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CENTRAL NUCLEAR ELECTRIC, A FUTURE OF ROMANIAN ENERGY

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Rezumat: *Statisticile oficiale ne arată cum an de an creşte ponderea energiei electrice produse în centrale electrice nucleare. Cele mai dezvoltate programe energetice nucleare sunt în: Statele Unite ale Americii, Franța, Japonia, Germania şi Canada. Deşi România a fost printre primele țări din estul Europei care a avut un program de cercetări nucleare, trecerea la reactoarele nucleare de putere s-a făcut extrem de greu şi de lent. Implicațiile acestui proces decizional au fost în primul rând de ordin politic şi apoi de ordin economic. Au fost o serie de oscilații între Sistemul WER oferit de URSS şi Sistemul CANDU-PHWR oferit de Canada. Considerând reactoarele nucleare WER insuficient protejate împotriva unui accident nuclear, precum şi controlul total solicitat de fosta URSS asupra ciclului combustibilului nuclear, factorii de decizie de la noi au optat pentru reactorul CANDU, alimentat cu uraniu natural, moderat şi răcit cu apă grea.*

Abstract. *Official statistics show the year increasing the share of electricity produced in nuclear power plants. The most developed nuclear energy programs are: the United States, France, Japan, Germany and Canada. Although Romania was among the first countries in Eastern Europe that had a nuclear research program, switching to nuclear power reactors has been extremely difficult and slow. The implications of this decision-making process were the first political and then economic. There were a series of oscillations between Wer system offered by the USSR and the CANDU-PHWR supplied by Canada. Considering nuclear reactors Wer insufficiently protected against a nuclear accident, and the total requested by the former Soviet Union on the nuclear fuel cycle, the decision of us have opted for CANDU reactor, fueled with natural uranium, moderated and cooled with heavy water.*

Keywords: Information, interaction systems, biotic and abiotic

1. Energy Resources [1,2]

1.1. General

Energy isinvolved in daily life in two different ways:

- Energy spent on heating, lighting, provision of means of communication, etc.;
- Energy integrated by manufacturing, the items that we use.

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In Table 1 are some current products and activities, measured in tonnes oil equivalent (t = 23.9 Joule 1T, T = 1012).

Table 1. Oil equivalent of several products and current activities

Objects or activities	*Equivalent consumption*
1 kg sugar	400 g oil
1 kg fabric synthetic	5 kg oil
Construction of houses of 100 m2	10 t oil
Heating	2.3 t oil/ year
Lighting	200 kg oil/ year
Manufacture a car for 1 tonne	1,3 t oil
Use a car for one year	1,3 t oil

What factors determine the socio-economic development demand for energy to meet basic needs and enhance the level of civilization of a society and are the means and resources to meet those needs? Here are two questions whose answers are crucial for establishing a strategy for energy development.

Energy demand is governed by the evolution of two main factors, namely: population growth and economic growth, expressed as energy consumption per capita.

Resources needed to meet energy needs can be addressed taking into account:
- Their distribution between the various politico-geographical zones of the planet;
- Considering the development of various resources in the share of energy supplied;
- State of development of methods for conversion into electricity the energy contained in various resources, both Regenerative these having a direct influence on the cost of using various resources.

In order to estimate the competitiveness of nuclear energy compared with other energy resources (such as coal or oil) we refer to as the components of the costs of nuclear power.

A cost analysis should take into account three basic elements:
1) cost of investment in construction CNE: while nuclear power plants of 600 MW that is 1700-3000 dollars in 1980/kw installed, it varies in the same power, between 950-1200 and 750-900 for coal to oil. These costs decline with increasing installed power;

2) the cost of fuel is between 9500-10500 U.S. dollars/kwh (for reacting with water under pressure) and 5000-7000 U.S. dollars/kwh. (for the heavy water reactor). For coal and oil that these costs are 18-36 and 44-72 (x10 U.S. dollars/kWh);

3) the cost of maintenance and repair power of 600 MW is $ 22 for LWR in 1980/kw; 29 for the heavy water reactor (HWR), 25.8 for coal plants and 15.3 for oil generation. This cost decreases with increasing installed power.

The specific economic and geographical areas which are located in the power lead to the inability to specify the values for single feasible costs above.

A cost analysis of energy dependence in terms of generated power, including those central to that entered into service in 1990, shows that nuclear energy is the net cost lower than the energy produced by oil and is comparable to the cost of energy from coal. In comparing the updated average cost of different types of power is noticeable lack of costs to fuel power plants due to specific hydro recuperative hydraulic resources. The existence of nuclear power, and partly justifies the gross installed power CNE, entailing more and more countries using nuclear energy for peaceful purposes (Table 2).

Table 2. Construction of CNE evolution in the world

Years	*1960*	*1965*	*1970*	*1975*	*1980*	*1985*
Gross installed power	1200	8100	22800	80900	21ooo	224000
Number of reactor	29	70	103	182	238	283
Countries involved	5	10	15	19	29	31

1.2. CNE-type classification

In Table 3 are listed the main types of nuclear power, and the last section of the table one can see some features on the technical solutions adopted in the various types of nuclear power, putting the focus on fuel issues and those related to clustering primary circuit elements jacket.

Table 3. CNE-type classification

CNE type (fig.)	*Fuel*	*Mode-rator*	*Cooling agent Type pr. T0C*	*Effi-ciency*	*Proposed technical solution*
G.C.R. (3.8, a)	Natural uranium	Graphite	CO_2 30 400	29%	Magnox siliques area of active GA in the before-compressed concrete
H.T.G.R. (3.8, b)	enriched uranium **90%** thoriu	Graphite	Helium 30,5 750	42%	Combined bile in ZA or bars in concrete and GA before-compressed
P.W.R. (3.8,c)	enriched uranium 3,5%	Water	Water 145 320	32%	ZA in the pressure vessel found with GA jacket.
B.W.R. (3.8, d)	enriched uranium 2,5%	Water	Water and steam 70 265	32%	ZA in the pressure vessel in radioactive steam turbine
P.H.W.R. (3.8, e)	Uraniu natural	Heavy water	Heavy water 100 300	30%	The pressure tubes roll with GA jacket
LM FBR (3.8, f)	Plutonium and natural uranium	-	Solid Liquid 6 580	40%	ZA and the establishment of heat Na-Na Na in the bath tub; secondary circuit water with Na-Ga

2. Electrical nuclear power

CANDU systems described in this paper are for the central type, with a power of 600 MW, they are essentially similar to those for a central 950 MW. There are several reasons why nuclear power CANDU type plays an important, if not first on the list of nuclear plants with the best performance. The basic principle of CANDU project consists in bringing an economy and maximum use of neutron fuel cycle opened with natural uranium. As a moderator and heat using heavy water (D_2O).

2.1. Central location

General conditions imposed on the construction site where they are to build a nuclear plant are as follows: Central should be in close proximity to a source of water flow with large area of land for power should be sufficient to ensure a buffer zone at least 1000 m from the reactors, Central must be conveniently located so as to be easily integrated into the electric utility grid, an ideal place for the location of a nuclear power plant is relatively new ground plan with a structure of sedimentary rock having a thickness of several meters above water level, whereas that in such conditions the costs of construction and time required to prepare the construction site would be considerably reduced; suitable means of access to land-or rail-road in order to transport heavy equipment. If the plant site is located on the course of waterways, use access to river transportation equipment most difficult.

2.2. Buildings and structures

Reactor building

The building houses the reactor nuclear reactor and auxiliary capacities, the primary heat transport, equipment and fuel handling instrumentation. Tire is separated from all other internal structural systems. This creates flexibility in construction and exclude interdependence of tire wall and other structures.

Building for ancillary services

Building houses for auxiliary services equipment which may be located outside the reactor building, general equipment such as workshops for maintenance of equipment and laboratories, located in the space from this building. Scheme sharing rooms in this building provide safe and efficient in operation both in terms of traffic, areas of radiation as well as links between the spread of the plant buildings. Equipment for irradiated nuclear fuel storage is also located in the vicinity of nuclear tire.

Turbine building

The building comprises turbine hall turbine, auxiliary equipment room and 2 rooms with a single floor. Room for auxiliaries is provided space for the distribution of electricity. Factory water treatment plant and diesel generators are located on a ramp in the annex buildings. In the turbine hall cranes (bridge cranes) used for lifting turbo-generators works and maintenance and auxiliary equipment. Turbine building has an infrastructure of reinforced concrete, a steel superstructure, the steel beams for the roof, walls and insulated metal roof.

Building cooling pumps

Building pumps is built from a concrete infrastructure that are located pumps cooling of condenser, pumps for water processing, fire pumps, screens, pumps and lattices laundering screens. A steel superstructure serves location engine pumps. The roof is fitted with seats for access to the work of installation and maintenance of pumps.

The safety

As with most metals, decreasing their fuel sheath resistance at temperatures very high. Sheath integrity is jeopardized where the accident takes place which makes cooling more fuel to be reduced to the power which it produces.

If such an accident occurs, the process of the reactor can often stop the activity or to moderate effects. Those running these operations are safe systems. They are independent of the process and independent of each other both in terms of both functional and physical and are not used in daily operation of the plant.

When necessary, they may be making off the reactor (the stop), the heat discharging residual fuel (cooling system damaged a reactor and those that prevent the Spreading of radioactivity in the environment that can escape from the reactor (systems of tire).

In support of these systems Friday special security systems that provide alternative sources of electricity (supply system crash with electricity, and water cooling).

The stop

There are two systems for stopping the reactor, with full capacity, each to be able to stop functioning reactor. The two staging systems are independent from each other physically and functionally. Functional independence is assured because of different principles of achieving shutdown: bare solid stainless steel with boron (1 system) and direct injection of liquid absorbent of neutrons in the moderator (system 2). Independence of physical systems is achieved by closing the vertical arrangement of elements stop using the top of the reactor and placing the tubes horizontally using the injection is to the sides of this reactor.

The safety drapery

These systems discharge heat originating from the reactor fuel and ensure that the release of radioactivity following the reactor shutdown after an accident does not exceed limits specified in the Guidelines for the Control Economic Community (which are consistent with those indicated by the International Commission on Radiological Protection).

The auxiliary safety

These systems can be used for normal operation of the plant and are used to support the operation of safety systems.

Grouping systems

To ensure protection against accidents with low probability of occurrence such as fire or local projects (for turbine blades, air attacks), the plant safety systems and drapery safety auxiliary systems are divided into groups that are independent one from another in terms of functionally and physically.

Each group is intended to perform the following functions: to stop the reactor, to remove heat from the fuel reactor to prevent the occurrence of accidents during the operation, which could jeopardize the safety barriers, to provide information necessary to ensure the supervision plant after the accident.

Systems that meet these safety systems are stopping the nuclear reactor, the normal processing system which closed normal electricity supply systems and water service, the emergency cooling of the reactor active zone to evacuate heat; tire systems which absorb any amount of energy released accidentally deliverance prevention radioactivity, which could result from such accidental leakage of energy; main control room or area to control secondary surveillance power by accident.

Nuclear reactor

The reactor currently in various construction consists of a cylindrical vessel (roll) containing moderator, heavy water, the control mechanisms and reactivity of the 380 fuel assemblies channel.

The main features of CANDU-type reactor are:

a) active area of the reactor is not designed as a huge container of pressure, but as a structure that contains channels with small diameter for nuclear fuel;
b) systems separate moderation, and cooling in heavy water;
c) opportunities to go to refuel nuclear fuel;
d) reactive devices that have not run at high temperatures or pressures;
e) fuel consists of natural uranium;
f) the negative consequences of reactor operation are limited whereas the excess of radioactivity due to nuclear fuel is low and the lifetime of neutrons is relatively long.

Channel of the fuel assemblies roll tubes containing the fuel and heavy water (cooling agent). Area of fuel channel tube roll is filled with gas (CO_2) to provide thermal insulation. To provide the heat dissipated by the moderator fuel assemblies, and heat of interaction with fission neutrons and gamma radiation, reactor is provided with a cooling system.

Roll is supported by the head protection, which protects areas of operation of the machine-loading fuel discharged by the reactor active zone.

Roll and the head protection are placed in a chamber of steel and concrete filled with light water which serves both as a cooling as well as biological protection.

The absorption of neutrons, both the liquid and solid as well, are used to control reactivity. Stopping fast reactor is stopped by bars or by the injection of liquid absorbent materials for neutrons, „liquid poisons" the moderator.

Each of the 380 fuel channels consists of a pressure tube alloy niobium-zirconium, expanded at each end in a terminal fitting in stainless steel.

Near the external fitting each terminal is a space which are attached to supply pipes, incoming and outgoing.

The closure of the channel consists of a flexible disk (closing) mounted on a body that is firmly in fitting air-tight terminal through a set of adjustable trimmer.

Plug protection is contained in each terminal fitting, where it crosses the end of protection. Both stopper protection as well as the closure of the fuel channel can be removed and returned to the car-load of fuel discharged during the fueling.

The reactor is fueled with natural uranium in the form of pills uranium dioxide (UO2).

Approximately 29 pills, placed end to end and closed in a sheath of zirconium lloy, forming the fuel. Thirty-seven such elements are assembled into a fuel = Denmark. Each fuel channel contains twelve such installments.

Tire

Envelope includes all components of the nuclear reactor, because failure could lead to the release of large quantities of radioactivity to the public. Given the large amount of energy accumulated in the cooling of the reactor, the tire must withstand a significant increase in pressure. The criterion for determining the effectiveness of the tire is full of losses during an excursion pressure (increased pressure above the normal return after a period of time). To meet the design requirements for losses shall be taken two ways. The first tire design involves minimizing the rate for sparkling. The second involves a system that will absorb the energy released, jacket, top to reduce the pressure and duration of trip pressure.

The absorption of energy consists of a source of water spraying system, with valves to open and the air coolers. The tire consists of a concrete structure before tense- after tense lined with plastic, a spraying system with automatic initiation; coolers air, an exhaust system and air purification with filters; holes for air access, a system with auto-open-closing tire, consisting of all pipes valves open or may open during normal operation, an automatic immersion.

If there is a major defect in the transport of heat, pressure and increases the building in case of excess of 3.5 kPa (0.5 psi) is closing the tire (if closing has not been triggered by a signal cessation of activity). Other sensors provided throughout the reactor will cause the closure of the reactor, and when necessary immersion system can be operated manually. Immersion system will start to operate automatically in an excess of 14 kPa and stop when the pressure drops to 7 kPa.

Operation can be continuous or cyclical, depending on the seriousness of the accident.

Condensation that occurs on the walls of the building and operation of the cooling circuits of the building reduce the air pressure of 7 kPa to the atmospheric pressure. The vapor recovery and air drying clean atmosphere tire when the dew point reached about 160C. This stage is followed by purging air fresh downloaded by circuit drying and ventilation system with air filter, remove the particles and so the radioactive iodine before the air is released into the air.

If a minor accident occurred in the transport of heat, refrigeration systems in the building will compress the cooling agent unloaded transport system of heat and pressure will keep building to the atmosphere.

Gamma activity, if pipeline before discharge from the ventilation system and / or the vapor recovery will produce signals that will close the dampers and tire valves to prevent the sparkle in the environment.

Issuance of a fission product in the machine room supply fuel produced as a result of the fall of one or more fuel elements will be made to discharge piping system of ventilation and insulation will cause tire.

Camera car fuel supply, boiler room and niches can purify the train through filters of the ventilation system of building the reactor to remove particles and radioactive iodine before the release of air in the atmosphere.

Heavy Water Management

Central has been designed that can be prevented any loss of heavy water (D_2O) of reactor systems.

Conduct safe water is heavier by using extensive joints by welding and a lower number as the joints in the circulation of heavy water, isolation (separation) as possible on the joints of the mechanical system and heavy water the light water system, the existence of a system for recovering heavy water as a liquid; building containing heavy water is weathertight and have a minimum of ventilation system to prevent vapor removal, the air in the building is kept dry with closed circulation systems and drying so that any increase in the level of moisture can be detected immediately. Heavy water vapor from the drying systems are restored, and rich.

System deutering and non-deutering

Resins used in columns of ion exchange in the transport of heat and system containing D_2O moderator. In the recovery D_2O resins are processed (non-deutering a leak down through the layers of H_2O resin) of the deutering and non-deutering.

Similarly, when the resins used for ion exchange are received from the power devices, they are are also processed (deutering through a passage from the bottom up by D_2O of the resin layer to remove H_2O).

Resins used for ion exchange in each system are processed separately and each part processes of D_2O is distorted, corrected and transferred to the cleaning of D_2O.

System cleanup

The cleanup of the D_2O of impurities, except water, contains three columns of ion exchange, a charcoal filter with two pumps and supplies. Columns of ion exchange removes ions of boron, lithium and iron, and other products of corrosion. Columns removed in November, also fission products such as radioactive iodine and retain. Charcoal filter removes oil present in heavy water and impurities such as amines and carbonates. D_2O cleaned is transferred to the enrichment of D_2O.

The vapor recovery

In the reactor building is a system for recovering vapor D_2O designed to maintain a dry atmosphere in areas where leaks can occur in D_2O. These areas are divided into three groups, each serving a portion of the system.

I. Areas accessible only during the reactor is closed as: areas in which the car with fuel supply, boiler room, including areas in which the cooling circuit of the reactor; room moderator (excluding the portion of the equipment around).

II. The moderator-space around equipment moderator.

III. Areas accessible during reactor operation: access routes for maintenance operations at car fuel supply to the monitoring room.

The collection D_2O

This system is intended to collect D_2O since the mechanical components in the reactor building and evacuated D_2O equipment before it goes to maintenance works.

D_2O is transferred from the reservoir by two pumps be to control system pressure and water or, when it was split on the cleanup of the D_2O.

The enrichment of D_2O

The enrichment of D_2O separated by recovery, a mixture of H_2O and D_2O in a distillation education, richer in water than light and the original combination in a lower richer in heavy water than the original combination.

The system supports enrichment mixtures ranging from 2% to 99% D_2O and enriches făcîndu them to reach the reactor type 99.8% D_2O. The higher distillation has a concentration of less than 2% D_2O.

Supply system with D_2O

Supply system with D_2O receives D_2O from two sources: fresh D_2O received from the reservoir or container; D_2O enriched received from the enrichment. 4 The storage tanks supply system with D_2O containing water for a moderator or a transport system of heat. The four working tanks and storage equipment for D_2O with a rich content of isotopes during normal reactor operation.

Nuclear fuels

Throw joined two of the composition of the used nuclear fuels (Table 4). We will also show compatibility with the cooling of metals and uranium dioxide (UC) and uranium carbide (UO_2). This is a very important aspect in the use of nuclear fuel in the reagents (Table 4).

Time spent nuclear fuel in the area of active nuclear reactor in a nuclear unit is only a stage in the cycle of production and reproduction of nuclear fuel.

Table 4. Composition of the used nuclear fuels

Name	Uranium Dioxide	Uranium carbide
Symbol	UO_2	UC
Form	sintered powder	cast bar
Density	10,6	13,5
(g/cm3)	86,9%	95%
Content:	0,1	0,1
Uraniu	10	10
Ag ppm	0,2	0,3
Al ppm		4,5-5%
B ppm	5	5
C 180 ppm	0,2	0,2
Ca ppm	10	10
Cd ppm	1	30

Cr ppm	0,02	0,01
Cu ppm	10	10
Dy ppm	25	50
F ppm	0,oo5	o,oo5
Fe ppm	1	20
Gd ppm	2	15
Mg ppm	0,5	4
Mn ppm	15	15
Mo ppm	-	100-300
Ni ppm	-	50-200
N ppm	10	10
O ppm		
Si ppm		

ppm - parts per million

Table 5. Compatibility with agents and cooling metal to UO_2 and UC

Material	UO_2	UC
CO_2	good to 900°C	rapid oxidation at 500°C 8 atm
H_20	good to 300°C	decomposed above 80°C
Hydrogen	good to high temperatures	compatible to high temperatures
Na-liquid	behavior variable in testing	compatible at 800°C for one month
Zirconium	responds to over 800°C	compatible to 1000°C
Stainless steel	good to 600^0C	react to 1100° C
Melting temperature	2750 40^0C	2350^0C

To have a clear picture of the nuclear fuel cycle in the quantities involved, consider that there should be a comparison of this cycle with another cycle fuel energy widely used today, such as coal (Table 6).

If nuclear power reactor using reproductive or type LMFBR (with fast neutrons using cycles 238 U, 239 Pu and reusing plutonium) or type HWR (cycles with 232 Th, 233 U), while in Table 7 are given consumption the fuel balance in the functioning of various fuel cycles.

Table 6. Fuel consumption and waste to a central 1000 Mwe

Fuel consumption	*Schedule*	*Daily*	*Annually*
Coal	345 t	8300 t	2300000 t
Uranium	0,15 kg	3,7 kg	1 t
Production of waste coal (ash)	34,5 t	830 t	230000 t
Uranium (overalll)	1,33 kg	32 kg	11,5 t
Highly radioactive waste	0,13 kg	3 kg	1,1 t
Other wastes	1,2 kg	29 kg	10,5 t

- equivalent of a train with 100 cars per day

Table 7. Fuel consumption equilibrium

Type of reactor	*Fuel cycle*	*Fuel consumption (kg/MW.year)*	
		Uranium	*Thorium*
CANDU	natural uraniumpassing through a reactor	167	-
	1.2% enriched uranium passing through a reactor		
	Plutonium/Uranium	118	-
	Uranium 235/Thorium	70	-
	Thorium self-susteined	32	1
	enriched uranium passing through a reactor	-	2
	Recycled uranium	200	-
	Recycled Plutonium/Uranium	170	-
LWR		125	-
LMFBR	Plutonium/Uranium		-

Use of nuclear fuel in CNE - CANDU presupposes the existence of a deposit for radioactive waste.

In the CANDU-CNE and the other for the operation of its systems: the moderator, pumps main transport system for transport of heat, power and control instrumentation, energy, safety systems and protection.

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