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Support scheme for CHP and its sensitivity on heat wasting

R. Neděla[1,*] and R. Neděla[2]

[1]Czech University of Life Sciences Prague, Technical Faculty, CZ 16521 Prague 6 – Suchdol, Czech Republic
[2]University of Economics, Prague, Faculty of International Relations, CZ 13067 Prague 3, W. Churchill 4 SQ, Czech Republic;
[*]Correspondence: nedela@tf.czu.cz

Abstract. This paper describes basic principles of the CHP, advantages and disadvantages, technologies. In first part of article are described principles of CHP from the viewpoint of the energy customer. Second part describes basic Directives by the European Commission on promotion CHP and third part the most important part focus on the sensitivity of primary energy saving (PES) on outputs especially heat wasting.

Key words: Combined heat and power, cogeneration, primary energy savings, primary energy, heat wasting, efficiency, support.

INTRODUCTION

Combined heat and power production (CHP) also known as cogeneration is the simultaneous production of electricity and heat from a single fuel source, such as coal, natural gas, biomass, waste heat, biogas, oil and etc. High efficient CHP is one of supported technology which can help to achieve the 20-20-20 goals the third target climate change and energy suitability. This ambitious European target means a 20% increase in energy efficiency and a 20% reduction of CO_2 emissions and a 20% renewables by 2020.

The main advantage is that the CHP systems are able to recover waste heat produced from the generation of electricity. That's why cogeneration has higher efficiency (Flin, 2010) than separate production of electricity and heat. The best example how to explain the principle of CHP is to look at it from a viewpoint of an energy customer. See Fig. 1 where principle separate production of electricity and heatis described. As we can see an overall efficiency of 58% is for separate production.

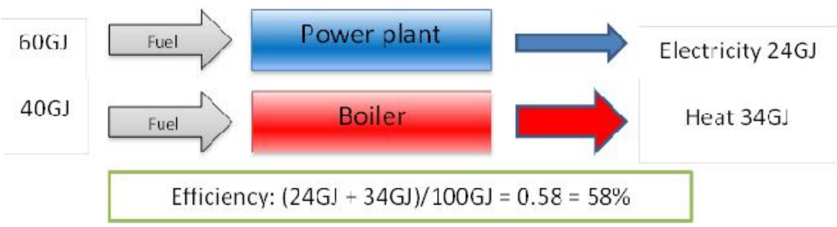

Figure 1. Separate production of electricity and heat.

The same example is but with CHP system; see Fig. 2 with an overall efficiency of 85%.

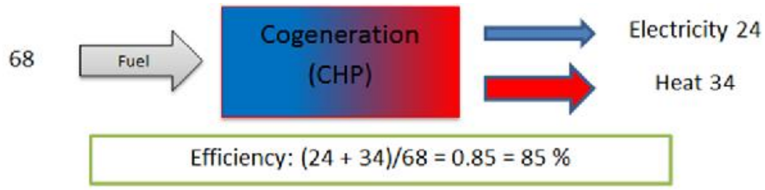

Figure 2. Cogeneration = simultaneous production of electricity and heat (Nedela & Nedela, 2013).

As you can see in the both figures the first advantage is that for same necessary units of energy (electrical energy and heat) for the end customer we will need less fuel units = less primary energy. Inputs and outputs are re-calculated for the same energy units. If we have less fuel units and less distribution of production losses then we will have also lower emissions to the environment in particular CO_2. So these are some of the advantages of CHP.

LEGISLATION

One of the most important Directives of the European Parliament and of the Council was 2004/8/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC. This directive shows potential for use of cogeneration as a measure to save energy. We can also find here a new important definition of high-efficiency cogeneration that provides primary energy savings calculated according to equation (1) of at least 10% compared with the references for separate production of heat and electricity, production from small scale and micro cogeneration units (defined by 1 MWe installed capacity) that must provide primary energy savings (that means higher than 0%) may be to qualify as high-efficiency cogeneration (EC Directive, 2004). The issue of PES is briefly described in paper (Nedela & Nedela, 2013).

PES calculation (EC Directive, 2004):

$$PES = \left(1 - \frac{1}{\frac{CHP\ H\eta}{REF\ H\eta} + \frac{CHP\ E\eta}{REF E\eta}}\right) \cdot 100\% \qquad (1)$$

where: *CHPHη* is the heat efficiency of the cogeneration production defined as annual useful heat output divided by the fuel input used to produce the sum of useful heat output and electricity from cogeneration. *RefHη* is the efficiency reference value for separate heat production. *CHP Eη* is the electrical efficiency of the cogeneration production defined as an annual electricity from cogeneration divided by the fuel input used to produce the sum of useful heat output and electricity from cogeneration. Where a cogeneration unit generates mechanical energy, annual electricity from cogeneration may be increased by an additional element representing the amount of electricity which is equivalent to that of a mechanical energy. *Ref Eη* is the efficiency reference value for separate electricity production.

In 2012 the new Directive 2012/27/EU of the European Parliament and of the Council on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealling Directives 2004/8/EC and 2006/32/EC, that is mostly about energy efficiency repeal the Directive 2004/8/EC and also sets important duties to Member States (Article 14) carrying out and notifying to the Commission a comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling. This information will be important for the investors and will help to develop a whole CHP sector.

Next important material is Guidelines on State aid for environmental protection and energy 2014–2020 (EC Guidelines, 2014). This material follows a policy Framework for climate and energy in the period from 2020 to 2030, where are new pillars of the 2030: greenhouse gas emission reduction, increase amount of renewable energy and energy efficiency. For cogeneration and district heating and cooling is there special part that described support scheme for new application of CHP.

SENSITIVITY OF PES PARAMETER

The PES parameter compares CHP with reference separate heat and separate electricity production and it is the most important parameter which qualifies if the CHP producer can receive some state support. This state support must be in line with Guidelines on State Aid for Environmental Protection and Energy for actual period (now 2014–2020).

Fig. 3 shows a basic CHP scheme. Input is a fuel energy which goes into a gas turbine and outputs are electrical energy and useful heat.

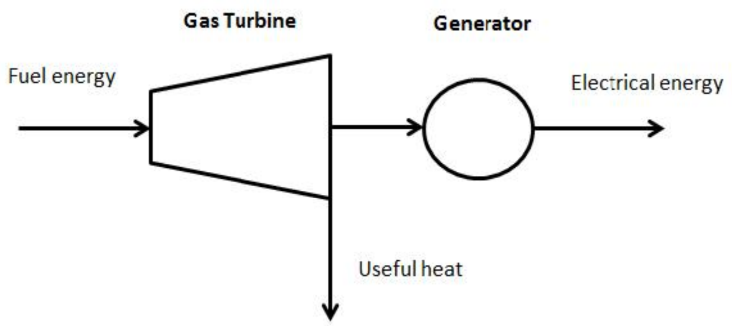

Figure 3. CHP scheme.

Overall efficiency is:

$$\eta = \frac{p + q}{f} \qquad (2)$$

where: η is an overall efficiency which is the ratio of all energy outputs to all energy inputs; p is an output of electrical energy; q is an output of useful heat; f is a fuel energy input.

If η is higher than 75% or 80% (depends on technology) than total electrical energy is an energy from cogeneration, if η is lower than we have to calculate a part of energy which is from cogeneration.

$$p_{CHP} = q_{CHP} \cdot C \quad (3)$$

where: p_{CHP} is an amount of electricity from cogeneration; C is a power to heat ratio.

Practical example:
p_{CHP} 20 units, q 65 units, f 100 units.

Overall efficiency is:

$$\eta = \frac{p+q}{f} = \frac{20+65}{100} = 0.85 = 85\% \quad (4)$$

Sensitivity of primaryenergy savings (PES) on useful heat shows Fig. 4.

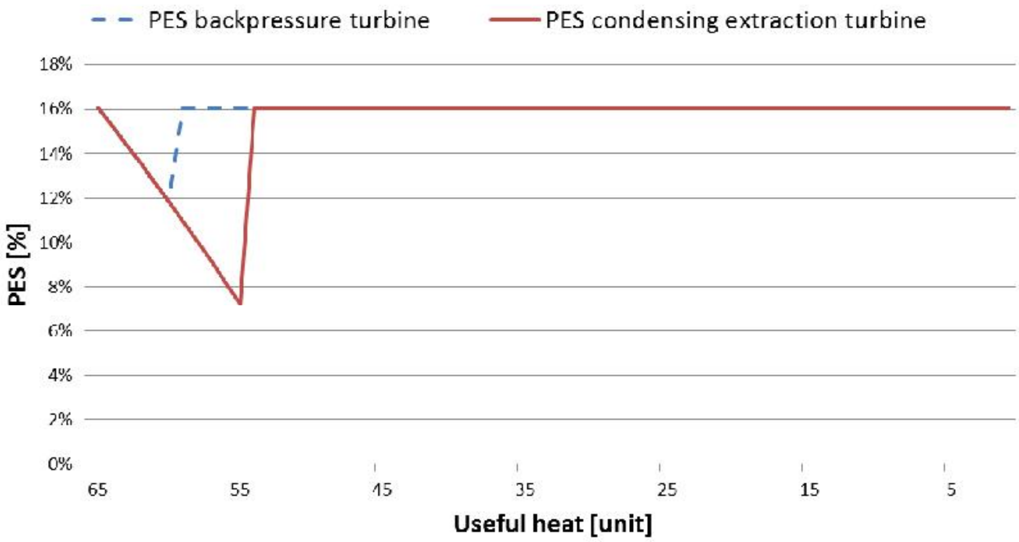

Figure 4. Sensitivity PES on useful heat, backpressure turbine and condensing extraction turbine.

The most importat information is in Table 1. Table shows a sensitivity of PES on useful heat. When an overall efficiency of condensing extraction turbine is between 75% to 78%;for a producer it is better to waste heat because a PES parameter is higher than 10% i.e. you are a high efficient cogeneration and you can receive a support from a government.

Table 1. Theoretical calculation backpressure turbine and condensing extraction turbine, primary energy savings and other important parameters

q_{CHP}	65	64	63	62	61	60	59	58	57	56	55	54
η	**85%**	**84%**	**83%**	**82%**	**81%**	**80%**	**79%**	**78%**	**77%**	**76%**	**75%**	**74%**
p_{CHP} backpressure	20	20	20	20	20	20	18.15	17.84	17.53	17.23	16.92	16.61
p_{CHP} condensing	20	20	20	20	20	20	20	20	20	20	20	16.61
p_{NOCHP} backpressure	0	0	0	0	0	0	1.85	2.15	2.46	2.77	3.08	3.38
p_{NOCHP} condensing	0	0	0	0	0	0	0	0	0	0	0	3.38
f_{NOCHP} backpressure	0	0	0	0	0	0	9.23	10.77	12.31	13.85	15.38	16.92
f_{NOCHP} condensing	0	0	0	0	0	0	0	0	0	0	0	16.92
f_{CHP} backpressure	100	100	100	100	100	100	90.76	89.23	87.69	86.15	84.61	83.07
f_{CHP} condensing	100	100	100	100	100	100	100	100	100	100	100	83.07
η_E backpressure	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
η_E condensing	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
η_T backpressure	65%	64%	63%	62%	61%	60%	65%	65%	65%	65%	65%	65%
η_T condensing	65%	64%	63%	62%	61%	60%	59%	58%	57%	56%	55%	65%
PES backpressure	16%	15%	14%	14%	13%	12%	16%	16%	16%	16%	16%	16%
PES condensing	16%	15%	14%	14%	13%	12%	11%	10%	9%	8%	7%	16%

Fig. 5 shows sensitivity of PES parameter on an overall efficiency, as you can see there is same situation like sensitivity on useful heat.

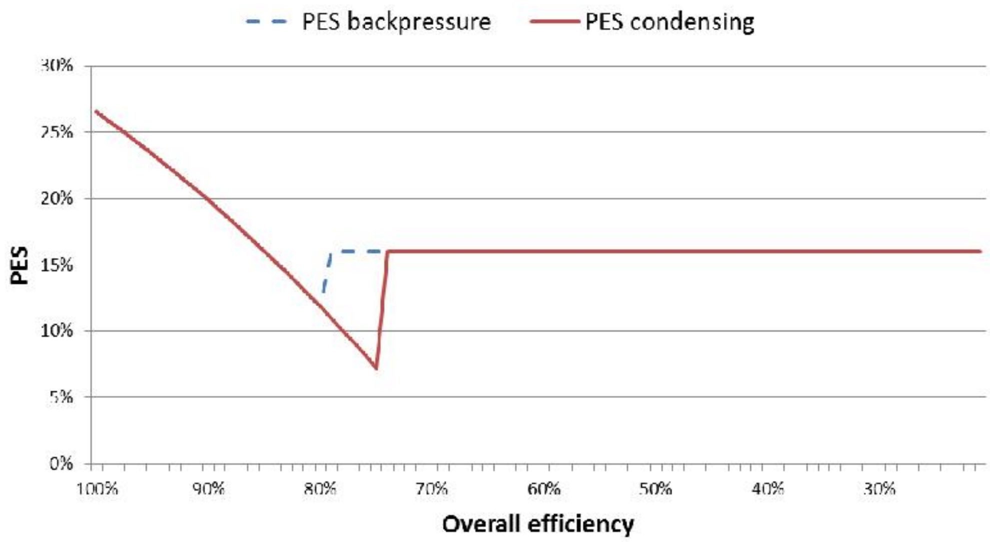

Figure 5. Sensitivity of PES on an overall efficiency, backpressure turbine and condensing extraction turbine.

Fig. 6 shows PES sensitivity on an overall efficiency with a different value of useful heat and cogeneration electricity.

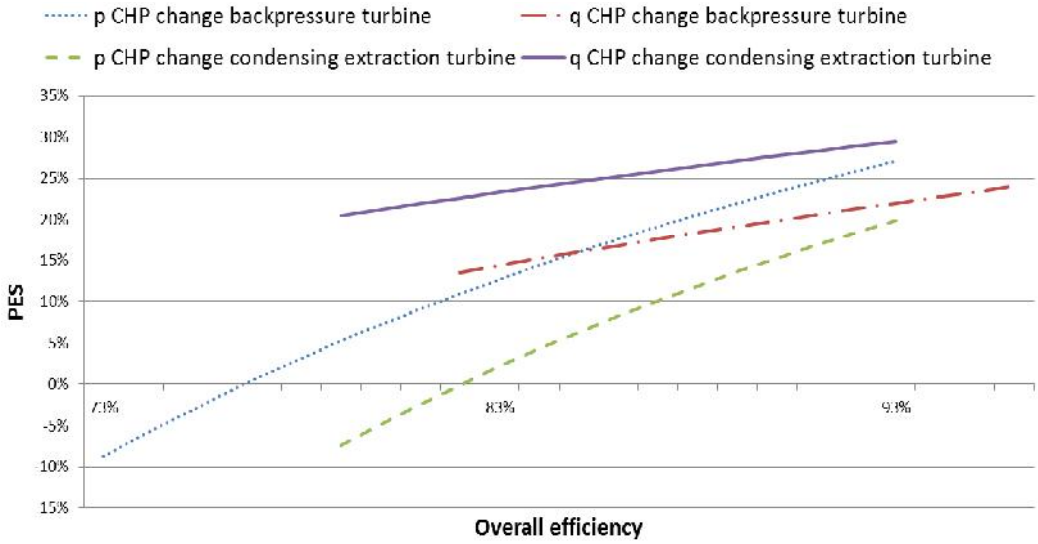

Figure 6. Sensitivity of PES on an overall efficiency, backpressure turbine and condensing extraction turbine.

Fig. 7 shows sensitivity of a PES parameter on an overall efficiency with a different value of electricity from a cogeneration. As you can see the most important parameter is electricity from a cogeneration, if this parameter is too low, then you have no chance, even you use all heat which you have, to get a better PES parameter. Negative PES parameter means that it is better to have a separate production of electricity and heat. For a better understanding the goal of a producer is to get a support.

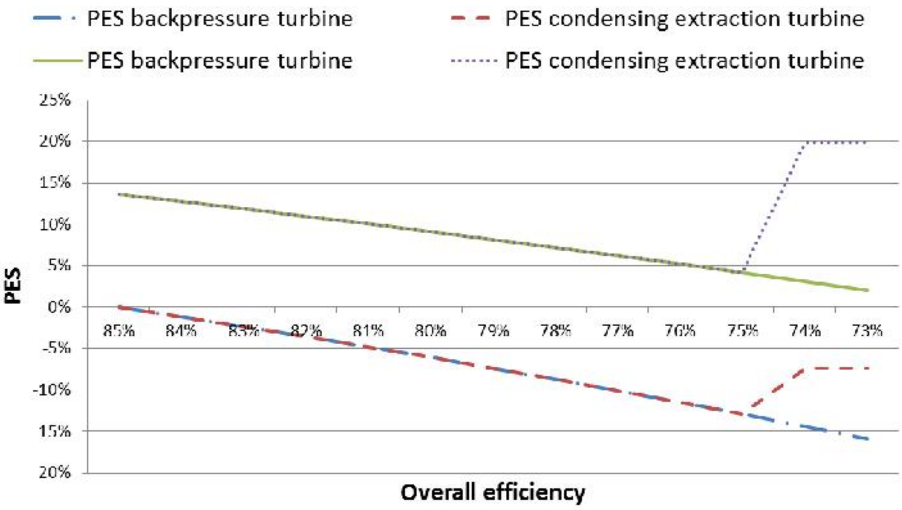

Figure 7. Sensitivity of PES on an overall efficiency, backpressure turbine and condensing extraction turbine with different values of electricity from cogeneration and different values of useful heat.

CONCLUSION

This paper briefly explains basic principles of a cogeneration andthe main legislation framework. The main focus is on primary energy savings parameter (PES) and sensitivity on heat waste. In a specific situation is better to waste heat according to use it. This is to be done because of virtual splitting possibility.

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