# Theoretical Potential of Post-harvest Residues in Međimurje County for Energy Generation

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**Summary**

Međimurje County, because of its relatively developed agricultural production has a great potential to collect and utilize agricultural residues in energy production. Instability of prices of energy-generating products, together with increase of ecological awareness, make renewable sources and, therefore, agricultural residues, more and more interesting raw material for energy production. The aim of this work was to determine the theoretical potential and availability of post-harvest residues under sustainability conditions in the agricultural sector in the Međimurje County area. Availability of agricultural residues makes it possible to estimate the amount of biomass, needed for energy production in the research area. The calculation includes the following agricultural crops: corn, wheat, barley and rapeseed. The results show that there are 22,846 tonnes of residues after corn production, 5,285 tonnes of residues after wheat production, 2,853 tonnes of residues after barley production and 2,686 tonnes of residues after production of rapeseed available in the County, for energy production.

**Key words**

agricultural residues, availability, energy potential, biomass

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Received: March 19, 2018 · Accepted: April 9, 2018

## Introduction

Term "biomass" includes several types of organically based materials, which can be, by various methods, processed to biofuels and various biological products (Pantaleo and Shah, 2013). Today, biomass is the fourth largest source of energy in the world, covering 15% of world's primary energy needs (Kaur, 2016). For thousands of years, biomass has been used as a source of energy, and it is the main fuel, according to quantitative usage conditions, around the world. Basically, more people around the globe depend on biomass as a source of energy than on any other fuel (Sambra et al., 2008).

Agricultural biomass is a desirable raw material in production of all forms of useful energy (Faaij, 2006; Rahman et al., 2012). Use of agricultural biomass reduces the dependence on fossil fuels, opens up new jobs and, at the same time, reduces the amount of residues and waste and thus the costs of their disposal (Voća et al, 2014). Utilization of biomass, in agriculture, gives the agricultural sector the opportunity to reduce their reliance on fossil fuels, and, at the same time, contributes to improving soil, water and air (Muller et al., 2007, Cantrell et al., 2008).

According to the International Energy Agency (IEA), the potential of biomass will likely be sufficient to enable it to make significant roles in global energy supply, if it holds up strict sustainability requirements. The global potential of biomass, for energy that could grow without disruption of biodiversity, soil and water potentials, depends on agriculture and forestry trends, being estimated at between 250 and 500 EJ/year. The potential of bioenergy, by 2050, by population and demand growing, could contribute global supply with 25 - 33% of energy. To achieve a long-term bioenergy potential, it should gear government policies and industry efforts to increasing the level of biomass yield and agriculture modernizing, through a direct increase in global food production and thus resources for biomass (Cigolotti, 2012).

Main agricultural residues include crop residues, as well as straw, stems, shells, pits and other residues. Residues can be divided into two general categories: residues on land, these are materials that remain in the field, orchard, or in vineyard when harvesting and/or gathering, and process residues that are the materials that remain after processing of crops to a usable resource (Asakereh et al., 2014). In the Republic of Croatia, only 30% of potentially available biomass can be used for energy purposes. Slags of cereals, corn stems and other lignocellulosic raw materials consist of three polymers: cellulose (40-50%), hemicellulose (25-35%) and lignin (15-20%). Unlike sugar-based and starch-based raw materials, lignocellulose biomass does not require soil preparation and it is not used directly in food production (Sarkar et al., 2012). Since today most of the agricultural residues in the Međimurje County remains unused, the aim of this work is to evaluate and determine the theoretical potential of post-harvest residues from agricultural production that could be used in energy production.

## Material and methods

Area of research is Međimurje County that is located in the far north of the Republic of Croatia. It spreads on 729.25 km$^2$, and it's the smallest county of Croatia with a share of 1.29% of Croatian territory. The climatic conditions in this area favour the production of almost all agricultural crops grown in moderate continental belt, especially the production of corn, mercantile potatoes, vegetables and industrial plants. Grains are sown in most of arable surfaces in the County. Corn dominates with approximately 12,000 hectares, wheat grows on 3,700 ha and barley on approximately 2,000 ha. Rye, oat and other grains are represented to a lesser extent, on about 800 ha (State Administration Office in Međimurje County, 2017).

**Table 1.** Surfaces of agricultural crops in the area of municipalities of Međimurje County (ha)

| Municipality | Wheat (ha) | Barley (ha) | Corn (ha) | Rapeseed (ha) |
|---|---|---|---|---|
| Čakovec | 443.7 | 295.8 | 1012.03 | 147.3 |
| Mursko Središće | 234.19 | 156.13 | 510.67 | 84.78 |
| Prelog | 317.99 | 211.99 | 1162.05 | 245.83 |
| Belica | 173.99 | 116.89 | 433.42 | 15.85 |
| Dekanovec | 21.77 | 14.51 | 158 | 16.09 |
| Domašinec | 154.03 | 102.69 | 760.04 | 48.49 |
| Donja Dubrava | 133.72 | 89.14 | 270.95 | 96.65 |
| Donji Kraljevec | 205.74 | 137.16 | 723.04 | 61.76 |
| Donji Vidovec | 74.28 | 49.52 | 213.21 | 106.54 |
| Goričan | 143.73 | 95.82 | 413.41 | 70.81 |
| Gornji Mihaljevec | 95.85 | 63.9 | 525.15 | 35.24 |
| Kotoriba | 122.33 | 81.55 | 279.29 | 135.9 |
| Mala Subotica | 259.9 | 173.26 | 948.87 | 104.94 |
| Nedelišće | 233.96 | 155.97 | 1090 | 131.59 |
| Orehovica | 101.07 | 67.38 | 515.36 | 41.31 |
| Podturen | 131.48 | 87.65 | 555.67 | 47.7 |
| Pribislavec | 88.07 | 58.71 | 71.2 | 11.54 |
| Selnica | 143.26 | 95.51 | 467.41 | 11.22 |
| Strahoninec | 95.61 | 63.74 | 104.21 | 9.51 |
| Sveta Marija | 150.87 | 100.58 | 309.82 | 139.39 |
| Sveti Juraj na Bregu | 116.27 | 77.51 | 427.83 | 23.72 |
| Sveti Martin na Muri | 95.67 | 63.78 | 355.49 | 20.64 |
| Šenkovec | 30.16 | 20.1 | 170.22 | 12.62 |
| Štrigova | 49.92 | 33.28 | 395.89 | 4.94 |
| Vratišinec | 130.43 | 86.95 | 217.24 | 30.8 |
| Total | 3,747.99 | 2,343.39 | 12,090.47 | 1,655.16 |

Statistical and cadastral data on agricultural land and data on yield of agricultural crops were used in this research. Spatial data on usage and assignment of County area of Department for Physical Planning of the Međimurje County were analysed. In addition, data on usage of agricultural land from the ARKOD browser of the Agency for Agricultural Payments, Fishery and Rural Development, as well as data on condition and changes of land cover and assignment of land from CORINE Land Cover Croatia of the Croatian Environmental and Nature Agency were analysed.

For the purpose of this research, agricultural crops were selected based on presented databases and sources on land use in the County. In calculating the amount of biomass from the residues of agricultural production, crops that have the largest share of surface were included, namely: wheat, barley, corn and rapeseed. An overview of surfaces under agricultural crops in the areas of municipalities of the Međimurje County used in the research is shown in Table 1.

Data on average ratio of grain mass and biomass of agricultural crops used in this research are shown in Table 2. The ratio of grain mass and biomass Wheat straw is the most often used for biomass, and ranges between 1 and 1.2 relative to the grain. Grain-straw ratio is calculated for the aboveground portion of the plant. The same ratio is found for barley, while for rapeseed, the ratio is 2 relative to the grain. According to measurements, the yield of corn leaves and stalks, without the lowest 20 cm, is 60-90% relative to the grain (Brkić and Janić, 2011). Given that there is no data on

**Table 2.** Average ratio of grain mass and biomass, average yield of agricultural crops and lower calorific value of agricultural residues used in the research

| Crop | Ratio grain/biomass | Yield (t/ha) | Biomass | Lower calorific value (MJ/kg) |
|---|---|---|---|---|
| Corn | 1:1 | 4.7 | Corn stalks | 16.47 |
| Wheat | 1:1 | 3.8 | Wheat straw | 16.44 |
| Barley | 1:1 | 6.3 | Barley straw | 17.90 |
| Rapeseed | 1:2 | 2.7 | Rapeseed straw | 14.62 |

yield of certain crops at County level (Croatian Bureau of Statistics, 2015), the average yield used in the research was calculated on a five-year (2010-2014) average basis (Table 2).

There are many different calculations for lower heating value of particular type of biomass, both in professional and scientific literature. Table 2 contains data on lower calorific value, used in the research. Heating value, which is the amount of energy released in full combustion, is the most important parameter in calculating biomass energy. Upper heating value is the amount of heat removed from fuel with the original and generated water in a condensed state. Lower heating value is that part of the heating value obtained when the flue gas cools only to the temperature above the water vapour dew point (sulphuric acid vapours, if the fuel contains sulphur). Lower heating value is lower than the upper heating value for the heat used to evaporate water and sulphuric acid from the fuel or water, produced during burning (Krička et al., 2012; Asakereh et al., 2014).

## Results and discussion

Available agricultural residues from agricultural production in the Međimurje County are wheat and barley straw and corn and oilseed rape stalks. Tables 3 and 4 present available residues of wheat and corn for energy production. The total amount of available wheat residues in the Međimurje County area is 5,284 tonnes with energy potential of 86.88 TJ (Table 3). All the municipalities in the County are analysed and compared. Municipality of Čakovec has the highest potential of available residues with a total amount of 626.04 tonnes, while the smallest potential has municipality of Dekanovec with only 31.02 tonnes. Taking into consideration the surrounding municipalities, the values of available residues are the highest in municipalities that gravitate to the towns of Čakovec and Prelog, which is understandable considering the amount of available areas under wheat.

In corn production (Table 4), the highest potential is in the area of Prelog town with available residue of 2,196 tonnes and energy potential of 36.17 TJ, and the lowest in the area of Pribislavec municipality with 134.19 tonnes and 2.21 TJ. The total available post-harvest corn residue of the County that can be utilized in energy production is 22,846 tonnes with total energy potential of 376.28 TJ. Potential residue for energy production that can be collected after corn harvest is higher for approximately 80% than the wheat residue, which is understandable considering the amount of cultivated areas under corn in the County.

Total available barley residue in the Međimurje County is 2,853 tonnes with an energy potential of 51.08 TJ (Table 5). The most available barley residue is in the area of Čakovec municipality with 337.44 tonnes and energy potential of 6.04 TJ, while the

**Table 3.** Potential residue and energy availability of wheat in the municipalities' areas of Međimurje County

| Municipality | Surface (ha) | Total yield (t) | 30% available for energy production | | |
|---|---|---|---|---|---|
| | | | Biomass (t) | TJ | MWh |
| Čakovec | 444 | 2,086.8 | 626.04 | 10.29 | 2,861.20 |
| Mursko Središće | 234 | 1,099.8 | 329.94 | 5.42 | 1,507.93 |
| Prelog | 318 | 1,494.6 | 448.38 | 7.37 | 2,049.24 |
| Belica | 174 | 817.8 | 245.34 | 4.03 | 1,121.28 |
| Dekanovec | 22 | 103.4 | 31.02 | 0.51 | 141.77 |
| Domašinec | 154 | 723.8 | 217.14 | 3.57 | 992.39 |
| Donja Dubrava | 134 | 629.8 | 188.94 | 3.11 | 863.51 |
| Donji Kraljevec | 206 | 968.2 | 290.46 | 4.77 | 1,327.49 |
| Donji Vidovec | 74 | 347.8 | 104.34 | 1.72 | 476.86 |
| Goričan | 144 | 676.8 | 203.04 | 3.34 | 927.95 |
| Gornji Mihaljevec | 96 | 451.2 | 135.36 | 2.23 | 618.63 |
| Kotoriba | 122 | 573.4 | 172.02 | 2.83 | 786.18 |
| Mala Subotica | 260 | 1222 | 366.6 | 6.03 | 1,675.47 |
| Nedelišće | 234 | 1099.8 | 329.94 | 5.42 | 1,507.93 |
| Orehovica | 101 | 474.7 | 142.41 | 2.34 | 650.85 |
| Podturen | 131 | 615.7 | 184.71 | 3.04 | 844.18 |
| Pribislavec | 88 | 413.6 | 124.08 | 2.04 | 567.08 |
| Selnica | 143 | 672.1 | 201.63 | 3.31 | 921.51 |
| Strahoninec | 96 | 451.2 | 135.36 | 2.22 | 618.63 |
| Sveta Marija | 151 | 709.7 | 212.91 | 3.50 | 973.06 |
| Sveti Juraj na Bregu | 116 | 545.2 | 163.56 | 2.69 | 747.52 |
| Sveti Martin na Muri | 96 | 451.2 | 135.36 | 2.23 | 618.63 |
| Šenkovec | 30 | 141 | 42.3 | 0.69 | 193.32 |
| Štrigova | 50 | 235 | 70.5 | 1.16 | 322.20 |
| Vratišinec | 130 | 611 | 183.3 | 3.01 | 837.73 |
| Total | 3,748 | 1,7615.6 | 5,284.68 | 86.88 | 24,152.68 |

**Table 4.** Potential residue and energy availability of corn in municipalities' areas of Međimurje County

| Municipality | Surface (ha) | Total yield (t) | 30% available for energy production | | |
|---|---|---|---|---|---|
| | | | Biomass (t) | TJ | MWh |
| Čakovec | 1,012.0 | 6,375.6 | 1,912.68 | 31.50 | 8,757.51 |
| Mursko Središće | 511 | 3,219.3 | 965.79 | 15.91 | 4,422.02 |
| Prelog | 1,162.0 | 7,320.6 | 2,196.18 | 36.17 | 10,055.56 |
| Belica | 433 | 2,727.9 | 818.37 | 13.48 | 3,747.03 |
| Dekanovec | 158 | 995.4 | 298.62 | 4.92 | 1,367.27 |
| Domašinec | 760 | 4,788.0 | 1,436.4 | 23.66 | 6,576.78 |
| Donja Dubrava | 271 | 1,707.3 | 512.19 | 8.44 | 2,345.14 |
| Donji Kraljevec | 723 | 4,554.9 | 1,366.47 | 22.51 | 6,256.60 |
| Donji Vidovec | 213 | 1,341.9 | 402.57 | 6.63 | 1,843.23 |
| Goričan | 413 | 2,601.9 | 780.57 | 12.86 | 3,573.96 |
| Gornji Mihaljevec | 525 | 3,307.5 | 992.25 | 16.34 | 4,543.17 |
| Kotoriba | 279 | 1,757.7 | 527.31 | 8.68 | 2,414.37 |
| Mala Subotica | 949 | 5,978.7 | 1,793.61 | 29.54 | 8,212.33 |
| Nedelišće | 1,090.0 | 6,867.0 | 2.060.1 | 33.93 | 9,432.49 |
| Orehovica | 515 | 3,244.5 | 973.35 | 16.03 | 4,456.63 |
| Podturen | 556 | 3,502.8 | 1,050.84 | 17.31 | 4,811.43 |
| Pribislavec | 71 | 447.3 | 134.19 | 2.21 | 614.41 |
| Selnica | 467 | 2,942.1 | 882.63 | 14.54 | 4,041.26 |
| Strahoninec | 104 | 655.2 | 196.56 | 3.28 | 899.98 |
| Sveta Marija | 310 | 1,953.0 | 585.9 | 9.65 | 2,682.63 |
| Sveti Juraj na Bregu | 428 | 2,696.4 | 808.92 | 13.32 | 3,703.77 |
| Sveti Martin na Muri | 355 | 2236.5 | 670.95 | 11.05 | 3,072.05 |
| Šenkovec | 170 | 1,071.0 | 321.3 | 5.29 | 1,471.12 |
| Štrigova | 396 | 2,494.8 | 748.44 | 12.33 | 3,426.85 |
| Vratišinec | 217 | 1,367.1 | 410.13 | 6.75 | 1,877.84 |
| Total | 12,088 | 76,154.40 | 22,846.32 | 376.28 | 104,605.5 |

**Table 5.** Potential residue and energy availability of barley in municipalities' areas of Međimurje County

| Municipality | Surface (ha) | Total yield (t) | 30% available for energy production | | |
|---|---|---|---|---|---|
| | | | Biomass (t) | TJ | MWh |
| Čakovec | 296 | 1124.8 | 337.44 | 6.04 | 1679.16 |
| Mursko Središće | 156 | 592.8 | 177.84 | 3.18 | 884.96 |
| Prelog | 212 | 805.6 | 241.68 | 4.33 | 1202.64 |
| Belica | 117 | 444.6 | 133.38 | 2.39 | 663.72 |
| Dekanovec | 15 | 57 | 17.1 | 0.31 | 85.09 |
| Domašinec | 103 | 391.4 | 117.42 | 2.10 | 584.30 |
| Donja Dubrava | 89 | 338.2 | 101.46 | 1.82 | 504.88 |
| Donji Kraljevec | 137 | 520.6 | 156.18 | 2.79 | 777.18 |
| Donji Vidovec | 50 | 190 | 57 | 1.02 | 283.64 |
| Goričan | 96 | 364.8 | 109.44 | 1.96 | 544.59 |
| Gornji Mihaljevec | 64 | 243.2 | 72.96 | 1.31 | 363.06 |
| Kotoriba | 82 | 311.6 | 93.48 | 1.67 | 465.17 |
| Mala Subotica | 173 | 657.4 | 197.22 | 3.53 | 981.40 |
| Nedelišće | 156 | 592.8 | 177.84 | 3.18 | 884.96 |
| Orehovica | 67 | 254.6 | 76.38 | 1.37 | 380.08 |
| Podturen | 88 | 334.4 | 100.32 | 1.79 | 499.21 |
| Pribislavec | 59 | 224.2 | 67.26 | 1.20 | 334.69 |
| Selnica | 96 | 364.8 | 109.44 | 1.95 | 544.59 |
| Strahoninec | 64 | 243.2 | 72.96 | 1.31 | 363.06 |
| Sveta Marija | 101 | 383.8 | 115.14 | 2.06 | 572.95 |
| Sveti Juraj na Bregu | 78 | 296.4 | 88.92 | 1.59 | 442.48 |
| Sveti Martin na Muri | 64 | 243.2 | 72.96 | 1.31 | 363.06 |
| Šenkovec | 20 | 76 | 22.8 | 0.41 | 113.45 |
| Štrigova | 33 | 125.4 | 37.62 | 0.67 | 187.20 |
| Vratišinec | 87 | 330.6 | 99.18 | 1.78 | 493.53 |
| Total | 2,416 | 9,511.4 | 2,853.42 | 51.08 | 14,199.19 |

**Table 6.** Potential residue and energy availability of rapeseed in the towns and municipalities area of Međimurje County

| Municipality | Surface (ha) | Total yield (t) | 30% available for energy production | | |
|---|---|---|---|---|---|
| | | | Biomass (t) | TJ | MWh |
| Čakovec | 147 | 396.9 | 238.14 | 3.48 | 967.88 |
| Mursko Središće | 85 | 229.5 | 137.7 | 2.01 | 559.66 |
| Prelog | 246 | 664.2 | 398.52 | 5.83 | 1,619.72 |
| Belica | 16 | 43.2 | 25.92 | 0.38 | 105.34 |
| Dekanovec | 16 | 43.2 | 25.92 | 0.38 | 105.34 |
| Domašinec | 48 | 129.6 | 77.76 | 1.14 | 316.04 |
| Donja Dubrava | 97 | 261.9 | 157.14 | 2.29 | 638.67 |
| Donji Kraljevec | 62 | 167.4 | 100.44 | 1.47 | 408.22 |
| Donji Vidovec | 107 | 288.9 | 173.34 | 2.53 | 704.51 |
| Goričan | 71 | 191.7 | 115.02 | 1.68 | 467.48 |
| Gornji Mihaljevec | 35 | 94.5 | 56.7 | 0.82 | 230.44 |
| Kotoriba | 136 | 367.2 | 220.32 | 3.22 | 895.45 |
| Mala Subotica | 105 | 283.5 | 170.1 | 2.49 | 691.34 |
| Nedelišće | 132 | 356.4 | 213.84 | 3.13 | 869.12 |
| Orehovica | 41 | 110.7 | 66.42 | 0.97 | 269.95 |
| Podturen | 48 | 129.6 | 77.76 | 1.14 | 316.04 |
| Pribislavec | 12 | 32.4 | 19.44 | 0.28 | 79.01 |
| Selnica | 11 | 29.7 | 17.82 | 0.26 | 72.42 |
| Strahoninec | 10 | 27 | 16.2 | 0.24 | 65.84 |
| Sveta Marija | 139 | 375.3 | 225.18 | 3.29 | 915.21 |
| Sveti Juraj na Bregu | 24 | 64.8 | 38.88 | 0.57 | 158.02 |
| Sveti Martin na Muri | 21 | 56.7 | 34.02 | 0.49 | 138.26 |
| Šenkovec | 13 | 35.1 | 21.06 | 0.31 | 85.59 |
| Štrigova | 5 | 13.5 | 8.1 | 0.12 | 32.92 |
| Vratišinec | 31 | 83.7 | 50.22 | 0.73 | 204.11 |
| Total | 1,658.0 | 4,476.6 | 2,685.96 | 39.27 | 10,916.70 |

least is in the area of Dekanovec municipality with 17.1 tonnes and 0.31 TJ energy potential.

The total rapeseed residue in the Međimurje County available for energy production amounts to 2.686 tonnes with an energy potential of 39.27 TJ (Table 6). The most available rapeseed residue is in the Prelog municipality area with 398.52 tonnes and 5.82 TJ energy potential, while in the Strahoninec and Strigovo municipalities area the value of available residue is extremely low, and amounts to only 16.2 tonnes (0.24 TJ) and 8.1 tonnes (0.12 TJ), respectively.

Presented results represent only 30% of total available agricultural residues potential of the County, while 70% of potential can be used in the cycle of returning of organic matter into the soil, for livestock production and other needs.

There is potential for gathering post-harvesting residues in the area of Međimurje County (Tables 3-6). The most available residues for energy production in the Međimurje County area are from corn, followed by wheat, barley and rapeseed residues. All together they amount to a total of 33,670 tonnes and energy potential of 554 TJ (Figure 1).

Similar or slightly higher values of available wheat residues Šegon (2012) obtained in his work, when the value of available residue after wheat production was 5,858 tonnes in 2005, 5,987 tonnes in 2006 and 5,999 tonnes in 2007. Such difference may be the result of the use of input data on arable surfaces under wheat, on total production and yield, on methodology of potentials calculating and on period covered by the research. Analysing the agricultural land area in the period from 2002 to present, area under wheat decreased from 6,471 hectares to 3,748 hectares, or by 42%. Such decrease has made significant differences in the research of available wheat residues, both in this and in other researches.

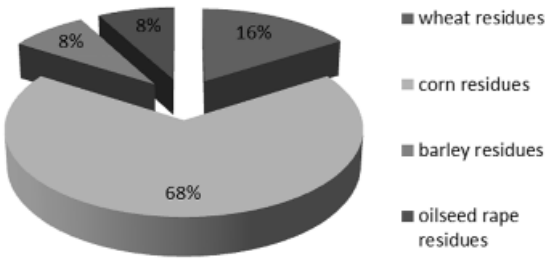


**Figure 1.** Available residues of agricultural production in the Međimurje County area

Comparing the value of available corn residues of 22,846 tonnes from this research and the values of 24,261 tonnes from research of Ćosić et al. (2011), it can be noted that there is no significant difference, respectively the value in this research is lower by 1,415 tonnes. The lower value in this research is the result of the decrease of the area under corn from 2002 to present, from 15,556 hectares to 12,090 hectares or a decrease of 22% over a period of 15 years. By comparing the value of corn residues in this research and the total available corn residues in Croatia, which is 492,730 tonnes (Ćosić et al., 2011), then the value of 22,846 tonnes makes up 5%

of corn residues available in Croatia. Given the database used in this research and comparison with the results of other researches, it can be said that the data presented does not show large deviations and can be used in further researches. Based on presented data, it can be concluded that the theoretical potential of biomass from the production of agricultural crops is significant. An amount of 33,670 tonnes (554 TJ) of agricultural biomass from agriculture production is sustainably available in the Međimurje County region.

By comparing and analysing the research results of many sources (Karaca, 2015; Dell' Antonia, 2014; Novickas et al., 2009; Fernanades and Costa, 2010; Lewandovski et al., 2006; Paiano and Lagioia; 2016, Scarlat et al., 2011) that investigated the potential availability of agricultural residues and their energy value, we noticed that these research results show that the agricultural biomass of agricultural crops can be efficiently used for the production of energy, heat, biogas or biofuel, by respecting the sustainability of utilizing the unused residues. Comparing the quantity of 33,670 tonnes of biomass obtained from agricultural production in Međimurje County, and the values of of 7973.34 tonnes available agricultural residues from agricultural production and from production of fruit and vine in in the Marvão region of Portugal in the research by Fernanades and Costa (2010), we notice that the available agricultural residues in the Marvão region make up 24% of agricultural residues available in the Međimurje County, bearing in mind that the Marvão region is 80% smaller than the Međimurje County.

Other studies (Celma et al., 2007; Daioglou et al., 2016; Singh, 2016) have also shown that agricultural biomass has energy potential, and it can be used for energy production, but production of agricultural crops depends on the volume of agricultural production, on crop production and crop yield. Furthermore, far the most important determinants of residues availability are the alternative use of such resources as animal feedstuff, improving of soil structure and heating needs. The results of the assessment suggest that agricultural residues for energy production can play an important role in mitigating climate changes. Climate policy will be a key factor influencing biomass supply in the future.

## Conclusion

Based on the research we can conclude that the total amount of biomass from agricultural production in the area of Međimurje County is 33,670 tonnes. Results show that the energy potential of agricultural production residues is of 554 TJ. The most available residues from agricultural production are located in the area of Čakovec and Prelog municipalities, as well as in the area of Nedelišće and Mala Subotica municipalities. So, we can conclude that the energy potential is concentrated on the south of the County. The Međimurje County has 72,926 ha of land. Arable agricultural land occupies 34,989 ha, which makes up 48% of the total surface of the County. It can be concluded that the Međimurje County has great potential for food production. Together with food it also has potential to produce energy from agricultural residues. It has 33,670 tonnes of biomass, available from existing agricultural residues. So, an energy value of 554 TJ can be obtained. These are existing values for energy production, but potential opportunities of County agriculture are much greater. It is expected to utilize the available agricultural biomass potentials for economic and ecological development of the Međimurje County. The inclusion of organic residues from agricultural production is of great importance, not only from the aspect of biomass use in energy production, but also from the aspect of their disposal, with direct gain through production and use of thermal energy.

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