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THE BREAKEVEN POINT GIVEN LIMIT COST USING BIOMASS CHP PLANT

Case studies

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Abstract

Biomass is a renewable source, non-fossil, from which can be obtained fuels, which can be used in power generation systems.

The main difference of fossil fuels is the availability biomass in nature and that it is in continue "reproduction". The use its enable the use of materials that could be destined destruction, as a source of energy "renewable", though result with many ecological values.

In this paper we will study, applying a calculation model in view optimal sizing of the cogeneration plant based on biomass, biomass cost limit for the net present value is zero.

It will consider that in cogeneration systems and in heating peak systems using biomass.

After applying the mathematical model for limit value of biomass cost will determine the nominal optimal coefficient of cogeneration, for which discounted net revenue value is zero. Optimal sizing of CHP plants based on using biomass will be given by optimum coefficient of cogeneration determined following the application of the proposed mathematical model.

1. Renewable energy sources – Settlements

Renewable energy resources, such as wind, solar, hydroelectric power, ocean energy, geothermal power, biomass and biofuels are alternative of fossil fuels which help reduce emissions of greenhouse gases, to diversification of energy offer and to reduce dependence of volatile markets and unreliability of fossil fuels, especially oil and gas.

In order to reduce dependence on imported of fossil fuels and reducing CO_2 emissions, one of the objectives of the European Union for over 10 years, is the expansion of energy production from renewable resources. Political impetus gave energy market development from renewable energy related to the stimulation of research in new technologies, to productive investment, to plus a possible strengthening social cohesion, the latter being visible in countries with industrial potential and in little measure in countries which importing technologies, such as Romania. The industrial intervention produces changes in the atmosphere with risks that quantifies differently depending on the way of achieving it.

The European Council approved Directive 28 in 2009 (2009/28 / EC). Through this directive it's aims the strengthen the European market of green energy and environmental protection, focusing on tools direct and indirect of intervention so that each member country be able to reach to a share of energy from renewable energy on average 20% of total gross final consumption of energy in 2020. [Plumb& Zamfir, 2009], [www.scribd.com/doc]

Producers of energy from renewable energy received from the Transmission and System Operator a number of green certificates in accordance with art. 6 paragraph 2 of Law No. 220/2008 as amended. But since 1 July 2013, the government decided to postpone the granting of part of green certificates to investors in small hydro plants, wind and photovoltaic plants, measure which follow to be valid until March 2017, for hydro and solar plants, and by 2018 for wind farms.

This ordinance amends and supplements Law 220/2008 for the establishment of promote system energy production from renewable energy sources.

According to the government, the respective ordinance provides temporary postponement of the grant of a number of green certificates for each 1 MWh produced by new hydro power plants installed with power less than or equal to 10 MW (one green certificate), by wind farms (one green certificate), respective by solar power plants (two green certificates).At the same time, in project was provided that, for photovoltaic units will be awarded only four certificates. Plants based on renewable energy sources such as biomass are not affected.

Starting with 1 April 2017, the recovery of postponed green certificates it will make for new hydropower plants by until to 10 MW, respectively for solar power plants, and for wind farms, the recovery will be starting from the 1st January 2018 in staggered intervals to no more than 31 December 2020. [Law 220/2008]

It made a top 10 of the largest plants worldwide which using green energy and it was found that biggest plant based on dry burned biomass is in Alholmens Kraft Oy from Pietarsaari, Finland

"Just like majority plants on dry burned biomass, plant Oy Alholmens Kraft is based on bark, branches and local flora muscles to supply the fuel tank enormous - the largest of its kind in the world - 550 MW of heat. Burning this quantity is generated a yield of peak - 240 MW of electricity. The plant longer generates and 160 MW steam, which is used directly by nearby industry and for the regional heating.Both muscles, as well burned wood, for this plant are harvested sustainably. In the case of wood, an equal number of trees with the cut trees is planted in every year after that are later harvested, at maturity. Also, the muscle is constantly regenerated by planting plants in wetlands and although it occurs at a low rate, can be harvested efficiently as long as it is nurtured with carefully. "We need more than 120 trucks of biomass per day. One single truck reach for six to seven minutes, "argues Nick Stig, Managing Director of the plant." [www.descopera.ro]

2. Technologies for the energy capitalization of biomass

Taking into account the relatively low yield of approx. 20% of energy generation technologies by burning biomass, result that plant using directly biomass as fuel, must be as close as the source of the biomass and by the area of energy consumption thus produced, such resulting the use of some plants with low thermal capacities. [Athanasovici et al., 2010]

Cogeneration is regarded as a method of streamline production, energy conservation, and not least to reduce emissions of greenhouse gases.

The energy efficiency of electricity production for CHP decreases sensitive due to the effect of scale, while energy efficiency overall is reducing little.The effect of scale of thermal capacity installed over energy efficiency, in the case thermal power plants is insignificant, especially in present, one time with the development equipping with boilers in condensing by low thermal capacities (<100 MWt). [Athanasovici, Bogdan, Voicu, 2010]

Cycle with steam turbine with condensing and adjustable outlet is more complex, ensure a lower efficiency of electricity generation, but has the advantage that electricity production is ensured and during periods when no heat is required.Also, this cycle presents a greater flexibility regarding the proportion of heat and power products. The disadvantage is that it presents higher investment expenditure regarding low-pressure body, the condenser and cooling system, but these costs are recovered through the sale of electricity produced additional. [www.scribd.com]

Another possible use of solid biomass for energy purposes is the burning its in combination with other fossil fuels, which presents the following advantages:

- flattening of variations (seasonal) in supply with the biomass;
- avoid oversize CHP, which increase the annual degree its load and avoids investment growth on implementing its;
- before combustion is not necessary treatment / gas cleaning products;
- gas-producing can operate up to 50% of nominal capacity;
- electric yield of biomass conversion reaches at 38-40%. [Athanasovici et al., 2010]

Cogeneration solution of urban consumers and those similar to them, is mainly characterized by an application of electricity and heat for domestic hot water consumption on throughout the year and heat consumption for heating in winter.

The characteristic values of climatic zones of Romania are shown in Table 1 (see you Annex).

A cogeneration system is characterized by the following technical indicators:

- indices that characterize the structure of energy demand/production;
- indices that characterizing sizing, respectively CHP design ;
- indices that characterizing energetic performances of equipment and the CHP assembly.

Are taken into consideration following hypotheses:

- the consumer of electricity and heat is not isolated by the NPS, hypothesis taken because in paper it's analyzes urban consumers and those like them, consumers that in generally have access to the national electricity grid;
- losses of electric and thermal energy, afferent CHP as well as energy needs for its own services it's deemed included in consumers consumptions;
- it's neglecting transmission and distribution losses of the two forms of energy, the analysis being performed at the level of "energy supplied" by source.

To implement the solution cogeneration is needed an analysison base which it's determined whether chosen solution is or not cost-effective and if there is a benefit brought through the implementation in compared to other capital recovery solutions.For this it's had in considering several possible technical alternatives of realization the project investment and following analysis it's choose the variant with the maximum economic effect. In this regard, in work it's considered the net present value as a criterion for assessing the economic efficiency. [Voicu, 2012]

Non-simultaneity between the heat demand and availability of renewable energy resources, in most cases require the use of energy storage capabilities. Type and the mode of sizing depend on the nature of heat demand, on type of heat source and on type of renewable energy resources available.

In case of using biomass, accumulation capabilities consist of sizing proper of deposits capacities of storing and drying its, ensuring thereby the taking over variations of heat and electricity demand.

It is envisaged that, in any case, energy storage capacities increase the value of investments related to the entire system of heat supply, the more so as the heat demand is uneven and non-simultaneous with electricity demand.

Increasing investment for cogeneration solution is strongly influenced by energy storage capacity when it is realized as storage capacities and preparation of biomass as a primary energy source. With increasing average annual loading of all equipment CHP is reduced installed capacity, necessary heat source, leading to an average annual load closer to optimal loading, and will result in ultimately reducing the unit cost of the proposed heat. [Athanasovici, Bogdan, Voicu, 2010]

3. Case study - Sizing CHP using biomass at a price limit

Achieving sizing calculations of optimal cogeneration solution are based on elaboration of a calculation mathematical model followed by a software for application of the respectively model.

In figure 1 (see you Annex) is outlined the mode of cover of classed annual curve of urban heat load, characteristic to climatic conditions in Romania.

It's made a spreadsheet program Excel where, for three climatic zones of Romania, based on economic criteria decision (NPV) was determined the optimal nominal thermal cogeneration coefficient of CHP.With its help it can establish the mode of CHP sizing. In figure 2, it's presents the main calculation modules (M1 ... M3) of detailed logical chart of the calculation program taken into account for determination of the optimal nominal thermal cogeneration coefficient.

It analyzes the situation when the investments is made in own funds.

As technical data entry were considered:

- maximum nominal thermal power required by the consumer 10 and 5 MW_t;
- energy efficiency of CHP with steam turbine with condensing and adjustable outlet: the global yield of the cogeneration installation 80%; electrical yield for separate production of electricity 15%; heat yield for separate production of heat energy - biomass 86%.

As economic data of entrance it's had in the view:

- the CO_2 emission factor corresponding biomass burned: 0;
- eco - tax CO_2 9 € / tCO_2;
- what percent of total costs related to fuel consumption, maintenance and operation, they represent of fuel costs, 65%;
- biomass cost, 6 €/MWh;
- prices for the capitalization of electricity produced in CHP: 40 €/MWh;
- specific investments for cogeneration plant (basic), respectively peak heating installation corresponding to the two cases of using biomass:
    - specific investment for the cogeneration installation using biomass 1.500 €/kWe;
    - specific investment for peak heating installation using biomass 80 €/kWe;
- the discount rate, 10%;
- the number of green certificates granted for each 1MWh electricity produced from renewable energy resources (biomass) and in conditions of high efficiency:
    - 3 green certificates granted for electricity production based on renewable energy resources;
    - plus the 4th green certificates granted for electricity production based on renewable energy resources in conditions of high efficiency;
- value of a green certificate for electricity production based on renewable energy resources:
    - V_{GC} = 28,157 ÷ 57,389 €/MWh (is selected the minimum 28 €/MWh);
- number of operating hours per year of CHP 8400 h/year.

The algorithm presented emphasizes that technical-economic efficiency of CHP using biomass as fuel is influenced by the following categories of factors:

a) *factors that characterize the nature and structure of heat demand*: the urban heat load for heating and hot water preparation consumption. Thus, in point of view of heating, technical-economic efficiency depends on the ranked curve shape of respective demand, ie by the local climate conditions.From point of view of hot water of consumption it's considered its share in total demand for heat with structure:

$$\rho_T = \frac{q_{whc}^{md,an}}{q_h^c + q_{whc}^{md,an}}$$

b) *the mode of coverage of the annual heat demand*, in point of view of primary energy used:
- winter, both ICG and ITV integral use of biomass;
- summer, the demand for hot water of consumption is provided by ICG only on the base biomass a view to obtaining green certificates and in the period this season.

c) *factors of a technical nature, related to the type ICG*: steam turbines with condensing and urban outlet adjustable of low pressure for hot water production

d) *the variation effects of load ICG and ITV* over annual average real yields in their operating;

e) *factors of an economic nature*, by: unitary cost of biomass, the selling price of electric power produced by CHP, green certificate value obtained for electric power on biomass base

f) the effect of heat capacity the nominal installed in CHP $\left(q_{CHP}^{n}\right)$

g) the effect of reducing in time (in years) of annual quantity of available biomass and of quality as fuel (of LHV) of its.

It's analyzed the effects of changing these factors, which can have various causes: lack of knowledge of their exact values, or the evolution in time, on duration of CHP life.

In this paper it's put the problem of determining the maximum permissible value of the biomass cost when NPV is zero.Using the model calculation above, it was obtained the limit prices of biomass for each area analyzed of Romania and for each case - the maximum rated heat output required by the consumer 10 and 5 MWt, at which we can say that we are at limit, we have no profit and no losses. These are presented below in figure 3 (see you Annex).

The nominal thermal cogeneration coefficient for different values of biomass cost, where NPV becomes zero is in most cases 0.2, except cold climate areas of Romania corresponding CHP with installed heat power 5MWt, where it is 0.3.

4. Conclusions

The benefit of green certificates during 15 years, if the putting in operation of plant it's made no later than the end of 2016, it appears that it promotes of energy producer profit, he recovers the investment much faster compared to the situation when would not benefit them.

The models used are static deterministic models results, obtained being influenced by input data used.

The objectives used in biomass domain have long service life of operation, approx. 20 years, or in that period of time, the future is characterized by uncertainties, respectively by other values of the input features to those considered in sizing.

The nominal thermal cogeneration coefficient for different values of biomass cost, where NPV becomes zero is in most cases 0.2, except cold climate areas of Romania corresponding CHP with installed heat power 5MWt, where it is 0.3.

The resulted findings in this paper are useful both for design and construction of urban CHP based biomass and for theoretical and applied research on the classification of heat supply systems.

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Appendices

Appendix A

Table 1
[SR-1907-1],[Athanasovici& Coman, 2010] The characteristic values

	Warm areas	Cold areas	Average areas
1. Annually duration of the heating period, h/year	4400	5760	5080
2. the average demand on the period of heating $\left(\bar{q}_h^{md}\right)$, reported to the value of calculation $\left(\bar{q}_h^{c}\right)$, %	0,45	0,50	0,48
3.average demands domestic hot water on period:: ▪ by heating $\left(\bar{q}_{whc}^{md}\right)$; ▪ by summer $\left(\bar{q}_{whc}^{md,s}\right)$, reported to the value of calculation $\left(\bar{q}_h^{c}\right)$, %	0,23 0,15	0,19 0,20	0,18 0,16
4. average total urban demand $\left(\bar{q}_u^{md}\right)$, reported to the value of calculation $\left(\bar{q}_u^{c}\right)$, %	0,35	0,42	0,39

Appendix B

Fig.1
Curve of urban heat load for CHP

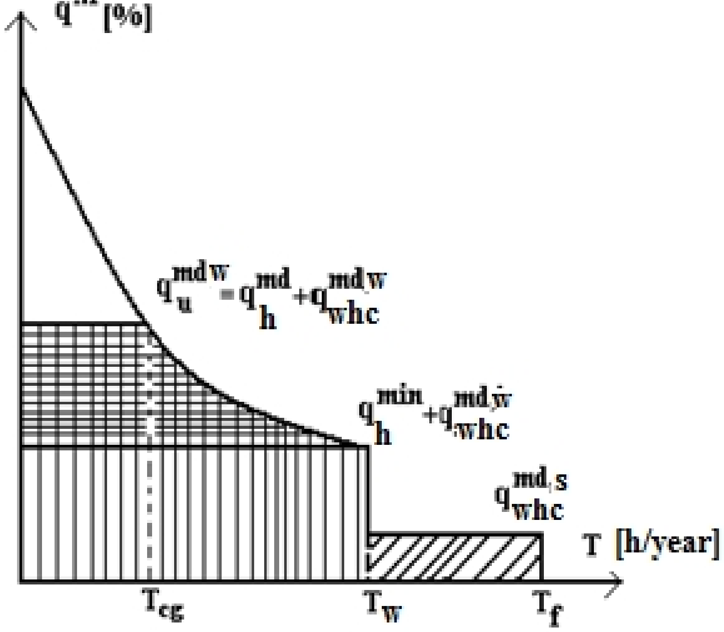
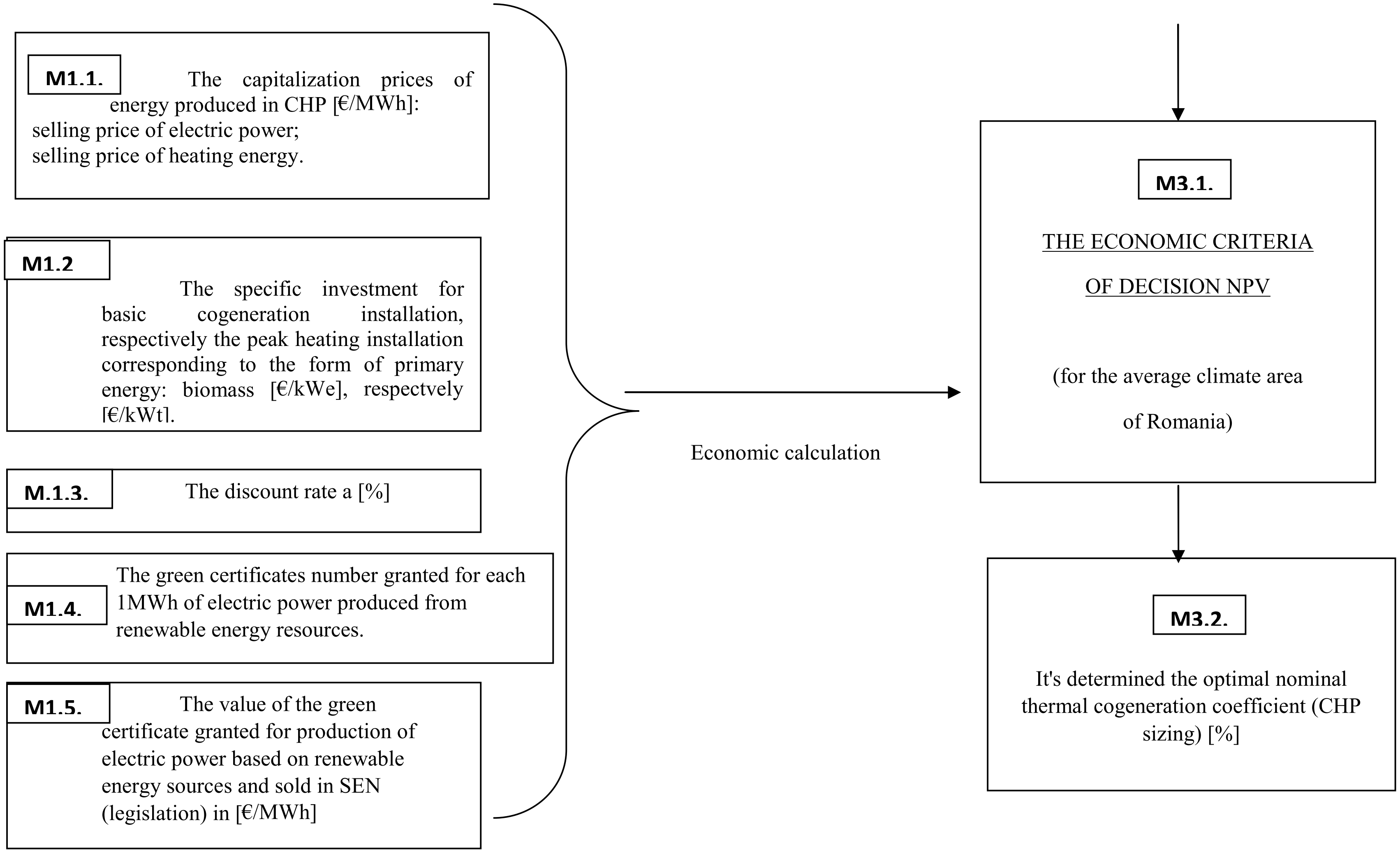


Fig. 2
The detailed logical scheme of the calculation algorithm [Athanasovici, Bogdan, Voicu, 2010]



M1.1. The capitalization prices of energy produced in CHP [€/MWh]:
selling price of electric power;
selling price of heating energy.

M1.2 The specific investment for basic cogeneration installation, respectively the peak heating installation corresponding to the form of primary energy: biomass [€/kWe], respectvely [€/kWt].

M.1.3. The discount rate a [%]

M1.4. The green certificates number granted for each 1MWh of electric power produced from renewable energy resources.

M1.5. The value of the green certificate granted for production of electric power based on renewable energy sources and sold in SEN (legislation) in [€/MWh]

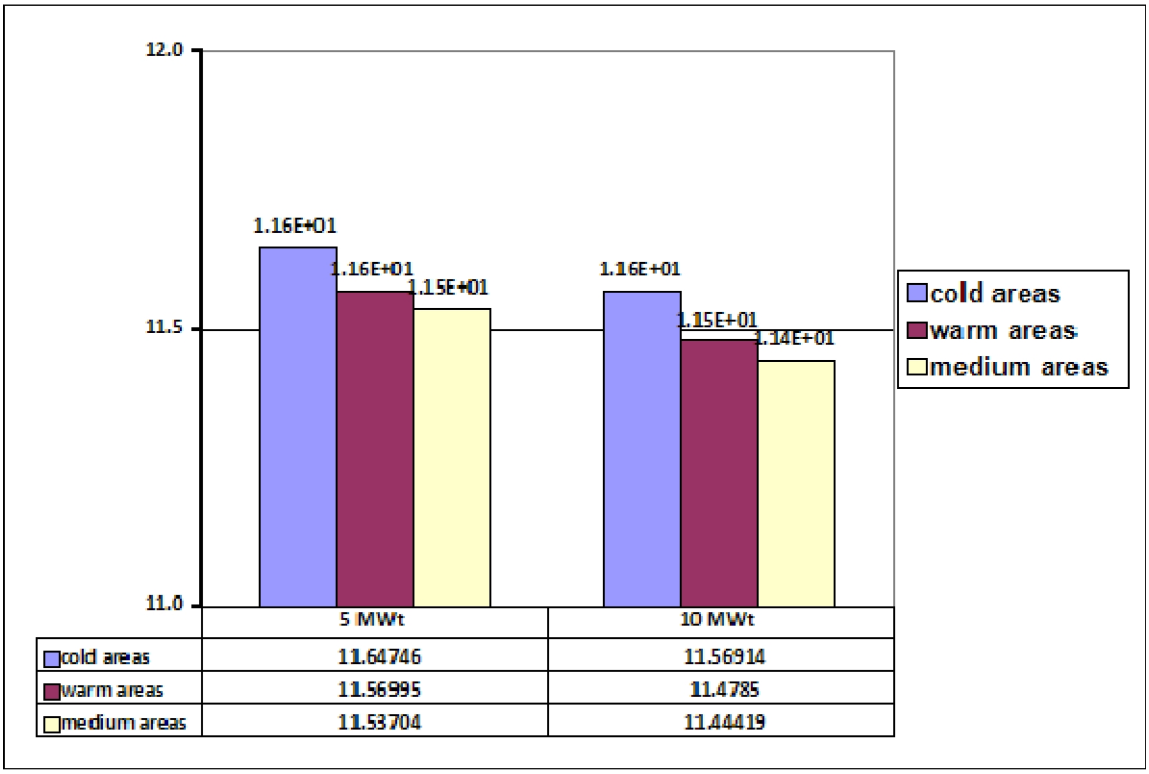
Economic calculation

M3.1. <u>THE ECONOMIC CRITERIA OF DECISION NPV</u>

(for the average climate area of Romania)

M3.2. It's determined the optimal nominal thermal cogeneration coefficient (CHP sizing) [%]

Fig.3
Maximum allowable value of solid biomass limit cost for that the net present value becomes zero (nominal heat power installed in the CHP-5 and 10MWt)



	5 MWt	10 MWt
cold areas	11.64746	11.56914
warm areas	11.56995	11.4785
medium areas	11.53704	11.44419

Appendix C

Notations

a	Discount rate	%
CHP	Cogeneration plant	-
CO_2	The carbon dioxide	-
CGI, PHI	Cogeneration installation, respectivelypeak heat installation	-
LHV	Lower heating value of the fuel	kJ/kg
$q_h, q_h^n, q_h^{md}, q_h^m$	Heat flow for any, nominally, average and minimum heating during heating	kWt
q_{whc}^n, q_{whc}^{md}	Heat flow nominal, respectively average for preparation hot water of consumption	kWt
q_{whc}^w, q_{whc}^s	Heat flows to preparation hot water for any consumption, in winter period respectively summer	kWt
$q_{whc}^{md,w}, q_{whc}^{md,s}$	Average daily flow of heat for preparation hot water of consumption during the winter respectively summer	kWt
$q_u^w, q_u^{n,w}, q_u^{md,w}, q_u^{m,w}$	Any, nominal, average respectively minimum, momentary heat flows corresponding winter period	kWt

$q_u^s, q_u^{n,s}, q_u^{md,s}, q_u^{m,s}$	Any, nominal, average respectively minimum, momentary heat flows corresponding summer period	kWt
q_c, q_s	The heating capacity demanded, respectively delivered to the consumer	kWt
q^{md}, q^m	Average flow, respectively minimum of heat delivered CHP	kWt
q_{CGI}	Any momentary heating capacity installed in cogeneration installation	kWt
q_{CGI}^n, q_{CHP}^n	Any nominal momentary heating capacity installed in cogeneration installation, respectively in CHP	kWt
NPV	Criterion net present value	-
ρ_T	The average relative value of the heat flow	-
τ	The current value of the year	h/year
τ^w, τ^s	The duration of heating in winter respectively in summer	h/year
τ_f	Duration yearly heat demand of the consumer	h/year