ENERGY PRODUCTION IN HYDROPOWERS AND ELECTRIC THERMAL POWER PLANTS FROM THE PERSPECTIVE OF EUROPEAN COMMUNITY LEGISLATION

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Abstract

Energy is the size that reflects the capacity of a physical system to perform mechanical work when it undergoing a transformation from its original state into another state chosen as the reference state, representing the source of man's daily activities.

The objectives of this work are analyzing future prospects of energy production of Electric Thermal Power Plants (CHPs Arad) and Hydro Power Plants (HPP – Crişul Pietros, Bihor county), in terms of their environmental impact and in terms of national and european legislation in the energy field.

Emissions of greenhouse gases and dusts of CHPs are believed to be responsible, in addition to smog and acid rains from industrialized regions, by the ozone depletion, with visible consequences of global climate change. Although water energy is considered a renewable resource, environmentally friendly hydropower plants often have a negative impact on the environment, especially on aquatic biodiversity.

National Energy Strategy, taken from the legislative provisions of the European Community (EC), having the main aim of ensuring energy security of the country, talks about the need of further improving of competitiveness by restructuring the thermal power sector.

Key words: energy, environmental impact, Electric Thermal Power Plants (CHPs), Hydro Power Plants (HPP), European energy legislation

INTRODUCTION

Energy is the size that reflects the capacity of a physical system to perform mechanical work when it undergoing a transformation from its original state into another status chosen as the reference status (Răduleţ, 1968); it is the source of man's daily activities.

After the fact that follows or not a natural regeneration cycle are as follows:

- non-renewable energy that is produced from resources generally considered non-renewable, being limited by respective reservoirs, fossil fuels (coal, gas, oil) and nuclear.
- renewable energy, which refers to renewable energy from natural processes. Thus, the energy of sunlight, of the winds, of waters (rivers, seas and oceans), of biological processes and of geothermal heat can be captured by people using various procedures.

CHPs are a systematic set of equipment and facilities that achieve an energy conversion chain in order to produce electricity and heat. The main

criterion for classification is the kind of primary energy, which is the basis of the transformation chain. After destination, thermal power plants are classified into:

- Thermal Power Plants (TPP), mainly producing electricity, heat is a secondary product.

- Electric Thermal Power Plants (CHPs), which produce, in cogeneration, both electricity and heat that prevails in winter.

Since the use of fossil coal, oil and natural gas, in CHP has been identified as the main cause of ozone depletion and global climate change, it has been the question of reducing the amount of energy produced in this way, in order to reduce the amount of greenhouse gases released into the atmosphere.

In all times, one of the oldest human concerns was to "of stealing" water energy (Baya, 1999), these being considered by Leonardo da Vinci "the nature motor" (De Azagara et Hevia, 1996).

Since between the renewable energy sources, the hydropower is the most accessible and the places on the main rivers of our country, favorable to the construction of HPP were in largely exhausted, it was stimulated by subsidies of the EC and other financial systems (green certificates) the arrangement of Micro Hydro Power (MHP), with low power around 1 MW, on small water streams.

The objectives of this work are analyzing future prospects of energy production in Electric Thermal Power Plants (CHP Arad) and Hydro Power Plants (MHP - Crişul Pietros, Bihor county), in terms of their environmental impact and in terms of national and European legislation in the energy field.

MATERIAL AND METHOD

For achieve the proposed objectives, were conducted two case studies, the first at CHP Arad and the second at MHPs from Crişul Pietros, being analyzed their environmental impact and productivity of the two technologies.

The choice for the case study of CHP Arad was because it was designed in 1988 to operate on solid fuel (coal-lignite) with the flame support of natural gas. To assess the impact of CHP Arad on the environment is analyzed technological process, it highlighting recent equipped with filters, evolution of main pollutants in air, water and soil, produced in the area and the energy production level.

The production of heat was estimated in accordance with Council Decision 278/2011, by summing the fuels energy, calculated on the base of energy content, using the formula:

$$Q = C_j \times PCN_j \times \eta_i; \qquad [1.]$$

Where: Q - produced energy, expressed in TJ;

Cj - fuel consumption, expressed in to or Nm^3;

PCNj - the net calorific value, expressed in TJ/to or TJ/Nm^3 for the fuel j;

ηi – the efficiency for the caldron i;

For quantitative characterization of hydropower resources of Crişul Pietros it used the concept "theoretical energy" (considering the yield η = 1) of rainfall, runoff, landscaped, etc. These energies can be defined like some potential energy of a mass of water, thus representing some powers; for whose designation in practice it use the name "Energy" respective "of potential". (Iovan, 2012)

For designing a MHP, must be known the hydraulic power available and the share from point of view technically and economically, arranged on that river.

The hydropower potential assessment of Crişul Pietros involves choosing potential sites of hydropower, generally in shedding of tributaries in the main river, sections which delineating the sectors of the natural water course.

Average flows of hydropower potential sites were evaluated using flow recorded in the control section, from spill, between 1991-2010 (Romanian Waters) proportional to surface water collection while upstream and downstream altitudes of sectors, were determined on the 3D spatial pattern of river basin using Google Earth.

The hydropower potential, corresponding of multiannual average flow, (Qm) on a sector I, with infinitesimal length δL, of a watercourse, comprised between altitudes H_i and H_{i+1}, is given by the relationship:

$$P\ (kW) = K_1 \int_{Hi}^{Hi+1} Q_m\ \delta H; \qquad [2.]$$

$$E\ (kWh/an) = K_2 \int_{Hi}^{Hi+1} Q_m\ \delta H; \qquad [3.]$$

Where: K_1 and K_2 have values of 9.81 and 9.81 X 8760, the yield being considered 100 %;

Particularizing for a certain sector of a water course, with finite length, ΔL (km) the theoretical power and energy relations can be written:

$$Q_{i\,av} + Q_{i+1\,av}\ \Delta H; \quad [4.]$$

$$\Delta H; \quad [5.]$$

Where: Qi am and Qi + 1 av (m^3/s) represent the multiannual average flow in the sector i of the watercourse, downstream and upstream of the confluence with a tributary;

ΔH (m) is droppings falling on the sector i of the watercourse;

For a graphical representation of the linearly potential, in the purpose of indicating an i sector with important potential, it can calculate the unitary power and energy with the help of relations:

[6.]

Where: P_i (kW), E_i (kWh/year) and Li (km) is the power, energy and the i sector length.

To assess the exploitation power of a MHP must be analyzed main energy parameters, i.e. the installed power and the energy production.

Smuda et Muge, 2001, taking account of the yields of each component of an MHP, given by the hydraulic load losses on adduction, the hydraulic load losses in turbine, the volumetric losses of water attached to the rotor, the mechanical losses, caused by the friction in bearings, to determine electrical power P_e they propose the relationship:

$$P_e = P_{AB} \bullet \eta_1 \bullet \eta_2 \bullet \eta_3 \bullet \eta_4 = 9{,}81 \bullet Q \bullet H \bullet \eta_1 \bullet \eta_2 \bullet \eta_3 \bullet \eta_4 \text{ (kW)} \quad [7.]$$

Where: η1, η2, η3 and η4 are the yields of hydraulic components, representing approx. 50 % of the theoretical power;

To highlight future trends in energy production are analyzed environmental conditions required for obtaining subsidies from the European Community (EC) for energy production.

RESULTS AND DISSCUSIONS

MHCs and CHPs impact on the environment - Case studies

Lignite CHP Arad. Emissions of gases with greenhouse effect and dust from CHPs are believed to be responsible, in addition to smog and acid rain in industrialized areas, by the ozone depletion, with visible consequences on global climate change. (Borota et Costea, 2000)

The main greenhouse gas results from burning coal in CHPs are SO_2, NOx, CO_2, etc. (Table 1.)

Table 1.

Emissions of gases with greenhouse effect and dust from Lignite CHP Arad (2000-2008)

Year	Gases with greenhouse effect			Dust	
	SO_2 t/ha	NO_x t/an	CO_2 mii t/an	in suspension mg/m^3	sedimentable g/m^2 şi lună
2000	15800	6850	12400	0.18	4.4
2001	15850	5900	10420	0.13	3.3
2002	11850	3760	10475	0.16	5.0
2003	14048	7200	27600	0.20	4.2
2004	13400	9850	28900	0.17	3.8
2005	11950	4300	22600	0.15	5.3
2006	11850	5750	24900	0.17	5.7
2007	11074	0	18100	0.15	8.35
2008	6780	4230	22430	0.155	6.6

The emissions values of sulfur dioxide (SO_2), determined in Arad, during the years 2000 to 2004 are between 11850 t/ha and 15850 t/ha, after which these values it reduce annually, reaching in 2008 at 6900 t/ha. Emissions values of nitrogen oxides (NOx) have the same annual reduction trend, reaching in 2008 at 4230 t/year. In the case of carbon dioxide emissions (CO_2) can be observed the period between 2003 and 2004, when they were determined highest values of 27,600 and 28,900 t/year, respectively.

If in the case of determined suspended dust, their reduction can be seen from the peak of 0.20 mg/m^3 in 2003 to 0.15 mg/m^3 in the last years, in the case of sedimentable dusts is visible the trend of increase, (8.35 g/m^2 in 2007) to those of the tailings pond adding those due to the car traffic in the city.

Explanation to reduce emissions of SO_2 and NOx and of in suspension dust, respectively, in the past years is given by the upgrade of CHP in 2004, occasion, which was put into operation the gas desulphurization installation and electrical filters for the solid particles retention.

At the CHP Arad results a large volume of sludge, namely: waste water from the production process, from filters cleaning, from ashes transport, water of cooling, water for equipment washing, fluviatile water from industrial platform, that polluting the groundwater in the area with sulfates, chlorides, sodium, calcium and acidic waters. (Pantea, 2011)

Because in the CET Arad, prevailing wind direction is from the west to the east, powders, dust, ash and hydrocarbons resulting from the combustion process are transported on eastern direction, polluted land areas are estimated at about 800 ha. (Sabău et al, 1999)

Given that CHPs use coal as the main raw materials, it must not overlook the impact of mining on the environment. (Fodor et Baican, 2001)

HPPs – Crișul Pietros. Although water energy is considered a renewable resource, environmentally friendly hydropower plants often have a negative impact on the environment, especially on aquatic biodiversity. Interruption of the natural course continuity, due to of water dams, will minimize the possibilities of movement from aquatic living beings, imposing the equipping them with "fish ladders". (Romocea, 2009)

The fitting of small rivers from mountains to produce electricity, with the help of MHPs, have a number of negative influences on landscape and biodiversity. During the construction period are taken out of certain land forest areas of mountain landscape, by the intervention of earthmoving equipment, used in riverbeds it intervenes brutally in mountain landscape. (Lengyel P., 2012)

In the case of "with deviation MHP", mountain rivers are captured with small cross thresholds and transported to the turbine on forced pipes, there is a risk of emptying the water of the river of the downstream catchment. Although, in accordance with current legislation, on downstream catchment of the watercourse must be kept "the servitude flow", in exploitation period, especially in dry summers, hunger for power could lead to processing the whole flow.

It is estimated that at the same amount of electricity produced, an MHP with deviation has an impact of 5-8 times higher on biodiversity, compared with an MHP with the dam in riverbed, making it necessary the promotion on the small watercourses of the MHPs on the water course, even if their performances are reduced.

Energy production in CHPs and MHPs - Case studies.

Lignite CHP Arad. The CHP was designed to operate on solid fuel (coal-lignite) in 1988 with the flame support of natural gas.

The average value of produced heat, in the period 2005 - 2008 is 5633.67 TJ; For the last two years of the presented period (2009 - 2010), production of heat it reduced to an average of 3918.36 TJ, this difference is of 1715.31 TJ. (Table 2)

Table 2.

Heat produced by CHP Lignite Arad (2005 - 2010)

Year	Heat (TJ)
2005	5.949,47
2006	5.805,56
2007	5.120,64
2008	5.461,77
2009	3.712,23
2010	4.124,48
Average 2005-2010	5.633,67

MHPs – Crişul Pietros. The main hydropower features of the Crişul Pietros basin: theoretical power Pk (kW) and theoretical energy Ek (kWh) of each sector, the theoretical linear potential pk (kW/km) and specific power ek (kWh/km) and the sum of the theoretical power of sectors Σ Pk (kW) are calculated and presented in table 3.

When analyzing the evolution of linear theoretical potential (kW/Km) along the watercourse is noted that the best emplacement for a hydropower plant is in downstream of the sector 4, for it is registered the maximum of 285.1 kW/Km.

In the situation of considered hydro locations, the sum of theoretical power Pk of river sectors i, suggests the maximum power, obtainable from total hydropower arrangement of Crişul Pietros, that is 4,732 MW. (Fig. 1.)

Table 3.

Hydropower characteristics of Crişul Pietros

Sectors	Sector length L (km)	Theoretical Power Pk = 9,80665 Qm*ΔZ (kW)	Theoretical energyEk = 8760 Pk (kWh)	Specific linear theoretical potential pk = Pk/L (kW/km)	Specific energy ek = Ek/L (kWh/km)	The sectors sum, P1 - 8 (kW)
1	5.43	1042.2	9129672	19.,9	1681339.2	1042.2
2	2.95	302.8	2652528	102.6	899162.0	1345.0
3	2.96	557.8	4886328	188.4	1650786.5	1902.8
4	0.50	142.5	1248300	285.1	2496600.0	2045.3
5	0.55	45.7	400332	83.1	727876.4	2091.0
6	0.45	30.2	264552	67.1	587893.3	2121.2
7	8.77	1457.1	12764196	166.1	1455438.5	3578.3
8	9.64	1154.4	10112544	119.8	1049019.1	4732.7

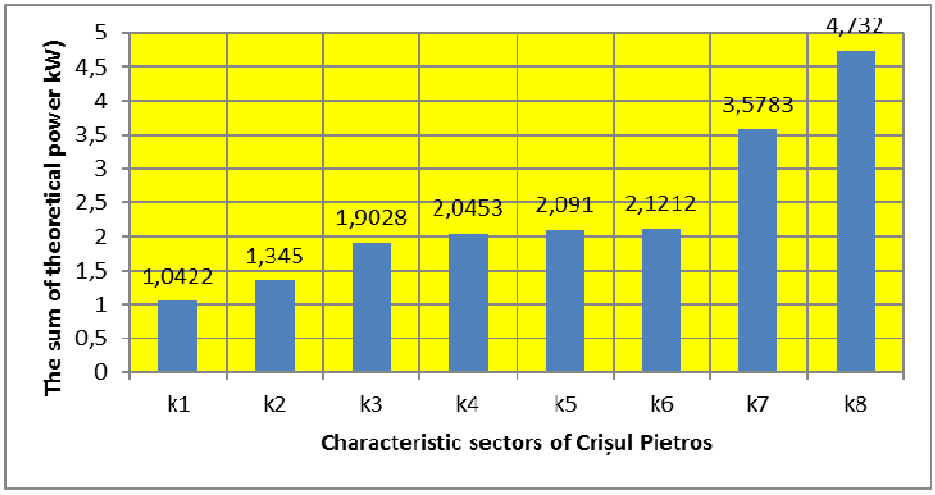

Fig.1. The sum of theoretical power on Crişul Pietros

If we consider that 1 TJ is the equivalent of 277.8 MWh, the average energy produced by CHP Arad, in the period 2005-2010 is 1.389 million MWh. Comparing the values of annual average thermal energy, produced by CHP Arad with the ones theoretical of Crişul Pietros, in the most advantageous section, (the spill) it is noted that in the operating conditions for 24 hours/day, with a 50 % yield, the annual production of 675 908 MWh represent less than half of that produced by CHP.

European and national legislative provisions for CHPs and MHPs.

Lignite CHP Arad. In Romania, the electricity produced in CHPs, at 01.01.2010 represents 57.49 % of the total available power, the share of solid fuels (coal) being 34.28 % higher than that of oil, which represents 23 21 %. (Fig.2.)

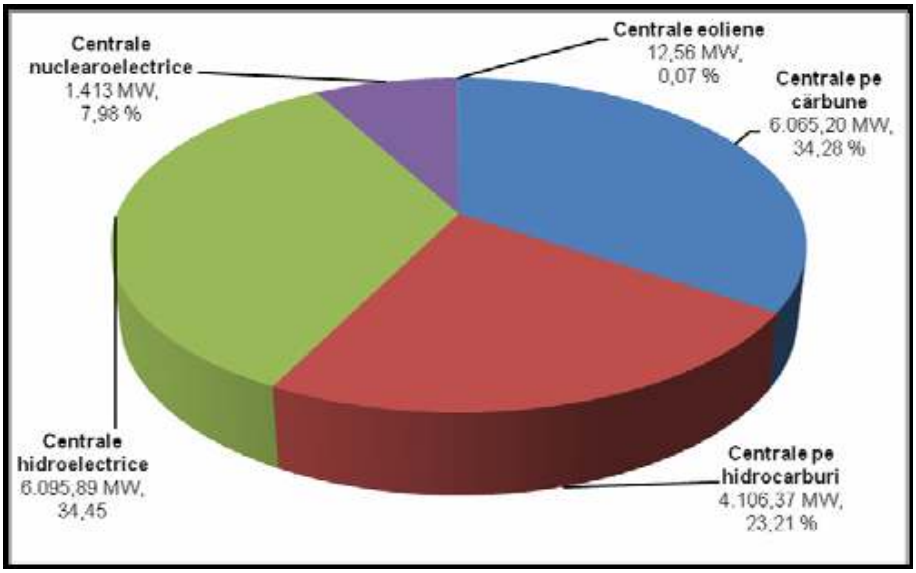

Fig.2. The available gross power of power plants at the disposal of SEN at 01.01.2010 Total 17 693 MW (after: Energy Strategy of Romania, 2013)

Romania's Energy Strategy for 2007-2020 has primarily aimed at providing energy security of the country, in compliance with the new energy policy and environmental EU assumed and with the principles of sustainability and competitiveness. Among the principles of sustainable development in the energy field may include: increasing energy efficiency; promoting the production of electricity and heat with high efficiency cogeneration plants; reducing the negative impact of the energy sector on the environment; rational and efficient use of primary energy resources;

Financing from structural funds and European investment is paid especially for heating and cooling systems and cogeneration of heat and power only if they have a high yield, they are effective in terms of energy and it is guaranteed the fact that the aid contributes to increasing the level of environmental protection. (C.E. 2014 / C 200/01)

In accordance with the above are eligible for this category of aids, in particular the CHPs that have more recent technology, with age under 20 years, on the condition that the made investments to demonstrate the emission reductions of greenhouse gas in the atmosphere.

Opinion of the European Economic and Social Committee on the processing and exploitation, for economic and ecological of industrial and mining waste in the European Union (2012 / C 24 03) highlights the importance of coal for electricity production, to ensure 44 % of gross energy of year 2030 compared with the 2008 level of 41 %.

Analysis of national primary energy resources in Romania, performed to substantiate Energy Strategy, emphasizes the importance of geological reserves of coal, of which huila is estimated that it can cover the production of electricity on 229 years, lignite on 47, followed by natural gas reserves, with insurance 15 years. (Table 4)

Table 4.

The national situation of primary energy resources
(after: Romania's Energy Strategy 2011)

Primary energy resource	Reserves						Estimated annual production	The estimated period of insurance		
	Reserves		Operated under concession		In new perimeters			Geological reserves	Concessioned exploitable reserves	In new perimeters
	Mil t.	Mil t.	Mil t.	Mil t.	Mil t.	Mil t.	Mil t.	Years	Years	Years
Coal										
Huila	755	422	105	38,8			2,2	229		
Lignite	1490	276	445	82,4	1045	133	3,0	47	15	30
Oil fuel	74	72					4,5	14		
Natural Gas	185	159					10,5	15		

Using coal to produce electricity in power plants has the advantage that it is cheaper than natural gas, whose price is constantly increasing, that respond to social commands, providing new jobs, allowing development of coal mining, and thereby reopening of in conservation some units, which create major environmental problems, especially the pollution with mine water.

Power plants cogeneration, whether they use solid fuel or natural gas, may receive financial support during operation, for effective use of resources and, in particular, aid for waste management, provided that contribute to waste disposal by burning. (2014 / C 200/01)

Also, Directive 2009/31 / EC on the geological storage of carbon dioxide, provides that the electricity sector can participate in the auction system to purchase certificates of carbon dioxide emissions as from the year 2013.

Due to financial incentives, provided by the European Community, to the thermoelectric and the mining sectors, has further mining development opportunities, with the condition of using the funds for retrofitting, to raise the economic efficiency and reduce negative environmental impact.

MHPs – Crişul Pietros. While exhausting nature of fossil fuels, the pollution produced by burning them and increased greenhouse effect leading to global warming, imposed to identify the other energy resources, renewable and inexhaustible. Thus, taking into account that hydropower is the cheapest (Fig. 3) in the European Union have formulated a series of

policies and measures for the use of renewable energy resources. (Directive 2009/28 / EC)

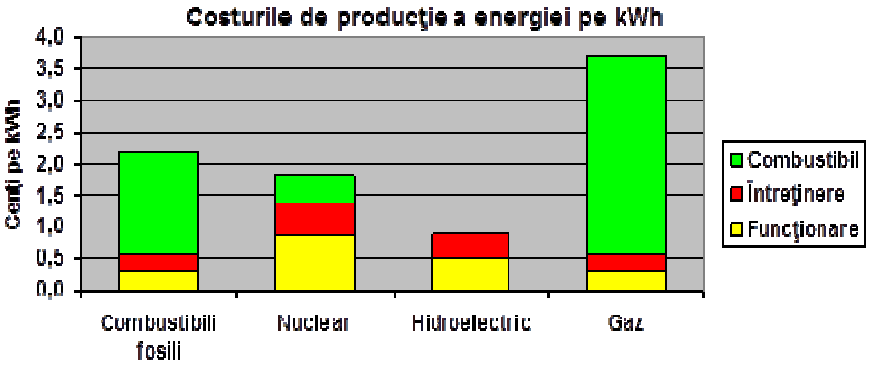

Fig.3. The costs of producing energy from different sources in 2005
(after: http://www.wvic.com/hydro-facts.htm)

Directive 2009/28/EC, also known under the acronym 20/20/20, provides for the EU, until on 2020, a share of energy from renewable sources, in gross final consumption by 20 % and reducing greenhouse gas emissions by 20 %. According to European commitments, Romania has the objective 24 % national share of energy from renewable sources and improving energy efficiency by 19 %.

In order to stimulate the production of renewable energy in our country, Law 220/2008 stipulates that producers of renewable energy benefits from 3 green certificates for each MWh produced in MHPs, with input power of 10 MW and delivered the national energy system.

EC legislation (EC, 2013) specified a series of measures to support the environment and energy, provided that state aids to be compatible with the internal market, among which may be mentioned: aids for energy production from renewable sources; aids for measures undertaken in the field of energy efficiency, including cogeneration and heating system; aids in the form of tradable certificates.

Roadmap towards an Efficient Europe in terms of energy and Council conclusions are calling on the phasing out of environmentally harmful subsidies. (http://ec.europa.eu/competition/consultations/2013_state_aid_environment/draft_guidelines_ro.docx)

As a result of environmental problems related in particular to preserving biodiversity found in MHC sites built in Romania, it was adopted Law 23/2014, for approving the Government Emergency Ordinance 57/2013 amending and supplementing Law no. 220/2008 for establishing the system for promoting energy from renewable sources that "in the period

July 1st 2013 - March 31st, 2017 is postponed temporarily trading of a number of green certificates from those provided in par. (2) for each 1 MWh produced and delivered by producers of electricity from renewable sources ... "

It is planned that during the period between 2020 and 2030, renewable energy sources confirmed, will allow the supply of network at competitive prices, which implies that subsidies and exemptions in balancing market responsibilities should be disposed of digressive. Present guidelines are consistent with this goal and shall ensure the transition to an efficient distribution, from costs point of view, through market mechanisms.

Consequently, aid for electricity from renewable energy sources should in principle contribute to market integration of electricity produced from renewable sources.

If legal provisions aforesaid granting of aid for periods of 10-15 years, current regulations specify that aid is granted only until the plant has been fully depreciated according to normal accounting rules, and any investment aid previously received must be deducted from aid exploitation.

Considering that CHPs produce electricity on basis of consumption, while MHPs producing during peak periods consumption, it cannot total dispense with the production of electricity in CHPs.

National Energy Strategy, having the main aim of ensuring energy security of the country, talks about the need to continue to enhance competitiveness through the restructuring of the heating sector.

CONCLUSIONS

With order to reduce the greenhouse gas quantities**,** discharged into the atmosphere, in EC countries it legislated the amount reduction of energy produced CHPs.

Directive 2009/28/EC, also known under the acronym 20/20/20, provides for the EU, until on 2020, a share of energy from renewable sources in gross final consumption by 20 % and reducing greenhouse gas emissions by 20 %.

Reducing emissions of SO2 and NOx and in suspension particulates respectively, from Lignite CHP Arad within the last years of the period 2000-2008 is due to the plant retooling from 2004, during which were put into operation gas desulphuring installation and electrostatic precipitators for solid particle retention. Nevertheless CHP Arad further pollute groundwater with sulphates, chlorides, sodium, calcium and acid water and the soils on about 800 ha.

Electricity generation using MHPs on Crişul Pietros presents a series of negative influences on landscape and biodiversity. At the same amount of

electricity, produced with a deviation MHP has an impact of 5-8 times higher on biodiversity compared with MHP with dam in the river bed.

The average value of the heat produced by Lignite CHP Arad in the period 2005 - 2008 is 5633.67 TJ. The total hydropower developments of Crişul Pietros allow obtains the maximum power of 4,732 MW. Comparing the average annual values of thermal energy produced by CHP Arad and possible annual energy production on Crișul Pietros, of 675,908 MWh, this is less than half of that.

Due to financial incentives granted by the European Community to the thermoelectric and mining sectors has opportunities of further mining development, in conditions of using the funds for retrofitting with the aim to raise the economic efficiency and to reduce negative environmental impact.

As a result of environmental problems related, in particular to preserving biodiversity found at the MHPs built in Romania between July 1, 2013 - March 31, 2017 is postponed temporarily trading of a number of green certificates granted initially for each 1 MWh produced and delivered by producers of electricity from renewable sources.

If legal provisions sowing the aid grand for periods of 10-15 years, current regulations specify that aid is granted only until the plant has been fully depreciated according to normal accounting rules, and any investment aid previously received to be deducted from aid exploitation.

National Energy Strategy, having the main aim of ensuring energy security of the country, shows the need to continue the enhance of competitiveness through the restructuring of the heating sector.

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