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Estonian Competition Authority

Principles of Allocation of the Costs in Heat and Power Cogeneration Plant

Guidelines

Heat and power cogeneration is a process in which a production unit delivers two kinds of energy products at the same time: thermal and electrical energy (hereinafter heat and electricity/power). Due to that it necessary to determine what is the price of each of the products.

Pursuant to the paragraph 7(2) of the District Heating Act (hereafter DHA) a heating undertaking shall keep separate accounts for the production, distribution and sale of heat and for other areas of activity, including for the cost incurred in electricity cogeneration. Paragraph 9(1) of the DHA stipulates that the price of heat produced in cogeneration process is a subject to approval by the Competition Authority. According to the Electricity Market Act (hereafter EMA) paragraph 55 section 4 a producer who is an undertaking in a dominant position as defined in the Competition Act and who generates electricity in a combined heat and power production regime shall, at the request of the Competition Authority, submit information on the allocation of revenue and expenses separately for the generation of electricity and for heat production together with the relevant reasons. The EMA does not stipulate an obligation for approval of the price of electricity produced in cogeneration process meaning that electricity is sold in conditions of open market. Thus, the legislative authority has provided an unambiguous signal that the task of the Competition Authority is to approve the price for heat in a manner in which cross-subsidising is avoided in the allocation of costs.

Paragraph 1(2) of the DHA stipulates that the production of heat shall be co-ordinated and conform to the principles of objectivity, equal treatment and transparency in order to ensure a secure, reliable and effective heat supply at a justified price in compliance with environmental requirements and the needs of the final customer. In order to avoid cross-subsidising and ensure a justified price for heat it is necessary to allocate the cost of heat and electricity production in cogeneration process. It is important that the heat production is treated equally to the electricity production and that the application of cogeneration is not damaging the interests of heat consumers. In other words the allocation of cost for electricity and heat shall be done in a way that ensures equal treatment of both product lines and avoids cross-subsidising between areas of activity. The present guidelines explain the allocation of cost for heat and electricity produced in a heat and power cogeneration plant (hereafter CHP) on the basis of the following two methods:

1. Stand-alone cost method or, the method of an alternative boiler house;

2. Physical method.

The alternative boiler house method can not be used for cost allocation if cogeneration is based on fuel (for example oil shale), what can not be used on heat-only boiler as similar technology is not available. That is why the method is not used in case of oil shale based heat and power cogeneration processes. In the latter case the cost of heat production is found using the physical method.

Alternative boiler house method

The method of an alternative boiler house considers the cost and justified return for the heat and electricity produced in cogeneration process separately from each other. The method assumes that the heat sold to consumers is produced separately from electricity production in a heat-only boiler house or, in an alternative boiler house. Advantages of the method are its simplicity, understand ability and application of the main principle according to which no more cost components can be included in the heat sale price than it would be done in the case of heat production with heat-only boilers. In other words, customers shall not pay for the heat produced in heat and power cogeneration process more than for the heat produced in an alternative boiler house. Herewith it is assumed that the production of heat in a boiler house with heat-only boilers is equally effective and environmental-friendly as it is in the case of cogeneration. If bearing in mind that the speciality of the CHP in comparison with condensing power plant is that the produced heat I used effectively and then the main effect is achieved through power generation. For the heat consumer the heat production in CHP should be as effective as in boiler house. At the same time the heat consumers shall not suffer if the investment in cogeneration appears inefficient.

In the alternative boiler house method the maximum price of heat is calculated as the division of the sum of heat production cost and justified return to the volume of heat sale according to the following formula:

$$p_{heat} = \frac{R_{heat}}{Q_{heat}}$$

where:
p_{heat} – maximum price of heat (MWh);
R_{heat} – cost of heat production and justified return (€);
Q_{heat}– quantity of heat produced (MWh).

The sum of heat production cost and justified return of an alternative boiler house (R_{heat}) includes all the cost needed for the production of heat (fuel cost, environmental charges, other variable costs, operating costs, capital expenditure) and justified return. The costs of heat production and justified return are found using the following equation:

$$R_{heat} = F + EC + VC + OC + J$$

where:
R_{heat} – cost of heat production and justified return (€);
F – cost of fuel (€);
EC – cost of environmental charges (€);
VC – other variable costs (€);
OC – operating costs (€);
J – capital expenditure and justified return (€).

The other variable costs in above formula (VC) are found by the following formula:

$$VC = VC_e + VC_o$$

where:
VC – other variable costs (€);
VC_e – cost of electrical energy (€);
VC_o – cost for water, sewage disposal, chemicals and other costs of variable nature (€).

The fuel cost (F) is calculated as the product of fuel price and the quantity of fuel used for heat production. The fuel price is the contractual price of an undertaking. However, it is compared with the market price and if the contractual price differs substantially from the market one, then the calculation of fuel cost will base on the market price. The quantity of fuel needed for heat production is calculated using boiler house efficiency and the volume of sale in accounting period. The fuel quantity and fuel cost is found by the following formula:

$$Q_{fuel} = \frac{Q_{heat}}{\eta_{production}}$$

$$F = Q_{fuel} \times p_{fuel}$$

where:
Q_{fuel} – quantity of fuel fed into boiler (primary energy) (MWh);
Q_{heat} – quantity of heat produced (MWh);
F – cost of fuel (€);
p_{fuel} – price of fuel (€/MWh);
$\eta_{production}$ – efficiency of heat production (%).

The cost of environmental charges (E) is calculated based on the valid established environmental charges and the fuel quantity needed for the production of heat. In case of the prices for administratively regulated goods and services the approved prices are taken as the basis (for example water supply service and electricity price lists).

The operating cost (OC) is found on the basis of a justified acquisition cost for the investment in an alternative boiler house, specifically, 5% of the acquisition cost of the investment.

The sum of capital expenditure and justified return (J) is found on the basis of the annuity payment formula (the financial function of *PMT* of *MS Excel*). In this manner the capital expenditure and justified return is divide proportionally over the whole technical lifetime of the investment. The components in the formula are the acquisition cost of a justified investment in the production of heat, a weighted average cost of capital (*WACC*) and a technical lifetime of the investment. The above components are determined from the following reasoning:

1) The thermal capacity of the boiler plant shall correspond to an optimal heat load.
2) The principle of technological neutrality (any specific technology cannot be unjustifiably preferred) and the conditions stipulated in paragraph 1(2) of the DHA are the reasoning for the determination of the boiler house cost and selection of its technology based on the grounded investment costs on market price.
3) For the interest rate of annuity payments (*PMT*) a weighted average cost of capital (*WACC*) is taken according to the Competition Authority's „Guidelines for Determination of Weighted Average Cost of Capital".

The following table serves as an example of the calculation of maximum price of heat on the method of an alternative boiler house:

Pos no	Cost basis	Unit	Value
A	B	C	D
1	Thermal capacity ($W_{thermal}$)	MW	
2	Investment cost (I)	€	
3	Weighted average cost of capital (*WACC*)	%	
4	Technical lifetime (T_{time})	years	
	Technical indicators:		
5	Production volume of heat (Q_{heat})	MWh	
6	Thermal efficiency of the boiler plant (η_{boiler})	%	
7	Quantity of fuel fed into boiler (primary energy) (Q_{fuel})	MWh	
8	Fuel price (p_{fuel})	€/MWh	
9	Quantity of electrical energy (El_{quant})	kWh	
10	Average price of electricity (El_{price})	€cents/kWh	
	Production costs:		
11	Fuel cost (F)	€	
12	Cost of environmental charges (EC)	€	
13	Cost of electrical energy (VCe)	€	
14	Cost of chemicals, water and sewage disposal (VCo)	€	
16	Operating costs (excl. capital expenditure) (OC)	€	
17	Capital expenditure and justified return as annuity (J)	€	
18	Total of heat production cost and justified return or, allowed sales revenue (R_{heat})	€	
19	**Production cost of heat (maximum price) (p_{heat})**	**€/MWh**	

Physical method

Prior to the allocation of costs in this method justified costs of cogeneration process are determined (incl. justified return) for the complete cogeneration plant.

The costs justified for heat and power production for both power and heat (fuel cost, cost of environmental charges, other variable costs, operating costs, capital expenditure and justified return) are found by the following formula:

$$R_{productionel+h} = F_{el+h} + E_{el+h} + VC_{el+h} + OC_{el+h} + D_{el+h} + JR_{el+h}$$

where:

$R_{productionel+h}$ – gross costs of heat and power coproduction and justified return (electricity own consumption by the plant is excluded) (€);
F_{el+h} – cost of fuel for heat and power cogeneration (€);
E_{el+h} – cost of environmental charges (€);
VC_{el+h} – other variable cost in heat and power cogeneration (€);
OC_{el+h} – operating costs in heat and power coproduction (€);
D_{el+h} –capital expenditure in heat and power coproduction (€);
JR_{el+h} – justified return in heat and power coproduction (€).

The basis for the determination of the fuel fed into boiler (primary energy) is the quantity of fuel. The price of fuel is the contractual price of an undertaking, compared with the market price. If the contractual price differs substantially from the market price, then the calculation of fuel cost will base on the market price. The fuel cost is found by the following formula:

$$F_{el+h} = Q_{fuel} \times p_{fuel}$$

where:
F_{el+h} – cost of fuel for heat and power cogeneration (€);
Q_{fuel} – quantity of fuel (primary energy) fed into boiler (MWh);
p_{fuel} – price of fuel (€/MWh).

The cost of environmental charges (E_{el+h}) is calculated based on the valid established environmental charges and the fuel quantity needed for the production of heat. In case of the prices for administratively regulated goods and services the approved prices are taken as the basis (for example water supply service and electricity price lists). The operating costs (OC_{el+h}), capital expenditure (D_{el+h}) and justified return (JR_{el+h}) are found according to the Competition Authority's methodology „Principles of Approval of Maximum Price of Heat".

In the physical method the share percentages of costs separately for heat and power are found on the basis of the primary energy (energy content of the fuel). The share of the cost for heat is gained if the primary energy (energy content of the fuel) used for heat production (MWh)[1] is divided by the quantity of energy contained in the fuel and fed into boiler or, the quantity of primary energy (MWh). Herewith, also the efficiency of equipment is taken into account, including the thermal efficiency of steam pipes and heat exchangers.

The gross costs of heat production are the costs of heat production that do not include the costs for electricity. The shares of gross costs of heat production are calculated by the following formula:

$$s_{heatgr} = \frac{Q_{heat}}{\eta_{heat} \times Q_{fuel}}$$

$$\eta_{heat} = \eta_{boiler} \times \eta_{he}$$

where:
s_{heatgr} – share of gross heat production costs;
Q_{heat} – quantity of heat produced (MWh);
Q_{fuel} – quantity of the fuel fed into boiler (primary energy) (MWh);
η_{heat} – efficiency of heat production (%);
η_{boiler} – efficiency of the boiler (%);
η_{he} – efficiency of heat exchanger (%).

The actual efficiency of the boiler is used in the formula; however, for a fluidized bed boiler not lower than 90% and for other technologies not lower than 80% can be taken. The actual efficiency of the heat exchanger is used in the formula, however, not lower than 98% can be taken.

The gross costs in the formula are taken without the own consumption of electricity. As the cogeneration process itself also consumes electricity for the process own needs, then the cost is allocated on the basis of gross electricity production and the electricity gross price is found and

[1] The primary energy (energy content of the fuel) used for heat production (MWh) equals with value of: quantity of heat produced in megawatt-hours ($Q_{heat)}$ divided with efficiency of heat production in per cent ($\eta_{heat)}$.

included in the price of both heat and electricity. The electricity gross production is the production on the generator's output terminals and thus it does not include the own consumption by the power plant's equipment. The share of gross electricity production costs is found by the following formula:

$$s_{eleltricitygr} = 100 - s_{heatgr}$$

where:
s_{heatgr} – share of gross heat production costs;
$s_{electricity\ gr}$ – share of gross electricity production costs.

The electricity gross price is calculated by the following formula:

$$p_{electricitygr} = \frac{R_{production_{el+h}} \times s_{electricitygr}}{Q_{electricitygr}}$$

where:
$R_{production\ el+h}$ – gross costs of heat and power coproduction and justified return (excluding cost of electricity own consumption) (€);
$s_{electricity\ gr}$ – share of gross electricity production costs.
$p_{electricitygr}$ – electricity gross price (€/MWh);
$Q_{electricitygr}$ – electricity gross production (MWh).

The costs for the electricity needed for heat production are calculated by the following formula:

$$VCe_{heat} = p_{electricitygr} \times El_{heat}$$

where:
VCe_{heat} – cost of own consumption electricity needed for heat production (€);
$p_{electricitygr}$ – electricity gross price (€/MWh);
El_{heat} – electricity needed for heat production (MWh).

The costs of heat production (R_{heat}) are found using the share of gross heat production costs (s_{heatgr}), the gross costs of heat and power coproduction and justified return ($R_{production\ el+h}$), the cost of electricity needed for heat production (VCe_{heat}) and the quantity of heat produced (Q_{heat}) by the following formula:

$$R_{\ heat} = \frac{s_{heatgr} \times R_{production_{el+h}}}{Q_{heat}} + VCe_{heat}$$

where:
R_{heat} – gross costs of heat in heat and power coproduction and justified return (incl. cost of electricity own consumption) (€);
$R_{production\ el+h}$ – gross costs of heat and power coproduction and justified return (electricity own consumption by the plant is excluded) (€);
s_{heatgr} – share of gross heat production costs;
VCe_{heat} – cost of electricity needed for heat production (€);
Q_{heat} – quantity of heat produced (MWh).

The maximum price of heat is found by the following formula:

$$p_{heat} = \frac{R_{heat}}{Q_{heat}}$$

where:

p_{heat} – maximum price of heat (€/MWh);
R_{heat} – gross costs of heat in heat and power coproduction and justified return (incl. cost of electricity own consumption) (€);
Q_{heat} – produced heat (MWh).

The following table serves as an example of the calculation of maximum price of heat on the physical method:

Pos no	**Cost basis**	**Unit**	**Total production**	**Heat production**	**Electricity production**
A	**B**	**C**	**D**	**E**	**F**
	Technical indicators:				
1	Quantity of the fuel fed into boiler (Q_{fuel})	MWh			
2	Production volume (Q_{heat}/ $Q_{electricitygr}$)	MWh			
3	Efficiency of production ($\eta_{heat}/\eta_{electricity}$)	%			
4	Efficiency of heat exchanger (η_{he})	%			
5	Boiler efficiency (η_{boiler})	%			
6	Gross share of costs ($s_{heatgr}/s_{electricitygr}$)		1		
7	Quantity of fuel in volume/weight unit	t			
8	Calorific heat value of the fuel	MWh/t			
9	Volume/weight unit price of the fuel	€/t			
10	Price of the fuel primary energy (p_{fuel})	€/MWh			
	Production costs:				
11	Cost of fuel purchase (F_{el+h})	€			
12	Cost of environmental charges (E_{el+h})	€kr			
13	Other variable costs (VC_{el+h})	€			
14	Operating costs (R_{el+h})	€			
15	Capital expenditure (D_{el+h})	€			
16	Justified return (JR_{el+h})	€			
17	Total coproduction costs and justified return ($R_{production\ el+h}$)	€			
18	Quantity of electricity own consumption ($El_{heat}/El_{electricity}$)	MWh			
19	Gross price of electricity ($p_{electricitygr}$)	€/MWh			
20	Cost of electricity in heat production (VCe_{heat})	€			
21	**Costs of heat production and justified return or, allowed revenue from heat production (R_{heat})**	€			
22	**Production price of heat (maximum price) (p_{heat})**	€/**MWh**			