

OPTIMIZATION OF GAS SUPPLY OF CHP SOURCES OF ENERGY

KOĢENERĒJOŠU SILTUMA AVOTU GĀZES PIEGĀDES OPTIMIZĀCIJA

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Introduction

The development of CHP (combined heat and power) sources of energy (including low-powered CHP plants) is one of the most important measures for economy of energy, according to position of European Union. In 2004 Latvia has signed the European Parliament's CHP Directive 2004/8/EK. According to this Directive, the member countries of European Union must support the establishment of new CHP plants.

Thanks to a CHP supporting state program's measures (obligate purchase, fixed price of electrical energy) now there are wider opportunities to create new CHP plants, or also to reconstruct existing boiler houses installing CHP equipment. Although there are many kinds of fuels which can be used in CHP plants (wood, derv, bio gas), gas is the safest fuel from the ecological point of view, and it is also the most effective one (produced electrical/produced thermal energy = 0.7-0.9). However, by now gas is available only in 1/3 part of Latvian territory. In future a/s "Latvijas Gāze" is planning to fund into the farther development of the existing distributive gas-supply systems and to provide many new consumers with gas. Soon it will be possible to use gas as a fuel for CHP equipment in many new regions.

A new planned CHP plant can be situated right in the area of gas-supply system or on a longer or closer distance from it. This article tries to find out in which circumstances it is profitable to build a special gas pipeline for a planned CHP plant.

The reconstruction of boiler house by the way of installing CHP equipment

In Latvia there is a large experience of reconstructing existing boiler houses in small towns and villages, and installing gas internal combustion engines instead. Internal combustion engines reduce the consumption of fuel to 40%, comparing to the variant, when heat and power are generated separately.

After the reconstruction of boiler house the old boilers are used as peak load boilers, which are put in motion when the outside temperature is low, because the capacity of CHP equipment is not considered for maximum consumption of heat. Choosing the CHP equipment's capacity before starting the reconstruction is a problem, because it depends on the total structure of consumers of energy.

The gasification of the object which will be reconstructed is connected with choosing the capacity of CHP equipment. It is possible to use gas as a fuel for all equipments of a reconstructed boiler house, or only for CHP equipment.

Let's take an example, where a boiler house provides a large district with heat. In the past there was not any distributive gas-supply system around, therefore wood was used as a fuel. Power of the boiler house is 5 MWe.

Now a distributive gas-supply system is being built at 5 km distance from the boiler house. It is possible to reconstruct the boiler house. After the reconstruction it will be a low-powered CHP plant which will use natural gas for fuel. It is important to find out if the reconstruction of the boiler house is effective, if it is profitable to build a special gas pipeline for the boiler house.

The first step is making the primary hydraulic calculation for a gas pipeline. It is necessary to define the precise length and diameter of gas pipeline, to design gas pressure-lowering devices. Having got the results of calculation it is possible to make up an estimate for designing and building of the gas pipeline.

The hydraulic calculation of gas pipeline must be made according to Latvian standards LVS 417 "Gāzes sadales un lietotāja sistēmas. Ārējie gāzesvadi un regulēšanas iekārtas. Projektēšana". The diameters of gas pipes must be chosen according to results of hydraulic calculation, taking into consideration that uninterrupted gas supply of all consumers must be guaranteed at the time of maximum consumption of gas.

The hydraulic calculation is made using special tables or programs (a/s "Latvijas Gāze" uses CadDy program), considering that the power of a boiler house after the reconstruction will be 5 MWe. Diameter of gas pipeline will be 200 mm. The cost estimate for 5 km long gas pipeline includes planning work, installation work, cost of PE gas pipes, pressure-lowering device, and all necessary extra devices.

When the cost of a new gas-supply system is known, it is possible to make the estimation of the project of reconstruction from the economical point of view. The main economical criterion for this project is the internal rate of return (IRR), which can not be lower than normative (a/s "Latvijas Gāze" normative is $IRR \geq 10\%$). This criterion also shows the possibility of credit paying with a credit rate up to 10%.

The analysis of the efficiency of gas-supply system's project using the method of calculation of IRR

Below there is the analysis of estimation of efficiency of gas-supply system's project using the method of calculation of IRR.

The 5 km long gas pipeline is designed for 5 MWe powered CHP plant. The reciprocating engine is used as a primary engine of the CHP plant. The alternative fuel for the reciprocating engine is derv. The prices for gas and derv are based on gas and derv marginal costs in the immediate future. According to the estimate, the costs for the 5 km long gas pipeline (the diameter of pipes is 200 mm) are 500 000 Ls. Estimated income from gas is 300 000 Ls per year (in comparison with derv).

- 1) gas delivery system (5 km) – 500 000 Ls;
- 2) incoming cash flow – 300 000 Ls per year.

The general period of repayment: $T = 500\ 000 / 300\ 000 = 1,7$ years.

The first variant of calculation is made for the 5 years long time period. The discount factor can be not lower than 10%. At first, the calculation is made considering that the 5MWe CHP plant works at full blast 2500 hours per year.

Table 1. The analysis of the cash flow for the CHP plant working at full load (12 500 MWe per year)

year	0	1	2	3	4	5
outgoing cash flow (thous. Ls)	-500	0	0	0	0	0
incoming cash flow (thous. Ls)	0	300	300	300	300	300
undiscounted cash flow	-500	300	300	300	300	300
diskount factor 10%	1	0.909	0.826	0.751	0.683	0.621
discounted cash flow	-500	273	248	225	205	186

year	0	1	2	3	4	5
undiscounted cash flow	-500	300	300	300	300	300
discount factor 53%	1	0.654	0.427	0.279	0.182	0.119
discounted cash flow	-500	196	128	84	55	36

In case if discount factor is 10%, the sum of DCF (discounted cash flow) is 637. Net present value (NPV) is positive. In the further calculation the discount factor is accepted 53%: In case if discount factor is 53%, the sum of DCF is -1. NPV is negative. Making it round, when NPV is 0, IRR is 53%. IRR is very high, which means that the efficiency of gas supply system will be very high.

But, as it is seen from the lines 1 and 3 (figure 1), the expenditure of energy during cold year or during warm year can be very different. It is necessary to reckon with this fact while maintaining the CHP plant.

On figure 1 there are the curves of duration of outward temperature for Riga. These curves have been made using observations for a warm, a cold, and a middle cold year (during many heating seasons). There have been examined 3 variants of choice of CHP plant's power: the diesel engine provides chargeable heat, when the outward temperature is up to 1) +5°C, 2) +0°C, and 3) -5°C. When the outward temperature is lower, the extra boilers are used. In all calculations there was used the temperature data of medium year (figure 1, curve 2).

On figure 2 there are the variations of consumption of energy in different meteorological conditions. Hereto, if diesel engine provides chargeable heat, when the temperature is, for example, up to -5°C, then during a warm year (curve 3) extra boilers are not used.

In future, there could be found other, than gas or derv, kinds of fuel for extra boilers - like wood or turf. These kinds of fuel are cheaper than derv, and the using of these is possible without reconstruction of the boiler house. In this case, the gas supply system, which was designed for generating 12 500MWe of heat energy per year, will be used for the less amount of gas. For example, if the consumption of gas is twice as little as it was planned, the efficiency of gas supply system will decrease a lot.

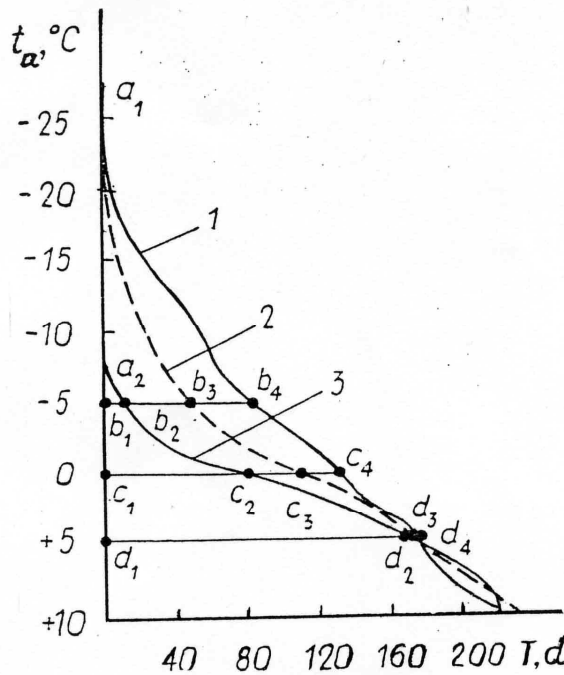


Figure 1. The temperature curves for Riga meteorological conditions

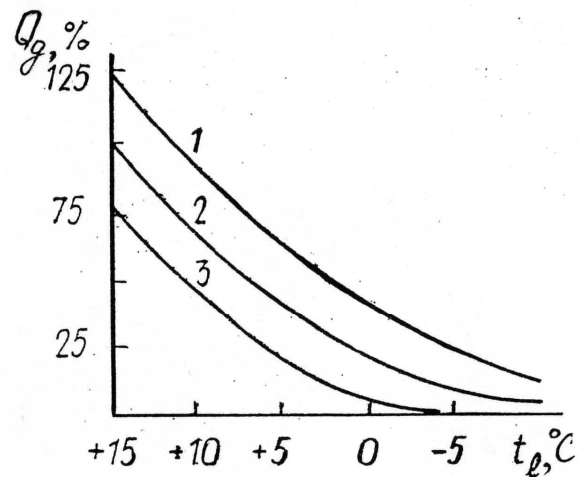


Figure 2. Divergences of energy consumptions of different meteorological conditions

There is a calculation of IRR for the case, when the consumption of gas is 50% of which was planned (6 250MWe per year). Incoming cash flow is $300\ 000\text{Ls}/2 = 150\ 000\ \text{Ls}$. Period of repayment is $T = 500\ 000/150\ 000 = 3.3$ years. The period of time, for which the calculation is made, is the same - 5 years.

Table 2. The analyses of the cash flow for the CHP plant working at 50% load (3 250MWe per year)

year	0	1	2	3	4	5
outgoing cash flow (thous. Ls)	-500	0	0	0	0	0
incoming cash flow (thous. Ls)	0	150	150	150	150	150
undiscounted cash flow	-500	150	150	150	150	150
diskount factor 10%	1	0.909	0.826	0.751	0.683	0.621
discounted cash flow	-500	136	124	113	103	93

If discount factor is 10%, the sum of DFS is 69. NPV is positive.

Making it round, when NPV is 0, IRR is 12%. It is still permissible ($IRR \geq 10$), which means that the gas supply system will be effective even when the CHP plant works at 50% load.

It is possible to find a limit load, when the gas supply system is still effective, in other words, when $IRR=10\%$. According to calculation, the limit load of CHP plant is 44% (5 500MWe per year). Incoming cash flow is $300\ 000/2 = 150\ 000$ Ls. Period of repayment $T = 500\ 000/132\ 000 = 3.8$ years.

Table 3. The analysis of the cash flow for the CHP plant working at 44% load (5 500 MWe per year)

year	0	1	2	3	4	5
outgoing cash flow (thous. Ls)	-500	0	0	0	0	0
incoming cash flow (thous. Ls)	0	132	132	132	132	132
undiscounted cash flow	-500	132	132	132	132	132
diskount factor 10%	1	0.909	0.826	0.751	0.683	0.621
discounted cash flow	-500	120	109	99	90	82

The curve on fig.3 shows how IRR depends on changes of load of CHP plant.

Using this method, there may be considered a longer period of repayment. Usually period of repayment must be ≤ 10 years.

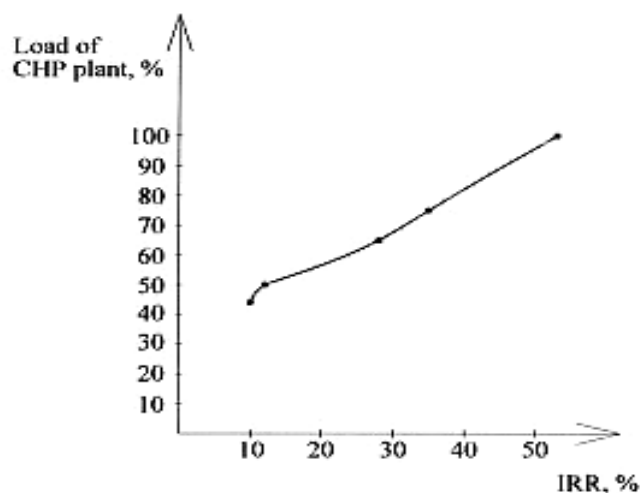


Figure 3. IRR dependence on changes of load of CHP plant

Conclusions

The method of calculation of permissible IRR is effective for analyzing the projects of CHP plants' gasification (also in case of reconstruction of existing boiler houses). IRR is an effective criterion of profitability of gasification, if the forecast of the consumption of gas is precise.

Using the method of calculation of permissible IRR it is possible to find the limits of load in which CHP plant must work, so that the project of gasification is efficient.

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Odiņeca T., Zēbergs V., Koģenerējošo siltuma avotu gāzes piegādes optimizācija

Rakstā tiek pētīta koģenerējošo siltuma avotu gāzes piegādes optimizācijas metode - pieļaujamās IAL aprēķina metode. Tā ir efektīva, novērtējot TEC gāzifikācijas projektus (arī katlumājas rekonstrukcijas gadījumā). Iekšējā atmaksāšanās likme ir efektīvs gāzifikācijas izdevīguma kritērijs, atkarībā no gāzes patēriņa prognozes precizitātes. Izmantojot IAL aprēķina metodi, ir iespējams noteikt slodzes robežas, kurās koģenerācijas iekārtai ir jāstrādā, lai projekts būtu efektīvs.

Odineca T., Zebergs V. Optimization of gas supply of CHP sources of energy

The article contains reviews the method of optimization of gas supply of CHP sources of energy - the method of calculation of permissible IRR. It is effective for analyzing the projects of CHP plants' gasification (also in reconstruction of existing boiler houses). IRR is an effective criterion of profitability of gasification, if the forecast of the consumption of gas is precise. Using the method of calculation of permissible IRR it is possible to find the load limits in which CHP plant must work, so that the project of gasification be efficient.

Одынец Т., Зебергс В. Оптимизация газоснабжения когенерирующих источников энергии

В статье рассматривается метод оптимизация газоснабжения когенерирующих источников энергии – метод расчета допустимого IRR. Он эффективен при оценке газификации проектов ТЭЦ (также в случае реконструкции котельной). IRR – эффективный критерий рентабельности газификации, в зависимости от точности прогноза потребления газа. Используя метод расчета IRR, можно определить пределы нагрузки, с которой должна работать когенерационная станция, чтобы проект был эффективен.