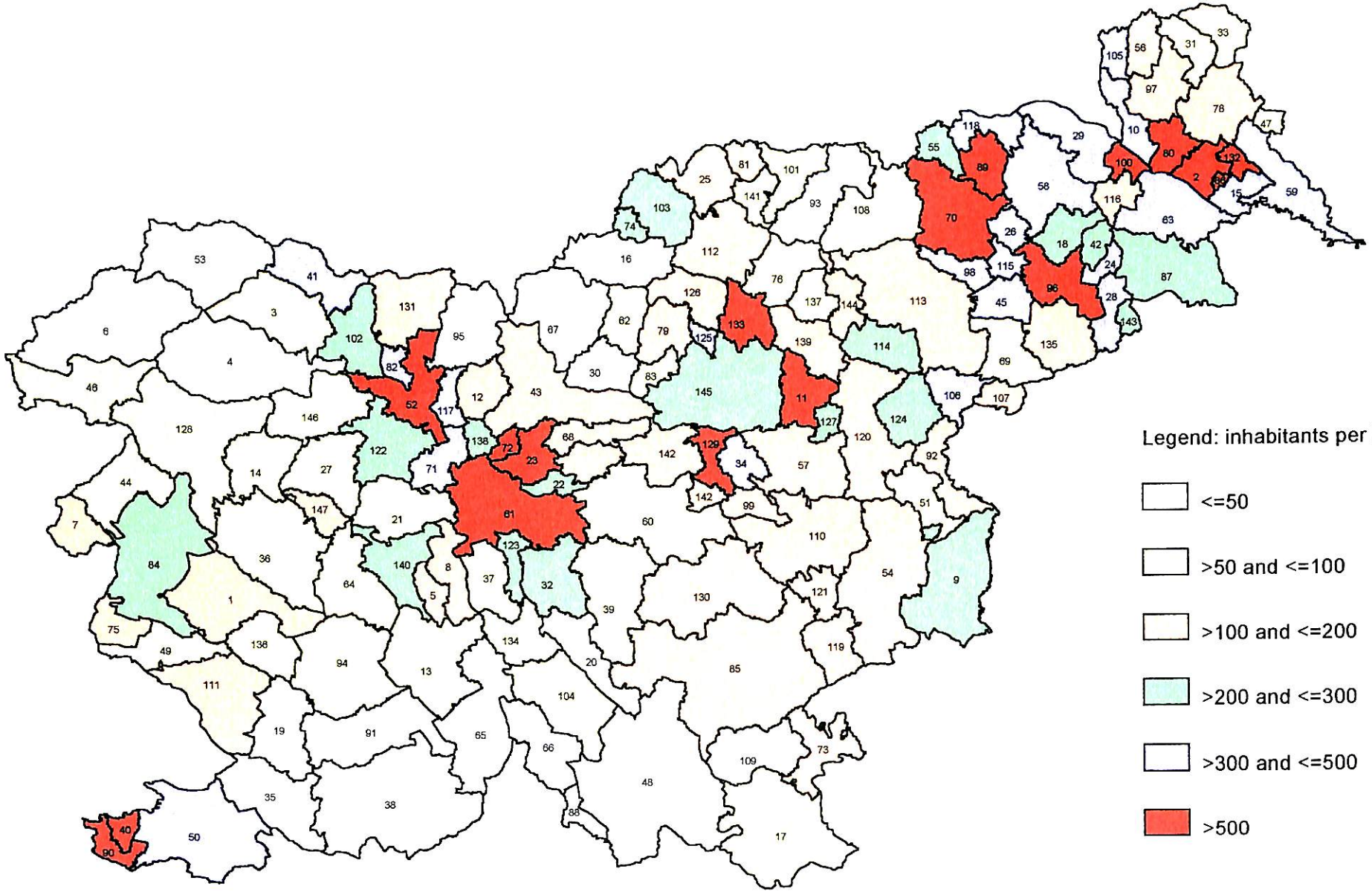

MAP 3

# Woodiness of local communities



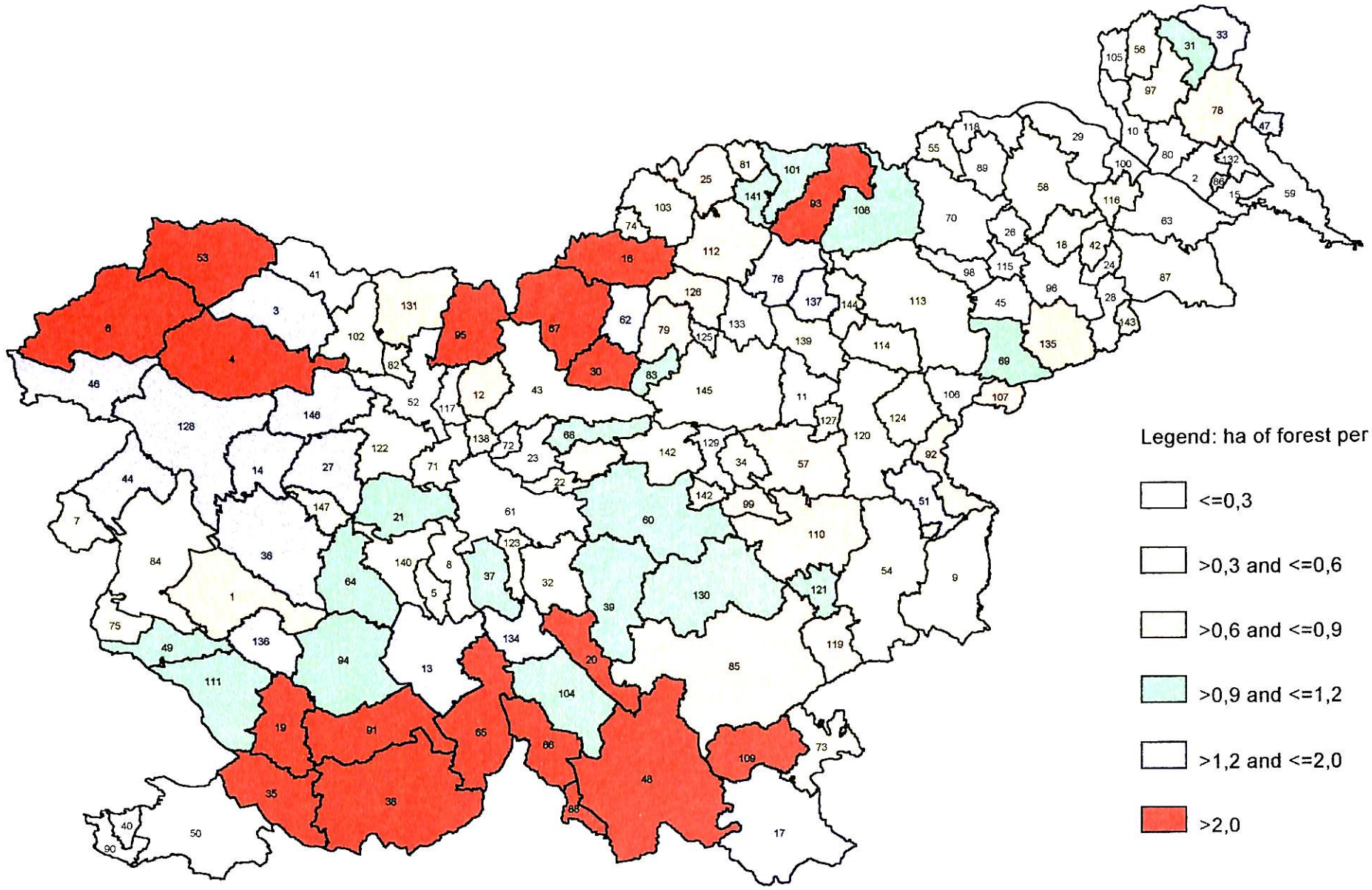

MAP 4

# Density of inhabitants




MAP 5

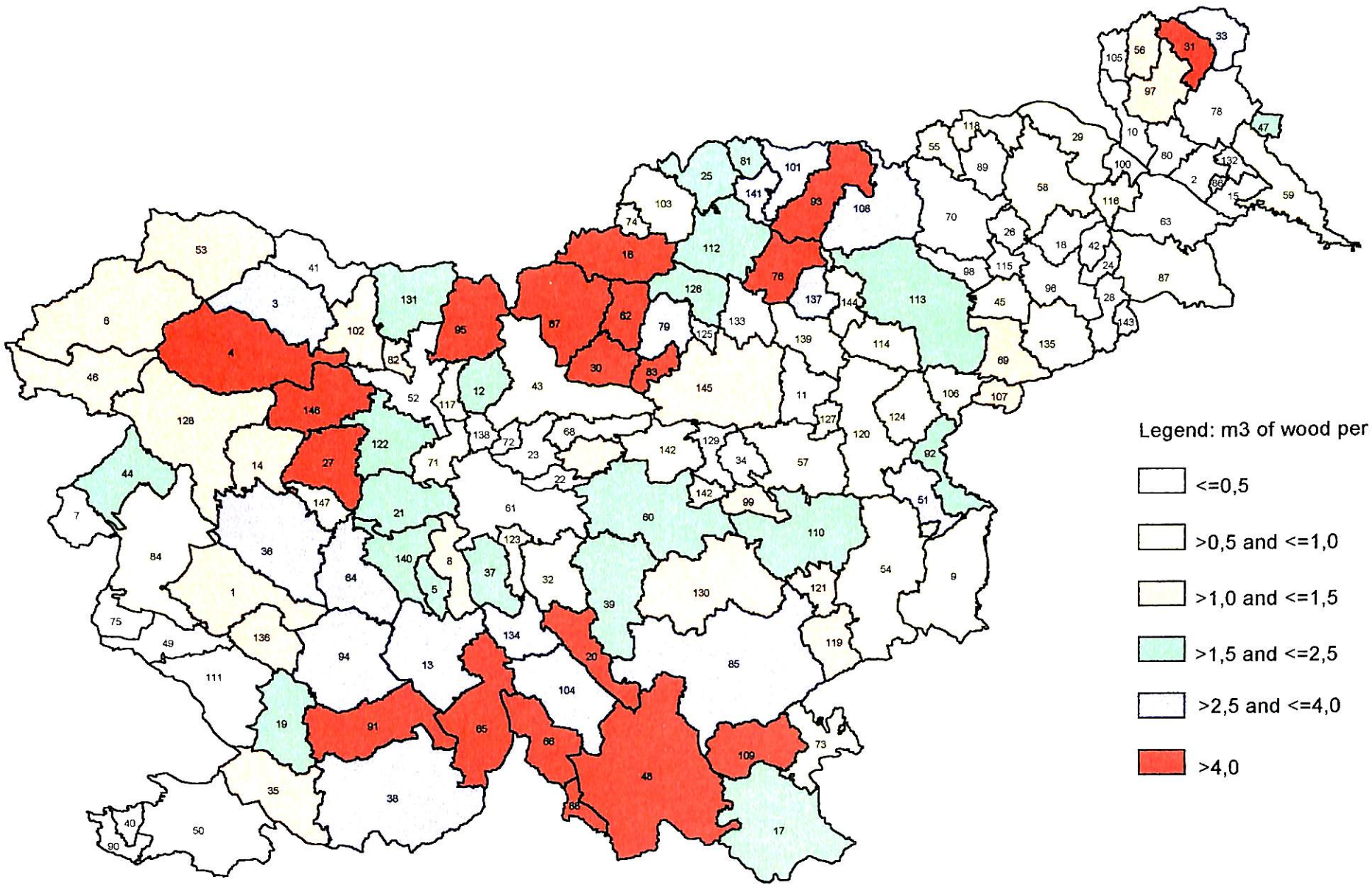
# Forest area per capita




MAP 6

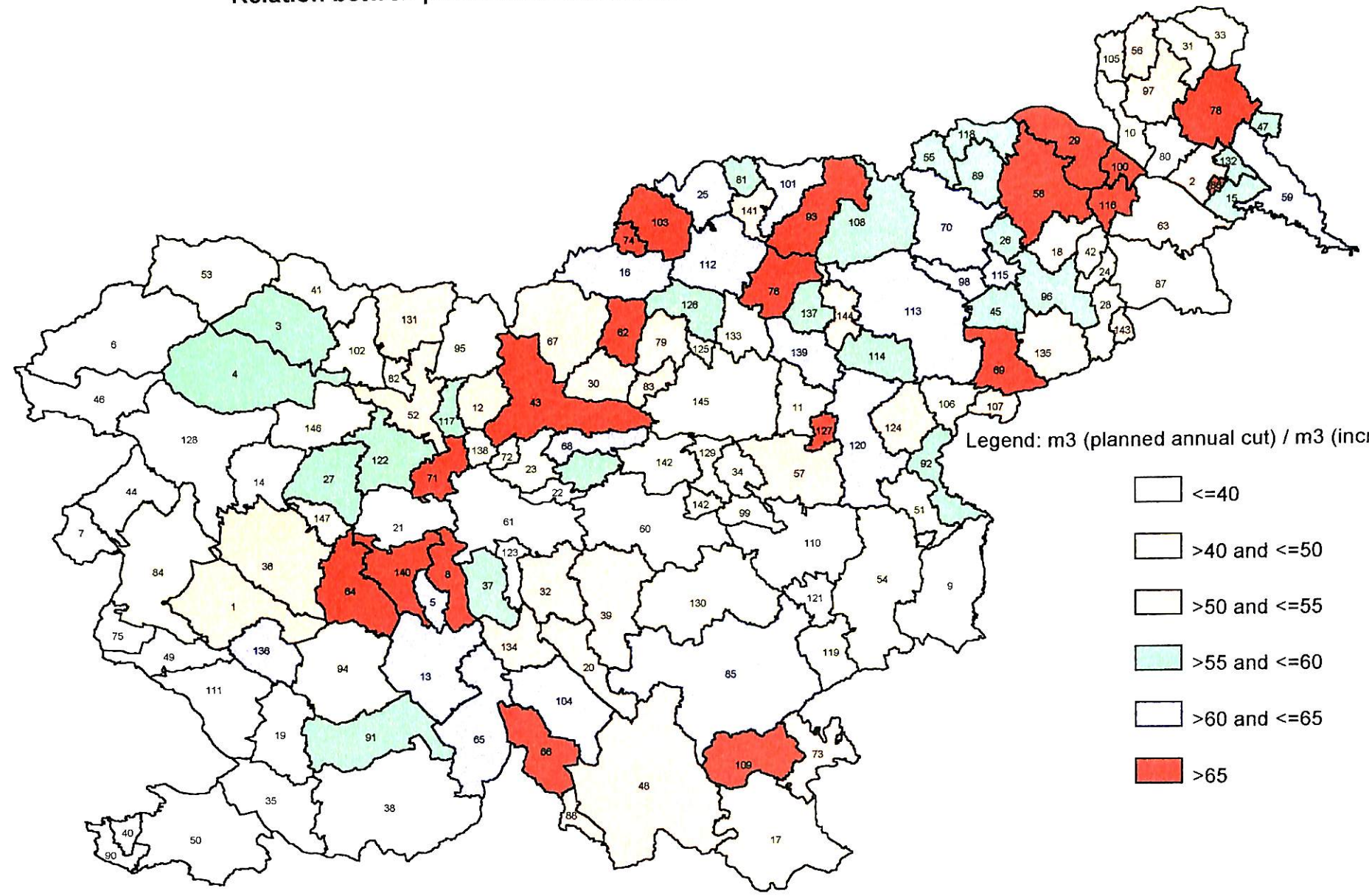
# Average felling per capita






MAP 7

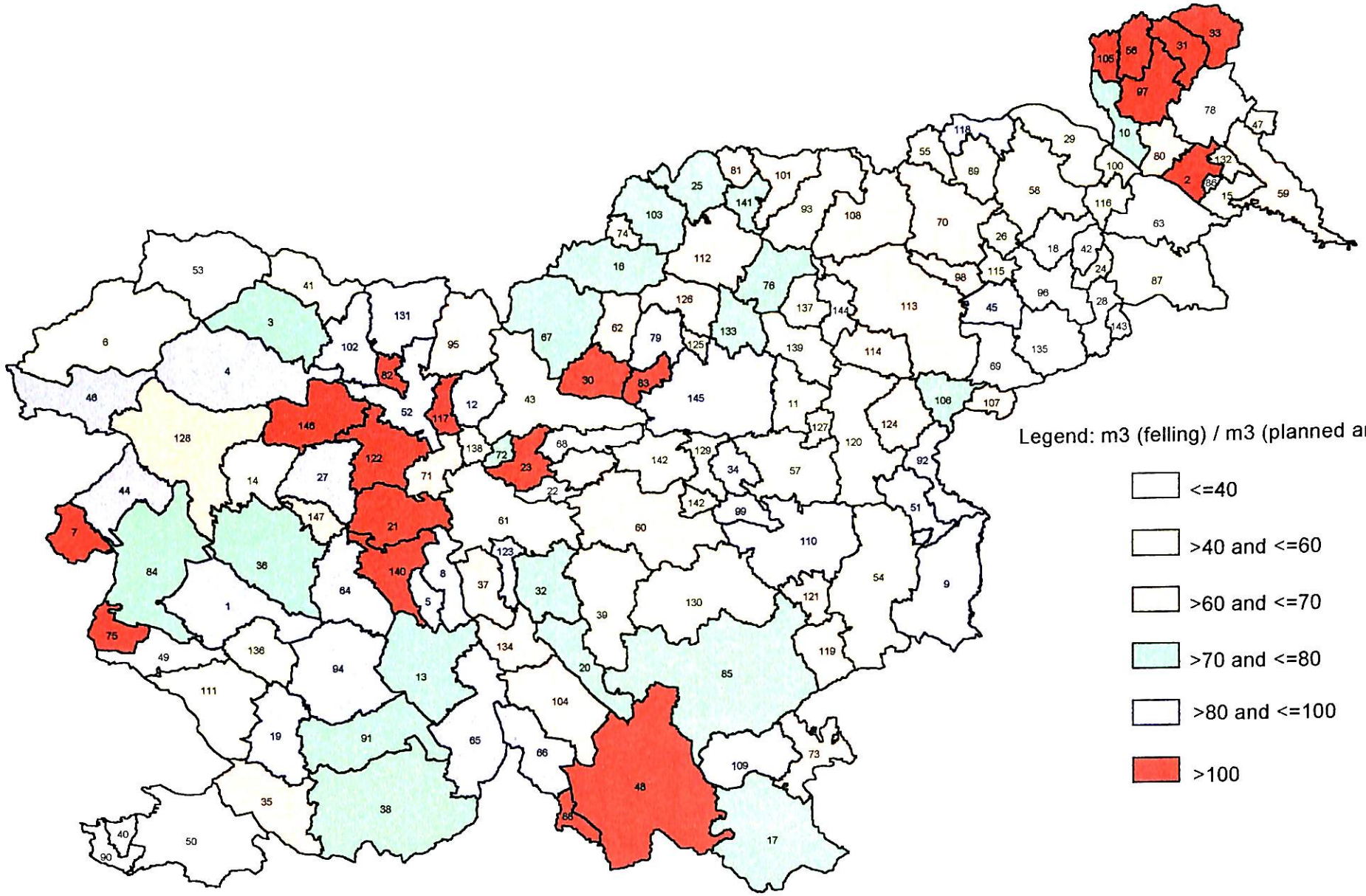
# Relation betwen planned annual cut and increment




50 0 50 100 150 Kilometers

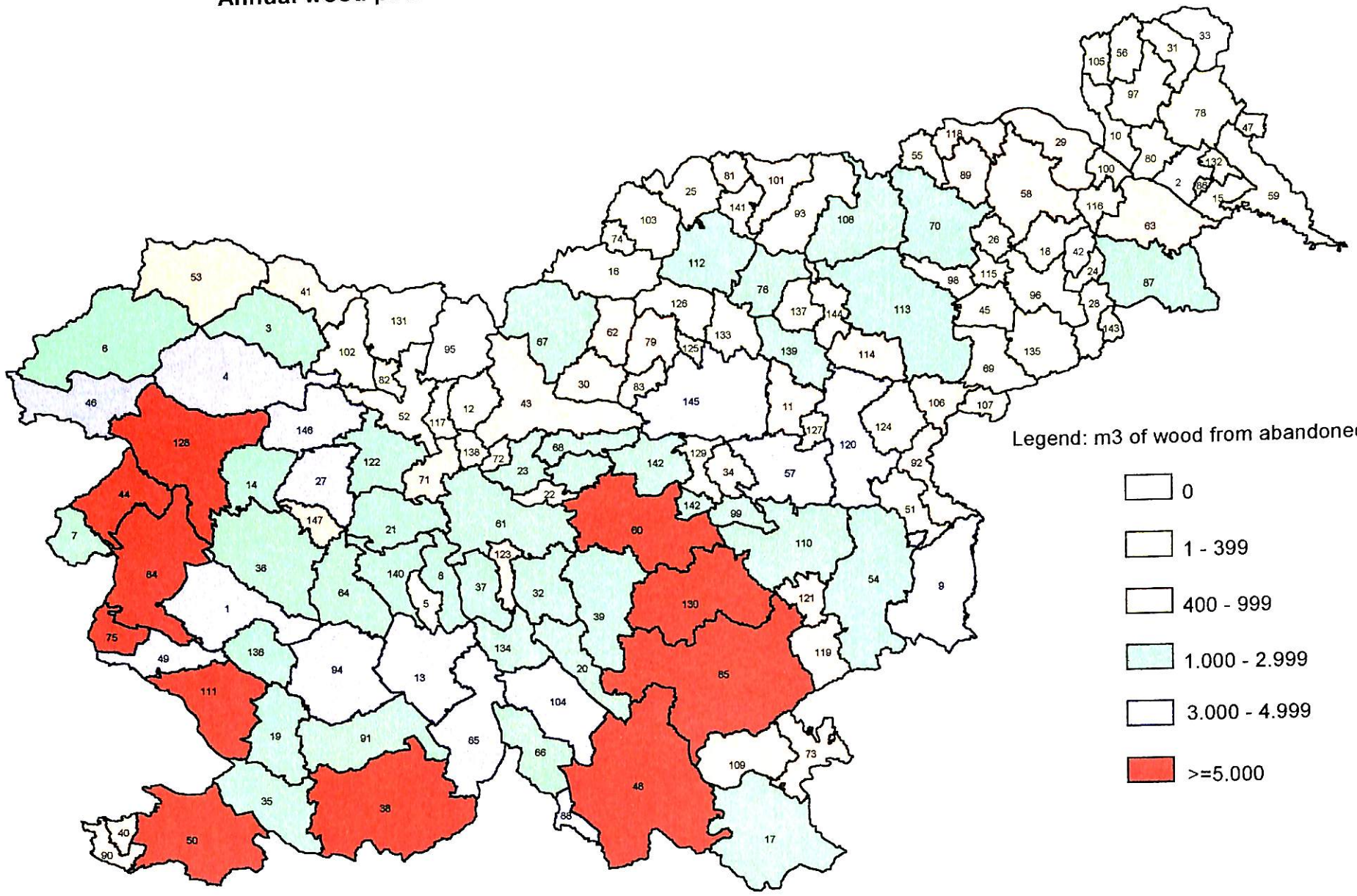
MAP 8

# Realisation of felling according to planned annual cut



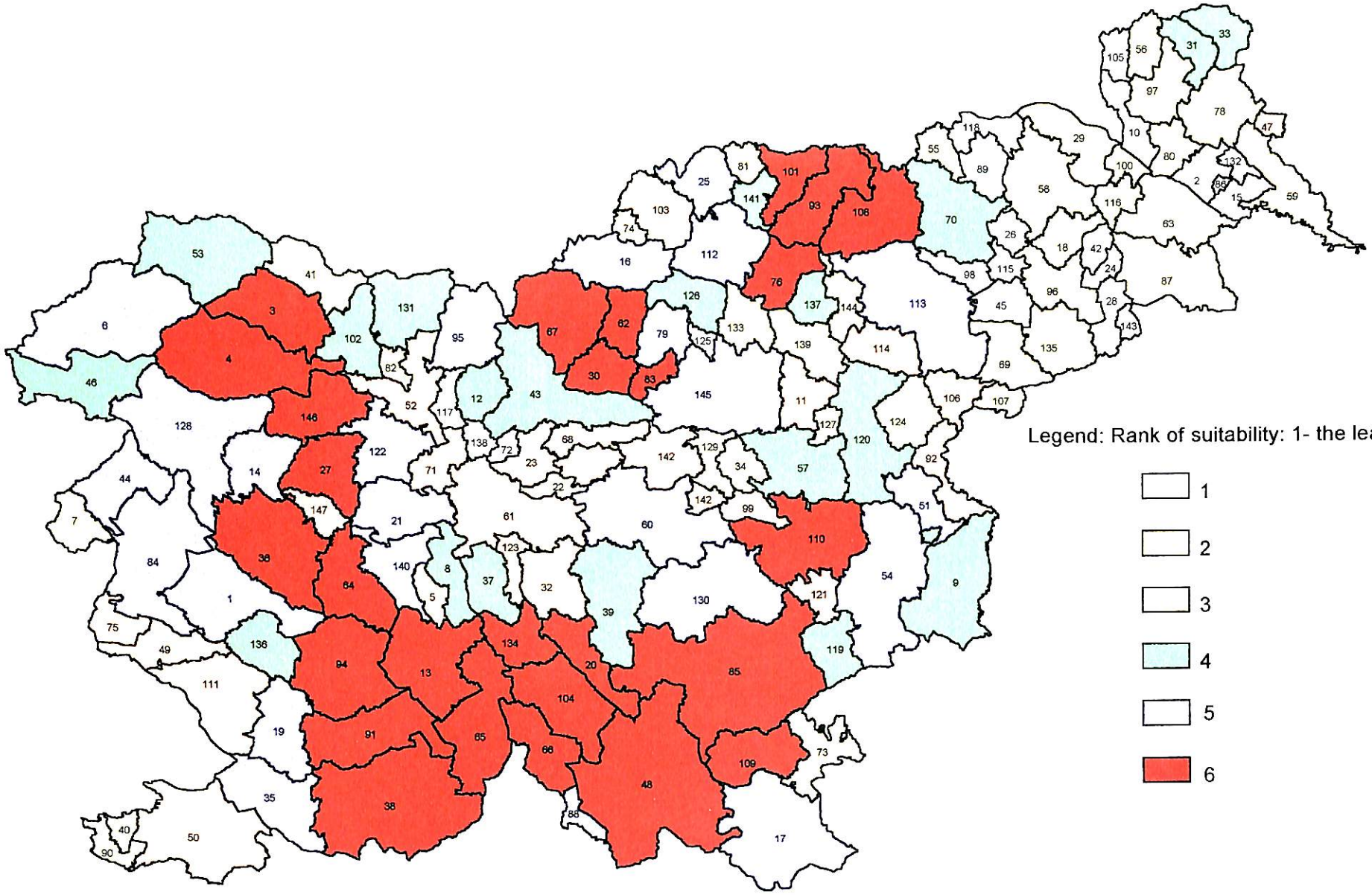

MAP 9

# Annual wood potentials from abandoned agricultural land




MAP 10

# Suitability of wood biomass potentials in local communities for distric heating projects




MAP 11


BF Odd. za gozdarstvo in obnovljive gozdne vire
GOZDARSKA
KNJIŽNICA
Večna pot 2
LJUBLJANA
Gozdarski inštitut Slovenije