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# THE STRUCTURE OF RENEWABLE ENERGY SOURCES IN ENERGY PRODUCTION IN THE EUROPEAN UNION STATES, WITH PARTICULAR CONSIDERATION OF POLAND AND CROATIA

# STRUKTURA OBNOVLJIVIH IZVORA U PROIZVODNJI ENERGIJE U ZEMLJAMA EUROPSKE UNIJE S POSEBNIM OSVRTOM NA POLJSKU I HRVATSKU

#### ABSTRACT

According to the Directive 2009/28/EC dated April 23,2009, the European Union intends to achieve, it is required that 20 percent of the energy consumed within the European Union will be renewable by 2020. The share of energy from renewable sources in transport is to achieve 10 percent at the same time. It is the mandatory minimum target for all Member States.

Due to the high diversification of potentials of particular Member States, related to the renewable energy sources (water conditions, wind conditions, sun illumination, resources of biomass and biogases) and initial conditions of the states, the 20 percent share of the entire Community has been recalculated to specify the individual (national) targets. Therefore, following the list of the Member States, Poland is to achieve the 15 percent and Croatia the 20 percent share of energy from the renewable sources in the final gross energy consumption.

In order to achieve these targets, Poland (in 2010) and Croatia (in 2013) approved the National Action Plans in the Field of the Renewable Energy Sources. These plans determine the concepts, time schedules and instruments of implementation of the actions assumed by the EU.

The objective of the paper is to discuss the descriptive and comparative analysis of the structure of the renewable energy sources in the energy production, in relation to the targets specified by the EU for particular Member States. The detailed analysis will cover the structure of energy mixes of Poland and Croatia, including, first of all, water power, wind energy, sun energy, biomass and biogases.

Keywords: energy, renewable energy sources, wind energy, sun energy, biomass, biogases.

# SAŽETAK

Europska unija, u skladu s direktivom 2009/28/EC od dana 23. travnja 2009. godine treba do 2020. godine, postići 20 posto udjela obnovljive energije u ukupnoj potrošnji energije i 10 posto udjela energije iz obnovljivih izvora u sektoru transporta (kao obveznog minimalnog cilja za sve zemlje članice). Zbog velikih razlika u potencijalu država članica u području obnovljivih izvora energije (resursi vode, vjetra, sunca, biomase, bioplina) i njihov početni položaj, pa je 20 postotni udio ka cilj zajednice, preračunat na pojedinačne ciljeve (nacionalno). Dakle, u izvješću zemlja članica, Poljska do 2020 očekuje dosegnuti 15 posto, a Hrvatska 20 posto udjela energije iz obnovljivih

izvora u bruto potrošnji energije. Kako bi se postigli ovi ciljevi, Poljska je u 2010 i Hrvatska u 2013. donijela Nacionalni akcijski plan za obnovljive izvore energije koji definiraju koncepte, planove i instrumente za provedbu ciljeva postavljenih od strane Europske unije. Svrha ovog članka je analizirati opisno-usporedne strukture obnovljivih izvora energije u proizvodnji energije u odnosu na zahtjeve koje postavlja EU u pojedinim državama članicama. Detaljnom analizom će biti obuhvaćena struktura energetskih troškova Poljske i Hrvatske, a u tom prije svega hidroenergije, vjetroenergije, solarne energije, biomase i bioplina.

*Ključne riječi:* energija, obnovljivi izvori energije, energije vjetra, solarne energije, biomase, bioplina.

## 1. Introduction

Renewable energy sources are such sources of energy, which are renewed within a short time and thus their utilisation is not connected with their long-term deficit. Renewable energy sources include, among others, wind, solar radiation, water gravitational energy, biomass, biofuels, geothermal energy. The policy of development of energy based on renewable energy sources in all EU Member States has been defined in the Directive of the European Parliament and of the Council 2009/28/EC on promotion of the use of energy from renewable sources. Its main objective is to limit greenhouse gas emissions and to meet the resolutions of the Kyoto Protocol to the Framework UN Convention on climatic changes, as well as to meet other EC and international obligations in the field of limitation of greenhouse gas emissions. Those objectives are in line with the European strategy against climatic changes "20-20-20". This plan assumes to achieve the following objectives to 2020:

- to limit greenhouse gas emissions by 20%,

- to increase the energy efficiency by 20%,

- a share of renewable energy equal to 20%.

Therefore, each Member State has individual goals in the field of renewable energy sources in the overall energy balance, depending on their possibilities and predispositions. In the case of Poland, the objective is to achieve 15%, and in the case of Croatia – the 20% share of renewable energy sources to 2020 in the final gross energy consumption.

## 2. Renewable energy sources in Poland and Croatia in comparison to the EU

Hydroelectricity, wind and wave power, solar and geothermal energy and combustible renewables and renewable waste (landfill gas, waste incineration, solid biomass and liquid biofuels) are the constituents of renewable energy. The gravitational energy of water is mostly used in the world as the renewable energy source. In 2013 it was used for production of 71% of energy from renewable sources. Successive sources are: wind energy (12%), biomass and biofuels (7.7%), solar energy (2.4%) and geothermal energy (1.4%). The current trends suggest that wind and solar energy will produce amounts of energy similar to hydropower plans to 2020, and the share of renewable energy will exceed 20% (1: accessed 15 February 2015). Table 1 presents the share of particular sources in the primary energy production in Poland and Croatia, within the EU structure.

Table 1	Share of	<sup>°</sup> particular	sources	in	production	of	the	primary	energy	in	Poland	and	Croatia
within th	ie EU stri	icture											

Total production of		Share of total production, 2012 [%]						
Country	primary energy, 2012	Solid fuels	Natural gas	Crude oil	Renewable			
	[Mtoe]				energy			
Poland	71.1	80.9	5.4	0.9	11.9			
Croatia	3.5	0	47.3	16.1	34.2			

Source: Own work, basing on

http://ec.europa.eu/eurostat/statisticsexplained/index.php/Energy\_production\_and\_imports/pl

Figure 1 shows the contribution of electricity produced from renewable energy sources to the national electricity consumption in 2012. Electricity produced from renewable energy sources comprises the electricity generation from hydro plants (excluding pumping), wind, solar, geothermal and electricity from biomass/wastes. Gross national electricity consumption comprises the total gross national electricity generation from all fuels (including autoproduction), plus electricity imports, minus exports.





Source: http://ec.europa.eu/eurostat/web/energy/statistics-illustrated

In Poland the share of renewable energy sources in the primary energy production has been increasing every year. It equalled to 2.6% in 2005 and it reached 8.2% in 2011; this means the increase by 312% and 30%, respectively, comparing to 2012. In Croatia, considering the higher starting level of the share of renewable energy sources in the primary energy production, this increase was not as impressive as in Poland; it reached 8% comparing to 2005 (32.8%) and almost 4% comparing to 2011 (34.2%). The share of renewable energy in gross final energy consumption in 2012, amounts respectively 11% for Poland and 16,8% for Croatia (Figure 2).



Figure 2 Share of renewable energy in gross final energy consumption in 2012

Source: http://ec.europa.eu/eurostat/web/energy/statistics-illustrated

# 1.1. Selected parameters of renewable energy sources in the EU with particular consideration of Poland and Croatia

I. Solid biomass

Solid biomass is acquired, first of all, from energy trees and crops. After harvesting they are used in the form of the fresh biomass or they are specially processed. Each year the consumption of the solid biomass for the production of electric power and heat in the European Union is increased. Following the data collected by the EurObserv'ER, the consumption of the primary energy from the solid biomass equalled to 91.5 MToe in 2013 in the European Union; this means the increase by 3.3% comparing to 2012. At the same time in Poland the decrease of almost 7% was noticed; in Croatia the moderate increase of 0.6% was noticed.

		2012		2013		
	UE	Poland	Croatia	UE	Poland	Croatia
Primary energy production of solid biomass [Mtoe]	86.043	6.988	0.694	88.100	6.497	0.700
Gross consumption of solid biomass [Mtoe]	88.639	6.988	0.497	91.459	6.497	0.500
Gross electricity production from solid biomass [TWh]	80.204	9.529	0.037	81.684	8.024	0.048
Heat production from solid biomass [Mtoe]	8.591	0.462	0.002	8.809	0.345	0.003

Table 2 Selected parameters of solid biomass in Poland and Croatia in comparison to the EU.

Source: Own work basing on EuroObserv'ER Solid biomass barometer 2014

#### II. Biogas

Primary energy production of biogas contains landfill gas, urban and industrial sewage sludge gas, others biogas (decentralised agricultural plant, municipal solid waste methanisation plant, centralised co-digestion plant). Following the data collected by the EurObserv'ER, the share of the biogas in the primary energy production equalled to approx. 13.4 Mtoe in 2013 in the European Union; this means the increase by 10.2% to 2012. However, the increase intensity in the sector was slower than in 2012 (16.9%, i.e. the increase by 1.8 Mtoe). In Poland the increase by 29.6% and in Croatia – by 8.4% comparing to 2012 was noticed in 2013.

		2012		2013		
	UE	Poland	Croatia	UE	Poland	Croatia
Primary energy production of biogas [ktoe]	12 137.1	193.8	16.6	13 378.7	251.2	18.0
Gross electricity production from biogas [GWh]	46 419.1	565.4	56.8	52 327.2	882.5	63.2
Gross heat production from biogas [ktoe]	353.2	5.1	2.7	432.4	7.2	3.0

Table 3 Selected parameters of biogas in Poland and Croatia in comparison to the EU.

Source: Own work basing on EuroObserv'ER Biogas barometer 2014.

## III. Renewable municipal waste

Municipal solid waste is an unavoidable by product of human activities. Estimates compiled by EurObserv'ER suggest that the production of primary renewable energy recovered by household refuse incineration plants in the countries of the European Union, only increased by 0.7% in 2013 to achieve 8.7 Mtoe.

**Table 4** Primary energy production from renewable municipal waste in Poland and Croatia in comparison to the EU

		2012		2013		
	UE	Poland	Croatia	UE	Poland	Croatia
Primary energy production from renewable municipal waste [ktoe]	8 668.7	32.5	-	8 727.0	32.5	-

Source: Won work basing on EuroObserv'ER Renewable municipal waste barometer 2014

#### IV. Solar power plants (photovoltaic)

Photovoltaics is a method of converting solar energy into current electricity, or production of the electric current of the sun radiation, using the photovoltaic effect. Following the estimated values of the EurObserv'ER, 24% decrease of the number of installed and connected photovoltaic devices was noticed in the Eu in 2012, comparing to 2011.

Besides, the share of the EU in the global photovoltaic market, equalled to 73.6% in 2011, is currently reaching only 26,5%. This sector has been clearly shrinking, mainly due to the reduced system of investment incentives, and resulting restoration of inspection of its development.

**Table 5** Photovoltaic capacity installed and connected in Poland and Croatia in comparison to the EU

		2011		2012		
	UE	Poland	Croatia	UE	Poland	Croatia
Photovoltaic capacity installed and connected [MWp]	22075.7	0.8	-	16692.9	1.2	3.6

Source: Own work basing on EuroObserv'ER 13th annual overview barometer.

## V. Wind energy

Electrical energy produced of wind energy is considered ecologically clean, since, apart from financial inputs required for construction of a wind-powered plant, production of energy does not involve combustion of any fuel. In 2013 the increase of 10.2% of the total power of wind-powered plants, comparing to 2012, was noticed in the EU; however its slowdown comparing to the past years was also noticed. In 2013 Poland reached the third place on the EU wind energy market in terms of the increase intensity of new investment comparing to 2012.

		./				
		2012		2013		
	UE	Poland	Croatia	UE	Poland	Croatia
Installed wind energy cumulative capacity [MW]	106806.6	2496.7	179.6	117730.0	3389.5	298.8
Electricity production from wind energy [TWh]	203.507	4.746	0.329	234.386	6.600	0.494

Table 6 Selected parameters of wind energy in Poland and Croatia in comparison to the EU.

Source: Own work basing on EuroObserv'ER Wind energy barometer 2014.

#### VI. Small hydro power plants

The small size hydroelectricity sector groups together installation with capacities of up to 10 MW yet has a vital role to play in achieving the targets set by UE for 2020. Following the estimations of the EurObserv'ER, the increase by 9.7% of the small hydraulic gross electricity production was noticed in 2012 in the EU, comparing to 2011.

**Table** 7 Selected parameters of small hydro power plants in Poland and Croatia in comparison to<br/>the EU

		2011		2012		
	UE	Poland	Croatia	UE	Poland	Croatia
Small hydraulic gross electricity production < 10MW [GWh]	41128	943	63	45135	940	77
Total small hydraulic net capacity < 10MW [MW]	13730.9	268	28	13928.0	273	28

Source: Own work basing on EuroObserv'ER 13th annual overview barometer.

#### 2. Polish and Croatian renewable energy sources strategy

Individual demands of particular EU Member States come down to the achievement of the 15% share by Poland and the 20% share by Croatia of energy from renewable energy sources in the final gross energy consumption to 2020. In order to achieve those goals Poland in 2010 and Croatia in 2013 adopted the National Action Plans for renewable energy sources. Those plans determine the ideas, time schedules and instruments for implementation of actions, specified by the EU, depending on predispositions and potential of renewable energy sources in each state.

National objectives for the year 2020, concerning the consumption of energy from renewable sources in three sectors, i.e. heating and cooling, electric power engineering and transport are presented in Table 8.

*Table 8* Share of renewable energy sources in heating and cooling, electric power engineering and transport to 2020

Sector	Poland	Croatia
Electric power engineering	19.1%	39.0%
Heating and cooling	17.0%	19.6%
Transport	10.1%	10.0%

Source: Own work basing on Polish and Croatian National action plan for renewable energy sources.

Following the provisions of the Croatian National action plan, utilisation of renewable energy sources in transport is to achieve 10% in 2020, and 19.6% in heating and cooling sectors. It was also decided to increase the share of renewable energy sources in the electric power engineering sector, from 35%, assumed in the past, to 39%, since its share already achieved 36.6% in 2013.

The Polish Action Plan is not a one-variant plan; it assumes different scenarios (the optimal, i.e. the recommended, the minimal and the maximal scenarios). According to the optimal variant, the target for 2020 is to achieve 10% energy from renewable energy sources in transport, 17% - in heating and cooling, and 19.1% in electric power engineering.

#### 2.1. Share of renewable energy sources in particular sectors

Ia) Electric power engineering - Croatia

Table 9 presents the assumed share of particular renewable energy sources technologies in electric power engineering to 2020.

Renewable energy sources	Megawatts
Biomass plants (solid biomass and biogas)	125
Geothermal	10
Wind energy	400
Large hydropower plants	2356
Small hydropower plants	100
Solar energy photovoltaic	52

Table 9 Share of particular renewable energy sources in electric power engineering to 2020

Source: Own work basing on Croatian National action plan for renewable energy sources.

In Croatia in 2020, the following breakdown of RES is expected in electricity production: 80,7% from large and small hydropower plants, 13,1% from wind plants, 4,1% from biomass plants, 0,3% from geothermal plants and 1,7% from solar plants. In Croatia, having the considerable potential in the field of renewable energy source and the opportunities to select different variants, it was decided to assign high priorities to the biomass, biogas and hydropower plants. On the other hand it was decided to enter limitations for wind energy production to 400 MW, and for solar energy production to 52 MW. One of the most important conditions was the perspective of possible creation of more new jobs than it would be possible in the case of promotion of solar and wind energy production.

Ib) Electric power engineering – Poland

Table 10 presents the assumed share of each of renewable energy technology in electric power engineering to 2020.

Table 10 Share of renewable energy sources in electric power engineering to 2020.

Renewable energy sources	Megawatts
Biomass plants (solid biomass and biogas)	2530
Wind energy	6650
Large hydropower plants	772
Small hydropower plants	380
Solar energy photovoltaic	3

Source: Own work basing on Polish National action plan for renewable energy.

In Poland in 2020, the following breakdown of RES is expected in electricity production: 64.3% from wind plants, 24.5% from biomass plants, 11.1% from large and small hydropower plants. Thus, the highest attention has been paid to the wind and biomass energy. However, due to the geographic location of Poland, the share of the solar energy is marginal in the list of the total energy production.

IIa) Heating and cooling - Croatia

Table 11 presents the assumed share of each renewable energy technology in heating and cooling to 2020.

 Table 11 Share of particular renewable energy sources in heating and cooling to 2020.

Renewable energy sources	Ktoe
Geothermal energy (excluding heat energy from low-	15.7
temperature sources in applications of heat pumps)	
Solar energy	97.3
Biomas (solid biomass and biogas)	396.8
Renewable energy from heat pumps	95.6

Source: Own work basing on Croatian National action plan for renewable energy sources.

The total amount of renewable energy for heating and cooling in 2020 will be about 605.4 ktoe. Biomass, with a share of 65.5% in 2020 will play the main role in total energy from RES in the production of thermal energy for heating and cooling. Solid biomass includes wood biomass and biomass from agriculture. Of the total consumption of biomass for heating and cooling, 50.7% is planned for consumption in general consumption (households, services, agriculture, construction). Solar energy will have a 16.1% share in total RES in heating and cooling. The Republic of Croatia has set the goal for installation of 0.225 m2 of heat collectors per capita in 2020 for the preparation of hot water. In the heating and cooling system, heat pumps will have a share of 15.8%, of which air-based heat pumps will account for 12.6%, and water-based heat pumps for 3.2%. The share of geothermal energy in total RES in heating and cooling will be 2.6% to 2020.

## IIb) Heating and cooling - Poland

Table 12 presents the assumed share of every renewable energy source technology in heating and cooling to 2020.

Renewable energy sources	Ktoe
Geothermal energy (excluding heat energy from low-	178
temperature sources in applications of heat pumps)	
Solar energy	506
Biomass (solid biomass and biogas)	5089
Renewable energy from heat pumps	148

Table 12 Share of particular renewable energy sources in heating and cooling to 2020.

Source: Own work basing on Polish National action plan for renewable energy.

In Poland the total amount of renewable energy for heating and cooling in 2020 will be about 5921 ktoe. Biomass, with a share of 85,9% in 2020 will play the main role in total energy from RES in the production of thermal energy for heating and cooling. Solar energy will have a 8,5% share in total RES in heating and cooling system, heat pumps will have a share of 2,5%. The share of geothermal energy in total RES in heating and cooling will be 3,0% to 2020.

#### IIIa) Transport - Croatia

In Croatia the total amount of renewable energy in transport to 2020 will be about 162 ktoe. Renewable energy consumed for transport in 2020 will primarily consist of energy from biofuels 8,85%, while the remainder to the 10% share will be electricity 1,15%, which will be used in all types of transport.

#### IIIb) Transport - Poland

In Poland the total amount of renewable energy in transport to 2020 will be about 2018 ktoe. Renewable energy consumed for transport in 2020 will primarily consist of energy from biofuels 9,98%, while the remainder to the 10% share will be electricity 0,2%, which will be used in all types of transport.

## 3. Final remarks

The European Community target, assuming the 20% share of energy from renewable energy sources in the final gross energy consumption in 2020 is implemented through objectives, determined for each of the Member States. In order to achieve those targets, the Member States adopt national action plans in the field of energy from renewable energy sources, including their provisional assumptions in the sectors of transport, electric power engineering, cooling and heating. The Polish and Croatian conditions allowing for the RES development are different. In the electric power engineering Poland is focused on the wind energy and Croatia – on the water power. On the other hand, in both countries the biomass (solid biomass and biogas) is to become the main source of renewable energy in heating and cooling.

Advantageous natural conditions of Croatia, i.e. the high hydropower potential, favourable conditions for utilisation of the wind energy, high biomass resources and the high level of sunshine, allow to easily achieve the 20% share of energy produced by RES, assumed by the EU, in covering the total, national energy demands. The multi-variant Action Plan in Poland points to the possibilities to achieve the 15% share of energy from renewable sources in the final gross energy consumption. One of the variants is considered to be the optimal, i.e. recommended variant. The minimal and maximal variants have been also prepared. Thus, the Action Plan has been prepared in a flexible way. Besides, it assumes the certain overcapacity for the case of drought, which could result in much lower biomass volume and its periodically limited use. However, legal, technical and financial barriers, as well as the insufficient level of co-operation between institutions, which are responsible for implementation of administrative procedures, characterised by uncertainty and risk in the field of RES investments, may create some threats both in Poland, and in Croatia. Investors are discouraged by the lack of transparency and appropriate regulations in the field of the financial support for a given investment. In Poland such issues will be regulated, to some extent, by the act of February 20, 2015 on renewable energy sources. It introduces the auction system, which will include tenders for production of electric energy from RES sources. The lowest price is to be the criterion of offer selection and the guarantee concerning the support for energy producers is to be valid for 15 years. Separate auctions will concern plants to 1MW and above 1MW. Besides, these new regulations promote the utilisation of locally available resources, and, as a result, at least 25% of electric energy would be produced in RES installations of installed power to 1MW.

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