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DanuP-2-Gas

Deliverable D.T2.1.1

Biomass Report (Hungary)

Activity A.T2.1: Agricultural biomass potential analysis

A PROJEKT AZ INTERREG DANUBE TRANSNATIONAL PROGRAMBÓL, AZ EURÓPAI REGIONÁLIS FEJLESZTÉSI ALAP TÁMOGATÁSÁVAL, AZ EURÓPAI UNIÓ ÉS MAGYAR ÁLLAM TÁRSFINANSZÍROZÁSÁVAL VALÓSUL MEG.

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The potential for exploitable organic residue for each participating country listing key aspects such as location, amount, transport options and costs.

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CONTENT

1. INTRODUCTION

This study aims to present the current status of biomass production in Hungary. The biomass country report is part of the 'Innovative model to drive energy security and diversity in the Danube Region via combination of bioenergy with surplus renewable energy' (DanuP-2-Gas) project. The Interreg Danube Transnational Programme highlights the importance of transnational cooperation in the field of renewable energy, the DanuP-2-Gas project pays special attention to biomass potential in the countries connected to the Danube. The country report gives a comprehensive overview of Hungary's biomass production and its legal environment both on a European and on a Hungarian level.

The importance of biomass can be understood by its effectiveness in reducing the usage of conventional fossil energy resources. When discussing this topic, it is crucial to bear in mind that bioresources and biomass can only help us mitigate the risks of climate change if they are produced, processed, and utilized sustainably and efficiently (Andersen et al., 2021). Up to this day, biomass is still the most promising renewable energy resource, that we can use in the European Union to tackle our 2030 climate targets (Leitner, 2019). From Hungary's perspective, biomass also has a great significance as the country's natural endowments, agriculture, and the food industry can provide a significant amount of raw material for biomass use (Demeter, 2021).

Biomass is the biodegradable products, wastes and residues from agriculture, forestry, food and related industries, as well as industrial and municipal waste. The use of biomass for energy purposes is considered 'carbon neutral', i.e., when burned, it produces only as much carbon dioxide as was captured by the plants through photosynthesis.

The following can be considered as biomass energy sources:

- agricultural crop residues, by-products and wastes (straw, maize straw/trash, etc.)
- crops grown for energy (rape, sugar beet, various tree species)
- biomass of animal origin (manure, animal residues, etc.)
- forestry and wood-processing by-products and waste (wood chips, sawdust, etc.)

According to its position in the production-use chain, Biomass can be primary, secondary, and tertiary. Primary biomass is natural vegetation, arable crops, forests, meadows, pastures, horticultural crops, and aquatic plants (fitomass). Secondary biomass is the sum of livestock, farm animals, and the main products, by-products and wastes of livestock production (zoomass). Tertiary biomass is the products, by-products and wastes of industries using biological materials, organic waste from human settlements.

International policy outlook of biomass production (IFC report) Biomass-based energy production can help our transition to a carbon-neutral future, but for it to spread fast enough, some external incentives are needed. Several countries have already recognised the necessity for a favourable policy framework and are therefore seeking to provide a supportive regulatory background for renewable

energy producers, including biomass producers. Support for renewable energy can take several forms. Firstly, it is worth pointing out that by reducing subsidies for fossil fuels, we are already creating a more favourable market setting for renewables. Additional carbon pricing[1] can also further help internalise externalities. Secondly, to increase the share of renewable energy in the energy mixture countries can establish renewable energy targets to boost commitment, but more importantly, they can introduce certain renewable energy mandates/obligations for consumers, suppliers, and generators. Finally, several public policy practices aim to provide financial support for renewables and create a competitive advantage for them, feed-in tariffs, tax incentives for renewable energy and supply chain development are notable examples (IFC, 2017).

The European Union's (formerly the European Communities) commitment to sustainable development has defined EU environmental policymaking for nearly half a century (Hey, 2007). Since the early 70s member states have been implementing comprehensive environmental policies on the national and supranational levels. Subsequently, policy measures covered a wide variety of actions, from funding ecological methods to setting climate targets to establishing emission decreasing schemes.

Energy policy of the European Union dates back to the Lisbon Treaty, which declares it as a shared competence between the European Union and Member states (Article 2C). Article 194 of the Treaty on the Functioning of the European Union (TFEU) is the only article dealing with energy policy and sets out the EU's energy policy objectives which are the following: (1) ensuring the functioning of the energy market, (2) guaranteeing the security of energy supply within the Union, (3) to promote energy efficiency and energy saving and to encourage the development of new and renewable energy sources, (4) promoting the interconnection of energy networks. As for the renewable energy resources, Table 1. contains the most important legislative acts of the EU until 2005.

The Renewable Energy Directive (2009/28/EC) established national targets for EU member countries, it was seen as a “novelty act”. Today, 173 countries in the world have such targets. The 2009 directive was revised in December 2018, and adopted as part of the Clean energy for all Europeans package. It includes a new binding renewable energy target for 2030 of at least 32%, with a clause for a possible upwards revision by 2023.

1 e.g. ETS of the EU (IFC, 2017)

Table 1. Legislative background of the renewable energy resources in the EU

Year	Legislation
1974	Decision on the development of energy saving policies
1980-1990	Setting energy policy objectives
1986-1995	Setting new common energy targets
1986	86/278/EEC on the disposal of sewage sludge
1990	90/313/EEC on rules on access to environmental information
1991	91/271 EEC on urban waste water treatment
1992	GATT agreement
1995	White Paper on Community Energy Policy
1996	96/92/EC: on the liberalisation of the energy market
1997	Decision 8522/97 ("Green Paper")
1999	Preparing for the implementation of the Kyoto Protocol
	1999/31 (IV.26.) EC Directive on the landfill of waste
	Council Directive 1257/1999 on the delimitation of less favoured areas
2000	2000/60 (X.3.) EC Water Framework Directive
2001	2001/77/ECr : promoting the use of energy from renewable sources
2002	Seville Framework Agreement on the development of renewable energy sources
2003	on conditions for access to the network for cross-border exchanges in electricity (1228/2003r)
	concerning common rules for the internal market in electricity and repealing Directive 96/92/EC (2003/54/EC)
	establishing a scheme for greenhouse gas emission allowance trading within the Community (amendment of Directive 96/91/EC, 2003/87/EC)
	2003/30 EC on the use of biofuels for transport
	23.06.2003 CAP reform support for energy crops
2004	on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC (2004/8/EC)

Source: Bohoczky, Bai, 2005, as cited in Kormányos, n.d.

In the European Union, the share of renewables among the gross final energy consumption was 17% (195 476 ktoe) in 2016. Within renewable energy sources, bioenergy was the main source, accounting for 59.2% (115 694 ktoe) and the heating and cooling sector was the largest end-user, consuming 74.6% of biomass energy (Scarlat et al., 2019). These numbers provide a clear image of the contribution of biomass to the energy sector and draw our attention to the production and supply of biobased energy resources. Biomass production and import have to comply with the European Union's effort to stop biodiversity loss and the degradation of our natural environment, thus it needs to correspond to strict sustainability criteria2 (European Commission, 2021). In the European Union, the main source of biomass is forestry, which accounts for more than 60% of all domestic biomass supply as of its outstanding importance, the EU has to guarantee that alas the increasing demand for forest biomass, extraction from the forests has to be sustainable3. Agriculture bioenergy source in 2016, crops and by-products covered 27% of the EU domestic biomass supply (Scarlat et al., 2019). In parallel with the growing importance of agriculture in the field of bioenergy, the European Union has taken a series of regulatory measures to protect the environment against agricultural

[2] e.g. Directive 2009/28/EC introduced several sustainability criteria. Available online: https://eur-lex.europa.eu/eli/dir/2009/28/oj (accessed on 30 of May 2022)

[3] See Directive (EU) 2018/2001 of the European Parliament and of the Council (102). Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=HU (accessed on 30 of May 2022)

overuse (Banja et al., 2019). Sustainability criteria for solid, liquid and gaseous biomass are specified in Directive 2009/28/EC of the European Parliament and of the Council. The directive requires that the Member States shall achieve a 20% share of renewable energy consumption in gross final energy consumption, and at least 10% share in the transport sector by 2020 (European Commission, 2015). However, the efforts of the European Union, only a few Member States have applied national schemes associated with sustainability requirements for solid biomass use, instead, they rely on voluntary schemes, that the European Commission has already recognised (Banja et al., 2019). In December 2019 the European Council and the European Parliament came to an agreement on the EU-wide classification system introduced by the Regulation on the Establishment of a Framework to Facilitate Sustainable Investment ((EU) 2019/2088) – hereinafter referred to as the Taxonomy regulation. The taxonomy regulation wishes to highlight those economic activities that the EU regards as sustainable, thus providing clarity and transparency on environmental sustainability to investors and encouraging investment in the aforementioned field (European Commission, 2020). The regulation had proposed sustainable labels for natural gas and nuclear power, which would decrease our dependence on fossil fuels, but the debate had risen whether these energy barriers were truly acceptable as sustainable in the long term or just means to switch from fossil resources.

In the late 90s in Hungary, several measures have been taken at the governmental level to increase the use of renewable energy sources. The Government adopted the proposal "The foundations of the Hungarian energy policy, the business model of energy" by its Resolution 2199/1999 (VIII.6.), which has as its main objectives energy saving, increasing energy efficiency, expanding the use of renewable energy sources and environmental protection. In order to achieve these priorities, the Government has drawn up a strategy for energy saving and energy efficiency until 2010 (Government Decision 1107/1999 (X.8.)). In the Accession Document (Annex II to Act XXX of 2004), Hungary committed to double the share of renewables in the total energy consumption (in 2003 it was 3.6%) and increase the share of renewable energy sources by 3.6% in the electricity consumption by 2010. Since Hungary joined the EU the issue of renewable energy sources and sustainability have gained significantly more importance, hence promoting legislative and governmental acts concerning renewable energy sources. Resolution 63/2005 (28.VI.) of the Hungarian Parliament set targets for making the use of alternative energy sources more efficient and established new aims regarding biofuels and biomass:

- *In order to promote the use of liquid fuels produced from agricultural raw materials, their blending into fuels should be mandatory. The interests of domestic feedstock producers should be given priority in the regulation. In order to promote the uptake of biofuels, they should be given preference over liquid biofuels derived from conventional petroleum when drafting excise legislation.*
- *To increase the production of biogas, the Gas Act should be amended to allow the introduction of biogas meeting quality standards into the existing gas system.*

- *The Ministry of Agriculture and Rural Development should develop a form of support for energy crops and other agricultural by-products in line with EU support schemes, whereby agricultural energy carriers of agricultural origin.*
- *The Forestry Act shall be amended to increase the area under energy crops.*

As mentioned previously Hungary has favourable natural endowments to produce biomass in abundance. Domestic biomass consumption for energy purposes was 3.5 million tonnes in 2020 which indicated a 9% rise compared to the previous year (Demeter, 2021). Renewable energy and biomass resources help advance the country's independence in the energy sector. The main objective of the new National Energy Strategy is to achieve energy sovereignty and energy security and to decarbonise energy production, which can only be achieved through a combination of nuclear and renewable energy sources. For conventionally energy-poor countries such as Hungary, energy sovereignty is a matter of welfare, economic and national security (ITM, 2020). The five tools proposed to achieve this goal are the following: (1) energy saving, (2) the use of renewable energy in the highest possible proportion, (3) the safe nuclear power and the electrification of transport based on it, (4) the use of bipolar agriculture (i.e., market-oriented flexible switch between food production and biomass production) for energy (5) and access to European energy infrastructure (Magyar Közlöny, 2011). For strengthening European ties in the energy production Hungary, Slovakia, Poland, the Czech Republic, Bulgaria, Slovenia, Croatia, Romania, and the Baltic states together with the European Commission created a VISION for the "Central and Eastern European Initiative for Knowledge-based Agriculture, Aquaculture and Forestry in the Bioeconomy" also known as BIOEAST (Hunyadi Borbélyné et al., 2021). The initiative enhances the cohesion, integration and development of the aforementioned countries.

The country report gives a comprehensive picture of the agricultural biomass from crops sources in Hungary.

2. METHODOLOGY

This Agricultural Biomass Report Hungary was prepared by the Institute of Agricultural Economics (AKI) as a deliverable for the DanuP-2Gas project. This report complements the following data sources and selected reports available in Hungary at national level:

- EUROSTAT: Renewable energy statistics
- OECD Environmental Performance Reviews: Hungary 2018
- AKI Institute of Agricultural Economics (Energy production of biomass in Hungary)
- Hungarian Energy and Public Utility Regulatory Authority (HEA)
- Report on the use of renewable energy sources in Hungary in 2017-2018
- Farm Accountancy Data Network (FADN)
- Hungarian State Treasury Database
- Hungarian Central Statistical Office (renewable energy statistics)
- Local authorities
- Literature review, expert estimations, and reference books

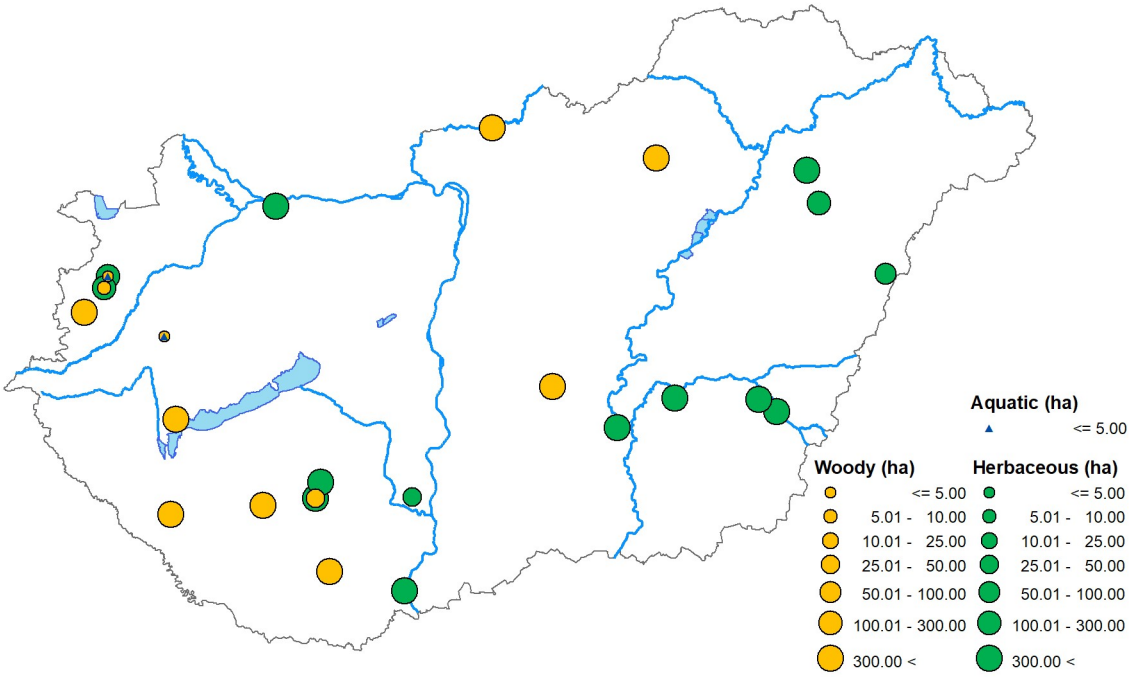
Data collection process for the development of agricultural biomass database at Hungarian national level was based on in-depth interview, the personal data of which were anonymised for data protection reasons.

Some of the farmers included in the survey were selected from previous participants in biomass research and from organizations listed in the BIONYOM register of the National Food Chain Safety Authority (Nébih) and had their own agricultural land. The other part of the respondents came from biomass farmers registered in the Farm Accountancy Data Network (FADN) and from the state forestry sector.

During the telephone inquiries, 239 calls were initiated among which 56 conversations were successful in sending out the questionnaires, up until now 23 answers came in with the filled-in survey sheets (Figure 1.). In the case of 5 state forestry, data on biomass were obtained using publicly available data. The quality of completions is low, respondents filled in the survey incompletely, unfortunately, even the necessary answers marked with an asterisk were left blank. Overall respondents filled in only 35% of the mandatory questions.

Typically, farmers responded to the amount of biomass produced, the location of the plant, and the distance from the nearest settlement of the plant. Fewer questions were answered about the amount of available biomass, moisture content, purchase price, transportation cost.

Figure 1. Location and biomass production area of the respondents



Source: own editing based on the survey data

3. BRIEF DESCRIPTION OF HUNGARIAN BIOMASS LANDSCAPE

Summary of call statistics and experiences

Some of the farmers we talked with expressed their disapproval of using the biomass for anything other than putting it back into the soil as green manure or trading it with livestock farmers who supply them with animal manure. A few potential respondents refused to fill in our questionnaires upon this reasoning. One farmer said that they traded previously biomass with other companies, but they are likely to minimize that exchange, as fertilizers are becoming more expensive, and they wish to reduce their costs. Another interviewed farmer added that he does not understand, why this research is being conducted as the European Union tries to reform agriculture to be more environmentally safe. In his opinion, the use of stalk residues for energy purposes is contrary to the requirements of the EU. Another farmer said that such use is not profitable due to transport costs. And livestock farmers are in such trouble with hay and straw that they already use chopped corn and sunflower stalks as deep litter. Some of the state forestry do not deal with biomass utilization of energy purposes.

The surveys for

- Identification: owner address, location name, longitude, latitude
- Quantity: Amount of biomass available (tons/year)
- Characteristics: Moisture content based on reference books or expert estimation
- Price: Annual average price (EUR/ton)
-

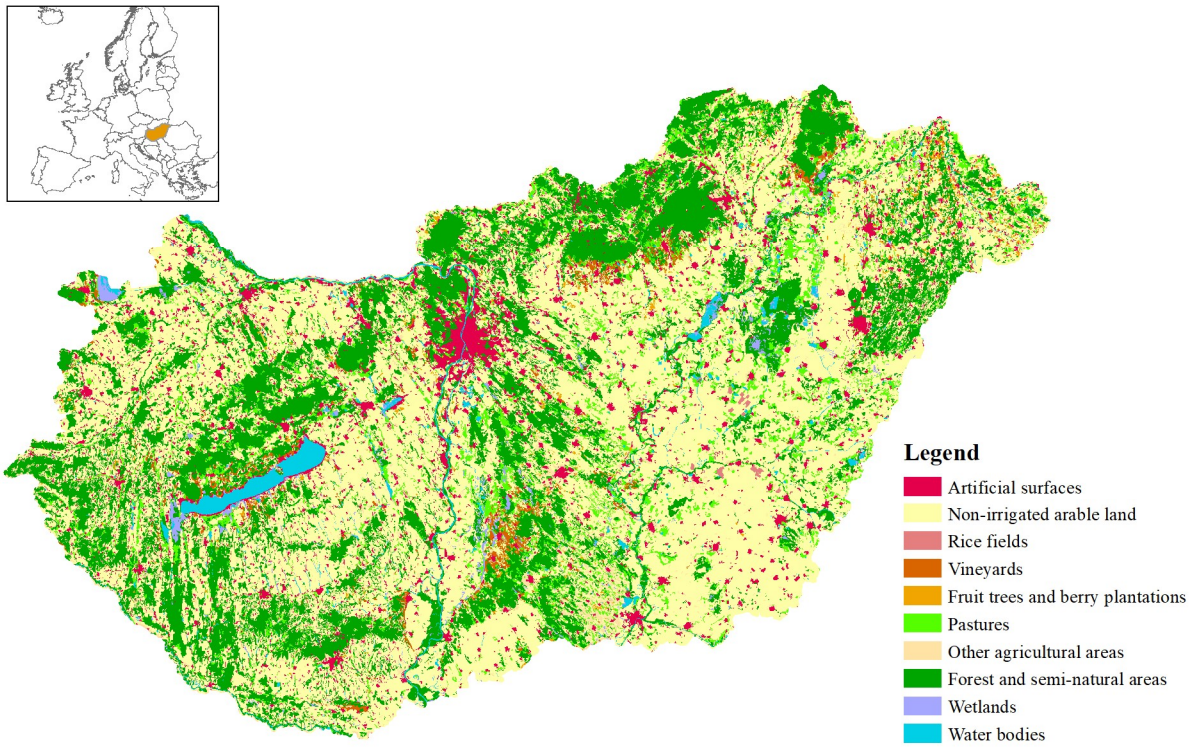
As a result of the survey, the following three types of producers can be identified:

- Producers who refrain from using biomass: They recycle the amount of biomass produced on their own farms for organic matter replacement or other own use
- Producers who, under certain conditions, would undertake: under appropriate price and delivery conditions, might consider selling.
- Producers who are already selling for this purpose: the surplus is being sold for sale, with a stable market

3.1 OVERVIEW OF BIOMASS PRODUCTION

Hungary lies in the Carpathian Basin, where the natural conditions (climate, water, soil, and biological resources), particularly in the lowlands and plains, are generally favourable for agriculture. Owing to the expansion of built-up areas, the productive land area is slowly decreasing, but still over 54% of the total area is used for agriculture (KSH, 2021). About 82% of the agricultural land is arable land (Figure 2.), the main crops are maize, wheat, sunflower, and rapeseed.

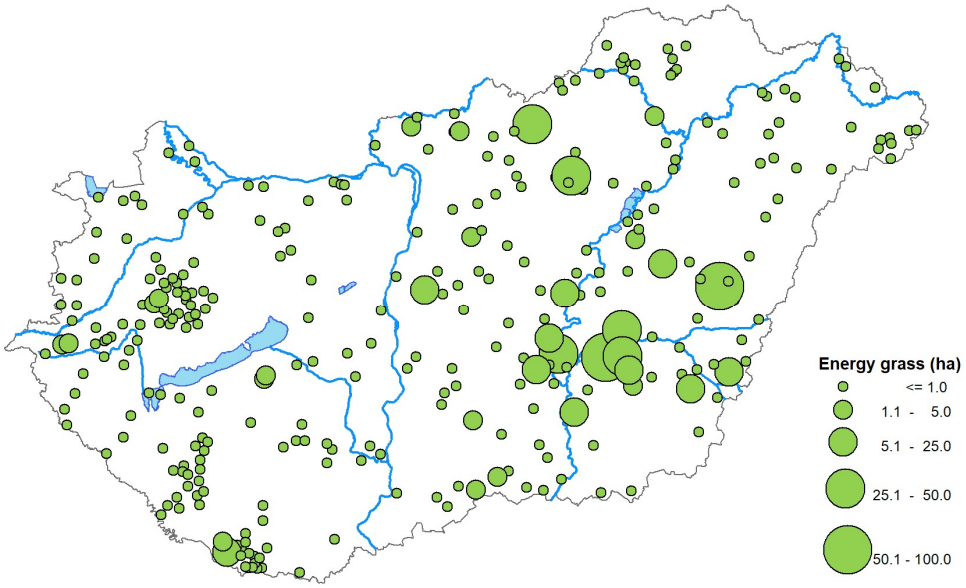
Figure 2. Location of Hungary within Europe and the land cover categories



Source: own editing based on CORINE 2018 database

Based on to the single application database of the Hungarian Paying Agency the total area under energy grass is below 500 hectares. The energy grass parcels are small, more than a quarter of them are up to 1 hectare, 46% is the parcels is between 1 and 5 hectares, 18% of them between 5 and 10 hectares, and approximately 10% is above 10 hectares. An average yield of 20 t/ha/year can be expected, except the 14 t/ha yield of the first year (Gyuricza, 2014). The parcels are scattered throughout the country, but the larger areas are in Békés county, in the South-East of the country (Figure 3.).

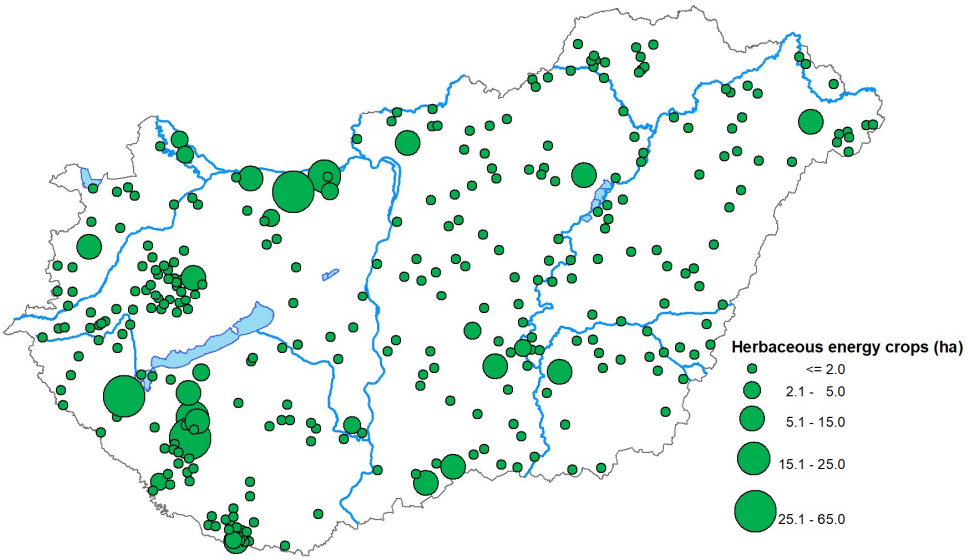
Figure 3. Energy grass cultivation by settlement (2021)



Source: calculated based on Hungarian Paying Agency data

The area of herbaceous energy crops (Sida, Miscanthus, and Arundo) is around 350 hectares. The distribution by parcel size is similar to that of energy grass, but slightly fewer parcels are between 5 and 10 hectares, and higher proportion is above 10 hectares. The average yield of them varies from 10 to 35 t/ha/year (Gyuricza, 2014). Due to their higher water demand the spatial distribution is different, having larger areas in the more humid Western part of the country (Figure 4.).

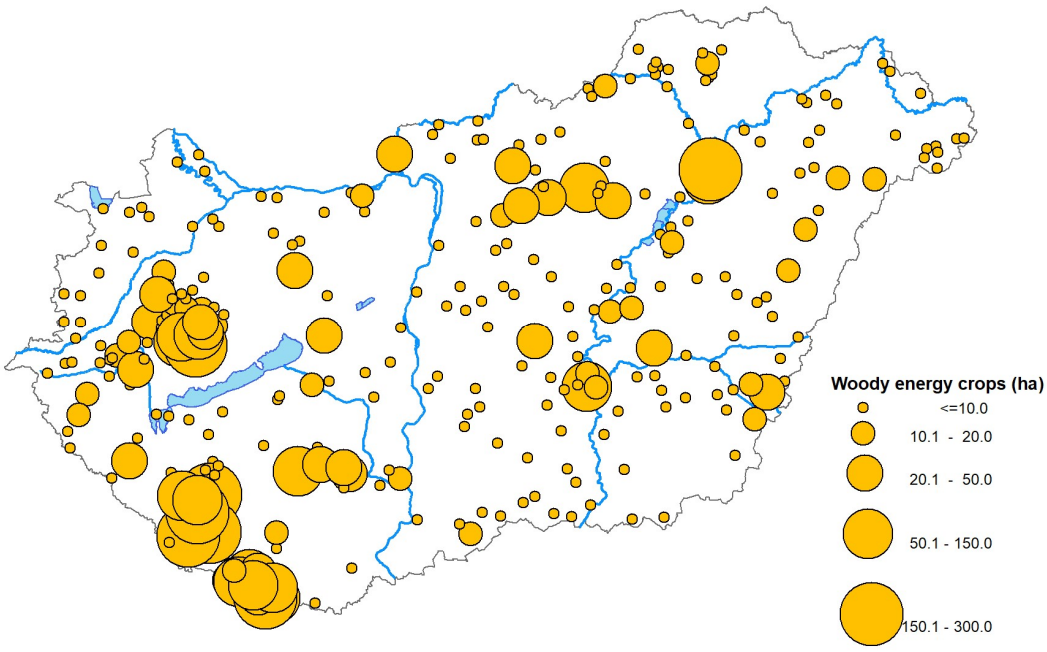
Figure 4. Herbaceous energy crop cultivation by settlement (2021)



Source: calculated based on Hungarian Paying Agency data

Woody energy crops in Hungary are mainly poplar, willow, and black locust species. Short-rotation energy plantations can be productive provided the appropriate tree species are planted. These energy plantations have different yields, ranging from 5 to 30 t/ha (Gyuricza, 2014; Szalay et al., 2019) depending on the cultivation area, technology, climate, and applied tree species. Due to their water demand larger poplar and willow areas can be found in the Western part of the country and near riverbanks. Black locust is mostly cultivated on the sandy soils of Southern Transdanubia and between the Danube and Tisza (Figure 5.).

Figure 5. Woody energy crop cultivation by settlement (2021)



Source: calculated based on Hungarian Paying Agency data

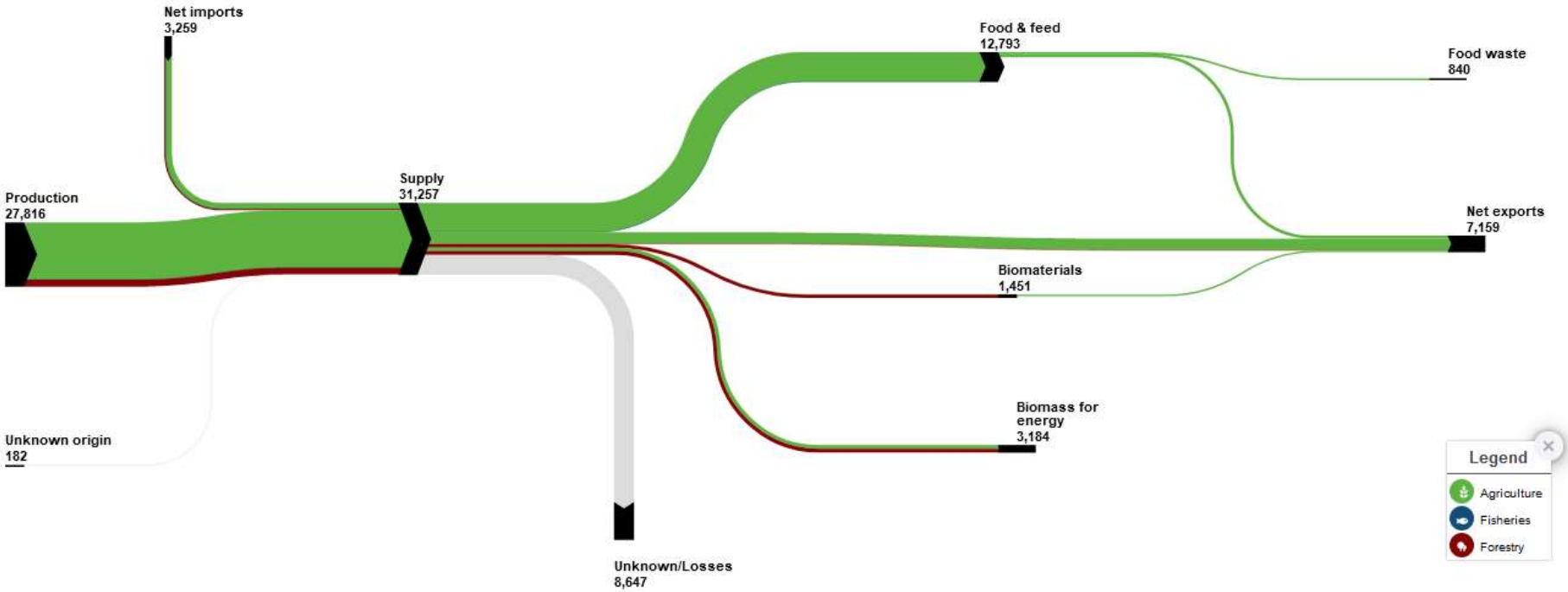
The JRC's EU Biomass Flows Sankey diagram (Gurria et al., 2022) represents flows of biomass through the different stages of its life cycle (Figures 6-8) using the latest available complete sets of data (2018 for agriculture, 2017 for woody biomass and 2016 for fisheries and aquaculture). It displays the harmonised data from the various Joint Research Centre (JRC) units contributing to the BIOMASS Assessment study of the JRC. Based on these data, the total supply of biomass in Hungary added up to approximately 31 million tonnes of dry matter (tdm). Almost 90% of this biomass was produced in Hungary, while 10% of the biomass supply was imported. The origin of only 0.5% of the total biomass could not be identified. The agriculture sector is the biggest producer of domestic biomass with 79% of the total, followed by forestry with almost 10% of the dry matter content (Figure 6.) but a significant portion of biomass from agriculture is recycled into production and is not available for energy use.

Agricultural biomass total supply (in net trade figures) amounted to approximately 27 million tonnes of dry vegetal biomass equivalents. The crop production is estimated at 18 million tonnes of dry biomass (67%) and harvested crop residues provide an additional 5 million tdm of biomass (18%). The grazed biomass

represents only 5% of the biomass supply. Most of the crops, residues and grazed biomass is used for feed and food products, only approximately 1.6 million tdm (6%) is used for bioenergy (Figure 7.). Almost the same quantity of biomass (1.6 million tdm) of directly or indirectly[4] gathered woody biomass were estimated to have been used for energy (Figure 8.).

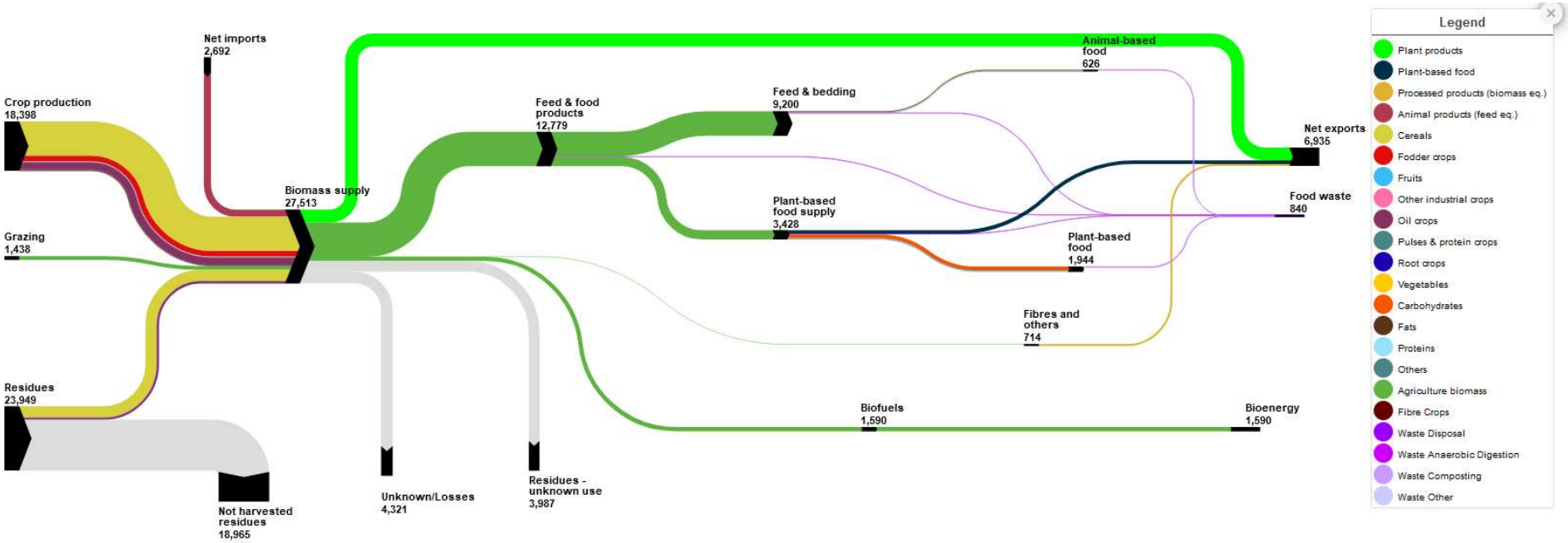
[4] From processed wood or as by- or co-product of industrial roundwood processing

Figure 6. Biomass flows in Hungary in 1000 T of dry matter (net trade), latest available data



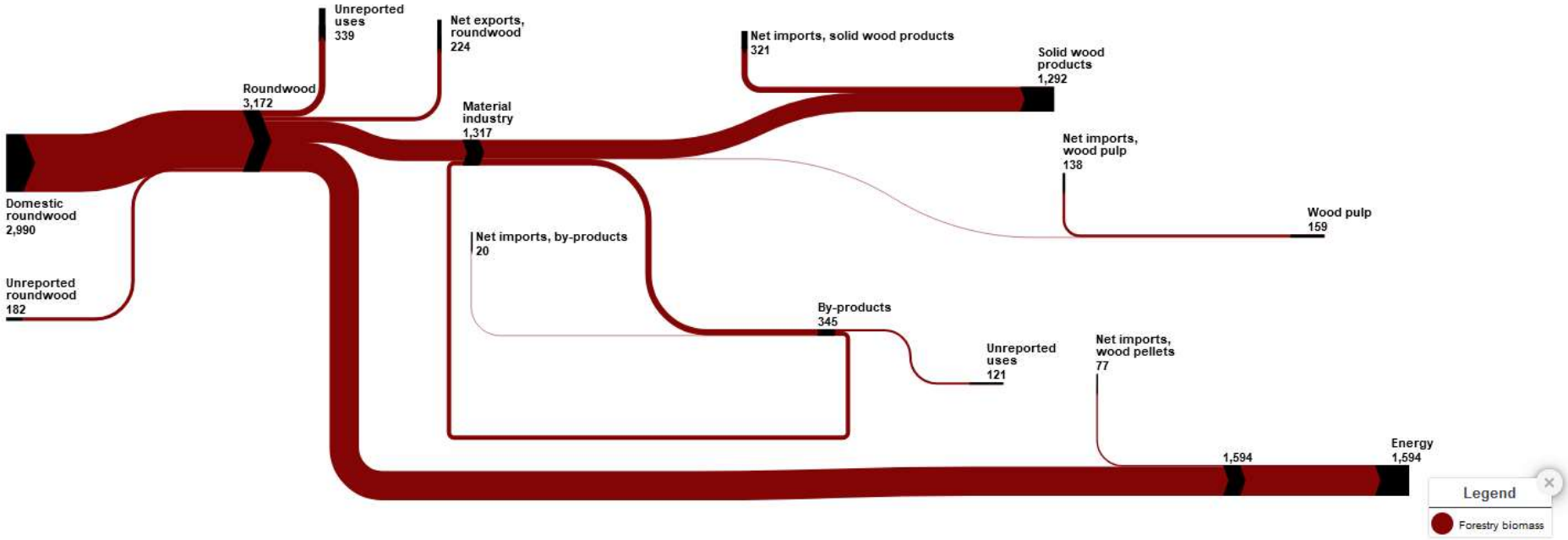
Source: data from the BIOMASS project, European Commission – Joint Research Centre

Figure 7. Agricultural biomass flows in Hungary in 1000 T of dry matter (net trade), latest available data



Source: data from the BIOMASS project, European Commission – Joint Research Centre

Figure 8. Forestry biomass flows in Hungary in 1000 T of dry matter (net trade), latest available data

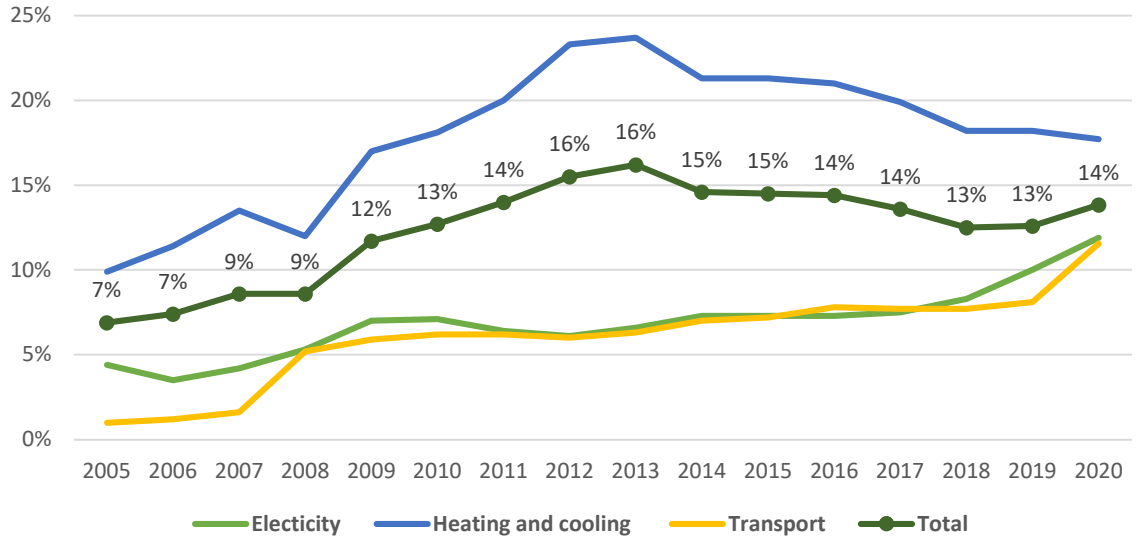


Source: data from the BIOMASS project, European Commission – Joint Research Centre

3.1.1 SHARE OF RENEWABLES FROM TOTAL ENERGY PRODUCTION

Share of energy from renewable sources in gross energy consumption in 2020 was 14%, this is a 1.3% increase in one year (Figure 9.). Share of electricity production from renewable sources within gross final electricity consumption from 10% increased to 11.9%, due to the significant increase in electricity generated by solar panels. Share of energy for heating ang cooling from renewable sources within gross energy consumption decreased from 18.2% to 17.7%. The decrease was mainly due to an increase in the share of fossil sources within the total use of energy for heating purposes in the residential sector, instead of renewables. The transport sector increased the share from 8.1% to 11.6% within one year, regarding the mandatory biofuel blending requirements (186/2019 (VII. 26.) Governmental Decision) and decreasing tend of energy use in transport sector.

Figure 9. Share of energy from renewable sources in gross energy consumption by sectors

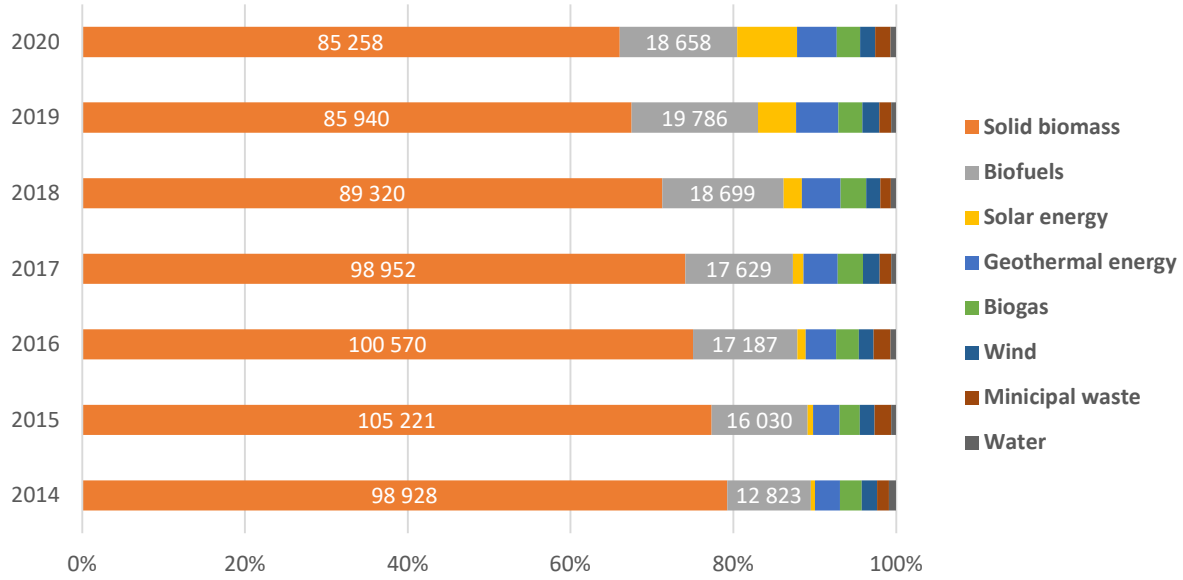


Source: Hungarian Energy and Public Utility Regulatory Authority (MEKH), 2022

3.1.2 QUANTITY OF RENEWABLE ENERGY PRODUCTION

Fluctuation of total primary renewable energy production was observed in 2014-2022 period (Figure 10). The highest share of primary renewables was made by solid biomass production, the decreasing trend of solid biomass was observed in 2020. The second largest increasing share of primary production was observed in biofuels sector. By the end of 2020, the total power capacity of solar panels connected to the electrical grid was higher than 2 000 MW, which exceeded the capacity of Paks Power Plant (MEKH, 2022). The total solar energy production has an increasing trend, in 2020 the primary solar energy production exceeded the 2019 level by 59.3%.

Figure 10. Primary renewable energy production, 2014-2020 (TJ)



Source: Hungarian Energy and Public Utility Regulatory Authority (MEKH), 2022

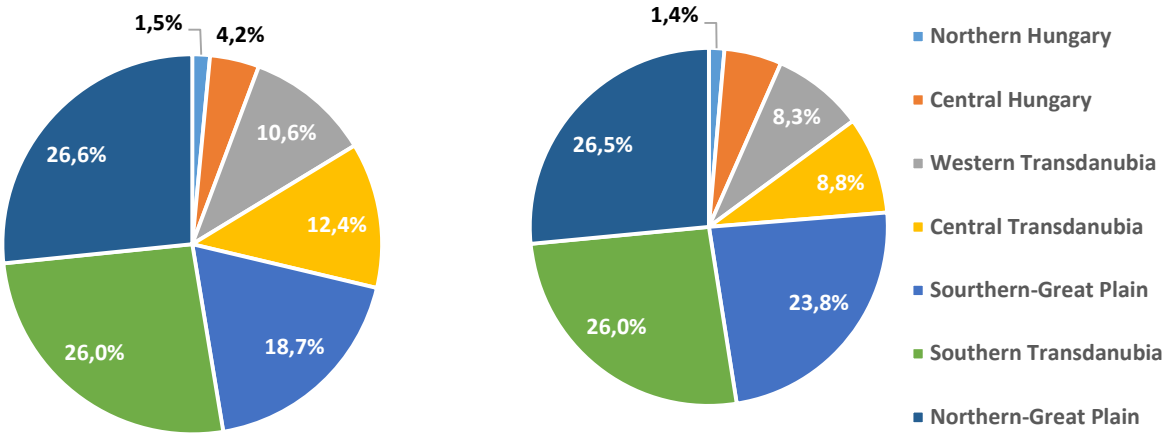
3.1.3 HUNGARIAN BIOMASS USAGE IN 2020

The Institute of Agricultural Economics collects data on relevant power plants, heating plants and biogas plants. The data collection covers all relevant plants using biomass sources, totally 66 biomass power plant, heating plant and biogas plant for energy purposes in 2020.

Quantity of biomass raw materials usage in 2020

Based on AKI statistical data collection in 2020 the domestic biomass consumption for energy purposes was 3.5 million tonnes (+9% increase compared to 2019), of which 84.8 thousand tonnes were imports in 2020. In 2020, one-third of all biomass raw materials were used for energy production in Central Transdanubia and more than 29% in Southern Transdanubia. More than half of biomass quantity for biogas production were used in two regions of country (26.5% in Northern Great Plain and 26% in Southern Transdanubia), the lowest share of other regions was used in Central Hungarian Region (5.2%) and Northern Hungary (1.4%) (Figure 11.).

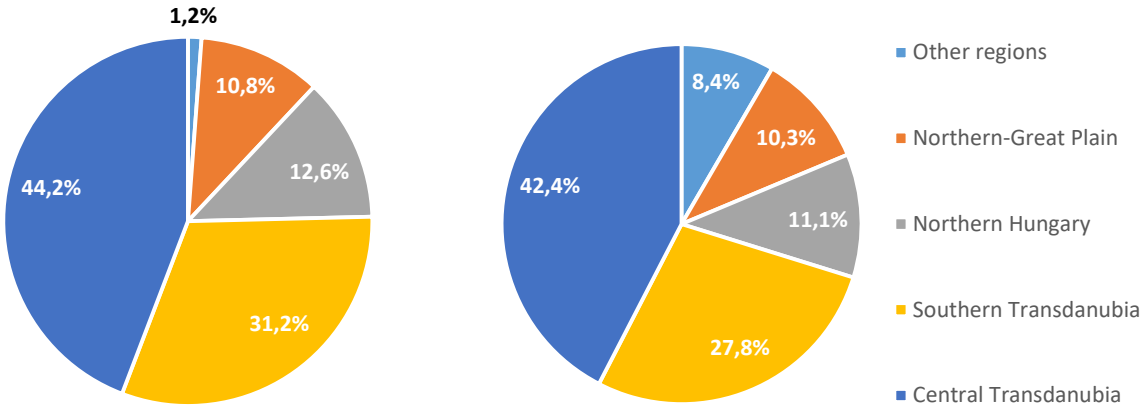
Figure 11. Distribution of biomass raw materials used in biogas plants by region, 2019 (right) and 2020 (left)



Source: AKI Agricultural Statistics Department, 2021

Substantial part of biomass (70.2%) in power plants and heating plants was used in Central Transdanubia and Southern Transdanubia regions (Figure 12.).

Figure 12. Distribution of biomass raw materials used in power and heating plants by region, 2019 and 2020



Source: AKI Agricultural Statistics Department, 2021

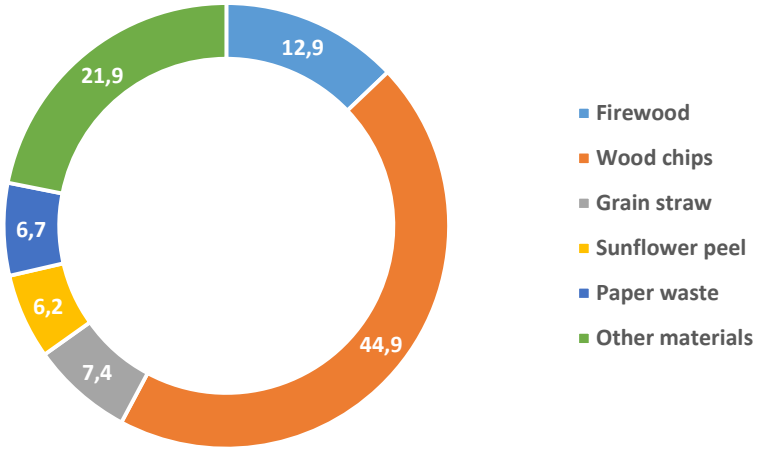
In 2020, power plants and heating plants using biomass raw materials in Hungary used 44.9% of wood chips (973,834 tonnes) for their energy production, a decrease of more

than 10% compared to the amount used in the previous year. The main raw material group used in biogas production is agricultural products, with a share of 42.0% (570.9 thousand tonnes). In 2020, animal manure accounted for 72.3% of this amount (Demeter, 2021).

Biomass raw materials of power and heat generation

Total biomass quantity used in power and heat plants in 2020 was 2 167 734 tones. The share of wood chips in biomass use was 44.9% (973 834 tones), 10% lower than in previous year (1 016 344 tones). Firewood (12.9%), grain straw (7.4%), paper waste (6.7%) and sunflower peel (6.2%) materials obtained the highest share of biomass usage (Figure 13.). Category of other materials consisted municipal waste (160 508 tons), agricultural products (80 933 tons), milling by-products (59 175 tons) and rape straw (40 156 tons).

Figure 13. Share of main raw materials of power and heating plants, 2020

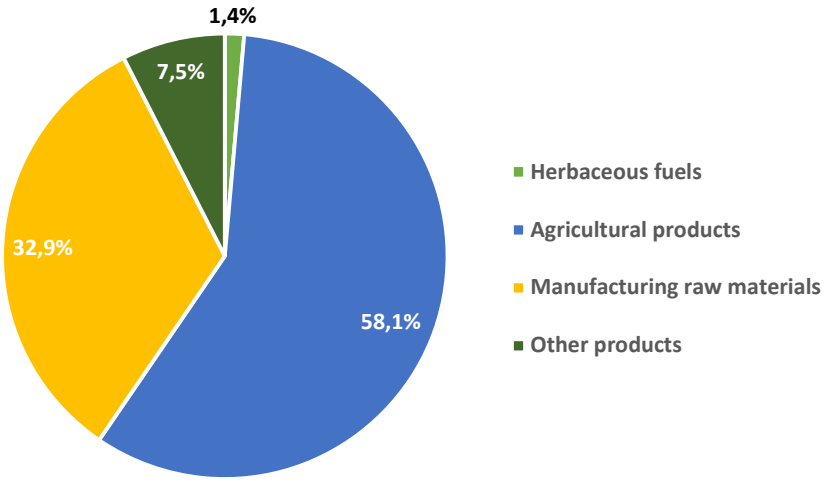


Source: AKI Agricultural Statistics Department, 2021

Biomass raw materials of biogas generation

Total biomass quantity used in biogas plants in 2020 was 1 360 084 tones. In biogas production the highest share of raw materials was obtained from agricultural sources (58.1%), mainly from manure as biogas materials (42% of total biogas raw materials). Second largest share was manufacturing raw materials (32.9%), mainly form by products of beverage industry (22.1%) (Figure 14.).

Figure 14. Share of main raw materials of biogas plants, 2020



Source: AKI Agricultural Statistics Department, 2021

3.1.4 HERBACEOUS AND WOODY BIOMASS POTENTIAL

Herbaceous biomass potential

In the case of herbaceous biomass potential, the plant groups with the highest arable by-product potential are autumn cereals and spring cereals; maize; sunflower. When counting the by-products of crop production, taking into account the requirements of soil protection and sustainability, only the proportion of biomass in which the amount of the main products produced reaches at least half of the county average yield was taken into account.

Békés County

Characteristics of crop production

The largest proportion of land use in the lands of Békés county is the arable land (71.53%) analysing the annual average data between 2015 and 2018, which serves as the basis for the significant biomass production of arable crop production. The size of the grasslands is 6.91%, which provides fodder for livestock by grazing and mowing. The reeds and fishpond occupy only 0.38% of the area (Figure 15). The amount of biomass generated here, judging from the land use rates, is negligible compared to the amount of by-products from crop production. The amount of main and by-products of biomass potential formed in arable land is presented below.

Figure 15. Use of land by branches of cultivation in Békés county (KSH)

Years	Arable land	Kitchen garden	Fruit	Grape	Lawn	Forest	Reeds	Fish-pound	Area set aside for cultivation	Total
	1000 hectar									
2015	383,00	5,10	1,00	0,10	30,70	26,00	0,90	1,10	93,80	541,80
2016	390,90	4,60	1,00	0,20	34,70	26,00	0,60	1,40	84,50	544,00
2017	396,20	2,90	1,20	0,10	43,00	25,90	0,50	1,60	82,50	553,80
2018	406,10	2,70	1,20	0,10	44,10	25,90	0,60	1,60	81,50	563,70
2015-2018 average	394,05	3,83	1,10	0,13	38,13	25,95	0,65	1,43	85,58	550,83
%	71,53	0,70	0,20	0,02	6,91	4,71	0,12	0,26	15,55	100

The most important feature of the sowing structure developed in Békés county is that in the field crop production the sown area of cereals, including maize (26.97%) and winter wheat (26.64%), as well as sunflower (22.97%) is decisive. These three main crops occupy more than 75% (260,987 hectares) of the total sown area of the county (34,987 hectares). In a smaller area, winter barley (6.81%), winter rape (5.28%), hybrid maize for seed (1.9%), silage maize (1.54%) and winter triticale (1.19%) are grown. The sown area of other crops grown in the county does not exceed 1% of the total area of the county per plant.

By - products suitable for combustion

Based on the available data, we examined what percentage of the total arable land of Békés county is the size of the area where the yield reaches half of the county's average yield.

Figure 16. The size of the areas reaching at least half of the average yield of Békés county and the potential amount of the by-product generated here

Crop	Total area	By product potential
	%	tonna
Maize	92,48	1 092 703,02
Winter wheat	94,22	360 254,88
Sunflower	94,24	210 551,71

Autumn barley	91,90	153 128,15
Autumn rapeseed	90,71	141 295,53
Hybrid maize for sowing	87,95	27 277,45
Sweat corn	83,47	35 968,57
Autumn triticale juice	93,30	19 622,20
Autumn durum wheat	95,95	12 484,13
Total		**2 053 285,62**

For the three main crops grown in the county (corn, sunflower and winter wheat), this proportion reaches 90%, which means that we can safely calculate the pre-calculated amount of biomass from these areas (Figure 16). After sorting the data, it is also clear that in the case of the crops shown in Figure 16, farmers grew more than half of the county average yield in 83-94% of the areas. The available by-product biomass potential is 2 103 327.77 tonnes, of which maize, winter wheat, sunflower, winter barley, winter rape, hybrid maize (for seed), sweetcorn, autumn triticale, winter durum provide a total of 2 053 285.62 tonnes

Biogas potential

Examining the sown area and biomass yield of well-gassed crops (silage maize, silage sorghum, sugar sorghum, Sudanese sorghum and sugar beet) at the district level, it can be observed that 36.5% of the total amount is produced in two southern districts (Mezőkovácsháza and Orosháza). to the trend experienced.

Herbaceous energy crops

The cultivation of energy crops is not yet widespread in Hungary, there is little practical experience in this field. Nevertheless, it is necessary to examine how the production volume of these crops in Békés County developed between 2015 and 2018. The size of the sown area is characterized by the fact that only 0.5% of the arable land of the county was cultivated with energy crops in the studied years. The species cultivated were: energy grass, hemp fiber, energy Miscanthus (Chinese reed). Total yields in the county averaged 1,617.3 tons over the four years. At the district level, almost 50% of the total county yields were produced in the Orosháza and Szarvas districts.

Hajdú-Bihar county

Characteristics of crop production

Analyzing the composition of the agricultural area of Hajdú-Bihar county in 2015-2018. Based on the data of the previous years, it can be stated that almost 53% of them are cultivated with arable crops, and the proportion of grasslands is very high, exceeding 18% compared to the other two counties examined. The proportion of kitchen gardens, orchards, vines, reeds and fishponds is only around 1-1% (Figure 17.).

Figure 17. Distribution of agricultural areas of Hajdú-Bihar county by cultivation branches

Years	Arable	Kitchen gardent	Fruit	Grape	Lawn	Forest	Reeds	Fish pound	Area set aside for cultivation	Total
	Tthousnd ha									
2015	329,80	5,00	3,70	1,40	110,00	69,80	9,90	6,80	78,80	615,10
2016	322,10	4,00	3,70	1,10	111,50	69,80	7,80	6,80	84,40	611,20
2017	322,10	3,50	3,20	0,90	112,40	69,80	6,50	6,80	86,00	611,20
2018	320,60	3,20	3,20	0,80	112,40	69,80	6,40	6,00	87,30	609,60
2015-2018 years average	323,65	3,93	3,45	1,05	111,58	69,80	7,65	6,60	84,13	611,78
%	52,90	0,64	0,56	0,17	18,24	11,41	1,25	1,08	13,75	100,00

Based on the data of 2015-2018, arable crops are grown on an average of 250,490 hectares. The sown area of maize is the largest (36.13%), but sunflower (22.76%) and winter wheat (20.39%) also occupy a significant area. In other words, almost 80% of the arable land of the county is cultivated with 3 crops (corn, sunflower, winter wheat), which shows a very limited use of crops from a professional point of view. In a smaller area, winter barley (4.63%), silage maize (2.41%), autumn triticale (2.25%), winter rape (2.15%), spring oats (0.75%), sugar beet (0, 54%) and rye (0.52%). The proportion of other plants was 2.79%.

By - products suitable for combustion

Based on the available data, we examined what percentage of the total arable land of Hajdú-Bihar county is the size of the area where the yield reaches half of the average yield of the county. utilized as biomass (Figure 18.)

Figure 18. The size of the areas reaching at least half of the average yield of Hajdú-Bihar county

Plant culture	Total area	By-product potential
	%	tonna
Corn	91,78	1 166 513,9
Sunflower	94,90	176 628,6
Autumn wheat	94,04	210 894,2
Sweetcorn	87,58	195 154,8
Autumn barley	92,93	86 391,5
Autumn triticale	91,73	24 778,7
Autumn rapeseed	91,72	47 472,4
Spring oats	87,53	5 356,8
Total		1 913 190,9

Biogas potential

In Hajdú-Bihar county, examining the sown area and the yield of green mass of well-gassed crops (silage maize, silage sorghum, sugar sorghum, Sudanese sorghum and sugar beet) at the district level, we found that in the Püspökladány district almost one third of the total yield .

Herbaceous energy crops

In Hajdú-Bihar county, we have very little data on the cultivation of energy crops. We were able to examine the combined data of only 5 districts. Based on these, it can be stated that in 2015-2018. On average, 571.9 tons of biomass from energy crops is produced in the county.

Vas county

Characteristics of crop production

Analyzing the composition of the agricultural area of Vas county in 2015-2018. Based on the data of the previous years, it can be stated that more than 45% of them are cultivated with arable crops, almost 30% have forests and the proportion of areas taken out of cultivation is very high, exceeding 20% compared to the other two counties examined. The proportion of grasslands remains below 4% of the size of agricultural land, and the proportion of kitchen gardens, orchards, vineyards, reeds and fishponds is below 1% (Figure 19.).

Figure 19. Distribution of agricultural areas of Vas county by cultivation branches (KSH)

Years	Arable areat	Kitchen garden	Fruit	Grape	Lawn	Forest	Reeds	Fisher pound	Area set aside for cultivation	Total
	ezer ha									
2015	145,0	2,80	1,80	1,00	13,10	94,20	0,30	0,10	66,10	324,40
2016	147,40	2,60	1,80	0,90	13,60	94,20	0,30	0,10	66,00	326,80
2017	158,90	1,40	1,80	0,70	13,60	94,20	0,30	0,10	67,40	338,30
2018	157,50	1,40	1,80	0,70	13,60	94,20	0,30	0,10	67,40	336,90
2015-2018 years avarage	152,20	2,05	1,80	0,83	13,48	94,20	0,30	0,10	66,73	331,60
%	45,88	0,62	0,54	0,25	4,06	28,42	0,09	0,03	20,13	100

Regarding the cultivated arable crops, the sown area of winter wheat was the largest (31.76%) based on the data of 2015-2018, but maize (20.38%) and winter rape (18.61%) also occupied a significant area. . In other words, more than 70% of the county's arable land is occupied by only 3 crops (winter wheat, corn, and rapeseed). In a smaller area, winter barley (7.44%), sunflower (6.12%), spring barley (5.01%), silage maize (2.28%), winter triticale (2.01%), spring wheat (1, 47%) and silage (0.84%).

By - products suitable for combustion

Based on the available data, we examined what percentage of the total arable land of Vas County is the area where the yield reaches half of the county's average yield, as

basically these by-products could be used as biomass with high safety, keeping in mind the requirements of soil protection and sustainability (Figure 20.).

Figure 20. The size of the areas reaching at least half of the average yield of Vas county and the amount of the potential of the by-product generated here

Plant culture	Total area	By product potential
	%-a	tonna
Autumn wheat	95,79	171 944,35
corn	93,72	313 727,99
Autumn rapeseed	93,50	207 675,88
Autumn barley	91,08	68 018,07
Sunflower	93,55	20 650,61
Spring barley	89,62	24 035,58
Silage corn	90,30	63 104,21*
Autumn triticale	92,02	116 58,23
Spring wheat	89,03	6 449,80
Total		817 710,70

* during the cultivation of silage maize we count on the main product (stem).

In the case of the three main crops grown in the county (winter wheat, maize, winter rape), this proportion is over 90%, which means that we can safely calculate the amount of biomass calculated from these areas. After sorting the data, it is also clear that farmers grew more than half of the county's average yield in 89-95% of the areas. The available by-product biomass potential is 840,750.99 tonnes, of which 817,710.70 tonnes (97%) are provided by the main crops.

Biogas potential

Examining the sown area and green mass yield of well-gassed crops (silage maize, silage sorghum, sugar sorghum, Sudanese sorghum and sugar beet) in Vas county at the district level, we found that in Szombathely district almost 30% of the total yield is produced, while in Szentgotthárd district only 1 /year.

Herbaceous energy crops

Data on the volume of energy crop production at the district level are only incomplete. According to county data, 2015-2018. The average annual yield of biomass is 184 tons.

Straw price changes in the three counties

The average straw yield measured in 2018 in the test plants of the three counties and their surrounding counties and the weighted average straw price calculated for the period 2017-2019 are shown in (Figure 21.).

Figure 21. Test plant straw yield and weighted straw sales price values measured in each region

Plant culture	Békés county		Hajdú-Bihar county		Vas county	
	Straw yield (t/ha)	Weighted average price (Ft/t)	Straw yield (t/ha)	Weighted average price (Ft/t)	Straw yield (t/ha)	Weighted average price (Ft/t)
Wheat and spelled	3,44	10 305,11	3,62	5 821,02	4,37	7 280,32
Autumn barley	7,13	7 609,14	6,75	4 000,00	8,15	7 870,90
Rye	3,20	7 333,33				
Grains of corn	10,98	7 153,88	6,98	4 206,58		
Spring barley					5,11	7 199,45
Triticale	3,36	8 910,71	5,33	5 047,57	5,51	6 360,78
Oats	3,90	8 000,00	4,51	6 000,00	3,00	6 381,02

Békés County and its catchment area have the highest average prices of arable by-products in the three regions examined. The average price of HUF 10,305 / t for wheat and spelled wheat is the highest within the framework of the study. Rye, winter barley, oats and triticale were HUF 7,333 / t, HUF 7,609 / t, HUF 8,000 / t and HUF 8,911 / t, respectively, with the exception of winter barley, which reached the highest values in the other two countries. compared to the district. The average price of the by-product of maize is HUF 7,154 / t. In total, the average unit price of the by-products examined in the catchment area of Békés county is between HUF 7,154 / t and HUF 10,305 / t, depending on the crop.

In Hajdú-Bihar county and its catchment area, the highest priced by-product is oat straw, which is HUF 6,000 / t, but this value is also significantly (25%) lower than in Mezőhegyes. The straw of wheat and spelled wheat is HUF 5,821 / t, the by-product of maize is HUF 4,207 thousand / t, the prices of which barely exceed half the price of Békés county. Autumn barley and triticale juice are similar, which amounted to HUF 4,000 / t and HUF 5,048 / t, respectively. In the catchment area of Hajdú-Bihar county, the average prices of various field by-products range from HUF 4,000 / t to HUF 6,000 / t.

In Vas County and its catchment area, the average prices of by-products of arable crops vary in a narrow range compared to the other two regions, between HUF 6,361 / t and HUF 7,280 / t, the lower value of which is given by triticale and the upper value by winter barley. The prices of wheat and spelled wheat, spring barley and oat straw are HUF 7,280 / t, HUF 7,199 / t and HUF 6,381 / t, respectively.

Woody biomass potential

In the case of woody biomass potential, the chapter summarizes the amount of biomass that can be produced by forest areas, afforestation, and existing and plantable woody energy plantations available and possibly established in Hungary in the next 25 years.

Békés County

According to the data of the Central Statistical Office (hereinafter CSO) in 2018, Békés County is the county with the smallest forest cover in Hungary with 4.6%. The size of its forest management areas is 27,734 hectares, and the living stock of forest stands is 4,124,964 m3.

Estimation of the annual amount of firewood and slaughterhouse debris

In the examined period, the distribution of the gross volume of timber that can be harvested in end uses by group of tree species, as well as the quantities of firewood and thinwood calculated on this basis in the case of Békés county are included in the work package F1., F2. and F3. annexes. The calculated annual average gross end-use volume, firewood and thinwood by group of tree species are shown in Table 8. Based on the table, it can be stated that between 2021 and 2045, an average of 18,468 atrotons of firewood and 3,694 tonnes of thin wood can be produced in the forest stands of Békés County on an annual basis (Figure 22.).

Figure 22. Average annual gross end-use timber volume of forest stands for the period between 2021 and 2045, and the amount of firewood and thin wood that can be produced from it, and their distribution by species, tree species group in Békés county

	Tree species, tree species groups									
	A	**B**	**CS**	**EKL**	**ELL**	**F**	**HNY**	**NNY**	**T**	**∑**
Firewood (at / year)	4 144	0	950	5 582	419	104	883	1 556	4 831	**18 468**
Thin wood (at / year)	829	0	190	1 116	84	21	177	311	966	**3 694**
End-use wood volume (m3 / year)	14 166	0	2 785	19 297	1 863	469	4 281	9 218	14 156	**66 235**

(legend: A - acacia, B - beech, CS - oak, EKL - other hardwood, ELL - other softwood, F - pines, HNY - domestic poplars, NNY - noble poplars, T - oaks)

However, it is absolutely important to note that the values given in the table above are theoretical maxima, ie the estimated total amount of firewood and thin wood produced in forest stands.

Survey of slaughterhouse usage patterns

Southern Great Forestry Private Limited Company (DALERD Zrt.) Operates in Csongrád and Békés counties, the latter's forest areas are managed by the forestry of Gyula and Kőrösvidék. The forestry of Gyula manages forest areas in 12 village boundaries, on about 7,100 hectares, the Kőrösvidéki forestry on 16 village boundaries, and on a total of about 5,800 hectares. The total annual net production of the forests of Békés County is on average 30,000 m3, of which 16,000 m3 belongs to the forestry of Gyula and 14,000 m3 to the forestry of Kőrösvidék. Table 9 shows the average annual population-prepared branches of Békés County calculated from the wood use data received from DALERD Zrt. For the years 2017, 2018 and 2019 (Figure 23.).

Figure 23. Sales of DALERD Zrt.'s annual branch-based branch wood based on a three-year average

Wood species	**Thin firewood volume (m^3)**	**Biomass volume (atroton)**
Acacia	586,319	342,996
Cherry oak	300,060	204,791

Other hard foliage	548,855	317,513
Other soft foliage	2,140	0,963
Domestic summer	149,088	61,499
Noble summer	451,807	152,485
Oak	657,387	448,666
Altogether	**2 695,655**	**1 528,913**

Estimation of the amount of wood from a secondary source of use

MK Zrt. Also provided us with the amount of timber stocked by county between 2016 and 2019 (unfortunately without detailing by stocking categories). The amount of timber harvested in Békés County and stockpiled by county engineer (Figure 24.).

Figure 24. Quantity of timber harvested from road afforestation in Békés county between 2016 and 2019

County	**2016 (m^3)**	**2017 (m^3)**	**2018 (m^3)**	**2019 (m^3)**
Békés	2 656,320	8 231,120	6 877,550	4 856,890

In order to determine the average amount of biomass available for energy use on an annual basis, the values in the table were averaged and the standard deviation was calculated. Given that no information is available on the proportion of hard (high density) and soft (low wood density) wood in the harvested wood, we made our own estimate. We based our estimates on literature data, installation practices, site knowledge, and online map observations. Accordingly, in addition to Békés, the other two counties affected by the project (Hajdú-Bihar and Vas) were found to have almost the same rate of application of soft and hard deciduous tree species at county levels, 1 / 3-2 / 3.

Using the average density and moisture data accepted by us, we converted the amount of wood extracted and stored from road afforestation in Békés County from 2016 to 2019 from forest cubic meters to atroton. The values were averaged, and the average was divided by the length of the county's road network to obtain the amount of wood produced in atroton in an average of 1 km of road section per year. The calculated data are shown in(Figure 25.).

Figure 25. Average annual amount of timber harvested from road afforestation in Békés county

County	Average (at / year)	Scatter (at / year)	Length of road network (km)	Distribution (atrotone / km / year)
Békés	3 104,853	1 335,778	1 601,854	1,938

On an annual basis, MK Zrt. Extracts and stores an average amount of timber corresponding to about 3,100 atrotons in Békés County, which corresponds to an average of 2 atrotons for the 1 km road section of the treated road network. In Békés county, engineering (storage sites) are located in Békéscsaba, Gyomaendrőd, Orosháza and Sarkad.

Determination of afforestation-based woody biomass potential

The spatial distribution of woody biomass that can be produced in the period between 2021 and 2045 by afforesting low-quality arable land in Békés County is illustrated in (Figure 26.). As the figure illustrates well, the northern and north-eastern districts of the county (Gyomaendrődi, Szeghalmi, Sarkadi) and the villages named in the caption have the highest biomass potential.

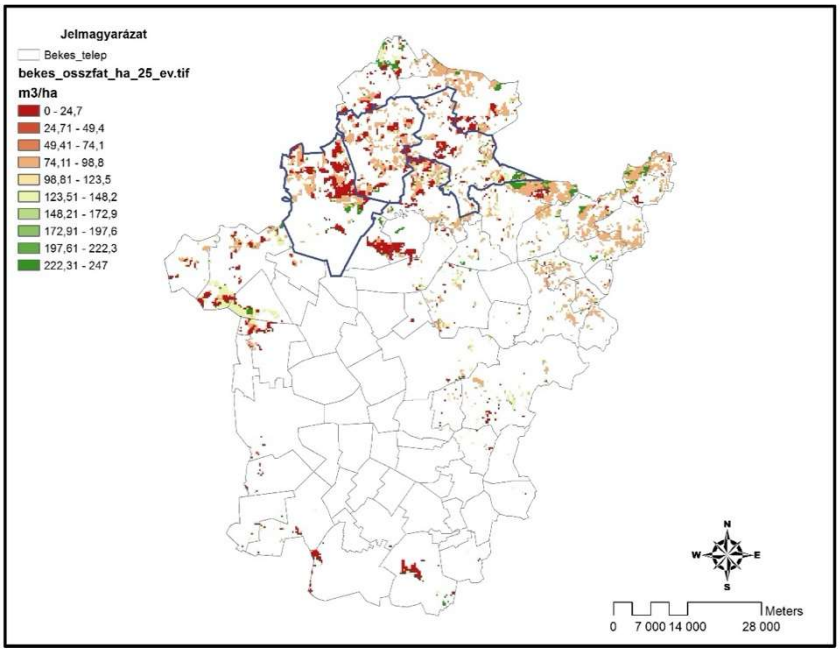


Figure 26. 25-year biomass potential in Békés county per hectare and the settlements with the highest biomass potential in Békés county (Szeghalom, Gyomaendrőd, Dévaványa)

In order to compare the amount of woody biomass produced in afforestation with the amount of biomass that can be produced in woody energy plantations in low quality arable land, the wood volume values were converted to weight units (atrotons). The calculation was based on the density and moisture content of the wood of each tree species measured in the wet state. Based on these, the biomass yields calculated for the target stocks determined in Békés county are shown in Figure 27.

Figure 27. Biomass potential of Békés county based on afforestation by tree species

Wood species	Area (ha)	Total wood volume (m3)	Density (kg / m3)	Moisture content (%)	Biomass (atroton)
Acacia	12 528	2 276 825	900	35	1 331 943
Domestic summer	31 176	3 070 836	750	45	1 266 720
Turkestan elm	1 287	108 108	850	35	59 730
Altogether	**44 991**	**5 455 769**			**2 658 392**

Determination of biomass potential of woody energy plantations

In Békés county, it would be worth planting an energy plantation on a total of 162 hectares of low-quality arable land (this is only about 0.3% of the 62 082 hectares with an agricultural suitability rating of 1 to 4). The reason for this is to be found in the unfavorable climatic conditions. The unfavorable arable land of Békés county belongs to the steppe climate, therefore it is worth planting energy plantations only in those areas where there is extra water in the soil (and other soil defects would not inhibit the growth of the plantation). The 162 hectares can produce about 1,872 atrotons of biomass per year, corresponding to 46,800 atrotons of biomass in a 25-year perspective. The area calculated for Békés county (size of areas suitable for planting energy plantations) and biomass are presented in Figure 28..

Figure 28. Quantity of biomass that can be produced in sprouting type woody energy plantations in Békés county

Tree species	Quality	Area	Annual yield (at))	Total yield (at/25 year)
Summer	good	126	1 512	37 800
	medium	36	360	9 000
	weak	0	0	0
Willow	good	0	0	0
	medium	0	0	0
	weak	0	0	0
Acacia	good	0	0	0
	medium	0	0	0
	weak	0	0	0
Total		**162**	**1 872**	**46 800**

Hajdú-Bihar county

According to the data of the CSO, Hajdú-Bihar ranks 13th in the forest ranking of the counties. The size of its forest areas is 73,764 hectares, and the living tree stock of forest stands is 10,953,702 m3. The forest cover of the county is 11.3%.

Estimate of the annual amount of firewood and slaughterhouse debris

The estimated average gross wood volume that can be harvested annually and by tree species group in the stands that become mature in the target period, as well as the expected average quantities of firewood and thin wood, are shown in Figure 29. Based on the table, it can be stated that in the forest stands of Hajdú-Bihar county, an average of 65,114 atrotons of firewood and 13,023 atrotons of thin wood can be produced annually between 2021 and 2045.

Figure 29. Average annual gross end-use wood volume of forest stands for the period between 2021 and 2045, and the amount of firewood and thin wood that can be produced from it, and their distribution by species, group of tree species in Hajdú-Bihar county

	Tree species, tree species groups									
	A	**B**	**CS**	**EKL**	**ELL**	**F**	**HNY**	**NNY**	**T**	**Σ**
Firewood (at / year)	30 135	0	81	4 238	974	11 775	848	5 074	11 989	**65 114**
Thin wood (at / year)	6 027	0	16	848	195	2 355	170	1 015	2 398	**13 023**
End-use wood volume (m3 / year)	103 026	0	236	14 652	4 331	53 280	4 113	30 066	35 132	**244 836**

(legend: A - acacia, B - beech, CS - oak, EKL - other hardwood, ELL - other softwood, F - pines, HNY - domestic poplars, NNY - noble poplars, T - oaks)

Due to its higher forest cover, the amount of timber that can be harvested in 25 years can be estimated to be much higher in Hajdú-Bihar county. The quantities indicated above are considered to be the maximum in principle, as in the previous county, the use of firewood and thin wood by the population covers a significant part of the extracted timber. Prior direct consultation with producers is required to plan power plant use.

Logging will be carried out in the largest number in the Nyíradony, Hajdúhadház, Debrecen and Derecskei Districts in the next 25 years.

Survey of slaughterhouse usage patterns

The area of operation of Nyírségi Erdészeti Zártkörűen Működő Részvénytársaság (Nyírerdő Zrt.) Covers Hajdú-Bihar and Szabolcs-Szatmár counties, on which it manages a total of 61,000 hectares of state-owned forest land. The distribution of forest areas between the two counties is almost 50-50%. The thin wood management practice of the joint stock company is similar to that applied by DALERD Zrt. The remaining wood (thin firewood) thinner than 5 cm in diameter remaining in the cutting areas is sold in the form of residential branch picking. Nyírerdő Zrt. Previously carried out the production and sale of wood chips, but this practice was abandoned due to the payment uncertainty of the recipient (Szakoly Biomass Power Plant). Machines purchased for this purpose are currently on sale at the joint stock company.

Figure 30. shows the average annual sales of residential branch wood in the forests of Nyírerdő Zrt. In Hajdú-Bihar County.

Figure 30. Sales of Nyírerdő Zrt. In the forests of Hajdú-Bihar county, on an annual basis, based on the three-year average

Wood species group	Thin firewood volume (m3)	Biomass volume (atroton)
Hard foliage	5 545,400	3 496,375
Soft foliage	622,000	236,360
Pine	463,200	204,734
Total	**6 630,600**	**3 937,469**

Estimation of the amount of wood from a secondary source of use.

According to the data provided by Magyar Közút Zrt., Between 2016 and 2019, the forests harvested in Hajdú-Bihar county cubic meters are shown in Figure 31.

Figure 31. Quantity of timber harvested from road afforestation in Hajdú-Bihar county between 2016 and 2019

County	2016 (m^3)	2017 (m^3)	2018 (m^3)	2019 (m^3)
Hajdú-Bihar	4 292,800	3 346,760	3 208,800	2 941,560

The values of the average amount of biomass stored per year, calculated on the basis of the average wood density and moisture content values calculated on the basis of the accepted tree species composition (soft and hard foliage ratio). As can be seen from the table, in Hajdú-Bihar county an average of 1 atrotonic timber is extracted and stockpiled per road kilometer per year. This amount is about half of the data in Békés county.

Figure 32. Average annual amount of timber harvested from road afforestation in Hajdú-Bihar county

County	Average (at/year)	Scatter (at / year)	Length of road network (km)	Distribution (atroton / km / year)

Hajdú-Bihar	1 892,667	322,874	1 821,918	1,039

Determination of afforestation-based woody biomass potential

According to the agricultural suitability classification, the amount of woody biomass produced in 25 years by afforestation of arable lands in Hajdú-Bihar county with poor endowments was determined as described for Békés county. The biomass potential of each village boundary is illustrated.

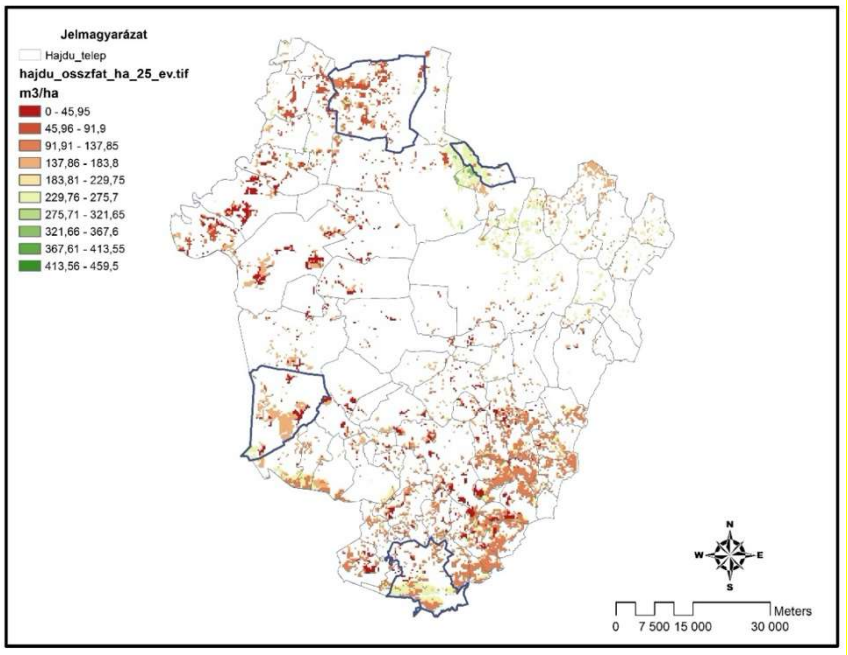


Figure 33. 25-year biomass potential in Hajdú-Bihar county per hectare and the settlements with the highest biomass potential in Hajdú-Bihar county (Komádi, Hajdúnánás, Püspökladány, Hajdúböszörmény)

It is clear from the table that acacia and domestic poplar have significant biomass potential in the county. The potential of afforestation-based biomass in Hajdú-Bihar county is more than twice that of Békés county.

Figure 34. Biomass potential of Hajdú-Bihar county based on afforestation by tree species

Wood species	Area (ha)	Total wood volume (m3)	Density (kg / m3)	Moisture content (%)	Biomass (atroton))

Acacia	36 549	6 993 027	900	35	4 090 921
Cherry oak	360	41 828	1050	35	28 548
Pine	81	13 284	680	35	5 872
White willow	9	4 136	870	55	1 619
Domestic poplar	32 058	3 351 015	750	45	1 382 294
Noble poplar	441	145 089	750	55	48 968
Turkestan elm	8 496	713 664	850	35	394 299
Total	**77 994**	**11 262 042**			**5 952 520**

Determination of biomass potential of woody energy plantations

The extent of the arable areas of Hajdú-Bihar county with agricultural suitability categories 1 to 4 is 89,136 hectares, of which, as shown in Table 19, a total of 14,130 hectares are suitable for planting woody energy plantations (15.9%). In the absence of an area with a wet hydrological category up to the surface suitable for the planting of willow varieties, the establishment of a willow energy plantation is not expected. It can be seen from the table that in the case of both poplars and acacias, areas with medium and poor conditions are predominantly predominant among low-quality arable land. In the case of Hajdú-Bihar county, an average of about 110,000 atrotons of woody biomass can be produced in the county areas on an annual basis, which corresponds to 2.7 million atrotons over a 25-year period (Figure 35.).

Figure 35. Quantity of biomass that can be produced in sprouting type woody energy plantations in Hajdú-Bihar county

Tree species	Growth force (ha)	Area (ha)	Annual yeald (at)	Total yield (at/25 year)
Poplar wood	jó	297	3 564	89 100
	közepes	4 023	40 230	1 005 750
	gyenge	3 204	25 632	640 800
Willow	jó	0	0	0
	közepes	0	0	0
	gyenge	0	0	0
Acacia	jó	72	648	16 200
	közepes	3 681	25 767	644 175
	gyenge	2 853	14 265	356 625

Total	**14 130**	**110 106**	**2 752 650**

Based on the financial models, only the sectoral results of acacia plants with weak growth vigor are negative. In light of this, it is worthwhile to set up an energy plantation on 11,277 hectares in Hajdú-Bihar county. The expected annual return is 95,841 atrotons and the projected return for 25 years is 2,396.

Vas county

According to the data of the CSO, Vas county is one of the most forested counties, with 28.2% in the 6th place. The size of the forest areas of the county is 98,562 hectares, the living tree stock of the forest stands is 24,595,117 m3.

Estimation of the annual amount of firewood and slaughterhouse debris

Based on Table 20, it can be stated that, as in the case of Hajdú-Bihar county, the largest amount of pine (mainly pine) is expected to be harvested in Vas county. The low proportion of soft deciduous tree species is also striking, accounting for less than 10% of the estimated total timber harvest. This means an average of 73,553 tonnes of atrotonic firewood and 14,711 tonnes of atrotonic thinwood per year (Figure 36).

Figure 36. Average annual gross end-use wood volume of forest stands for the period between 2021 and 2045, and the amount of firewood and thin wood that can be produced from it, and their distribution by species, group of tree species in Vas county

	Tree species, tree species groups									
	A	**B**	**CS**	**EKL**	**ELL**	**F**	**HNY**	**NNY**	**T**	**Σ**
Firewood (year / year)	17 315	4 178	3 042	16 736	4 822	16 992	173	376	9 918	**73 553**
Thin wood (at / year)	3 463	836	608	3 347	964	3 398	35	75	1 984	**14 711**

End use Wood volume (m3 / year)	8 916	59 197	12 016	57 859	21 432	76 885	839	2 230	29 065	**268 439**

(legend: A - acacia, B - beech, CS - oak, EKL - other hardwood, ELL - other softwood, F - pines, HNY - domestic poplars, NNY - noble poplars, T - oaks)

In the case of Vas county, the demand for thin wood in the population is lower than in the eastern part of the country, ie about half of the resulting slaughterhouse chips are sold as wood chips. Nevertheless, the importance of prior consultation with forest managers when planning the use of biomass at power plant level is undisputed.

Survey of slaughterhouse usage patterns

The state forest areas in Vas County are managed by the Szombathely Forestry Limited Liability Company. The area managed by the joint-stock company is 47,600 hectares, of which about 44,000 hectares are covered by forest; the average annual net wood use in forest stands is 253,000 m^3 (Figure 37).

Figure 37. The average annual volume of residential branch wood sold by Szombathelyi Erdészeti Zrt

Wood species group	Thin firewood volume (m3)	Biomass volume (atroton)
Hard deciduous tree	16 730,988	10 548,888
Soft deciduous tree	148,433	56,404
Pine	12 929,581	5 714,875
Total	**29 809,001**	**16 320,167**

There is a significant difference between the quantities of thin wood sold in the three counties examined, which can be explained by the fact that the forest cover of Vas county is the highest of the three counties, so Szombathelyi Erdőgazdaság Zrt. Furthermore, the environmental conditions of Vas county are more favorable from the point of view of forest vegetation, therefore the total tree yield of forest stands, thus the amount of thin wood generated during end uses, is also higher compared to the other two counties.

The projected annual average amount of thin wood for Vas County is lower than the amount of thin wood currently produced by Szombathelyi Erdészeti Zrt., Which farms about 50% of the forests of Vas County. The reason for this is to be found in the fact that the amount of thin wood leaving pre-uses (cleaning, thinning) is also included in the statement of forestry, while this wood was not taken into account in the 25-year forecast.

Estimation of the amount of wood from a secondary source of use

According to the data provided by Magyar Közút Zrt., The amount of timber extracted in Vas county between 2016 and 2019 and stored at the plant engineering is measured in forest cubic meters.

Figure 38. Quantity of timber harvested from road afforestation in Vas county between 2016 and 2019

County	2016 (m^3)	2017 (m^3)	2018 (m^3)	2019 (m^3)
Vas	2 422,152	3 524,750	3 799,410	2 696,242

Compared to Békés and Hajdú-Bihar counties, Vas County, which has a much wetter climate, uses different types of wood when planting road plantings, adapting to the local production conditions. However, the proportion of soft and hard deciduous tree species is similar to that observed in the other two counties studied, i.e. about 1 / 3-2 / 3. Table 23 shows the value of the average annual biomass stock calculated on the basis of the average wood density and moisture content values calculated taking this into account. It can be seen from the table that the amount of stored biomass from the road afforestations of Vas county is similar to that calculated in the case of Hajdú-Bihar county (almost 1 atroton / km / year), (Figure 39.).

Figure 39. On average, the amount of timber harvested from road afforestation in Vas county on an annual basis

County	Average (at/year)	Scatter (at / year)	Length of road network (km)	Distribution (atroton / km / year)
Vas	1 707,741	360,231	1 741,963	0,980

Determination of afforestation-based woody biomass potential

The biomass potential of some village boundaries of Vas county, and the biomass potential of the county in terms of tree species.

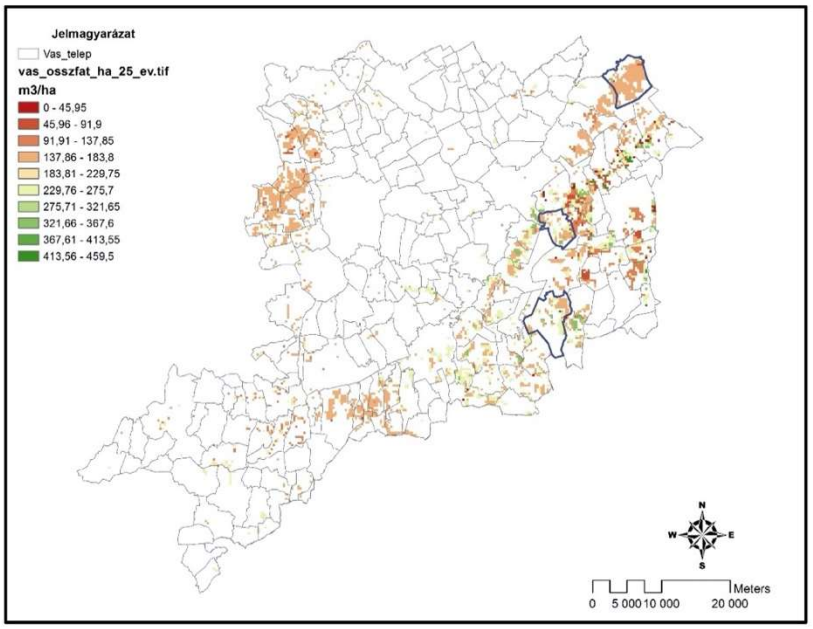


Figure 40. 25-year biomass potential in Vas county per hectare and settlements with the highest biomass potential in Vas county (Pápoc, Hosszúpereszteg, Gérce)

Figure 41. Potential of woody biomass based on afforestation in Vas county by tree species, based on a period of 25 years

Wood species	Area (ha)	Total wood volume (m^3)	Density (kg/m^3)	Moisture content (%)	Biomass (atrotonna)
Acacia	14 823	3 091 451	900	35	1 808 499
Cherry oak tree	8 928	1 303 394	1050	35	889 566
White willow	279	111 677	870	55	43 722
Domestic poplar	1 350	270 774	750	45	111 694
Pedunculate oak	3 042	556 416	1000	35	361 670
Sessile oak	5 796	826 236	1100	35	590 759
Gummy alder tree	63	13 946	820	35	7 433

Noble poplar	450	150 966	750	55	50 951
Total	**34 731**	**6 324 858**			**3 864 294**

Determination of biomass potential of woody energy plantations

Out of the poorly classified arable lands of Vas county, 22,311 hectares are suitable for the planting of woody energy plantations with different types of trees and shoots. The total area of arable land with an agricultural suitability value of 1 to 4 in the county is 35,136 hectares, ie 63.5% of these areas are suitable for planting. Based on the average annual lifetime yields established for these tree species and growth categories in these areas, approximately 168 thousand atrotons of biomass can be produced per year, which means 4.2 million atrotons of biomass for the project planning period. The amount of biomass that can be produced in woody energy plantations cultivated with sprouting technology in Vas County (Figure 42.).

Figure 42. Quantity of biomass that can be produced in shoots of woody energy plantations in Vas county

Tree species	Growth force	Area (ha)	Total yield (at)	Total yield (at/25 year)
Poplar wood	good	225	2 700	67 500
	medium	2 061	20 610	515 250
	weak	1 107	8 856	221 400
Willow	good	207	2 484	62 100
	medium	693	6 930	173 250
	weak	0	0	0
Acacia tree	good	4 266	38 394	959 850
	medium	9 801	68 607	1 715 175
	weak	3 951	19 755	493 875
Összesen		**22 311**	**168 336**	**4 208 400**

Based on the financial models, similarly as in Hajdú-Bihar county, the sectoral results of acacia plantations with weak growth vigor are negative. In light of this, it is worthwhile to set up an energy plantation (poplar, grass, acacia) in 18 360 hectares in Vas county. The expected annual yield is 148,581 atrotons and the projected yield for 25 years is 3,714,525 atrotons.

3.2 TRENDS OF PRODUCTION OF BIOMASS RAW MATERIALS AND USE

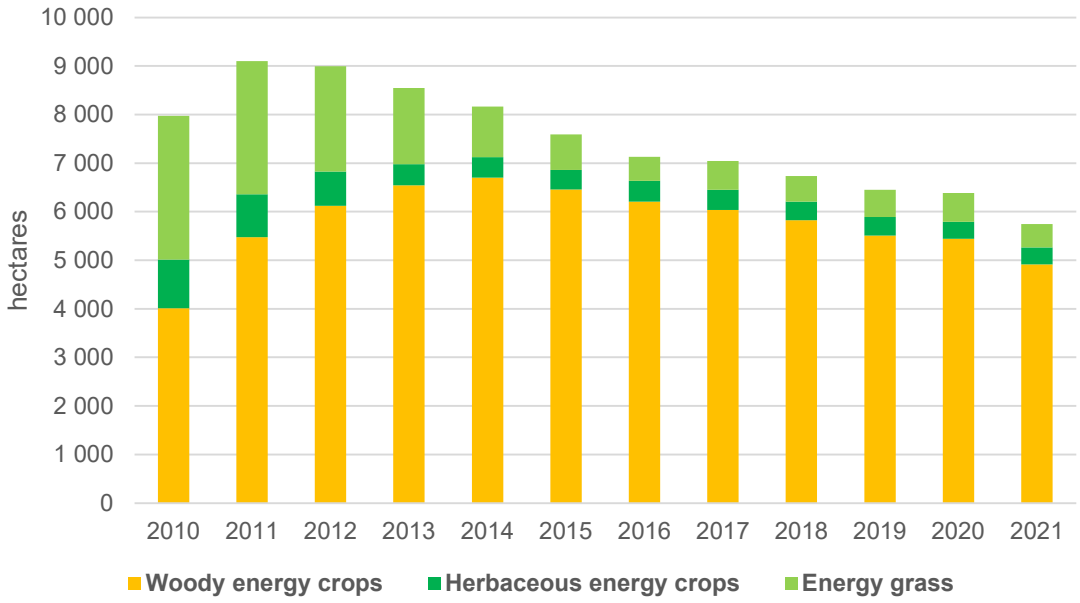
3.2.1 PAST TRENDS IN BIOMASS PRODUCTION

In Hungary there is no integrated database of biomass production, therefore, trends are presented based on several data sources.

Energy crops have been considered in the single area payment scheme (SAPS) since 2006, but the list of eligible crops has changed several times. Therefore, Figure 43. shows the changes in area under energy crops since 2010, based on the single application database of the Hungarian Paying Agency. The total area under energy crops peaked in 2011, since then has been on a decreasing trend, and currently covers less than 6000 hectares. Woody energy crops have been dominated throughout the period examined (between 50 and 87%) consisting mainly of poplar, black locust, and willow species. The

area under energy grass had steadily and significantly decreased from almost 3000 hectares to 500 hectares. The area of herbaceous energy crops (Sida, Miscanthus, and Arundo) also halved in 2013, but has been relatively stable since then (350–400 hectares).

Figure 43. Area under energy crops



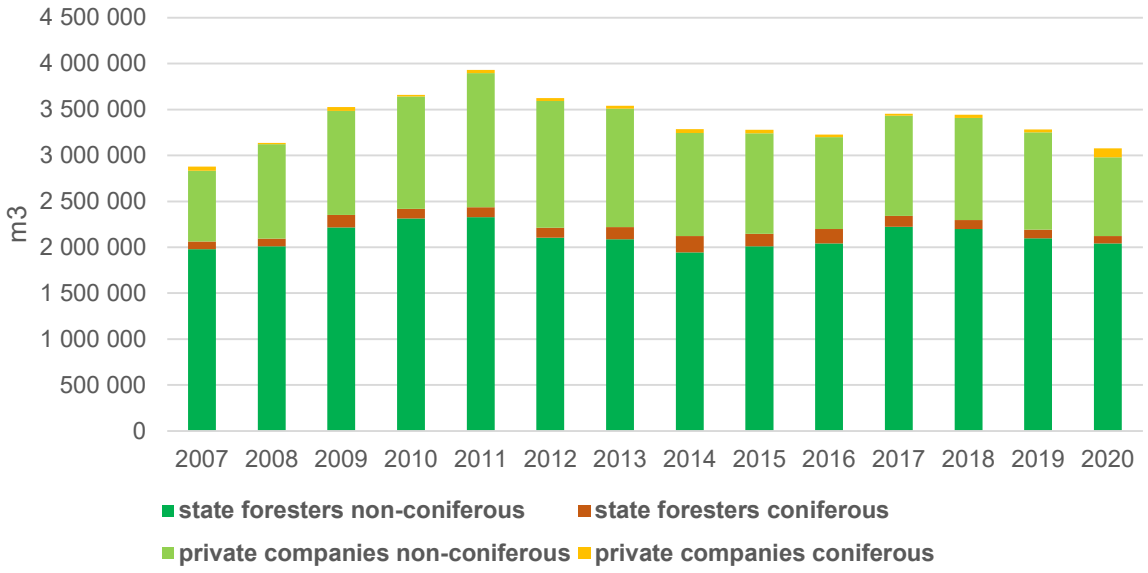
Source: calculated based on Hungarian Paying Agency data

According to the previous data, the creation of new energy plantation has completely ceased in recent years. However, due to the characteristics of the country and the high percentage of arable land, the potential of herbaceous agricultural by-products is outstanding in Hungary (straw from grain cereals, maize stover, sunflower stem and oilseed rape straw). Cereal straw consumption is mostly in livestock sector, other part of agricultural residues is chopped and used as soil amendment, but significant quantity still remains for potential energy purposes. In addition, the utilization of horticultural woody by-products from pruning can be significant. Although the heating value of these horticultural by-products is very similar to wood, and the pruning chips can easily be stored and transported, its current use for energy purposes is low (Barta et al., 2014). The most important aspect of usability is organizing by-product collection. The scattered geographical location of the orchards and vineyards (see Figure 2.) where these by-products are generated must also be taken into account (Szalay et al., 2019).

The aim of the Net Timber Production data collection (within the National Statistical Data Collection Programme, OSAP 1257) is to estimate the net volume of timber

harvested from domestic forests. The data collection is exhaustive for state forest holdings and based on a sample survey for other state, community, and private forest companies. In recent years, fuelwood has accounted for around 52–55% of total net logging. The vast majority of fuelwood production (around 95%) is from non-coniferous trees, and 60–70% from state foresters (Figure 44.). The total yearly net fuelwood logging showed an increasing trend until 2011, after which it decreased volatile and currently is around 3.1 million m^3.

Figure 44. Net fuelwood logging

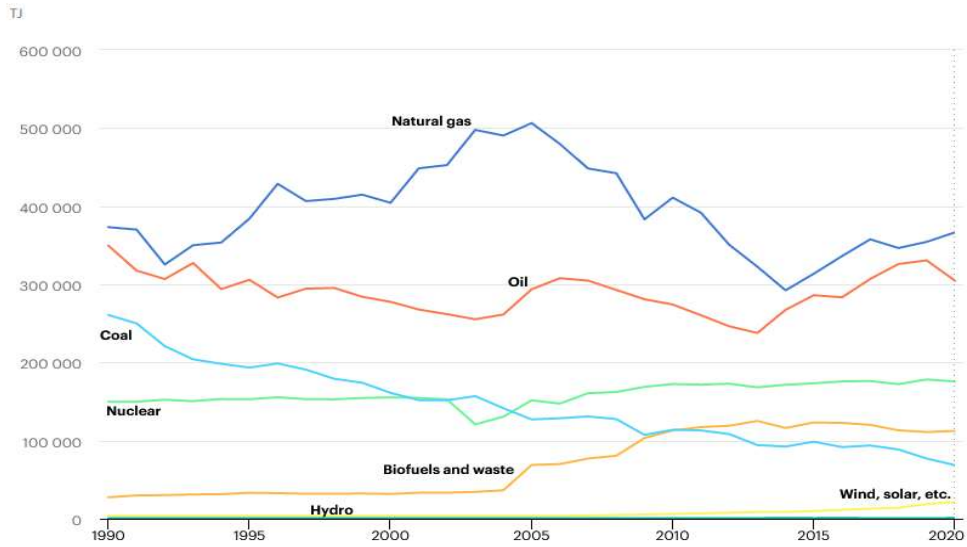


Source: edited based on OSAP 1257 data

3.2.2 PAST TRENDS IN BIOENERGY USE

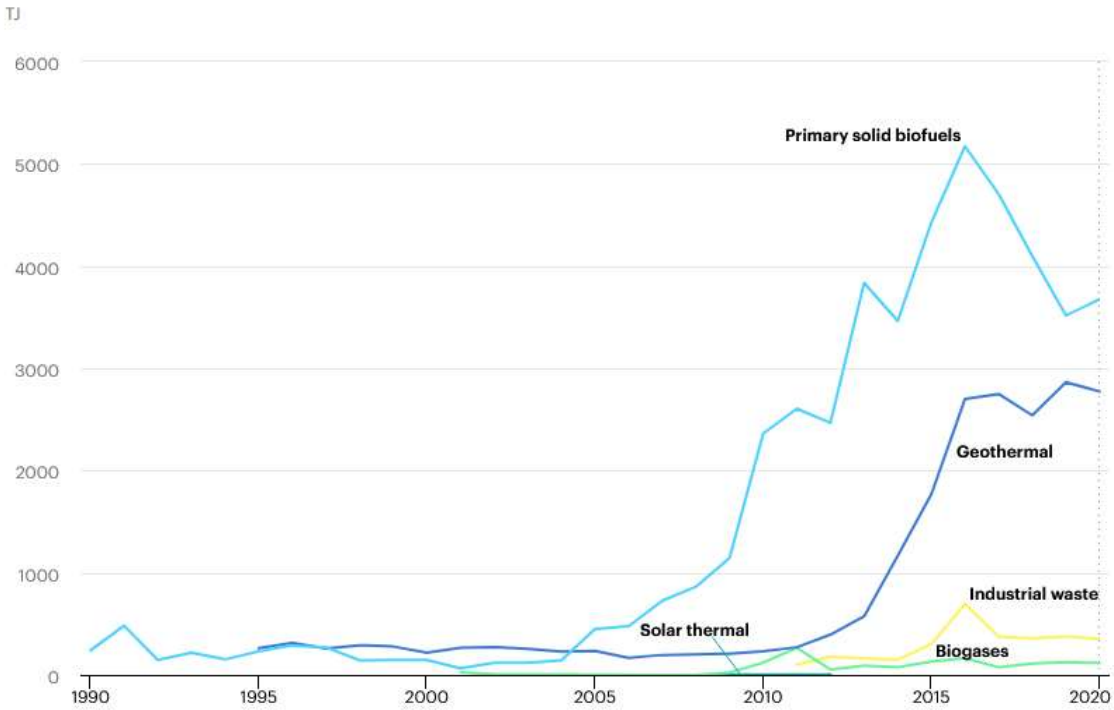
Renewable energy supply has increased significantly since 2000, but growth in the sector has slowed (OECD, 2018; IEA, 2021). Biomass, whose supply has more than tripled, dominates renewable energy sources (Figure 45.) and is used mainly for heating (Figure 46.).

Figure 45. Total energy supply by source, Hungary 1990–2020



Source: IEA (https://www.iea.org/countries/hungary)

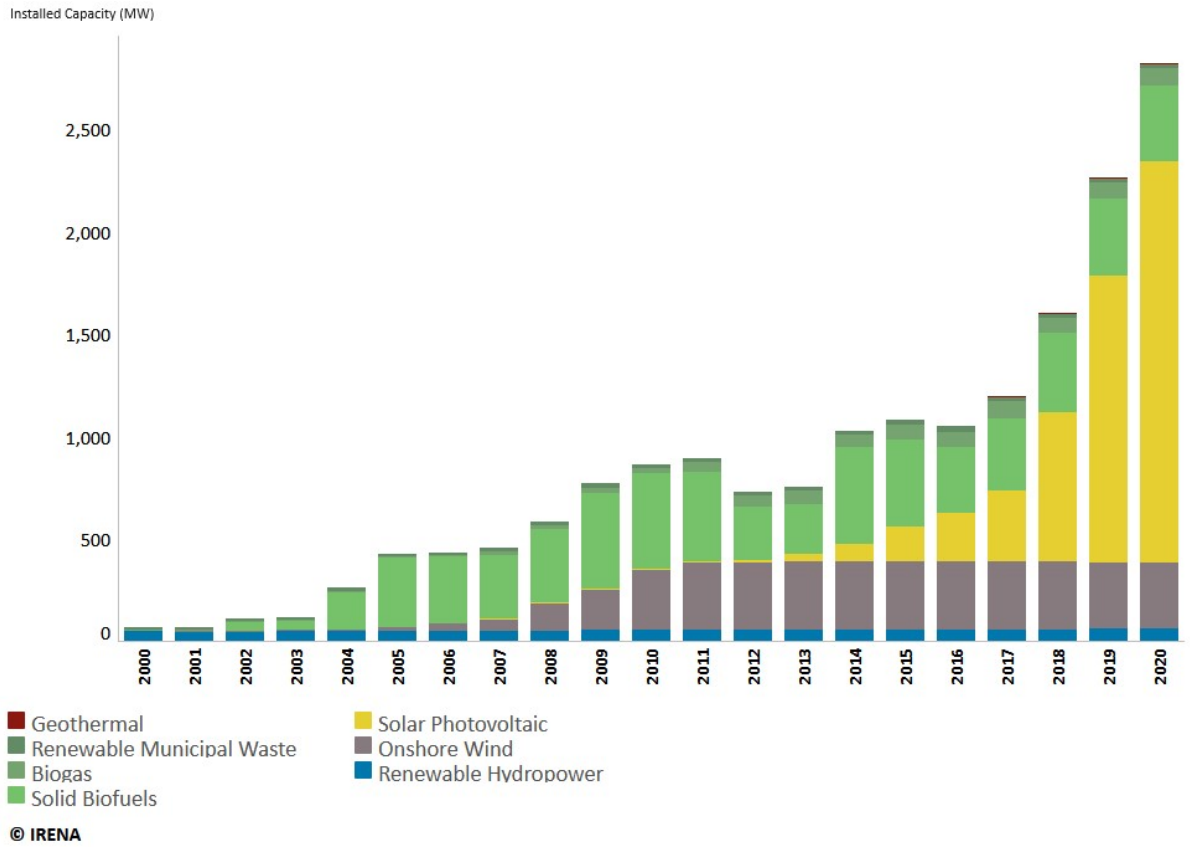
Figure 46. Heat generation from renewables and waste by source, Hungary 1990–2020



Source: IEA (https://www.iea.org/countries/hungary)

The International Renewable Energy Agency (IRENA) measures the renewable power generation capacity as the maximum net generating capacity of power plants and other installations that use renewable energy sources to produce electricity. Based on these data (IRENA, 2021), the use of renewable energy has been showed accelerating growth. In the 2000s the use of solid biofuels, while in the last years solar energy has been dominated the capacity expansions (Figure 47.).

Figure 47. Trends in renewable energy, Hungary 2000–2020



Source: IRENA (https://public.tableau.com/views/IRENARETimeSeries/Charts)

3.2.3 EXPECTED FUTURE TRENDS IN BIOMASS PRODUCTION

The National Forest Strategy 2016-2030 (NFS) corresponds with main objectives of the EU Forest Strategy of 2013 and enables the maintenance of multiple functions of Hungarian forests through their balanced impact on environment, society, and the economy. Options for using Hungarian forests are determined within the framework of district forest planning, in consideration of sustainability requirements. Most State forests are managed by state-owned forestry companies, where ten-year forestry plans comprise the basis for three-year strategic plans and annual plans. Climate change has already caused unprecedented damage to forests, disrupting the planned course of forest management. Although domestic deciduous species, and measures already introduced in forest management and by forest holdings contribute to preventing larger scale damage to forests, such damage may be impossible to rule out, which (due to the

necessary logging of dead trees) can lead to the temporary sharp increase in the availability of wood biomass, followed by its expected decline (ITM, 2020).

The NFS (FM, 2016) has identified that the upper limit for the extraction of forest biomass for energy purposes has already been reached, but the afforestation programme is planned to be continue (Figure 48). The long-term goal is to achieve 27% forest cover by 2050 instead of the actual 22%. Projections for the future logging show slightly increasing or decreasing volumes depending on the scenarios (Figure 49). Another possible solution is to expand the area of energy plantations, which can produce more woody biomass per unit area. However, this is not forestry but an alternative agricultural activity.

Figure 48. Expected annual forestation rate (hectares) in Hungary

Scenario	2017	2021	2022	2025	2027	2030
WEM	855	2 500	2 500	2 500	2 500	2 500
WAM	855	2 500	2 500	3 600	3 700	3 800

Source: NECP

Figure 49. Projection for the future logging of existing forests (m^3/year) in Hungary

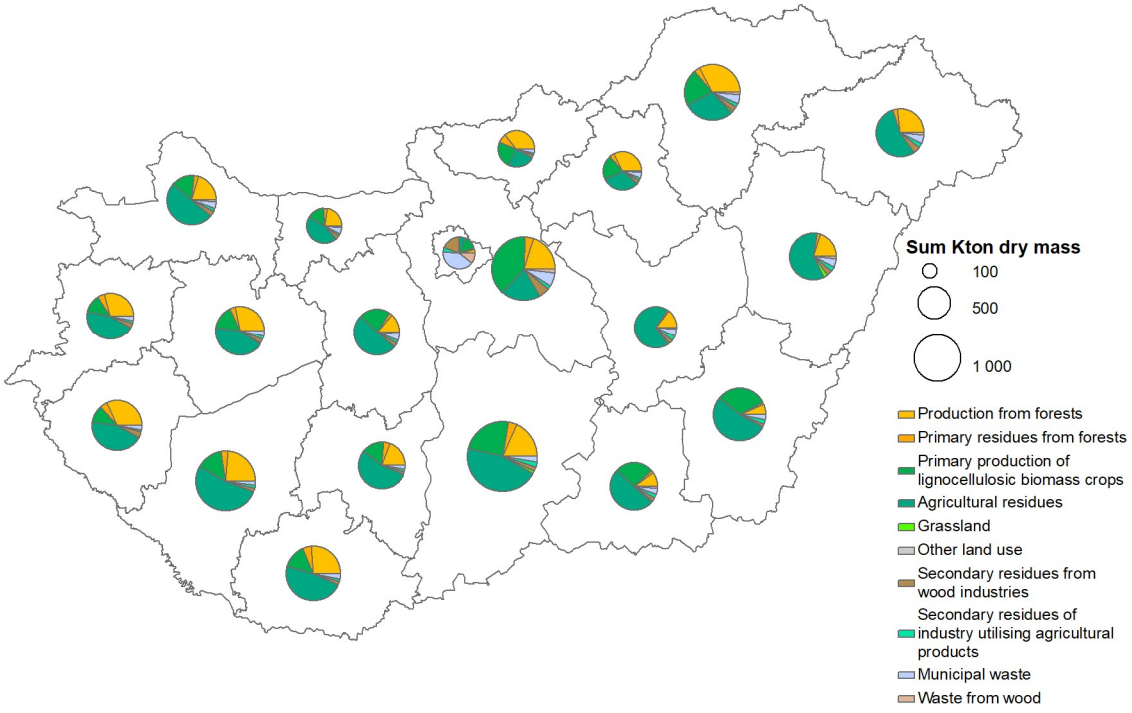
Scenario	2017	2021	2022	2025	2027	2030
Forest Reference Level (FRL*)	8 214 933	8 407 166	8 533 025	8 901 248	9 094 494	9 462 459
Increased logging rate	7 519 615	7 861 951	7 971 424	8 244 473	8 462 816	8 754 144
Logging kept at a low level ***	7 519 615	7 295 296	7 310 638	7 300 791	7 330 677	7 339 032

* : FRL: assumed logging at Forest Reference Level prescribed under the LULUCF Regulation.
**: Increased logging: scenario assuming increased logging compared to current level.
***: Logging kept at a low level: logging kept at approximately current level.
Source: NECP

The S2Biom project analysed the lignocellulose biomass potential in Europe on NUTS 3 level. Data are provided for 2012, 2020 and 2030, for several 'potentials' including: a

technical potential; a **base potential** considering currently applied sustainability practises (e.g., what amount of residues are needed to keep the soil organic carbon (SOC) content stable); and further potential levels that are determined considering changing sustainability restrictions, mobilisation measures and different constraints to account for competing use (Dees et al., 2017). According to the project's results sustainable lignocellulosic biomass potential from residues, dedicated perennial crops, biowastes and post-consumer wood totals 16.5m dry tonnes/year by 2030, of which 9.7m dry tonnes/year (59%) comes from agriculture. Among the agricultural residues the high potential of maize stover (4.5mt) and cereals straw (3.2mt) can be highlighted. Primary forestry production accounts for an additional 4.8m dry tonnes/year. However, the project did not account biomass from short rotation coppice (SRC) plantations in Hungary. (Figure 50.)

Figure 50. Biomass base potential by 2030 in Hungary



Source: own editing based on S2Biom data

Estimates by Barta et al. (2014) show slightly smaller agricultural biomass potential. They found that every year 4–4.5 million tonnes of straw is produced from the cultivation of grain cereals and of this about 2.4–2.8 million tonnes could be used for energy production in a sustainable manner. In addition, 8–10 million tonnes of maize stover is

produced annually and 2.5–3.0 million tonnes could be utilised as biomass for energy production. Significant amount of sunflower stem and oilseed rape straw are produced as well, and about 150–200 thousand tonnes of residual biomass obtained from pruning of vineyards and a further 400–500 thousand tonnes from orchards.

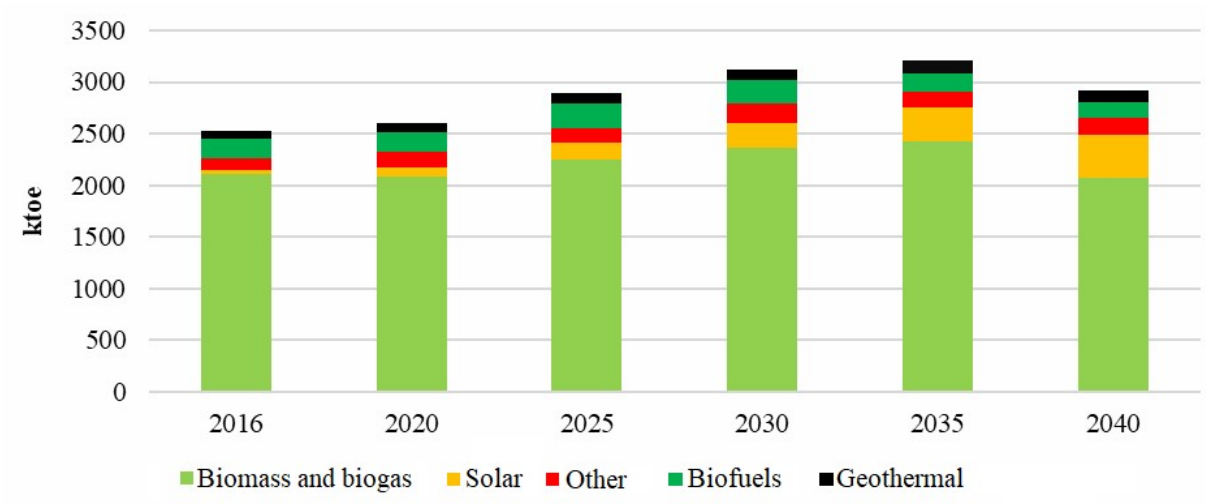
The research work of the JRC (Scarlat et al., 2019) distinguished the theoretical potential of crop residues, the technical potential (harvestable with current technologies and equipment), environmental potential (that could be collected from land without affecting soil fertility), and sustainable potential, which means the amount of crop residues that could be mobilized considering both technical and environmental constraints. The sustainable potential of crop residues in Hungary was estimated at 5.5 Mt DM.

3.2.4 EXPECTED FUTURE TRENDS IN BIOENERGY USE

Although several studies reviewed the Hungarian biomass potential, data are scattered throughout the literature and usually consist only of the calorific value of the different types of biomasses. Estimations for future trends are also very different.

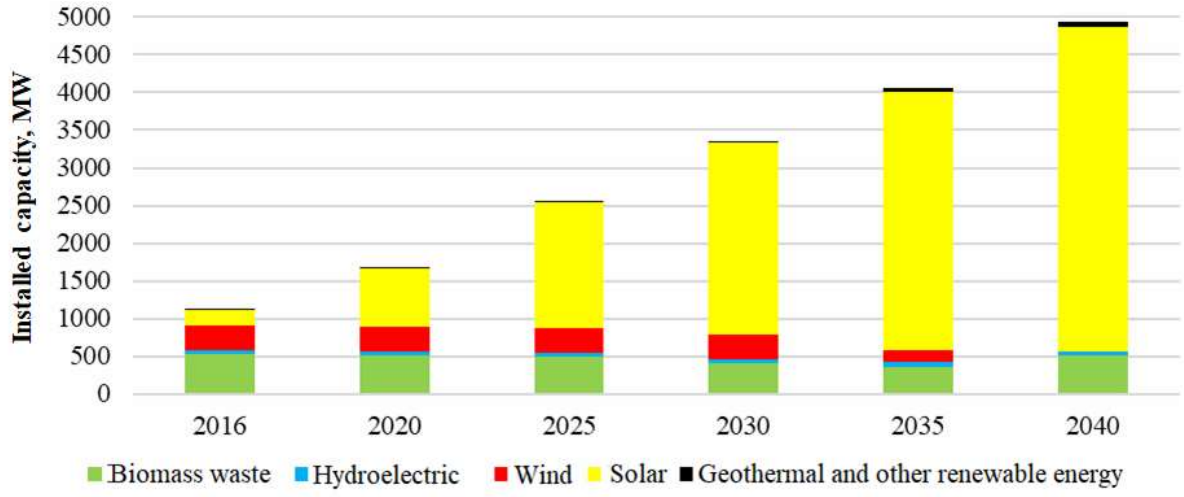
Currently biomass use accounts for a dominant share of renewables in Hungary, but the government has set the target of diversifying the composition of renewable energy consumption. Under the **WEM scenario**, the share of renewables will moderately increase in Hungary from around 14.1% in 2016 to 14.7% in 2030. By 2030, the dominance of biomass can be reduced with an upturn in solar energy. The National Energy and Climate Plan (NECP) foresees major potential for the efficient use of biomass in both individual heating equipment and in district heating, while the increase of solar PV capacities would be the core element of renewable energy sources within electricity consumption. The share of biomass use will remain dominant but decrease to 75%. The share of solar energy within renewables will significantly rise, from the initial 1% to around 8% by 2030. A moderate increase in the use of geothermal energy is also expected (Figure 51.). Capacities used for biomass-based electricity generation, still operating today, will gradually be phased out until 2035 (Figure 52.), but the total capacity will again rise to around 500 MW by 2040 (ITM, 2020).

Figure 51. Use of renewable sources of energy by fuel in Hungary


3500
3000
2500
2000
1500
1000
500
0
ktoe
2016
2020
2025
2030
2035
2040
Biomass and biogas
Solar
Other
Biofuels
Geothermal

Source: NECP

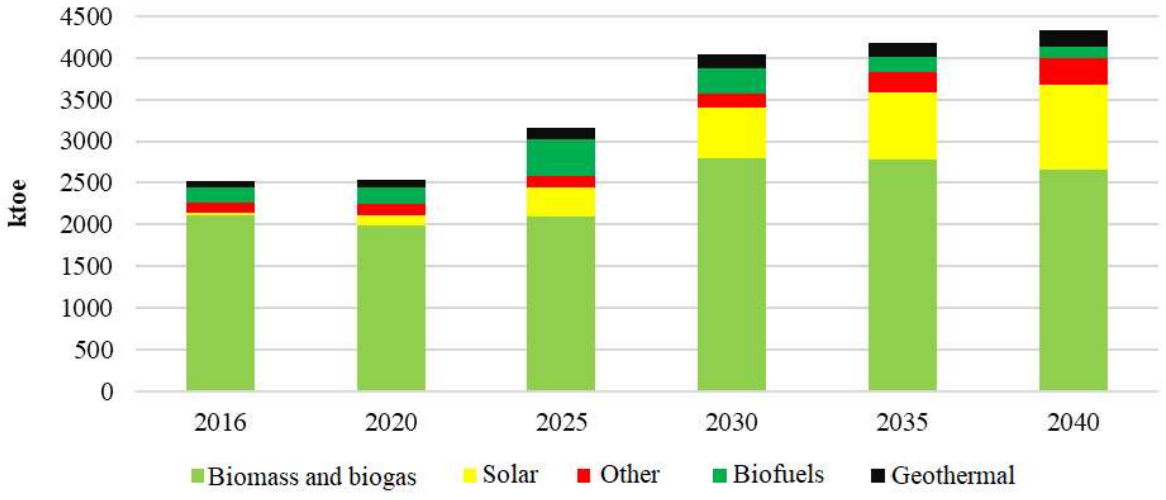
Figure 52. Installed capacity with existing measures in Hungary



Source: NECP

Under the **WAM scenario**, the share of renewable energy consumption will reach 21% by 2030 and increase to 22.4% by 2040. Since four fifths of total renewable energy consumption was based on biomass in 2016, Hungary has set the target of diversifying the composition of renewable energy consumption. By 2030, the dominance of biomass can be reduced with an upturn in solar energy. Under the WAM scenario, in parallel with growing use of solar energy, the use of both geothermal and other renewable sources of energy will increase. The use of biomass, however, will still account for more than two thirds of total renewable energy consumption in 2030 (Figure 53).

Figure 53. Use of renewable sources of energy by fuel under the WAM scenario

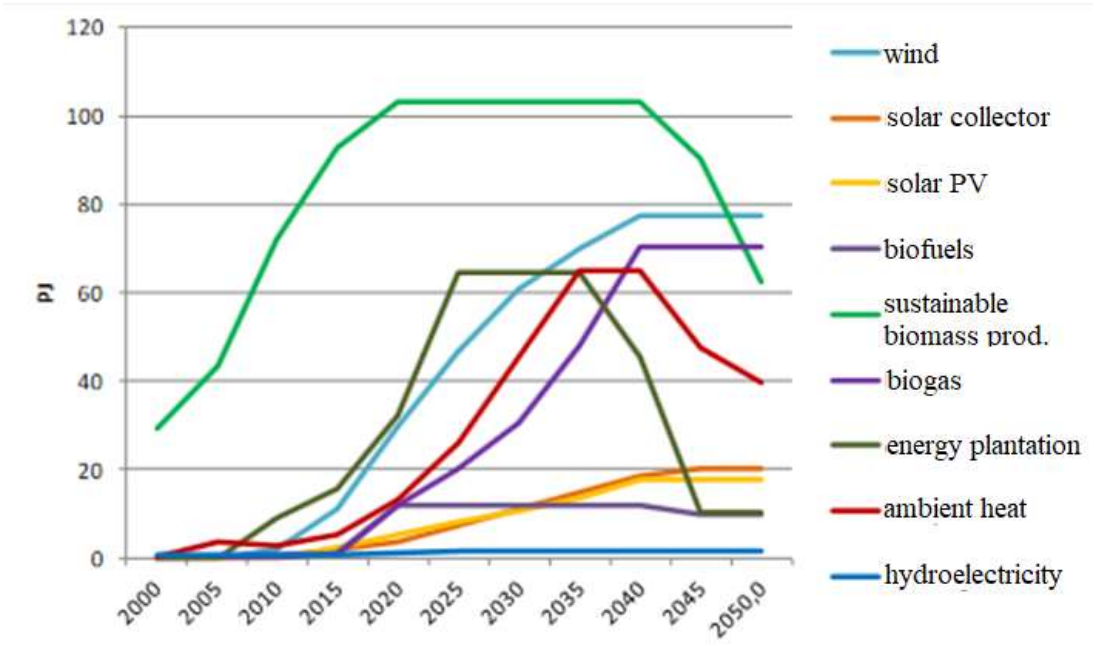


Source: NECP

However, based on the calculations of Todorov et al. (2019) it would require roughly 15 million tonnes of solid biomass per year but they estimate that only half of that amount is available, as the utilization of agricultural residues, industrial waste and biomass from energy plantations is limited. Analysing the national energy strategies Bart et al. (2018) also proposed for consideration the reduction of the high share of biomass in the renewable mix. At present a lot of this biomass is fuelwood that is probably not sourced sustainably and will likely not be classified as biomass after 2020, potentially causing compliance issues.

The “Erre van előre” (The way forward) energy research group of ELTE University pointed out that instead of firewood from forestry the energy recovery of organic waste from agriculture, forestry and other sources should play a more important role in the future (Munkácsy et al., 2014). According to their calculations for the most popular wood species used for fuel (black locust, beech, oak, turkey oak), the total available energy from sustainable forest management would be 24.5 PJ per year. They counted with 0.5 million hectares of energy plantation resulting 64.9 PJ/year potential energy. For the remaining 4 million hectares of agricultural land 78.5 PJ potential energy was calculated from the agricultural residues, taking into account that these by-products are also used as fodder and soil amendment. For biodiesel production rapeseed is the main raw material, while for bioethanol corn and wheat. However, the production and use of biofuels has raised several sustainability concerns in recent years, therefore, they play a modest role in the scenario. The study also calculated with waste-based (from agriculture, livestock, wastewater, and landfill) biogas production expecting a rapid growth and estimating a potential of 80 PJ. By increasing energy savings and energy efficiency, a significant reduction in consumption is expected from 2045 onwards (Figure 54.).

Figure 54. Possible sources of renewable energy production from 2000 to 2050 based in Hungary



Source: Munkácsy et al., 2014

The energy modelling research of the German Wuppertal Institut and Hungarian Energiaklub (Lechtenböhmer et al., 2016) assume a significantly higher long-term potential for biomass of about 445 PJ.

3.3 RELATED CALLS FOR BIOMASS PRODUCTION (IN THE PERIOD 2014-2020)

In Hungary several tender schemes were announced to support the production and increase of biomass production with the support of the EU. These application forms, their planned sources and supported projects have been collected in more detail in the appendix.

- **Environmental and Energy Efficiency OP (KEHOP)**

The programme has earmarked and grouped a total of 19 259 000 EUR in the form of non-repayable grants for biomass under the priority axis of increasing energy efficiency and funding renewable energy resources. The measures, based on the calls for proposals, were as follows:

Calls for proposals available in 2022

There are currently two measures for the use of biomass for energy purposes under the Environmental and Energy Efficiency OP, worth 206.89 billion HUF. The eligible activities under the measures include biomass, including agricultural by-products, horticultural

by-products, energy crops, forestry main and by-products, wood and other industrial waste and by-products or their mixed by-products or their mixed-use for heating and/or heating assistance.

- **Rural Development Programme (VP)**

The Rural Development Programme has encouraged the use of biomass both as a modernisation measure to reduce energy use and as a means of promoting the use of renewable energy technologies. Within the Programme, 24 calls for proposals were launched to support such improvements. The total planned budget for energy efficiency investments was 416.74 billion HUF. The improvements could be implemented through two types of support schemes: a mandatory action under the grant and an optional action linked to other improvements, but not eligible for support on its own.

Calls for proposals available in 2022

Currently, 2 measures for biomass for energy purposes are available to applicants under the Rural Development Programme, worth 53.0 billion HUF. These measures support the installation of biomass-based systems and the production of renewable energy from green waste or the use of the energy produced.

- **Competitive Central-Hungary OP (VEKOP)**

The Competitive Central Hungary Operational Programme promoted the use of biomass by supporting the use of renewable energy technologies. Within the Programme, 3 calls for proposals were launched to support such developments. The total planned budget for investments in energy efficiency was 36.675 billion HUF.

- **Territorial and settlement development OP (TOP)**

The Territorial and settlement development Operational Programme promoted the use of biomass by supporting the use of renewable energy technologies. Within the Programme, 10 calls for proposals were launched to support such developments. The total budget for energy efficiency investments was 354 150.0475 million HUF.

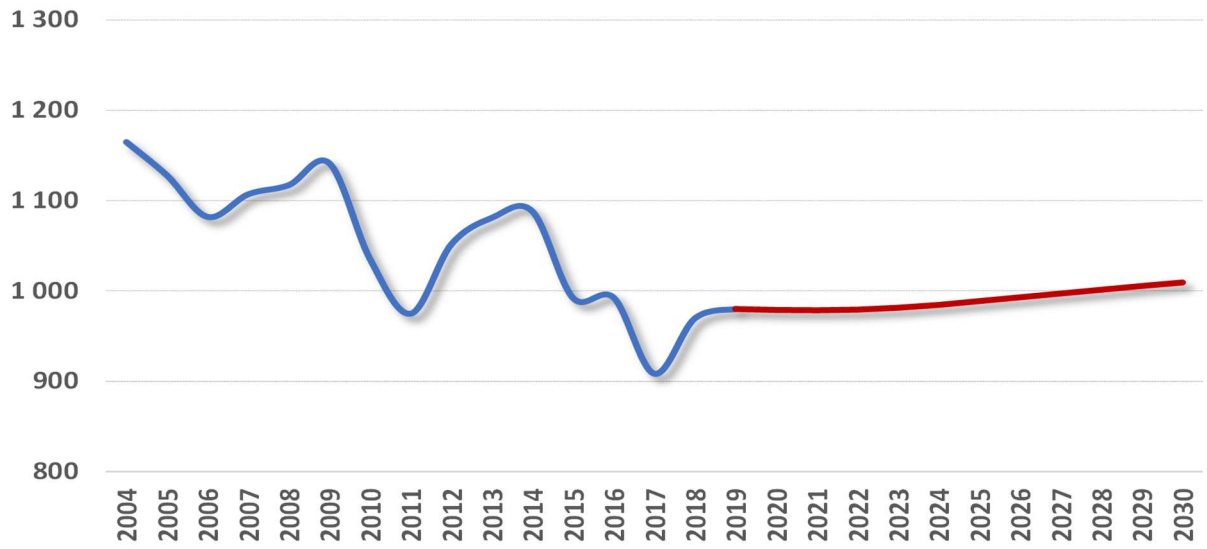
3.4 SECTORAL PROJECTIONS

Projections were made for the Hungarian crop structure using the AKI-SIM agent-based simulation model (developed at Institute of Agricultural Economics) using Hungarian Farm Accountancy Data. In the coming years, the strategic objectives of the EU's Common Agricultural Policy and the Green Deal will focus on environmental sustainability, sustainable crop production, food security, enhancing biodiversity, reducing environmental pressures, and promoting the production of protein crops. Considering that the CAP 2021-2027 plan has not yet been finalised, the basic

assumption was that direct payments in the modelled agricultural sectors would remain unchanged until 2030 (Gyuricza et al., 2020).

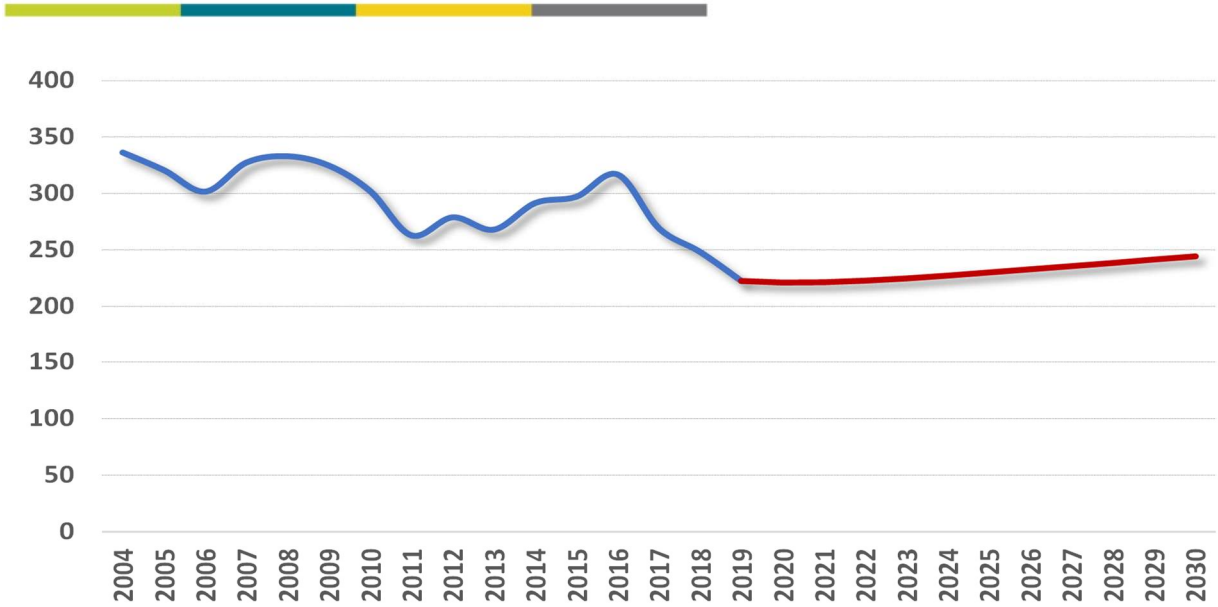
The simulation model projects a slight increase in the area of cereals (winter wheat, maize, and barley together +1%), while a decrease in the area of oilseed crops (sunflower and rapeseed together -3%) by 2030 compared to 2019. The projection shows a 3% increase in the area under winter wheat (about 30 thousand tonnes in terms of yield) and a 9% (about 22 thousand tonnes) decrease in winter barley, while a 2% (about 23 thousand tonnes) increase in maize (Figure 55., Figure 56). An increase in the use of cereals for fodder could encourage farmers to sow. However, the expected decline in the industrial use of maize under the EU's revised Renewable Energy Directive (RED II) could discourage it.

Figure 55. Winter wheat area, 2004-2019 and 2020-2030 (thousand hectares)



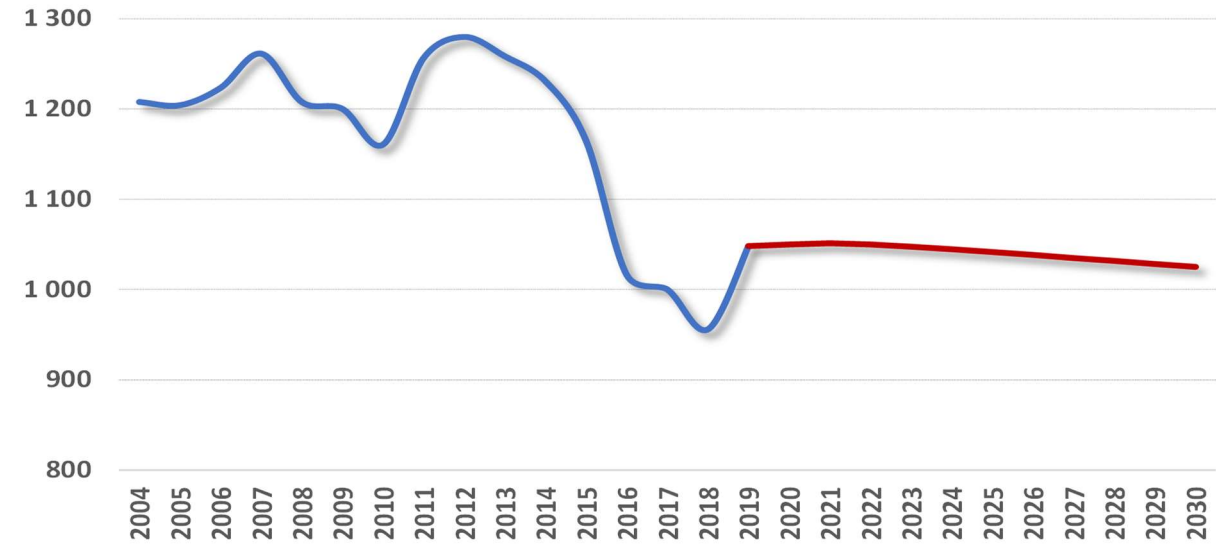
Source: Gyuricza et al., 2020

Figure 56. Winter barley area, 2004-2019 and 2020-2030 (thousand hectare)



Source: Gyuricza et al., 2020

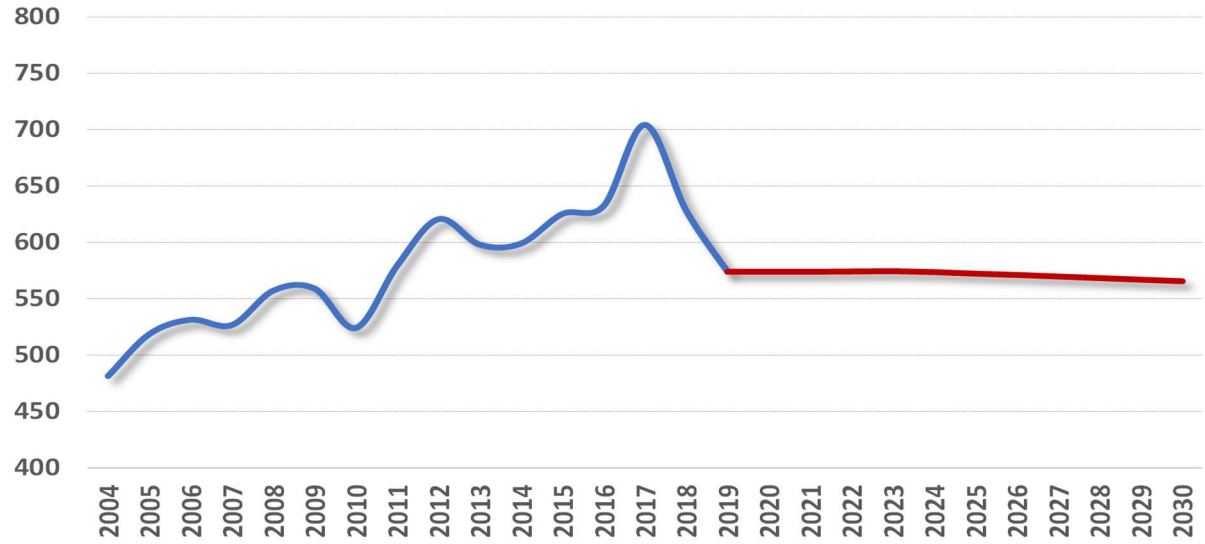
Figure 57. Maize area, 2004-2019 and 2020-2030 (thousand hectare)



Source: Gyuricza et al., 2020

Sunflower area is expected to decline by only 1.5% by 2030, as production will be maintained at the level of domestic processing capacity (Figure 58).

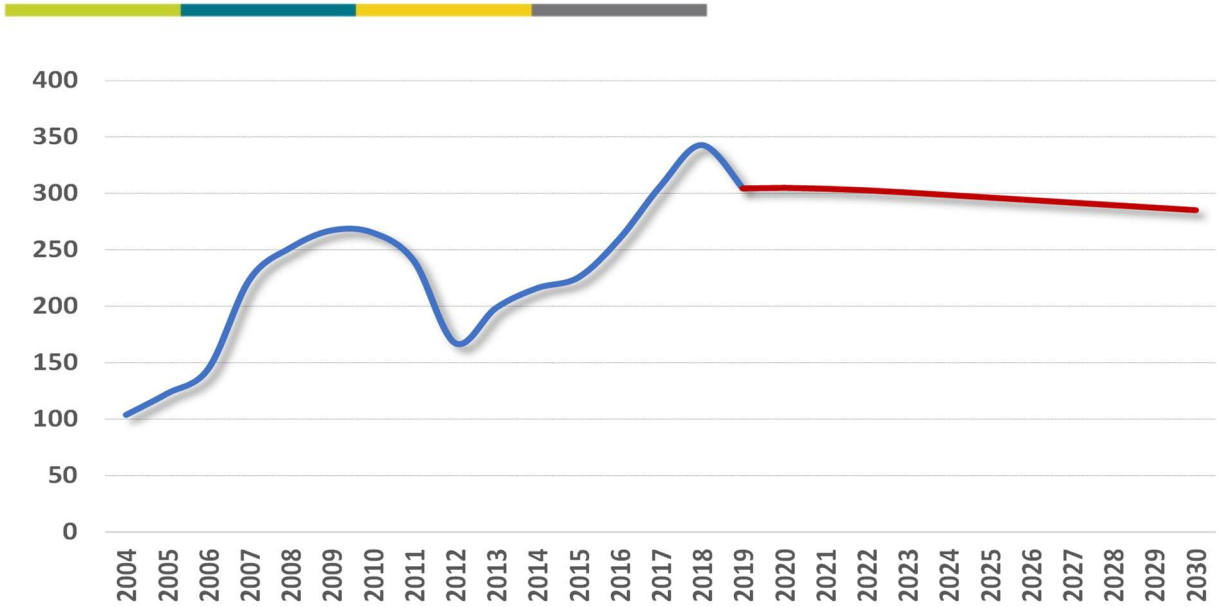
Figure 58. Sunflower area, 2004-2019 and 2020-2030 (thousand hectare)



Source: Gyuricza et al., 2020

A decline of more than 6% in rapeseed area is also possible (Figure 59). Rapeseed production is limited by both the declining demand from the biofuels industry due to the aforementioned RED II directive and the narrowing range of pesticide active substances that can be used in the crop and the resulting, as yet unresolved, crop protection challenges. The impact of these has already been felt in Hungary in the last 1-2 years, but in many European rapeseed producing countries the area under rapeseed has been declining for several years.

Figure 59. Rapeseed area, 2004-2019 and 2020-2030 (thousand hectare)



Source: Gyuricza et al., 2020

3.5 RESULTS OF BIOMASS-MIX SURVEY OF THREE PILOT COUNTY

In this chapter, in Békés, Hajdú-Bihar and Vas counties, we present the composition and potential of the available raw material revealed during a previous research, the energy content of which can be used to plan the method and volume of energy production (Gyuricza et al., 2019).

Békés county

In the survey of biomass raw materials of animal origin, we relied on the data provided by the National Food Chain Safety Authority (NÉBIH), Nitrate. The annual amount of manure produced by our most important farm animal species, as reported by farmers, is collected separately in the data sheet. The average annual value of manure production in the county for four years (2015-2018) was 1,000,628 t, with the following weightings for each animal species:

- cattle litter manure = 449 846 t
- cattle slurry = 89 824 t
- pig litter manure = 49 718 t
- pig slurry = 379 724 t
- poultry litter manure = 31,516 t

The utilization of fertilizer materials is widely possible through biogas technologies. Due to the peculiarities of biogas technologies, the use of animal manure alone is not typical

(lower gas yield), so we only calculate the amount of energy that can be extracted together with plant materials in all three counties.

5.1.2. Herbaceous plant biomass raw materials

In the case of herbaceous plants, district-level crop production data are also available. In this case, we can describe the biomass potential values characteristic of each area separately, here again in the average of the four-year period between 2015-2018 (Figure 60).

Figure 60. Agricultural by-products potential in the districts of Békés county in 2015-2018 on average

Country district	By-product quantity of spring cereals	Quantity of maize by-product	By-product quantity of autumn cereals	Amount of sunflower by-product	Total
	(t)	(t)	(t)	(t)	(t)
Békés	3944	136 882	48 467	21 685	210 978
Békéscsaba	1133	192 522	61 335	22 762	277 751
Gyomaendrőd	8168	83 395	62 892	31 289	185 743
Gyula	529	93 634	34 541	12 207	140 910
Mezőkovácsháza	1052	325 323	107 382	25 928	459 685
Orosháza	1463	197 835	94 851	28 873	323 022
Sarkad	945	71 662	47 271	26 257	146 135
Szarvas	2164	87 906	62 809	20 164	173 043
Szeghalom	4322	65 953	79 336	35 653	185 264
Total	**23 718**	**1 255 111**	**598 884**	**224 817**	**2 102 531**

Source: Gyuricza et al., 2019

Taking into account the four herbaceous plant categories presented in Table 26, a total of 2,102,531 tons is generated annually in Békés County.

When recovered by conventional incineration, the energy potential can be calculated from the total amount of 2,336,145 tons, with a moisture content of 0% and an average calorific value of 17 MJ / kg, to be 39,714,474 GJ, while the energy that can be produced is 11,031,796 GWh.

At the district level, the most significant biomass mass is provided by the Mezőovovácsháza, Orosháza, Békéscsaba and Békés regions.

In the case of energy production for biogas, silage sorghum, silage maize, Sudanese sorghum, sugar sorghum and sugar beet plants with outstanding fermentation properties can also be considered in the county districts as follows (Figure 61).

Figure 61. Average potential of biogas feedstocks in the districts of Békés county between 2015-2018

County district	Area	Total return
	(ha)	(t)
Békés	555	15 985
Békéscsaba	559	16 961
Gyomaendrőd	461	13 016
Gyula	647	18 208
Mezőkovácsháza	1 147	35 847
Orosháza	1 039	33 676
Sarkad	356	8 856
Szarvas	780	25 272
Szeghalom	843	23 005

Source: Gyuricza et al., 2019

The districts of Mezőkovácsháza (35,847 t) and Orosháza (33,676 t), like the table of crop production by-products presented above, are of key importance in the cultivation of plants that can be optimally used for biogas production, followed slightly by the Szarvas and Szeghalom regions.

At the county level, the energy potential of biogas that can be produced from animal and plant materials (crop production by-products and highly gassed plants) is 5,679,382 GJ - 8,278,008 GJ per year. In the case of energy crops, the total yield was 1,617 t in an area of 161 hectares, with the Orosháza and Szarvas districts being of great importance.

Woody biomass raw materials

According to the utilization, the available data can be divided into four parts:

- as firewood
- as a thin tree
- for road afforestation
- and energy tree plantations

According to the forecast for the period from 2021 to 2045, the annual biomass potential is on average 18,468 atrotons per year as firewood, 3,694 atrotons as thin wood, 3,105 atrotons for road afforestation and 1,872 atrotons from energy crops. From the total

quantity described, 497,111 GJ of energy potential and 138,932 GWh of energy can be produced on an annual and annual average.

Combustion and gasification technologies offer a solution for the energy utilization of the material group at the plant level, so we only calculated with this solution here. Technology recommendations at the county level are provided later in the report.

Other substances falling under the waste category

According to the data of the National Environmental Information System in 2018, 7,742 tons of waste were generated in Békés County, the primary energy utilization of which can take place in biogas plants, taking into account the current trends. Such materials, due to their content characteristics (favourable fermentation characteristics), their cost of acquisition (the owner of the waste pays for disposal in many cases) from more distant sites, can also be obtained cost-effectively from the plant's raw materials than animal and plant biomass.

Hajdú-Bihar county

Biomass materials of animal origin

In Hajdú-Bihar county, the following average values (for 2015-2018) were typical for animal fertilizers:

- cattle litter manure = 778 617 t
- cattle slurry = 119 813 t
- pig litter manure = 76 275 t
- pig slurry = 629 217 t
- poultry litter manure = 65,731 t

The total amount of manure produced in the candidate's four years is 1,669,654 tons, which is 669,026 tons more than in the case of Békés county. The most significant potential in both counties is the amount of cattle manure and pig slurry. Of the total county volume, 94,865,321 m3 of biogas can be produced with a methane content of 52,832,330 m3.

Based on the method used in Békés county, in the optimistic and pessimistic cases, the amount of manure that can be utilized on an annual basis is 481,842 t and 337,289 t, of which the recoverable biogas yield is 31,475,541 m3 and 22,032,879 m3.

Herbaceous plant biomass raw materials

Table 29: Potential of crop by-products in the districts of Hajdú-Bihar county in the average of 2015-2018

Total biomass potential in the county

2,032,594 tons per year, which is almost the same size as in Békés county. Examining biogas plants, there are three farms in Hajdú-Bihar county based on agricultural raw materials, in the districts of Püspökladány, Hajdúszoboszló and Hajdúböszörmény. In the districts of the county, by far the largest amount of by-products (1,484,405 tons) is given by the corn plant out of the total amount.

In the districts of the county, we performed separate calculations for the so-called for highly aerated crops (silage sorghum, silage maize, Sudanese sorghum, sugar sorghum and sugar beet) with a total average cultivation area of 7,834 ha with a yield of 285,920 t (Table 30).

When utilized by conventional incineration, the energy potential can be calculated from the total amount of 2,258,438 tons, with a moisture content of 0% and an average calorific value of 17 MJ / kg, 38,393,446 GJ, while the amount of energy that can be produced is 10,664,847 GWh (Figure 62).

Figure 62. Average potential of biogas feedstocks in the districts of Hajdú-Bihar county between 2015-2018

County district	Area	Total return
	(ha)	(t)
Balmazújváros	707	21 831
Berettyóújfalu	942	27 838
Debrecen	326	9 603
Derecske	401	12 594
Hajdúböszörmény	630	25 232
Hajdúhadház	8	151
Hajdúnánás	1 635	63 321
Hajdúszoboszló	1 219	52 010
Nyíradony	47	1 124
Püspökladány	1 918	72 215

Source: Gyuricza et al., 2019

Three districts stand out from these crops, Hajdúnánás, Hajdúszoboszló and Püspökladány, which account for 65% of the total yield of the county.

At the county level, the energy potential of biogas that can be produced from animal and plant materials (crop production by-products and highly gassed plants) is 5,604,268 GJ - 7,997,233 GJ per year.

In terms of energy crops, the county is engaged in the cultivation of energy grass and sulfur. We were able to collect data on this in five county districts, which we report together. In a total area of 56 hectares, the total yield is 572 tons.

Woody biomass materials

We determined the principles described in the previous county when determining the woody biomass potential. The usable quantities were further divided into groups based on the four utilization methods.

- as firewood
- as a thin tree
- for road afforestation
- and energy tree plantations

According to the forecast for the period from 2021 to 2045, the annual average biomass potential is 65,144 atrotons per year for firewood, 13,023 atrotons for thin wood, 1,893 atrotons for road afforestation and 95,841 atrotons for energy crops. The total amount described represents 3,283,772 GJ of energy and 912,159 KWh of power.

Other substances falling under the waste category

Based on the data retrieved from the National Environmental Information System, Hajdú-Bihar County also has a significant surplus of waste material (9,725 t).

Vas county

Biomass materials of animal origin

In the case of Vas county, we performed our calculations with annual fertilizer quantity data for cattle, pig and poultry animal species. Based on the characteristics of the county, animal husbandry is much less important, compared to the other two counties, the total amount is 306,897 tons / year in total.

- cattle litter manure = 183 878 t
- cattle slurry = 65,745 t
- pig litter manure = 11 269 t
- pig slurry = 25 884 t
- poultry litter manure = 20 121 t

The total amount of manure generated here is only one third of that in Békés and less than one fifth of that in Hajdú-Bihar county. For this reason, the utilization of manure

potential is less promising, possibly in connection with a large livestock farm with a concentrated availability.

Herbaceous plant biomass raw materials.

Figure 63. Potential of crop by-products in the districts of Vas county, average between 2015-2018

County district	Amount of by-product of spring cereals	Quantity of maize by - products	Quantity of by-product of autumn cereals	Amount of sunflower by-product	Total
	(t)	(t)	(t)	(t)	(t)
Celldömölk	4 010	59 048	51 740	5 770	120 569
Körmend	4 443	68 349	32 580	3 002	108 375
Kőszeg	3 012	24 971	24 163	1 328	53 474
Sárvár	10 250	68 375	72 090	5 728	156 443
Szentgotthárd	591	16 083	4 549	924	22 147
Szombathely	13 984	66 179	66 489	3 750	150 403
Vasvár	1 669	31 096	24 947	3 045	60 757
Összesen	**37 958**	**334 102**	**276 559**	**23 549**	**672 168**

Source: Gyuricza et al., 2019

The total amount of by-products of the herbaceous plants of the districts is 672,168 tons per year, which is significantly lower than the data of Békés and Hajdú-Bihar counties (Figure 63). Unlike the two counties discussed above, the amount of by-products harvested during the cultivation of corn and winter cereals represent a nearly similar amount.

When utilized by conventional incineration, the energy potential can be calculated from the total amount of 746,854 tonnes, with a moisture content of 0% and an average calorific value of 17 MJ / kg, to be 12,696,518 GJ, while the energy that can be produced is 3,526,810 GWh.

When presenting the energy mix of the county, the plants suitable for biogas production should be mentioned here as well. As expected, Vas County also provided the smallest area and yield data for these plants (Figure 64).

Figure 64. Average potential of biogas feedstocks in the districts of Vas county between 2015-2018

County district	Area	Total return
	(ha)	(t)
Celldömölk	1 026	23 339
Körmend	670	15 252
Kőszeg	302	17 018
Sárvár	824	20 229
Szentgotthárd	36	793
Szombathely	1 214	40 335
Vasvár	801	25 604

Source: Gyuricza et al., 2019

In the comparison of the individual districts, Szombathely was by far the best performer, with its yield of 40,335 t. In the whole county, the total cultivation of this type of crops took place on 4,874 hectares, with a total yield of 142,570 t.

From energy crops, energy grass, fiber-grown hemp, energy Miscanthus were grown at the county level during the study period. On average over four years, the total annual volume is 153 tonnes from an area of 16 hectares.

Woody biomass materials

The county has a significant forest area, for which we calculated the woody biomass potential based on the four divisions described earlier. According to the forecast for the period from 2021 to 2045, the annual biomass potential is on average 73,553 atrotons per year as firewood, 14,711 atrotons as thin wood, 1,707 atrotons for road afforestation and 148,581 atrotons from energy crops. The total amount described represents 4,488,479 GJ of energy and 1,246,800 GWh of power.

Other substances falling under the waste category

The data of the waste category also show much less in the case of Vas county (1,491 t) than in the other two counties. The quantity obtained here is more than 6,000 tons less in Békés and 8,000 tons less in Hajdú-Bihar county.

3.6 DRIVING FORCES OF DEVELOPMENT OF SECTOR AND ATTITUDE OF BIOMASS PRODUCERS

Currently Hungary's energy supply relies mostly on fossil natural gas and oil from beyond its borders, which has increased the dependence on foreign markets. The Government of Hungary assigns a priority to strengthening energy independence and places emphasis on improving energy efficiency, maximising the sustainable exploitation of renewable resources (ITM, 2020).

Alternative processes – besides eliminating dependencies and emitting excess greenhouse gases (GHG) – can be promoters of innovations and new start-ups building on local attributes by means of natural and human resources too. In return, multiplicative effects will also associate, such as economic growth, job creation and parallel development of connecting sectors. The most important but not the most effective driver is the status of the environment and the way it should evolve to sustain a healthy and liveable surrounding for the future generations. The most effective driver is the economic viability of the solution, which depends on policies and governmental actions, as being the third driver, (Barta et al., 2014).

Kondor and Antal (2008) found that the energy crop subsidy had its promoting role only on those areas where because of the bad soil conditions the energy crop producing was more profitable than other alternative (non-energy) crops.

3.7 SWOT ANALYSIS OF SECTOR (STRENGTHS, WEAKNESSES, OPPORTUNITIES, THREATS)

An environmental impact assessment study (Szilvácsku et al., 2021) calls attention to the fact that the use of solid biomass by incineration is a major source of particulate matter pollution, which is also causing serious problems in Hungary. In particular, small capacity boilers are causing these problems. The transport needs associated with biomass utilisation also have an adverse effect on air quality through increased traffic. However, among the interventions aimed at increasing renewable energy production, developments beyond biomass incineration can have a particularly positive impact on air quality. The use of biomass for energy also has negative ecological impacts, therefore, may be supported only as a complementary activity, as collection up to the extent of the ecological regeneration of the resource area.

The use of landfill gas from municipal landfills, sewage sludge and agricultural by-products and wastes for biogas production is a positive process from energy, waste management and sustainability point of view. The intensive monoculture cultivation of crops grown specifically for biogas production, is not environmentally acceptable (Munkácsy et al., 2014).

The study of the Energiaklub Climate Policy Institute (Munkácsy et al., 2020) emphasized that the current form of biomass use in Hungary already raises serious sustainability concerns, as – in some important fields, as firewood usage – the rate of consumption is already exceeding the rate of reproduction, even in densely forest-covered areas (Figure 65).

Figure 65. SWOT Analyses of biomass use in Hungary

Strength	Weaknesses
• energy self-sufficiency • balancing weather-dependent renewable generators • locally available energy source • „carbon-neutral” • the volume of green trees is increasing • hight expertise regarding in using biomass • R&D projects of biomass-sector at universities and research institutes	• not widely accepted • use of traditional fuel and fuel lobby • long transportation distances • higher demand for equipment and machinery • higher price of product compared to conventional fuels for personal users • lack of decentralized smaller power plants • quality of plants is different in every harvest season
Opportunities	**Threats**
• decreasing energy dependence • more sustainable economy • job opportunities in the rural areas • further development in the field of research and innovation	• soil degradation • growing monocultures • negative effect on food security • investors interested in bigger investment opportunities

• strengthening regional cohesion within EU MSs • energy cost reduction by increasing efficiency • stable internal market • more favourable market setting for biofuels over conventional fuels • public suppert for biomass	• additional land use might lead to in-direct land-use changes, in the worst case to deforestation • further loss of biodiversity • transport is mostly on road in Hungary, tariffs for cargo are relatively high • particulate matter pollution

4. SUMMARY

This study aims to present the current status of biomass production in Hungary. The biomass country report is part of the 'Innovative model to drive energy security and diversity in the Danube Region via combination of bioenergy with surplus renewable energy' (DanuP-2-Gas) project. The Interreg Danube Transnational Programme highlights the importance of transnational cooperation in the field of renewable energy, the DanuP-2-Gas project pays special attention to biomass potential in the countries connected to the Danube. The country report gives a comprehensive overview of Hungary's biomass production and its legal environment both on a European and on a Hungarian level.

The importance of biomass can be understood by its effectiveness in reducing the usage of conventional fossil energy resources. When discussing this topic it is crucial to bear in mind that bioresources and biomass can only help us mitigate the risks of climate change if they are produced, processed, and utilized sustainably and efficiently (Andersen et al, 2021). Up to this day, biomass is still the most promising renewable energy resource, that we can use in the European Union to tackle our 2030 climate targets (Leitner, 2019). From Hungary's perspective, biomass also has a great significance as the country's natural endowments, agriculture, and the food industry can provide a significant amount of raw material for biomass use (Demeter, 2021).

This Agricultural Biomass Report Hungary was prepared by the Institute of Agricultural Economics Nonprofit Kft. (AKI) as a deliverable for the DanuP-2Gas project. This report

complements international and national statistics, databases and and selected reports available in Hungary at a national level or in international publications

Data collection process for the development of agricultural biomass database at Hungarian national level was based on in-depth interview, the personal data of which were anonymised for data protection reasons.

The implementation of the survey encountered many difficulties due to the low activity of farmers. Completing the questionnaires required a great deal of energy due to the lack of cooperation from the farmers. Overall, only 35% of the respondents completed the mandatory questions. The reason for this was that several people did not consider the use of biomass for energy purposes to be a good direction. Or, if they have a recording market, they don't want to change it.

In Hungary, the natural conditions (climate, water, soil, biological resources) are generally favorable for agriculture, especially in the lowland and lowland areas. Due to the expansion of built-up areas, the production area is slowly declining, but even more than 54% of the total area is used for agriculture (CSO, 2021). About 82% of the agricultural land is arable, the main crops being maize, wheat, sunflower and canola.

The utilization of biomass requires special attention, as this resource is conditionally renewable due to possible overuse, which means that its ability to renew is tied to the framework of sustainable farming.

That is, if this renewable energy source is overexploited during utilization, renewable capacity will be reduced or eliminated. The potential of biomass from agricultural production should be taken into account, which is confirmed by the fact that farmers plan to use the potential of biomass from agricultural production primarily in agriculture. In addition to the main products used in crop production, the biomass generated as a by-product is mainly used by farmers to replenish the soil's organic matter and to litter animals. In areas with favorable yields, where the average yield is high, the utilization of the large amount of organic by-products generated for energy purposes may be considered.

In addition to crop production, the other main sector of agriculture is animal husbandry, a valuable by-product of which is organic manure, which is mainly used to maintain or increase soil organic matter stocks. In our research, we investigated the potential of biomass from crop production.

Among the plants that can be grown on a large area and in large quantities for energy purposes, energy grass and tree plantations are the most suitable in Hungary. Although technology has already been developed for growing and harvesting perennial energy grass, the high mineral content of combustion is still a problem, which requires the use of special firebox boilers or combustion technology. All cultivated soils are suitable for growing fast-growing tree species. In Hungary, the total area of tree plantations planted for energy purposes is 2.6–3 thousand hectares. This could be increased to 25-30 thousand hectares by 2020 and up to 100 thousand hectares by 2030. However, these investments require significant capital expenditure.

According to the Paying Agency's single application database, the total area of energy grass is less than 500 hectares. The plots are scattered throughout the country, but the larger areas are located in Békés County, in the southeastern part of the country.

The area of herbaceous energy crops (Sida, Miscanthus and Arundo) is about 350 hectares. Their average yield varies between 10-35 t / ha / year (Gyuricza, 2014). Due to their higher water demand, their spatial distribution is different, with larger areas in the wetter western part of the country.

Woody energy plants in Hungary are mainly poplar, willow and acacia varieties. These energy plantations have different yields depending on the production area, technology, climate and the species of wood used, ranging from 5 to 30 t / ha (Gyuricza, 2014; Szalay et al., 2019). Due to their water demand, there are larger areas of poplar and willow in the western part of the country and near the riverbanks.The agriculture sector is the biggest producer of domestic biomass with 79% of the total, followed by forestry with almost 10% of the dry matter content but most of but a significant portion of biomass from agriculture is recycled into production and is not available for energy use.

Interviews exploring the use and characteristics of the biomass from agriculture revealed that the vast majority of farms use plant by-products for soil power management and for on-farm use, and as a result no surplus is available for sale.

Some of the farmers we talked with expressed their disapproval of using the biomass for anything other than putting it back into the soil as green manure or trading it with livestock farmers who supply them with animal manure. A few potential respondents refused to fill in our questionnaires upon this reasoning. One farmer said that they traded previously biomass with other companies, but they are likely to minimize that exchange, as fertilizers are becoming more expensive and they wish to reduce their costs. Another interviewed farmer added that he does not understand, why this research is being

conducted as the European Union tries to reform agriculture to be more environmentally safe. In his opinion, the use of stalk residues for energy purposes is contrary to the requirements of the EU. Another farmer said that such use is not profitable due to transport costs. And livestock farmers are in such trouble with hay and straw that they already use chopped corn and sunflower stalks as deep litter. Some of the state forestry do not deal with biomass utilization of energy purposes.

5. APPENDIX

- **Environmental and Energy Efficiency OP (KEHOP)**

The programme has earmarked and grouped a total of 19 259 000 EUR in the form of non-repayable grants for biomass under the priority axis of increasing energy efficiency and funding renewable energy resources.

- **Environmental and Energy Efficiency OP (KEHOP)**

The programme has earmarked and grouped a total of 19 259 000 EUR in the form of non-repayable grants for biomass under the priority axis of increasing energy efficiency and funding renewable energy resources. The measures, based on the calls for proposals, were as follows:

Activities eligible for support:

Biomass, including agricultural by-products, horticultural by-products, energy crops, forestry by-products and co-products, wood and other industrial waste and by-products or their mixed by-products or their mixed-use for heating and/or heating auxiliary purposes.

The aforementioned activities received a total of 193,8 billion HUF from the operational programme between 2014-2020, in total 230 projects were funded.

Name of measure	Measure code	Planned Budget (HUF billion)	Number of projects supported	Amount of aid granted (HUF billion)
Priority energy efficiency improvements in public buildings	KEHOP-5.2.2.	201.46	129	159.58
Building energy improvements in churches with the possibility of using renewable energy resources	KEHOP-5.2.3.	15.38	77	14.96
Energy efficiency improvements in	KEHOP-5.2.12	5.43	20	4.85

state-owned sport facilities				
Energy efficiency investments by central government bodies phased projects	KEHOP-5.2.4.	14.02	4	14.45

Source: Széchenyi 2020

Activities eligible for support:

Development of a grid-connected off-premises renewable electricity generation system or a grid-connected off-premises renewable combined heat and power generation system.

Under 2 measures for 13 projects over the 7-year planning cycle (2014-2020) a total of 26.4 billion HUF in funding has been awarded for the above-mentioned activities.

Name of measure	Measure code	Planned Budget (HUF billion)	Number of projects supported	Amount of aid granted (HUF billion)
Promoting renewable green electricity generation by installing electricity generator systems with an installed capacity of more than 4 MW	KEHOP-5.1.1-17	26.40	7	26.40
Promoting renewable green electricity generation by installing electricity generator systems with an	KEHOP-5.1.2-17	12.96	6	12.80

installed capacity not exceeding 0,5 MV				

Source: Széchenyi 2020

Activities eligible for support:

Biomass - the biodegradable fraction of products, wastes and residues (including those of plant and animal origin) from agriculture, forestry and related industries, and the biodegradable fraction of industrial and municipal waste - for the production of domestic hot water and/or heating and/or auxiliary heating.

The activities listed above have received funding for sports facilities and for energy efficiency improvements to buildings under state aid rules. Thanks to this measure, 21 projects have been awarded grants totalling 2,83 billion HUF, 78,6% of the planned budget.

Name of measure	Measure code	Planned Budget (HUF billion)	Number of projects supported	Amount of aid granted (HUF billion)
Energy efficiency improvement of gyms, swimming pools and sports facilities	KEHOP-5.2.6.	2.00	13	1.81
Energy efficiency improvements in buildings under state aid rules	KEHOP-5.2.8.	1.60	8	1.02

Source: Széchenyi 2020

Activities eligible for support:

Structural and mechanical works for the construction of buildings that comply with near-zero energy building standards. (Purchase of a biomass boiler)

Between 2014 and 2020, almost three-quarters of the planned budget for the measure was used (67.4%), with 6 projects and a total of HUF 4.2 billion in funding.

Name of measure	Measure code	Planned Budget (HUF billion)	Number of projects supported	Amount of aid granted (HUF billion)
Construction of near-zero energy buildings as a pilot project	KEHOP-5.2.5.	6.23	6	4.20

Source: Széchenyi 2020

Activities eligible for support:

Development of a grid-connected, off-premises renewable electricity, combined heat and power generation system and sale of the heat and electricity generated. Biogas production and use (Development of a biogas production system for the combined production of heat and electricity from wastewater.)

Between 2014 and 2020, these activities were supported to promote renewable green electricity production by a 1.07 billion HUF.

Name of measure	Measure code	Planned Budget (HUF billion)	Number of projects supported	Amount of aid granted (HUF billion)
Promotion of renewable green electricity production by installing electricity generation systems prepared in the	KEHOP-5.1.3-17	1.47	1	1.07

KEOP-7.9.0 construction				

Source: Széchenyi 2020

Activities eligible for support:

Construction, partial or complete conversion to renewable energy sources, capacity increase of existing renewable energy installations, construction of districtheating/cooling and district heating systems using renewable energy sources.

The supported activities included support for meeting local heating and cooling needs from renewable energy sources in the period 2014-2020. Three quarters of the planned budget (74.9%) contributed to 11 projects for a total of 12.66 billion HUF.

Name of measure	Measure code	Planned Budget (HUF billion)	Number of projects supported	Amount of aid granted (HUF billion)
Meeting local heating and cooling demand with renewable energy sources	KEHOP 5.3.2-17	16.90	11	12.66

Sources: Széchenyi 2020

Activities eligible for support:

Construction of district heating systems using renewable energy sources and connection to the district heating distribution network, or energy upgrading of district heating systems construction of a new cogeneration system using renewable energy sources to meet district heating and own electricity demand, connection to the district heating distribution network.

The measure supported the development of renewable local heat demand by district heating companies between 2014 and 2020. Three quarters (74.9%) of the planned budget was used, with 2 developments receiving a total of 12.66 billion HUF.

Name of measure	Measure code	Planned Budget (HUF billion)	Number of projects supported	Amount of aid granted (HUF billion)

Meeting the renewable local heat demand of district heating suppliers	KEHOP 5.3.4-21	19.60	2	12.66

Sources: Széchenyi 2020

Calls for proposals available in 2022

There are currently two measures for the use of biomass for energy purposes under the Environmental and Energy Efficiency OP, worth 206.89 billion HUF. The eligible activities under the measures include biomass, including agricultural by-products, horticultural by-products, energy crops, forestry main and by-products, wood and other industrial waste and by-products or their mixed by-products or their mixed-use for heating and/or heating assistance.

Name of measure	Measure code	Planned Budget (HUF billion)
Priority energy efficiency improvements in public buildings	KEHOP-5.2.2.	201.46
Energy efficiency improvements in stateowned sports facilities	KEHOP-5.2.12-17	5.43

Source: Széchenyi 2020

- **Rural Development Programme (VP)**

The Rural Development Programme has encouraged the use of biomass both as a modernisation measure to reduce energy use and as a means of promoting the use of renewable energy technologies. Within the Programme, 24 calls for proposals were launched to support such improvements. The total planned budget for energy efficiency investments was 416.74 billion HUF. The improvements could be implemented through two types of support schemes: a mandatory action under the grant and an optional action linked to other improvements, but not eligible for support on its own.

Activities eligible for support:

heating/cooling energy demand, domestic hot water demand, electricity demand partially or fully met by renewable energy sources (solar collectors, biomass and heat pump systems, geothermal energy, biogas production, solar PV, wind energy).

Between 2014 and 2020, a total of 15 measures provided agricultural operators with 743.93 billion HUF in funding for the above-mentioned activities.

Name of measure	Measure code	Planned Budget (HUF billion)	Number of projects supported	Amount of aid granted (HUF billion)
Support for the development of livestock farms	VP2-4.1.1.-20	43.20	689	338.97
Improving the energy efficiency of agricultural and processing plants	VP5-4.1.6-4.2.3-17	35.00	393	25.57
Modernisation of poultry farms	VP2-4.1.1.2-16	5.97	198	28.40
Modernisation of cattle farms	VP2-4.1.1.3-16	5.97	544	33.76
Modernisation of sheep and goat farms	VP2-4.1.1.4-16	1.19	310	4.72
Modernisation of pig farms	VP2-4.1.1.5-16	5.97	169	24.51
Aid for the renewal of livestock holdings	VP2-4.1.1.9-21	3.00	1 417	39.04
Construction and modernisation of a small-scale crop storage, drying and cleaning facility	VP2-4.1.2-16	6.98	745	34.34
Support for the development of crop storage, dryers and cleaners	VP2-4.1.7-21	4.00	232	60.24
Complex development of food processing plants	VP3-4.2.1-4.2.2-2-21	15.00	389	67.60
Support for product development and resource efficiency in the winery	VP3-4.2.2-16	12.66	429	26.54
Support for the development of crop	VP2-4.1.7-21	4.00	232	60.24

storage, dryers and cleaners				
Horticulture - Support for the development of mushroom production facilities	VP2-4.1.3.4-21	2.00	No information available	No information available
Support for the development of fodder production plants	VP3-4.2.1.3-21	5.00	No information available	No information available
Food plant development	VP3-4.2.1-4.2.2.-1-21	4.00	No information available	No information available

Source: Széchenyi 2020

Activities eligible for support:

The use of biomass, including agricultural primary and by-products, horticultural and livestock by-products, energy crops, forestry primary and by-products, wood and other industrial waste and other by-products, to meet all or part of the demand for hot water for domestic use and/or to provide auxiliary heating (installation of boiler systems).

The use of biomass for energy has also become eligible for support in the context of the modernisation of horticultural holdings in 2014-2020 thanks to three measures. During the period under review, 601 projects received support totalling HUF 102.79 billion.

Name of measure	Measure code	Planned Budget (HUF billion)	Number of projects supported	Amount of aid granted (HUF billion)
Modernisation of horticultural holdings	VP2-4.1.3-20	30.00	311	65.26
Modernisation of horticulture - installation of glass and foil houses, increasing energy efficiency by using geothermal energy	VP2-4.1.3.1-16	9.40	139	19.02

Modernisation of horticulture - creation of mushroom houses - cold stores, modernisation of existing mushroom houses - cold stores	VP5-4.1.3.4-16	11.50	151	18.51

Source: Széchenyi 2020

Optional activities that are not individually eligible: heating/cooling energy demand, domestic hot water demand, electricity demand partially or fully met from renewable energy sources; use of solar collectors, installation of biomass and heat pump systems, use of geothermal energy, solar photovoltaic system.

The listed actions are complementary and optional elements of other mandatory improvements, which were included in 6 rural development measures between 2014 and 2020. The total amount of aid granted was 110.07 billion HUF with 1 626 projects receiving support.

Name of measure	Measure code	Planned Budget (HUF billion)	Number of projects supported	Amount of aid granted (HUF billion)
Aid for investments for the creation and development of nonagricultural activities	VP6-6.4.1–16	35.94	632	26.07
Development of smallscale infrastructure and basic services in rural areas - Development of infrastructure for local markets for the sale of products, development of public catering	VP6-7.2.1-7.4.1.3-17	12.64	403	9.51

Development of smallscale infrastructure and basic services in rural areas - Development of infrastructure for local markets for the sale of products, development of public catering	VP6-7.2.1.1-20	13.00	128	9.86
Adding value to agricultural products in processing	VP3-4.2.1-4.2.2-18	50.00	463	65.03
Support for Short Supply Chain investments in the food and wine sector	VP3-4.2.1-4.2.2-19	1.50	No information available	No information available
Diversification of nonagricultural activities - Development of rural tourism	VP6-6.4.1–21	50.00	No information available	No information available

Source: Széchenyi 2020

Calls for proposals available in 2022

Currently, two measures for biomass for energy purposes are available to applicants under the Rural Development Programme, worth 53.0 billion HUF. These measures support the installation of biomass-based systems and the production of renewable energy from green waste or the use of the energy produced.

Name of measure	Measure code number	Planned budget (HUF billion)	Eligible activities
Aid for the renewal of livestock holdings	VP2-4.1.1.9-21	3.00	Heating/cooling energy demand, domestic hot water demand, electricity demand

			partial or total from renewable energy sources (solar collectors, biomass-based and installation of heat pump systems, use of geothermal energy, biogas production, solar panels system design, use of wind energy).
Aid for the renewal of horticultural holdings	VP2-4.1.3.5-21	50.00	The green waste or pruning residues from the horticultural holding concerned by the project or transfer to renewable energy sources or to the for the production of renewable energy or for energy production on the plant

Source: Széchenyi 2020

- **Competitive Central-Hungary OP (VEKOP)**

The Competitive Central Hungary Operational Programme promoted the use of biomass by supporting the use of renewable energy technologies. Within the Programme, 3 calls for proposals were launched to support such developments. The total planned budget for investments in energy efficiency was 36.675 billion HUF.

Activities eligible for support: the installation of briquettes, pellets, wood chips, and wood gasification boiler systems to meet all or part of the heating and hot water needs of the building under development.

Under the measure, access to loans was granted to increase the energy efficiency and renewable energy use of residential buildings between 2014 and 2020. The planned budget has been fully used, with two developments receiving a total of HUF 14.70 billion in support.

Name of measure	Measure code	Planned Budget (HUF billion	Number of projects supported	Amount of aid granted (HUF billion)
Loan to increase energy efficiency and renewable	VEKOP-5.2.1-17	14.70	2	14.70

energy use in residential buildings				

Sources: Széchenyi 2020

Activities that are not individually eligible: The use of renewable energy technologies to meet the energy needs of economic production processes and on-farm buildings by generating renewable energy.

The measure supported improvements to help micro, small and medium-sized enterprises adapt to modern business and production challenges between 2014 and 2020. Investments in the use of biomass could take the form of optional actions. The planned budget was fully used, with 2 projects receiving a total of 14.70 billion HUF.

A mikro-, kis- és középvállalkozások modern üzleti és termelési kihívásokhoz való alkalmazkodását segítő fejlesztések támogatása	VEKOP-1.2.6-20	18.82	1 316	31.27

Forrás: Széchenyi 2020

Activities that are not eligible on their own: Activities to increase the use of renewable energy: only and exclusively the production side of heat and/or electricity is eligible (in the case of a biomass boiler system: up to the secondary stub of the biomass boiler.

The measure provided access for businesses to loans for energy efficiency improvements in buildings using renewable energy between 2014 and 2020. During the period, 61 projects were supported for a total amount of 1.43 billion HUF.

Name of measure	Measure code number	Planned budget (HUF billion)	Number of projects supported (number)	Amount of aid granted (HUF billion)

Support for businesses for installing energy improvements using renewable energy in the Central Hungary region with a combined loan product.	VEKOP-5.1.1-5.1.2-16	3.16	61	1.43

Source: Széchenyi 2020

- **Territorial and settlement development OP (TOP)**

The Territorial and settlement development Operational Programme promoted the use of biomass by supporting the use of renewable energy technologies. Within the Programme, 10 calls for proposals were launched to support such developments. The total budget for energy efficiency investments was 354 150.0475 million HUF.

Activities eligible for support: replacement of an existing fossil-based heat generator with a more modern fossil-based heat generator or installation of a biomass boiler system.

Support for these activities was made available to municipalities through 5 measures under the Operational Programme between 2014 and 2020. During this period, a total of 1581 projects were supported, worth 181.83 billion HUF.

Name of measure	Measure code number	Planned budget (HUF billion)	Number of projects supported (number)	Amount of aid granted (HUF billion)
Energy modernisation of municipal buildings	TOP-3.2.1-15	71.13	756	66.08
Energy modernisation of municipal buildings	TOP-3.2.1-16	60.40	656	55.58

Energy modernisation of municipal buildings	TOP-6.5.1-15	26.95	41	22.16
Energy modernisation of municipal buildings	TOP-6.5.1-16	33.74	84	19.74
Energy modernisation of municipal buildings	TOP-6.5.1-19	18.13	44	18.27

Source: Széchenyi 2020

Activities eligible for support: meeting own (public) heating, cooling and electricity needs with biomass based renewable energy.

The measure supported municipalities' development of renewable energy sources as optional actions between 2014 and 2020. The number of projects supported was 48, and the total amount was HUF 12.68 billion.

Name of measure	Measure code number	Planned budget (HUF billion)	Number of projects supported (number)	Amount of aid granted (HUF billion)
Implementation of a municipality-directed energy supply system for the exploitation of renewable energy sources, adapted to local conditions, in the framework of complex	TOP-3.2.2-15	15.72	41	9.97

development programmes				
Implementation of a municipality-directed energy supply system for the exploitation of renewable energy sources, adapted to local conditions, in the framework of complex development programmes	TOP-6.5.2-15	5.60	7	2.71

Source: Széchenyi 2020

Activities that are not eligible on their own: investments to improve the energy efficiency of the building or the use of renewable energy sources to be developed within the project.

The above listed activities were available as additional supported activities under three measures for sustainable tourism development for the period 2014-2020. A total of 378 projects received support totalling HUF 117.17 billion under these measures.

Name of measure	Measure code number	Planned budget (HUF billion)	Number of projects supported (number)	Amount of aid granted (HUF billion)
Socially and environmentally sustainable tourism development	TOP-1.2.1-15	61.38	211	59.58
Socially and environmentally sustainable	TOP-1.2.1-16	38.90	142	37.74

tourism development				
Socially and environmentally sustainable tourism development	TOP-6.1.4-15	22.20	25	19.85

Source: Széchenyi 2020

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Data sources

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- OECD Environmental Performance Reviews: Hungary 2018
- AKI Institute of Agricultural Economics (Energy production of biomass in Hungary)
- Hungarian Energy and Public Utility Regulatory Authority (HEA)
- Report on the use of renewable energy sources in Hungary in 2017-2018
- Farm Accountancy Data Network (FADN)
- Hungarian State Treasury Database
- Hungarian Central Statistical Office (renewable energy statistics)
- Local authorities
- Literature review, expert estimations, and reference books