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EXPERIMENT ON THE USE OF A NEW SOURCE OF RENEWABLE PRIMARY ENERGY IN ROMANIA FOR RENDERING EFFICIENT THE POWER CO-GENERATION

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Reînnoirea combustibilului din centrale care folosesc cărbune este dictată de prețurile energiei impuse de piața concurențială. Respectarea acestei restricții reclamă scăderea ponderii combustibilelor în costul energiei de la 75% la 35% prin utilizarea unui nou combustibil (porumb) cu o putere calorifică de peste 4000 kcal/kg față de cărbune cu numai 1700 kgcal/kg. Această reînnoire aplicată în România – centrala Oradea conduce la obținerea următoarelor performanțe: reducerea la jumătate a costurilor energiei produse prin cogenerare, energia termică produsă din economii poate încălzi anual 2.10^6 apartamente, resursa umană se reconfigurează prin transformarea minierilor în fermieri cultivatori de porumb diminuarea poluării mediului se reduce total, cenuşa rezultată din arderea porumbului este un îngrăşământ performant pentru porumbul cultivat. Indicatorii tehnico-economici aplicați în acest caz la nivelul experimentului arată că rata de formare a capitalului creşte la 1,5 lei venit/leu investit iar riscurile probabile se acoperă lejer din profiturile realizate anual.

The fuel renewing in the coal-running power plants, has been ordered by the competitive market mandatory prices of energy.
The compliance with this restriction claims the decrease of fuels share to the energy cost from 75% to 35% by using a new type of fuel (corn) with a heat value ober 4,000 Kcal/Kg, compared with that of the coal, 1700 Kcal/Kg. This renewal applied to Romania, Oradea power plant has resulted in the following performances: reducing to half of the co-generation power costs, the thermal power produced from energy savings can heat, annually, 2.10^6 apartments, the reconfiguration of human resource by the conversion of miners to corn-cultivating farmers, completely environment pollution diminishing the ash resulted from corn combustion, is a performing fertilizer for the cultivated corn. The technical-economic parameters, applied in this particular case to the experiment, show that the capital formation rate increases to 1.5 lei revenue/1 invested leu and the probable resources can be recovered, easily, from the annual resulted profits.

Key words: fuel renewing, reconfiguration of human resource ,

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1. Matter wording and attempt motivation

The matter of fuel renewal in power plants which use the coal of medium heat value as a primary energy resource is imposed by the new energy selling conditions on the competitive energy market. The fulfillment of the market requirements, failing major risks claims for decreasing the fuels share to the energy cost from (70÷75)% to (30÷35)%. This change is also sustained by the growth of the new primary source heat value to 4,000 kcal/kg compared with (1700÷2300) kcal/kg, incorporated in the coal, used at present, in Romanian power plants and not only.

The exchange of classical primary resources with renewable ones has claimed financial efforts to design new boilers for a new fuel combustion and re-design the crushing mills. The effects of such renewals are multiple, as follows: decrease of electricity and thermal power cost to half of the traditional cost, possibility of coal revaluation by gasifying and profile changing of the human resource, involved in mining activity, for generating the cultures which form the new structure of renewable resources. In this way, we can reduce prices, obtain considerable resource savings and approach the economic-engineering structures of thermal power plants and cogeneration ones to the power plants burning fules of higher heat value.

2. Experiment description regar-ding the use of the new source of renewable energy in ora-dea power plant

Improving the energy efficiency and promoting the use of renewable energy sources, as well as the sustainable use of natural resources represent priorities, mentioned in chpt. 13, Industrial Policy of the Government Program.

It is also stipulated, in chpt. 18, Environment Protection Policy, "the actions for reducing green house impact gas emissions by improving energy efficiency in the production of power and heat and by **conversion of some fossils user industries to biomas users**, as well as by using other sources of renewable energy".

Taking also into account that pollutants reducing, especially CO_2 and SO_2 is one of the main goals of the world environment protection policy and Romania must align to these goals for the future European Union joining, in S.C. Electrocentrale Oradea S.A., the decision makers lastly, kept on their actions for finding the conversion means to ever more intensely, use renewable and non polluting resources with the view to obtain energy.

Biomass represents a non conventional, solid fuel source, of high heat value, low price and very easy to procure, as it is renewable within a short time. The biomass-running boilers use as fuels the following: cereals, wood dust, wooden wastes, plant remainders resulted from agricultural or wood trades, wooden pellets, s.f.

For fuel selection, it was taken into account that the latter should simultaneously fulfil the following but not limited to the conditions:

- it can be easily procured and in big amounts, necessary for this purpose;
- it shall have the physical-chemical characteristics allowing an appropriate heat value development, under minimum contamination;
- it can raise the least questions regarding its transport, storage, processing;
- it shall be competitive, in terms of energy cost resulted;
- it shall allow the use at maximum of the existing power generation capacities so that the demand for new investments shall be minimum.

Studying all fuel alternatives for biomass-running boilers, we noticed that maize is the most appropriate to the equipment of Oradea CPP1..

The dry corn heat value is 4718 kcal/kg (acc. to some other sources 6,200 kcal/kg). If we also assume humidity (14%), then the specific heat is reduced to 3885 kcal/kg (acc. to other sources 5,300 kcal/kg). (Table 1)

From the experiment determining we took off on some corn samples, we obtained the following results:

Table 1

No.	Sample name	Humidity (%)	Ashes (%)	Heat Value (kcal/kg)
1	Corn grains – sample 1	14	2.2	3759
2	Milled corn cob (grains + cob of sample 1)	14	1.7	3941
3	Corn grains – sample 2	14	1.9	3855

To draw a comparison, the coal used in CPP has on average, the following characteristics:

- humidity = 35 – 45%;
- ashes = 40 – 50%;
- heat value = 1600 – 2000 kcal/kg.

Studying the pedological – climatic potential of Bihor county, it has resulted the possibility of assuring, without any problems, the annual demand of fuel corn for SC Electrocentrale Oradea, from the county only. In this way, it is also assured a market for corn, in deficit at present.

We must underline that it is also solved the biggest problem, raised at present by the fossils combustion, namely the reduction of sulphur oxides pollution, as the corn fails the sulphur content. To be able to operate, within the European environment norms, with the actual thermal power plants, it is mandatory to build a desulphuring system, assuming considerably high investments. For one single boiler (400 – 420) t/h, boilers included in 50 MW units components, the cost of such a desulphuring system is 30-35 million $, around.

The balance of CO_2 production is negative, as the corn absorbs more CO_2 gas, during its growth than it releases, during combustion process.

The photosynthesis process uses CO_2 gas breathed out by beings, or eliminated by industry, generating sugars and oxygen:

$$6\,CO_2 + 6\,H_2O \xrightarrow[clorophyle]{light} C_6H_{12}O_6 + 6\,O_2$$

The above relation can be named the “life equation”.

From the point of views of persons and environment protection, we can also ascertain that corn is safe since it fails exploding, whereas in the case it is wasted, by accident, it fails soil or ground waters contamination

At the same time, the question of combustion-resulted wastes storage is considerably simplified, as these wastes are re-included in nature circuit, as a soil fodder. The test reports on the chemical analysis of the ashes, resulted from corn combustion, which are reports issued by the National Chemical and Petrochemical Research – Development Institute – ICECHIM Bucharest, underline that the resulted ashes is a valuable fodder of high phosphorus and potassium content.

During the session of Oradea Municipality on 15.02.2006 the local Council approved the study regarding the “Conversion of boiler no. 6, 350 t/h from fossil fuel to biomass (corn) operation”.

The modification works started on the spot, by virtue of S.C. Electrocentrale Oradea S.A. own solutions, from the following premises:

- one biomass running boiler uses the fuel in the same way as coal-running boilers;
- the fuel is burnt in the furnace;
- the fuel burns with air intake;
- the resulted heat is transferred, raising the water or steam temperature and pressure.

We underline that modifications are minimum so that the same boiler can burn corn or coal, by case.

On 07.03.2006, there were finished the works on the system afferent to one the 8 fan-mills of the boiler. They were carried out by their own forces, making just the necessary modifications so that they can operate on coal, again, if necessary.

On 07.03.2006, the boiler was converted to corn feeding, instead of coal, using this type of mill and it was noticed an appropriate operation: good milling and combustion, boiler steam rated parameters reaching, excluding other operation matters.

The continuous monitoring system of flue gas emissions on stack no. 2, on which only boiler 6 operated at that time, registered a 12% decrease of SO_2 concentration in the flue gas, when it operated with 6 coal mills and one corn mill, compared with the case of 6 coal mills operation.

The investment for boiler modification, about 30 billion old lei will be depreciated in less than one year.

It results from the performed analyses, that if the other boilers, running on coal at present, are modified too, the total fuel cost, for one year, will be reduced with the company S.C. Electrocentrale Oradea S.A, by over 600 billion old lei which would completely eliminate subsidies.

The corn cultivated area, in Romania, was 3,311,000 ha, representing about 3% of the world total cultivated corn area (about 120 million ha, in 1978).

This is the situation in which the surface of Romania represents 0.16% only of the Planet land surface, there were years when the cultivated area represented more than this: 3,884,000 ha.

From the above data it results that Romania has got a considerable pedological-climatic potential for this type of culture.

Taking 1979 as a reference year with respect to the possible corn – cultivating area, at the country's level and, assuming an average corn output of 8,000 kg/ha, it results:

3,311,000 ha x 8,000 kg/ha = 26,448,000 tons

If we divide this quantity, 50% for food consumption and in zootechnics and 50% for Power generation fuel and is we assume a heat value of 4,000 kcal/kg (4 Gcal/t) it results: **0.5 x 26,488,000t x 4 Gcal/t = 52,976,000 Gcal**.

If we assume half thermal power and half electricity it means that we can produce 26,500 Tcal in one year, by means of which we can provide thermal power for 2 million flats and 30,819,500 MWh electricity (3,518 MW) available power, that is the equivalent of 5 power units of NPP Cernavoda.

The key diagram, destined to the recovery of the renewable energy in the electrical and thermal power co-generation plants, can be watched in figure 1.

We have to underline that not only corn can be used as a fuel. The range of biomass-resulting fuels is extremely diversified and we'd like to mention here, the wastes resulting from sugar of beer processing, wastes of special, stimulating results from the tests and determining made in the laboratory of S.C. Electrocentrale Oradea S.A..

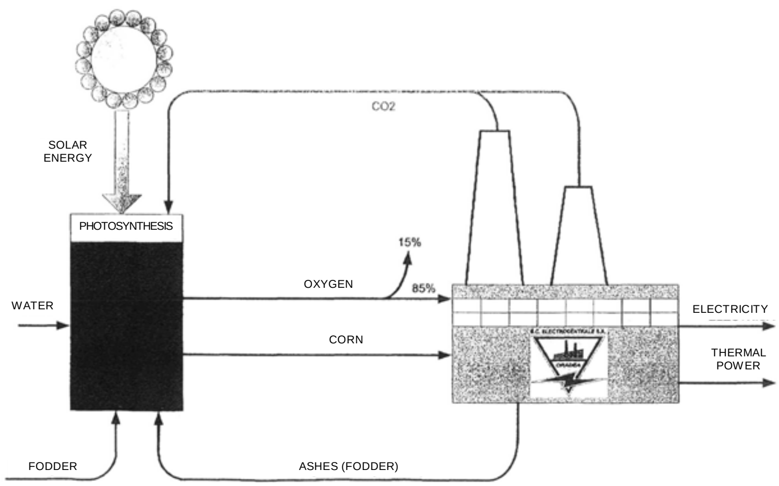

Fig. 1 - Diagram of the renewable resources conversion to electrical and thermal power

3. Energy costs profitability of the renewable fuel new combustion attempt

The analysis of the power cost structure, at the level of national and world power systems, resulted in the following characteristic configurations:

Table 2

Power systems / Cost structure	Romania NPS	FPS – EdF France	WPS – World Power System
Fuel	(0.7 ÷ 0.75)C_{tyear}	0,22 C_{tyear}	0,30 C_{tyear} *
Operation	0,15 C_{tyear}	0,17 C_{tyear}	0,30 C_{tyear}
Manpower	0,07 C_{tyear}	0,21 C_{tyear}	0,08 C_{tyear}
Management	0,04 C_{tyear}	0,35 C_{tyear}	0,25 C_{tyear}
Miscellaneous	0,02 C_{tyear}	0 050 C_{tyear}	0 07 C_{tyear}

* C_{tyear} = yearly total costs

The new type of renewable fuel will allow the coal replacing and also performing the power cost structure similar with the trends reached in the high performing world power systems (Table 1).

The design parameters of the new electrical and thermal power generating structures, allowing the as certaining of the new type of conventional fuel combustion efficiency, are the following:

a. Capital formation rate

$$r_{fc} = \frac{V_{income} + R_{risk\ converted\ to\ savings}}{I_{total\ investment}} \succ 1 \left[\frac{\text{income lei}}{\text{invested leu}}\right]$$

b. Risk correlated to total income

$R_{risk} = p_{failure}\ E_{ni} + I_{sp}\ P_{av} \leq V_{total\ incomel} = p_{ei}\ E_{locally\ consumed} + (p_{external} - p_{internal})E_{exported}$

c. Electrical and thermal power price

$$p_{cei} = \left[\frac{C^{ee}_{tac}}{g_i\ Ep \cdot dv} + t^{ee}_{taxa\ de\ re\c{t}e\c{t}} + t^{ee}_{power\ supply\ distribution\ tax} + t^{ee}_{power\ market\ connecting\ tax} + p^{ee}_{programmed\ profit}\right] < p_{external}\ [\text{lei/kwh}]$$

$$p_{eti} = \frac{C^{et}_{tac}}{g_i\ Qp\ dv} + t^{et}_{axes} + p^{et}_{profit}\ [\text{lei/Gcal}]$$

d. Present total discounted costs, under traditional alternative and in operational researches

$$C_{tac} = \sum_{i=1}^{dv} (1 + r_a)^{-i}\ C_{tan1} \qquad C^{ee}_{tac} = k^{ee}_{breakdown\ key} \cdot C_{tac}$$

$$C^{et}_{tac} = k^{et}_{breakdown\ key} \cdot C_{tac}$$

in which: Ep = produced electricity,
Qp = produced thermal power,
r_a = discount rate =

$$= \left[r_{interests\ to\ credit} + r_{inflation} + r_{risk}\right]$$

g_i = power plant load degree,
dv = equipment lifetime

C_{tani} =

- Traditional Model $= [C_{fuel} + C_{operation} + C_{manpower} + C_{management} + C_{miscellaneous}]$
- Operational researches model $= [C_{sustainable\ development} + C_{commercial} + C_{production} + C_{human\ resources} + C_{economic\ financial} + C_{decision\text{-}comunication}]$

e. Information entropy of electrical and thermal power generation plants

$$E_{\substack{\text{enthropy of}\\ \text{the whole power}\\ \text{plant}}} = 3{,}32\left(-\,p_{s1}^{t}\lg p_{s1}^{t} - p_{i1}^{t}\lg p_{i1}^{t}\right)[\text{beets/event}]$$

$$E_{\substack{\text{enthropy of}\\ \text{electrical}\\ \text{equipment}}} = 3{,}32\left(-\,p_{s2}^{ee}\lg p_{s2}^{ee} - p_{i2}^{ee}\lg p_{i2}^{ee}\right)[\text{beets/event}]$$

$$E_{\substack{\text{enthropy of}\\ \text{thermal}\\ \text{equipment}}} = 3{,}32\left(-\,p_{s3}^{et}\lg p_{s3}^{et} - p_{i3}^{et}\lg p_{i3}^{et}\right)[\text{beets/event}]$$

in which: successful probabilities (p_s) and failure probabilities (p_c) are calculated with the equations, under the form:

$$p_s^t = \frac{t_{successful}^{total}}{t_{calendar}}; \qquad p_i^t = \frac{t_{failure}^{total}}{t_{calendar}};$$

$$p_s^{ee} = \frac{t_{successful}^{ee}}{8760}; \qquad p_i^{ee} = \frac{t_{failure}^{ee}}{8760};$$

$$p_s^{et} = \frac{t_{successful}^{et}}{t_{calendar}}; \qquad p_i^{et} = \frac{t_{failure}^{et}}{t_{calendar}};$$

$(p_s + p_i) = 1$

Both total enthropies and those for electrical and thermal equipment show the disturbance degree of the studied power plants, estimated in terms of losses from boilers, turbines, power generators and within supporting installations. If enthropies minimum values are achievable by reducing the failure time periods, then the solution of using the new type of renewed primary resource can be by no doubt accepted.

4. Conclusions on the renewal fuel structure for electricity and thermal power generation, at national level

The experiment on primary resources (coal) conversion to renewable resources (combined with other renewable products) allows decreasing the share of fuel cost to the cost of electricity and thermal power, produced in one co-generation power plant, from 75% to 35% which allows the performance of finite products diminished costs, to 50% around, compared with the use of coal.

The renewable resource (corn) providing for power generation purpose, does not raise special questions. More over, Romanian experts show the advantages of this device, creating opportunities for upgrading activities and facilitates increasing the profit, considerably, in Romanian co-generation power plants.

The feasibility study, issued for the implementation project of the new type of fuel (corn) to CPP Oradea, shows that the following performances can be obtained:

- Annual quantity of renewable fuel per year $24{,}448 \cdot 10^6$ tone
- Sold thermal power 26500T assuring heat for $2 \cdot 10^6$ flats
- Present total discounted cost of the produced power unit is 0.5 of the cost of the same power unit, produced by traditional means
- Re-configuration of human resource by miners conversion to corn-cultivator farmers, meant to efficiently operate the new co-generation power plants of the National Power System
- Environment pollution reducing as the new fuel resulting flue gas allows the SO_2 concentration diminishing by 12%, compared with the old fuel type. In addition, the corn-combustion collected ashes can be used, without any risks, as a fodder for the new cultures and thus, it allows obtaining a higher production than the preceding year.

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