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COGENERATION SOLUTION FOR RECOVERING RENEWABLE RESOURCES EXISTING IN THE EUROPEAN UNION

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Rezumat. *Cogenerarea sau combinatele de energie electrică şi termică (CHP), constituie una din alternativele aflate la dispoziţia Uniunii Europene, pentru realizarea obiectivelor politicii energetice, cu condiţia de a se implementa noi măsuri de sprijin al acestei tehnologii, care asigură reducerea consumului de energie primară, reducerea emisiilor de* CO_2*, diminuarea pierderilor în reţele şi creşterea concurenţei în domeniul pieţei de energie. În acest context, Parlamentul European, prin rezoluţia promovată în data de 26 ianuarie 2009, referitoare la a doua revizuire strategică a politicii energetice, a salutat planul Comisiei pentru industrie, cercetare şi energie, de a urmări cu atenţie evoluţia cogenerării (CHP), dar a reamintit şi chemat Comisia, ca în cadrul revizuirii Planului de acţiune pentru eficienţă energetică în 2009, să identifice şi să promoveze metode, procedee, instrumente care să garanteze valorificarea în întregime a potenţialului de cogenerare folosind resursele regenerabile existente pe întreg teritoriul U.E.*

Abstract. *Cogeneration or the factories that produce heat and power, represent one of the alternatives available to the European Union to achieve the objectives of energy policy, with the obligativity to implement new measures to support this technology, which ensures the reduction of the consume of primary energy, reducing CO2 emissions, reducing network losses and increasing competition in the electricity market. In this context, the European Parliament, by the resolution promoted on January 2009, regarding the second strategic review of energy policy, welcomed the Committee plan on industry, research and energy, to follow carefully the evolution of cogeneration, but called and reminded the Commission, that during the review of the Action Plan for energy efficiency in 2009, to identify and promote methods, processes, tools that will ensure full valorification of the cogeneration potential using renewable resources existing throughout the EU.*

Keywords: cogeneration, energy, heat, power

1. Introduction

Currently, the global energetic system faces a number of key issues such as[1]:

- **limited energy resources**, focusing more and more in some countries, for which the earnings obtained from the energy ensure the base of the entire economic and energetic policy and are a central element in deciding foreign policy situations. A study coordinated by Professor Häfele (Austria) under the

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aegis of the International Institute for Applied Systems Analysis entitled "Energy in a finite world" underlined that we are in a transition phase regarding the energetic resources, when the world will shift resources from the fossils ones to the renewable ones[2];

- **huge increases in energy consumption**, which will double resulting from the data provided in the report "Global Trends 2025: A transformed world" conducted by the National Information Council of the United States of America. Consumption doubling will be determined by both population growth with 1.2 billion by 2025, combined with increased consumption due to the middle class and the huge energy demand of India and China. Analyzing the evolution of gross inland consumption of energy produced in the period 1990-2006 by the world states operating on the energy market, determined on the basis of growth indices with fixed base the year 1990, there is a general tendency to increase, which occurs mainly in South Korea, China, India, Brazil and Mexico: see Figure 1.

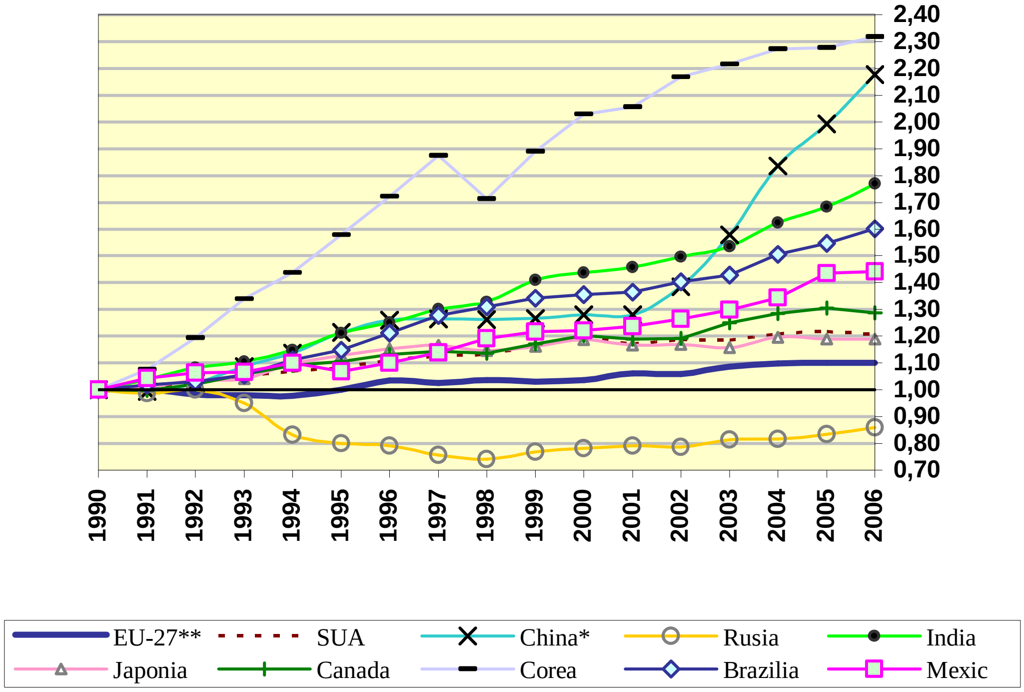

Fig. 1. Gross Inland Consumption (1990=1)
Source: OECD (* Including Hong Kong, ** Source: Eurostat, December 2008)

If we analyze the evolution in the structure of the gross inland consumption of energy, we see that three countries (U.S., EU and China) have over 50%: see Figure 2.

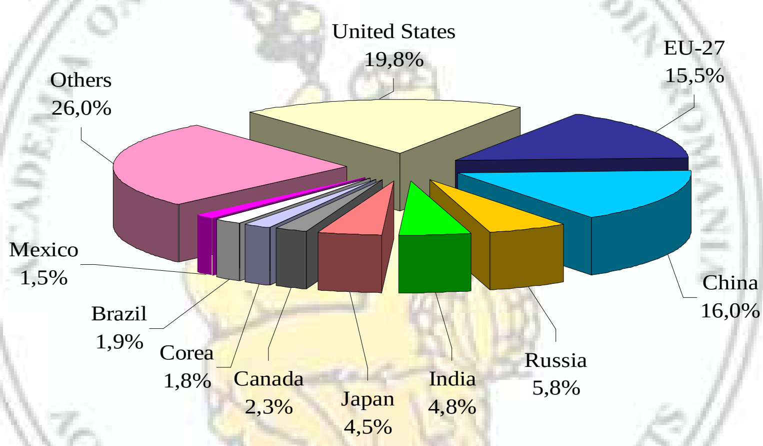

Fig. 2. Gross Inland Consumption by Country (Shares, %)
Source: OECD (* Including Hong Kong, ** Source: Eurostat, December 2008)

For the year 2030 it is forecasted a total demand of energy higher with about 50% than in 2003 and with about 46% higher for oil. This doubling of total energy demand will be determined primarily by the economies in transition due to growth and structural changes in the economy.

- **technology issues**, that relate to both production capacity worldwide, and transport one, which are currently limited. To meet this huge increase in energy consumption it is needed an investment in new technological capabilities, which will allows the reduction of carbon dioxide emissions, renewable energy production and energy efficiency, including in the developed world.

- **management is a key issue** in energy both globally and nationally, which has the role to establish objectives to ensure passage of the energetic system from the current state to a future one, to identify actions and to bring forces involved in achieving the set targets, with the ultimate goal of realizing the sustainable development of the human society.

Major challenges of energy management in the world are represented by the changing and adapting economic activities in order to reduce environmental impact and use of renewable resources and the changing lifestyle of each individual, starting from basic education, which should have as a permanent aim the creation of a responsibility in the energetic sector.

- **the negative impact on environment, including climate change issues**, impose in the following decades the promotion of sustainable development, of an effective energy economy, competitive, with low carbon dioxide, secured from an energetic point of view.

All these developments have led the International Energy Agency forecasts a dramatic transformation of the energy industry worldwide in the coming years and to report current energy policy as unsustainable, since it can not counteract the increase of CO_2 emissions - estimated at 130% by 2050.

On how to tackle these challenges in the energy field there are two different ways of action characterized by the existence or absence of a distinct and comprehensive vision for the future of energy in general.

Adapting to new conditions imposed by the evolving economy, requires the knowledge of the future social - economic forces and the existing trends in developing the technology for the use of energy resources.

2. Cogeneration: viable solution for the sustainable development of European energy systems

Signing the Kyoto Protocol of the Framework Convention of the United Nations on Climate Changes, by the EU states, has set in motion the action of elaboration the strategy for energy policy, which consists of objectives of increasing energy efficiency and reducing the impact on the environment.

Implementation of the first phase of the European Programme for Climate Changes has determined the reconsideration of the position regarding the cogeneration domain, observing that achieving these goals can be realized by using the technology of the simultaneous production of heat and electricity, which compared with separate production of heat and electricity allows energy savings and reducing or avoiding CO2 emissions.

European Parliament and the European Union Council, noting the recommendation made by the European Commission[3] under the terms of the Social - Economic Committee[4] and Committee of Regions[5] decided to take the necessary steps to unlocking the potential of cogeneration in the European internal market of energy, by promoting the **2004 Directive 8/EC of 11 February 2004 on the promotion of cogeneration based on useful heat demand on the internal energy market, which modifies the Directive 92/42/EEC.**

By promoting this directive sought to harmonize specific national circumstances to the European ones, by promoting and developing high-efficiency cogeneration based on useful heat demand and primary energy savings in order to increase efficiency and to improve energy security in energy supply for each member state.

According to the principles of subsidiary and proportionality, Directive 2004/8/EC, is focused on ensuring the framework for achieving goals (e.g. 20-20-20 for 2020), referring to what is necessary to do so that each member state starting from the fundamental elements of European policy in the field of cogeneration are able to choose and implement solutions that meet the national situation.

Defining the notions of cogeneration, *cogeneration of micro and small power, high efficiency cogeneration, useful heat, justifiable economic demand, electric energy from cogeneration, efficiency, quantity of energy produced in cogeneration.*

This definition was adopted in order to create a harmonized base, by putting in accordance all variations used by member states to define cogeneration, both for statistical purposes, as well as for choosing public mechanisms for national support or for establishing the criteria to be considered in determining and assessing the energy efficiency of energy production in cogeneration.

Starting from the basic definition of cogeneration, the directive clears the meaning and notions of ***cogeneration of small power, high efficiency cogeneration, as follows:***

- ***small power cogeneration*** represents the groups of cogeneration with an installed capacity below 1 MWe. The cogeneration group is an assembly of equipment, facilities reunited because of the functional characteristics and that can operate in a cogeneration regime, producing simultaneously in a correlated process useful heat and electricity and / or mechanical energy.

Cogeneration of small power may include ***micro-cogeneration*** represented by *cogeneration groups with an installed capacity below 50 kWe* and ***groups of distributed cogeneration***, such as those that feed isolated areas or limited energy demands in residential areas, commercials and industrials.

- ***high-efficiency cogeneration*** is defined by the primary energy savings obtained from the use of combined vs. separate production of heat and electricity, which must be greater than 10%. In the case of groups of micro-cogeneration and small power it can be considered as high-efficiency cogeneration, the production of energy in the situation of realising primary energy savings.

In order to calculate primary energy savings from cogeneration, The European Commission established in 2006 harmonized reference values for the efficiency of separate production of electricity and heat, which will be reviewed for the first time on 21 February 2011. After this time the review will be completed once every four years, depending on the technologies development and the changes in the distribution of energy sources.

Although by 2010, the determination of primary energy savings can be made using alternative models, to ensure the origin and statistical reports, the amount of electricity from cogeneration shall be calculated using the methodology provided by the Directive.

Factors with a major impact on technical performance and economic activities, determine the classification of cogeneration facilities, as follows:

- cogeneration facilities at a very low power, low power, medium power and high power, defined in terms of electrical power scale installed, which can run from tens of kW to hundreds of MW. Because these areas of electric power are not fixed, determined by norms, different from country to country within the European Community, the ***Directive 2004/8/EC*** establishes groups of very small power (micro - cogeneration) as Pelectrica <500 kW and those with Pelectrica <1 MW defines them as groups of small power (small cogeneration power). In our country, groups are considered medium power, groups Pelectrica <20 MW.

- if it is taken into account the degree of interconnection in the electricity part, cogeneration installations can be isolated, which provides power to a particular consumer, or may be interconnected with available deficiency or electricity (are fueling a certain consumer, but are connected to public network exchanges that are permanent or very frequent electricity). Technical and economic conditions in which the exchange of electricity in a cogeneration factory(CHP) with the public network (both ways) influence the final rate of recovery of such investments.

- and at last the technical solution, and heating type machine, which determines the thermodynamic performance level(efficiency of production of mechanical work) and technical (the maximum possible degree of recovery of exhaust heat from the thermodynamic cycle) and some limitations (i.g. maximum level of heat obtained by recovery), determine the classification of cogeneration solutions in plants with steam turbines (ITA), with gas turbines (ITG), with combined cycle gas-steam (ICGA) and thermal engines (IMT).

3. The main technical and economic aspects of cogeneration plants used in Romania

a. Installations with cogeneration steam turbines are used in the average power, using a simple cycle with reduced parameters of steam at the entrance. In using cycle steam turbine can be chosen two variants, namely:

- backpressure turbine or backpressure and outlet;
- condensation turbine with one or two adjustable outlets.

Using various types of steam turbine is determined by several factors, such as:

- the nature and duration of use of annual maximum demand in the form of heat;
- structure index of consummation determined by reporting the electricity demand to the amount of heat required by the consumer;
- desired degree of independence between the amount of electricity produced and delivered heat;
- the nature of heat (steam or hot water) used to supply with heat and its parameters.

In general, ***backpressure turbines*** are used for heat consumption with high duration of the use of peak flow, when demand for electricity and heat have the same degree of variation. In case of change of the degree of variation of the two different forms of energy, the use of backpressure turbine is disadvantageous because of the strict dependence between the heat flow delivered and the electrical power produced.

The solution of cogeneration with turbines with backpressure recommends the use of turbines capacity dimensioned like this, very close to its nominal value, over a long period of time. During operation the electric power produced is strictly proportional to the flow of heat supplied, with a coefficient of proportionality characteristic of each turbine.

The cycle with simple backpressure, using hot water as an agent into the primary cycle, can loosen up the steam to a low pressure with a good ratio between electricity and heat produced, but production of electricity depends on the consumer of heat, which can be offset by the use of an additional cooling, so as to maintain the production of electricity during summer when the heat requirement is very low. [6]

Turbines with condensation and plugs are used where one wants less dependence between flow rate of heat supplied and the electrical power produced simultaneously. The degree of independence of the two sizes depend on the construction of the turbine, i.e. the dimensioning of the low pressure body or tail of the condensate.

These turbines allow at partial thermal load to produce electric power greater than those determined strictly by the boot. Added power thus obtained is produced under the condensate regime, with specific fuel consumption higher than that for the electrical power produced in the operation of the cogeneration system.

Also, compared with backpressure turbines, these cogeneration facilities allow the production of electricity and in periods when there is not a need to record high heat (summer), with greater flexibility on the ratio between electricity and heat produced.

Greater complexity of the cycle with adjustable condensate and plugs causes higher investment spendings, on the body of low pressure, condenser and cooling system, which, however, recovere through a higher efficiency of electricity production and, by selling electrical energy produced additional.

Cogeneration with steam turbine, operating decentralized, uses turbines in the range 1-10MW, with steam pressure at the entrance of 30-70 bar and temperature of 400-500 ^{o}C[7].

Concluding this type of cogeneration plant although it has the ***advantage*** *that allows the use of any type of fuel*, has the ***disadvantage*** *that it dos not produce the best result in terms of operation with partial load,* which implies ***increased costs of operation.***

b. Cogeneration installations with gas turbines coupled with a boiler are currently used in cogeneration for base-load, with the possibility of using several schemes depending on the type of gas turbine used, such as micro-turbines in centrals of block type, or gas turbines with steam injection (both in the turbine and in the combustion chamber).

Plants with gas turbine combine some qualities of a modern steam turbine, such as the compact construction, high speed, the important power, with characteristic elements: fast start, work with high gas temperature, low-cost and low consumption of water cooling. These technical and economic characteristics, including that they start quickly (generally within 3 - 5 minutes), make that plants with gas turbines to be used for fitting the peak power and reserve plants to be used as a mobile power unit.

Among the ***disadvantages*** of these cogeneration facilities, ***I underline first*** those that have ***a direct influence on the costs*** and increase due to their inability to use solid fuels and a low overall efficiency, etc..

c. Cogeneration installations with combined gas-steam cycle have imposed them selfs in the last decade as an attractive option for production in the same time of electricity and heat, although their performance are being recognized by more than 25 years.

The performance of this facility is approximately 85% in a cogeneration production and about 50% in operation only for producing electricity.

The steam necessary to the steam turbine in condensation is produced in the recovery boiler, powered by heat from the gas turbine exhaust gases. Excess oxygen in the combustion gases allows additional use of fuel burning in the recovery boiler, which is more efficient than combustion in a classic boiler, without the need of prewarming the air.

If an advantage is that approximately one third of the heat recovered from exhaust emissions of the gas turbine can be used to heating at a temperature, which does not affect the production of steam for steam turbine and power produced by it, ***the fact that the gas turbine works with natural gas, is a disadvantage.***

d. cogeneration facilities with internal combustion engines (heat engines with internal combustion) are recommended in the operation of power up to 10MW, is characterized by a total system efficiency of 36-38%, as for energy power to over 90% if all recovered heat is used in a circuit with the heating temperature on the tour about 90^{o}C.

The first characteristic of these engines is the fact that they make the chemical energy of fuel into mechanical energy and heat.

These cogeneration plants, generally equipped with four-stroke engine with the speed of 1,500 rpm for powers up to 5MW (usual maximum for gas engines) can use a variety of fuels, including renewable resources (natural gas, biogas, biomass, lightweight liquid fuels, diesel)

Although, these cogeneration plants, allow the reduction of primary energy consumption because the heat is recovered from the combustion gases, from the cooling system of the engine and from the overcharged system, their use is appropriate for systems with low temperature heating on Tour (120^{o}C).

The types of cogeneration installations listed are among the most widely used in Romania, differentiating themselves mainly through the technological process of cogeneration, fuel used, carrier agent, the heat supply and cogeneration index.

4. Measures taken by the European Union and Member States

In 2006, cogeneration (CHP) covered 13.1% of final energy consumption of the EU, with different weights from one country to another, existing countries where the share reached over 40% as seen in figure no. 3.

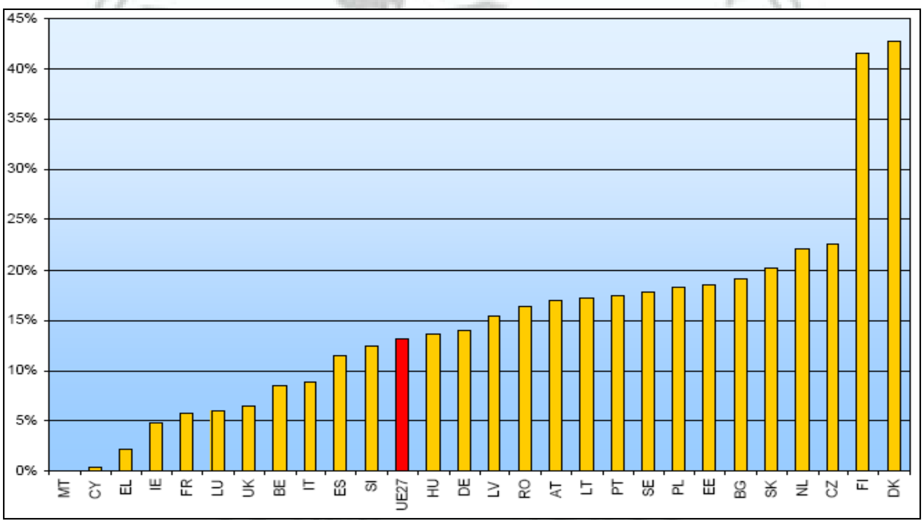

Figure 3. Contribution of energy from cogeneration from CFE Member States, Source: Eurostat 2006

In the EU27, production capacity for electricity from cogeneration amounts up to about 100 GW, representing 13.6% of the total capacity of electricity production over the 27 states. In 2006, electricity produced from cogeneration in the EU27 amounted to 366 TWh, representing 0.9% of total electricity production. The level of production varies greatly from one state to another, positioning it self between 0.3% in Cyprus and over 40% in Latvia and Denmark. [8]

The advantages in terms of energy savings are estimated, in present, at about 35 Mtep / year in the EU27, a saving equivalent to gross domestic product in Austria. Savings in the generation of CO2 are up to about 100 Mt / year.

CHP is a technology to save energy that contributes today with about 2% to achieve annual savings target of primary energy by 20% in 2020.

At present, the countries where cogeneration capacities have a relatively significant share, are those which have a relatively important share of heat. Industrial applications of cogeneration represent another possibility for the future development of this technology.

The evolution of other energy related measures will also influence cogeneration. Such measures relate to energy labelling in 2009 for implementing the boilers of eco-design from the Directive, in micro-cogeneration case, and for cogeneration on a large scale, the proposal to amend Directive 2003/87/EC to improve and extend the community system of trading emissions of greenhouse gases, and proposition for the adoption of the Directive on the promotion of using energy from renewable sources, which will govern the calculation of preferential reducing emissions from power cogeneration using fuels from renewable sources.

Countries like the Netherlands and Sweden link the promotion of cogeneration based on the use of renewable resources, such as biomass, with tax incentives, while Germany, Austria and Denmark grant a legislative support to the cogeneration facilities with high-efficiency, which uses pellets - solid fuels with low humidity, obtained from sawdust, wood chips or even tree bark.

Conclusions

Cogeneration of electricity and heat is a energetic technique very efficient, which allows greater energy savings in comparison with other technologies, including through the use of renewable energy sources, and it can be used in a wide range of capacities, from micro-cogeneration at level 1 kW in private homes, to hundreds of megawatts in heating and industrial plants.

Cogeneration or heat and power factories (CHP), represent one of the alternatives available to the European Union to achieve the objectives of energy policy, provided to implement new measures to support this technology, which ensures the reduction of primary energy, reducing CO2 emissions, reducing network losses and increasing competition in the electricity market.

Moreover, cogeneration as a decentralized technology that encourages local and regional development and employment locally. In rural and isolated areas, (CHP), especially based on renewable energy sources, provide good opportunities for economic development and creating new jobs.

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