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In pursuance of Article 73 paragraph 1 of the Law on Energy ("Official Gazette of Montenegro", No. 28/10), the Ministry of Economy has enacted the following

RULEBOOK
ON TYPES AND CLASSIFICATION OF THE POWER PLANTS FOR
ELECTRICITY GENERATION FROM RENEWABLE SOURCES OF
ENERGY AND HIGH EFFICIENCY COGENERATION

Purpose
Article 1

This Rulebook shall prescribe types and classification of plants for production of electricity from renewable sources of energy and plants for high efficiency cogeneration per groups.

Types of plants using renewable energy sources
Article 2

The plants for production of electricity from renewable sources of energy are:

- 1) hydropower plants;
- 2) wind mills;
- 3) power plants using at least 90 % of primary energy at the annual level from solid biomass (solid biomass power plants);
- 4) solar thermal power plants;
- 5) power plants using at least 90% of primary energy at the annual level from solid waste (solid waste power plants);
- 6) power plants using at least 95% of primary energy at the annual level from the waste gas and facilities for waste water treatment facilities (waste gas power plants);
- 7) power plants using at least 95% of primary energy at the annual level from the biogas from waste and residues of the agricultural and food processing industries (biogas power plants).

Types of plants for high efficiency cogeneration
Article 3

For the purpose of this Rulebook, the plant for cogeneration is the plant intended for simultaneous production of the electrical power and heat, which use the energy of fuel and/or energy from the renewable sources as primary energy.

The plants defined under paragraph 1 of this Rulebook are plants that use:

- 1) combined processes of gas and steam turbine;
- 2) non-condensing steam turbine;
- 3) condensing turbines with steam reduction;
- 4) gas turbines with use of waste heat;
- 5) internal combustion motors;
- 6) micro-turbines;
- 7) Sterling motors;
- 8) burning cells;

- 9) steam machines;
- 10) organic Rankin's processes;
- 11) other technologies for simultaneous production of electrical/mechanical energy and heat in one process.

Plant for high efficiency cogeneration is the cogeneration plant of:

- 1) installation strength less than 1 MWe** which saves primary energy;
- 2) installation strength exceeding 1 MWe which saves primary energy for at least 10% compared with the total consumption of the primary energy at separate plants for electricity and heat production.

Primary energy saving referred to in paragraph 3 of this Article is a relative saving of the primary energy compared with the equivalent production at separate reference plants which is calculated in accordance with methodology attached in Annex 1, which represents an integral part of this Rulebook.

Classification of plants for production of electricity from renewable energy sources per groups Article 4

Plants for production of electricity from renewable energy sources are classified according to following groups:

Group 0.1. – plants with the installed strength not exceeding 1 MW connected to the distribution system:

0.1.1. hydropower plants:

- 0.1.1.1. of installed strength upto 100 kW(micro hydropower plants);
- 0.1.1.2. of installed strength exceeding 100 kW (micro hydropower plants);
- 0.1.1.3. hydropower plants at the existing infrastructure, such as pipeline and/or dam;

0.1.2. windfarms;

0.1.3. solid biomass plants from:

- 0.1.3.1. forestry and agriculture;
- 0.1.3.2. wood-processing industry;

0.1.4. solar plants:

- 0.1.4.1. on buildings or engineering constructions;
- 0.1.4.2. as independent objects;

0.1.5. solid waste plants;

0.1.6. waste gas plants;

0.1.7. biogas plants;

Group 0.2. – plants with the installed strength from 1 MW to 10 MW connected to distribution or transmission system:

0.2.1. hydropower plants;

0.2.2. windfarms;

0.2.3. solid biomass plants from:

- 0.2.3.1. forestry and agriculture;
- 0.2.3.2. wood-processing industry;

0.2.4. solar plants;

0.2.5. solid waste plants;

- 0.2.6. waste gas plants;
- 0.2.7. biogas plants;
- Group 0.3. - plants with the installed strength exceeding 10 MW connected to transmission system:
 - 0.3.1. hydropower plants;
 - 0.3.2. windfarms;
 - 0.3.3. solid biomass plants from:
 - 0.3.3.1. forestry and agriculture;
 - 0.3.3.2. wood-processing industry;
 - 0.3.4. solar plants;
 - 0.3.5. solid waste plants;
 - 0.3.6. waste gas plants;
 - 0.3.7. biogas plants;

Group O.N. – plants that are not connected to the distribution or transmission system:

- O.N.1. hydropower plants;
- O.N.2. windfarms;
- O.N.3. solid biomass plants from:
 - O.N.3.1. forestry and agriculture;
 - O.N.3.2. wood-processing industry;
- O.N.4. solar plants:
 - O.N.4.1. on buildings or engineering constructions;
 - O.N.4.2. as independent objects;
- O.N.5. solid waste plants;
- O.N.6. waste gas plants;
- O.N.7. biogas plants.

Classification of plants for high efficiency cogeneration per groups Article 5

The plants for high efficiency cogeneration are classified in following groups:

Group K.1. – plants for high efficiency cogeneration of the installed strength upto 1 MWe
Connected to distribution system:

- K.1.1. of installed strength upto 50 kWe (micro plants for cogeneration)
- K.1.2. of installed strength exceeding 50 kWe (mini plants for cogeneration);

Group K.2. - plants for high efficiency cogeneration of the installed strength from 1 MWe to 10 MWe connected to distribution or transmission system;

Group K.3. - plants for high efficiency cogeneration of the installed strength exceeding 10 MWe connected to transmission system;

Group K.N. - plants for high efficiency cogeneration that are not connected to the distribution or transmission system.

Concluding provisions
Article 6

This Rulebook shall enter into force on the eight day following its publication in the "Official Gazette of Montenegro ".

Number: 01-1451/3

Podgorica, 25 May 2011

Minister

dr **Vladimir Kavarić**, s.r.

Methodology for calculation of saving for primary energy of the plant for high efficiency cogeneration

A) Primary energy saving (PES)

The primary energy saving at the cogeneration plant is calculated according to the following formula:

$$UPE = 1 - \frac{1}{\frac{\eta_e}{\eta_{ref,e}} + \frac{\eta_h}{\eta_{ref,h}}}$$

Where

$\hat{\eta}_e$ [-] - the average annual efficiency of the electricity production plant for cogeneration is calculated according to the following formula:

$$\eta_e = \frac{3600 \cdot E_k}{Q_f}$$

$\hat{\eta}_h$ [-] - the average annual efficiency of the useful heat production plant for cogeneration is calculated according to the following formula:

$$\eta_h = \frac{H_k}{Q_f}$$

Q_f [MJ] – the annual consumption of the primary energy from fossil fuels for the cogeneration plant generation and is calculated as the sum of the products with bottom calorie power of $H_{d,i}$ And the total annual quantity of m_i from each of n_f fossil fuels used at the plant:

$$Q_f = \sum_{i=1}^{n_f} H_{d,i} \cdot m_i$$

H_k [MJ] – useful heat produced in the process of cogeneration that is used in technological processes, heating processes or secondary processes of cooling (tri-generation) and does not exceed economically justified demand, that is demand that does not exceed demand that could be cover with some other heat sources, is calculated as prescribed under item b of this Annex;

E_k [MWh] - the electricity produced in the process of cogeneration, is calculated as prescribed under item c of this Annex;

$\hat{\eta}_{ref, h}$ [-] - reference boiler room efficiency – is determined depending on type of used fuel and method of utilisation of the waste heat (for production of steam/hot water or directly in the process), in the manner prescribed under item d of this Annex;

$\eta_{ref, h}$ [-] - reference plant efficiency – is determined depending on type of used fuel and the construction year of the plant for cogeneration at average climate conditions and avoided losses of transmission and distribution of electricity, in the manner prescribed under item e of this Annex.

b) Calculation of the useful heat produced at the cogeneration plants

The useful heat produced at the cogeneration plants is calculated according to the following formula:

$$H_k = H_u - H_b - H_g - H_p$$

where:

H_u [MJ] - the total annual heat produced during the process of cogeneration, which is measured at the plant boundary;

H_b [MJ] - the heat produced at the cogeneration plant beyond the cogeneration process (for example heat produced at the top boiler or the annual heat produced at the boiler for waste heat with combustion of additional fuel less losses of the boiler or the steam heat taken from the steam generator before turbine);

H_g [MJ] - the total annual losses resulting from use of the produced heat exceeding the technologically justified losses (for example excessive losses which occurred at the distribution system);

H_p [MJ] - the total annual heat of reversible condensate measured at the plant boundary.

c) Calculation of the electricity produced at the cogeneration plant

The total annual electricity produced at the cogeneration plant (E_{u1} [MWh]) is the total electricity produced at the cogeneration plan, measured at main generators terminal.

The total efficiency of the cogeneration plant η_e is calculated according to the following formula:

$$\eta_u = \frac{3600 \cdot E_u + H_u}{Q}$$

where:

Q [MJ] – annual consumption of the primary energy for work of the cogeneration plant and is calculated as sum of products of bottom calorie power $H_{d,i}$ and the total annual quantity of m_i of every n fuel:

$$Q = \sum_{i=1}^n H_{d,i} \cdot m_i$$

The electricity produced during the cogeneration process is determined with the application of the following formula:

$$E_k = E_u$$

in following cases:

- 1) At cogeneration plants belonging to Group K.1. referred to in Article 5 of this Rulebook, with the total efficiency η_u exceeding or equal with 75% at the annual level;
- 2) At cogeneration plants belonging to the groups K.2. and K.3. referred to in Article 5 of this Rulebook, with the total efficiency η_u exceeding or equal with 80% at the annual level.

If the total annual efficiency η_u is lower that the values defined under paragraph 3, sub-item 1 or 2 of this item, the electricity produced during cogeneration process is calculated with the application of the following formula:

$$E_k = \frac{C \cdot H_k}{3600}$$

where:

C – ratio between electricity and heat from cogeneration.

The calculation of the electricity from the cogeneration process is grounded on real ration between electricity and heat from cogeneration, C.

In regard to micro cogeneration plants, the calculation of the electricity is performed on grounds of the projected values.

If the value of the ration between electricity and heat from cogeneration is unknown, the values listed under Table 1 can be applied.

Table 1: Ratio between electricity and heat depending on type of the cogeneration unit

Technology for cogeneration	C
Combined process of gas and steam turbine	0.95
Non-condensing steam turbine	0.45
Condensation turbine with steam reduction	0.45
Gas turbine with use of waste heat	0.55
Motor with internal combustion	0.75

d) Calculation of reference boiler efficiency

The value of the efficiency of the boiler room is determined against bottom fuel calorie power and standard state of surrounding (temperature 15°C, pressure 1,013 bar, relative humidity 60%) according to the following table:

Table 2: Value of the reference boiler room efficiency

Fuel type	Steam/hot	Direct use of
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	water **	exhaust gases **
Hard coal / coax	88	80
Lignite / lignite briquet	86	78
Quag / quag briquet	86	78
Wood	86	78
Agricultural biomass	80	72
Biodegradable (communal) waste, solid	80	72
Non-renewable (communal and industrial) waste, solid	80	72
Shale	86	78
Light distillate oil, crude oil, TNG	89	81
Bio fuels, liquid	89	81
Biodegradable waste, liquid	80	72
Non-renewable waste, liquid	80	72
Natural gas	90	82
Refined gas/hydrogen	89	81
Biogas	70	62
Cox gas, high furnace gas, other waste gases, waste heat	80	72

* Reference efficiency of separate production of steam/water is reduced for 5% if the reversible condensate heat is calculated in the useful heat.

** Values from this column are applied if the temperature of the exhaust gas exceeds 250°C.

In case that several types of fuels are used, the efficiency of the reference boiler room $\eta_{ref,t}$ is determined in accordance with the following formula:

$$\eta_{ref,h} = \frac{\sum_{i=1}^n H_{d,i} m_i \eta_{ref,h,i}}{\sum_{i=1}^n H_{d,i} m_i}$$

where:

$\eta_{ref,t}$ - efficiency of the reference boiler room referred to in Table 2.

e) Calculation of the reference power plant efficiency

The efficiency of the reference power plant $\eta_{ref,t}$ is determined according to the following formula:

$$\eta_{ref,e} = (\eta_{R,e} + k_t) \cdot k_g$$

where:

$\eta_{R,e}$ - uncorrected value of the reference power plant efficiency;

K_t – correction of efficiency, determined on grounds of deviations from average climate conditions of the location from the standard climate conditions;

K_g – factor of correction of avoided losses at the electro-power system.

If only one fuel type is used at the cogeneration plant, the uncorrected value of the reference power plant efficiency $\eta_{R,e}$ is determined depending on year of construction, type of the used fuel compared against bottom calorie power of fuel and standard state of surrounding (temperature 15° C, pressure 1,013 bar, relative humidity 60%) as referred to in Table 3.

In case of use of several types of fuel, the uncorrected value of the reference power plant efficiency $\eta_{R,e}$ is determined according to the following formula:

$$\eta_{R,e} = \frac{\sum_{i=1}^n H_{d,i} m_i \eta_{R,e,i}}{\sum_{i=1}^n H_{d,i} m_i}$$

where:

$\eta_{R,e,i}$ - uncorrected value of the reference power plant efficiency according to the type of fuel and year of construction of the plant for cogeneration referred to in Table 3.

The efficiency correction K_t [%] is determined on basis of a difference between medium annual temperature of the location and the standard temperature of the surrounding (15° C) as per the following formula:

$$K_t = 0,1(15 - t_L)$$

where:

t_L [C] - medium annual temperature of the location, which is determined on grounds of data from the Montenegrin Institute of Hydrometeorology for the meteorological stations closest to the location of the cogeneration plant.

Table 3: Reference power plant efficiency $\eta_{R,e}$ [%]

Fuel type	Year of construction										
	1996 and earlier	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006-2011
Hard coal / coal	39,7	40,5	41,2	41,8	42,3	42,7	43,1	43,5	43,8	44,0	44,2
Lignite / lignite briquet	37,3	38,1	38,8	39,4	39,9	40,3	41,1	41,4	41,6	41,8	42
Quag / quag briquet	36,5	36,9	37,2	37,5	37,8	38,1	38,4	38,6	38,8	38,9	39
Wood	25,0	26,3	27,5	28,5	29,6	30,4	31,1	31,7	32,2	32,6	33
Agricultural biomass	20,0	21,0	21,6	22,1	22,6	23,1	23,5	24,0	24,4	24,7	25
Biodegradable (communal) waste, solid	20,0	21,0	21,6	22,1	22,6	23,1	23,5	24,0	24,4	24,7	25
Non-renewable (communal and industrial) waste, solid	20,0	21,0	21,6	22,1	22,6	23,1	23,5	24,0	24,4	24,7	25
Shale	38,9	38,9	38,9	38,9	38,9	38,9	38,9	38,9	38,9	38,9	39
Light distillate oil, crude oil, TNG	39,7	40,5	41,2	41,8	42,3	42,7	43,1	43,5	43,8	44,0	44,2

Bio fuels, liquid	39,7	40,5	41,2	41,8	42,3	42,7	43,1	43,5	43,8	44,0	44,2
Biodegradable waste, liquid	20,0	21,0	21,6	22,1	22,6	23,1	23,5	24,0	24,4	24,7	25
Non-renewable waste, liquid	20,0	21,0	21,6	22,1	22,6	23,1	23,5	24,0	24,4	24,7	25
Natural gas	50,0	50,4	50,8	51,1	51,4	51,7	51,9	52,1	52,3	52,4	52,5
Refined gas/hydrogen	39,7	40,5	41,2	41,8	42,3	42,7	43,1	43,5	43,8	44,0	44,2
Biogas	36,7	37,5	38,3	39,0	39,6	40,1	40,6	41,0	41,4	41,7	42
Cox gas, high furnace gas, other waste gases, waste heat	35,0	35,0	35,0	35,0	35,0	35,0	35,0	35,0	35,0	35,0	35,0

The correction factor for avoided losses at the electro-energy system (transfer and distribution of the electricity) k_g is determined according to voltage level of the cogeneration plant connection and the quantity of the annually produced, used and delivered electricity. The value of the correction factor k_g is determined according to the formula:

$$k_g = \frac{E_L}{E_u} \cdot k_L + \frac{E_I}{E_u} \cdot k_I$$

where:

E_u [MWh] - the total annually produced electricity at the cogeneration plant, measured at main generators terminal;

E_I [MWh] - the total annually delivered electricity, measured at connection of the cogeneration plant with the electro-power system;

E_L [MWh] - the electricity used at the plant; if it is not measured, it is determined according to the formula $E_L = E_u - E_I$;

K_L - factor of the correction of consumption at the plant referred to in Table 4;

K_I - factor of correction of delivery of electricity in the system as referred to in Table 4.

Table 4: The correction factors K_L and K_I for avoided losses at the electro-power system

Voltage level of connection	K_I - delivery of electricity in the system	K_L - consumption of electricity at the plant
> 200 kV	1.000	0.985
100 – 200 kV	0.985	0.965
50 – 100 kV	0.965	0.945
0,4 – 50 kV	0.945	0.925
< 0,4 kV	0.925	0.860