SMALL-SCALE CHP POTENTIAL IN LATVIA AND ESTONIA

MAZĀS JAUDAS KOĢENERĀCIJAS POTENCIĀLS LATVIJĀ UN IGAUNIJĀ

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Introduction

The potential for using cogeneration as a measure to save energy is underused in the EU at the present time, according to the EU Directive 2004/8/EC on the promotion of cogeneration based on a useful heat demand on the internal energy market. Promotion of high-efficiency cogeneration (CHP) based on a useful heat demand is a Community priority given the potential benefits of CHP with regard to saving primary energy, avoiding network losses and reducing emissions, in particular of greenhouse gases[1].

Latvia and Estonia are the member states of the European Union and they both have a high potential for CHP development. The Estonian vision, according to the “Energy Sector Development Plan 2020” is that up to 20% of electricity should be produced by CHP [2]. As for Latvia, regarding the “Guidelines for Energy Sector Development 2007-2016” the installed capacity of Latvian CHP potential should reach 550 MWel [3]. These purposes include both big centralised thermal electrical plants development and small scale CHP development. During the research the potential for CHP in Latvia and Estonia is analyzed.

Factors, which have influence on the CHP development in Latvia and Estonia

The factors, which influence the CHP development in Latvia and Estonia, can be divided into political, economical, geographic- climatological factors, and technological factors.

Political factors: Strong political factor, which influences the small-scale CHP development in Latvia and Estonia, is Baltic dependence on Russian fuel and electricity sectors. Baltic dependence on Russian energy supplies can serve as a convenient way of exerting economic pressure [4].

The Baltic countries can obtain natural gas only from Russia and are thus totally dependent on the “Gazprom” monopoly. There are oil pipeline

connections between Latvia on one side and Russia on the other, but there are no connections with other countries. This factor can influence the small-scale CHP development in two ways. Firstly, dependence on natural gas supply results in local fuel consumption increasing. Secondly, the political problems between the Baltic countries and Russia stimulate Latvia and Estonia interest to develop local electricity production.

Both Estonia and Latvia have big amount of bioenergy resources, which results in increase of bioenergy based CHP usage: wood-based CHP technologies, biogas technologies, biofuel-based CHP. Peat can be used for small scale CHP too, but this type of fuel has very high CO₂ emissions and is not considered to be renewable energy source. At present time the peat production in the Baltic States is very low.

For Estonia the most important local energy source is an oil shale. Share of energy converted by oil shale is more than 90% [5]. There is no perspective for using oil shale in a small-scale CHP because of various factors such as high ash content and low efficiency of this type of fuel in small-scale equipment. Electrical plants should have high installed capacity [6].

The most widely used and perspective small-scale CHP technology is an internal combustion engine, where natural gas and oil can be used. Political instability can decrease an interest to install natural gas and oil based CHP both in Estonia and in Latvia.

The Baltic electricity grids are connected to each other and to Russia. Estonia does not depend on import of electricity from Russia which is minimal and much lower, than Estonian electricity export to Latvia and Lithuania. But as regards Latvia the political factor can influence the local electricity production. Comparing prices for natural gas and electricity, it is better to develop the local electricity production based on natural gas and oil CHP, rather than import electricity [4].

Summarizing the political factors influence on the small scale CHP development:

- Baltic dependence on Russian oil and natural gas;
- Bioenergy and peat based CHP development;
- Decrease of interest to install CHP based on natural gas/.

Next factors, which influence the CHP potential in Latvia and Estonia, are *geographic-climatological factors*.

Estonia and Latvia are located in the northern part of Europe, and an average air temperature of the five coldest days ranges for Latvia from -18,3°C (Liepāja) to -25,1°C (Alūksne) [7], but for Estonia from -18.5°C (Kärdla) to -25.5 °C (Tartu) [8]. The heating season duration in Latvia is from 193 days (Liepāja) to 214 (Alūksne) [7]. Heating period in Estonia is from 216 days (Võrumaa) to 224 days (Järvamaa) [9]. It means that there is a necessity in high heating loads during a long period. It gives a possibility for CHP produced heat consumption but at the same time is considered to be one of the most important problems for CHP.

Local natural resources in Latvia and Estonia are the important geographical factors for CHP. The natural resources' situation in both countries is different, but common for the both countries is that there are no local resources of natural gas or oil.

For Estonia the main fuel types are oil shale, peat and wood. The oil shale can be used for two purposes: to produce electricity in power plants or to produce the so-called shale oil. The wood and the peat are used in the boiler houses. The domestic fuels are dominant to meet the need for energy. Although the domestic resources of fossil fuel are large enough for covering the domestic energy needs for the next decades, more and more attention has been paid in recent years to the utilization of alternative and renewable energy resources.

One of the recent developments in the wood-based CHP technology in Estonia was a new biofuel and peat fired CHP plant located in Vao, which started to produce electricity in the beginning of 2009.

Latvian main local resource for power production is the hydroenergy. The largest part of electricity generated in Latvia comes from the three leading hydropower plants in Latvia: the Kegums HPP, the Plavinas HPP and the Riga HPP. This type of energy source can't supply stable electricity production and in a so-called "dry" year it is estimated to be only 60% self-sufficient. The CHP technology can serve as a balance capacity.

Another type of local fuel in Latvia is wood. There are many wood-based boiler houses and 3 wood-based CHP with 2 MW of common installed electrical capacity. [13].

According to geographical-climatological factors we can summarize the influence on the small scale CHP development:

- the long and cold winters result in high and stable load for central heating, where CHP produced heat can be used;
- there are local electricity sources both in Estonia (oil shale) and in Latvia (hydropower). The Estonian oil shale is a fossil fuel which is not eligible for CHP. But it is difficult for CHP produced electricity to compete with cheap electricity produced by oil shale power plants. However some certain EU ecology norms demand the reduction of oil shale share in state energy sources consumption. This may bring an interest growth towards the wood-based and natural gas based CHP systems installation. In Latvia the CHP can serve as a balance capacity for the hydropower plants. Amount of an accessible energy wood in Latvia and Estonia can motivate the wood-based CHP development.

Legislative factors: Common for the both states is the Directive 2004/8/EC on the promotion of CHP based on a useful heat demand in the internal energy market potential.

In the framework of this Directive is proposed a mechanism which ensures that the producers and others with an interest in the CHP can request a guarantee of origin for the electricity produced from CHP; additionally is defined a methodology to determine the energy savings from the CHP.

The Directive determines that the Member States are obliged to carry out the analysis of their national potential for the CHP. Both Latvia and Estonia have improved the legislative acts in accordance of the support schemes for the CHP.

As regards legislative acts in Estonia, a supporting scheme for the use of renewable energy sources for electricity generation was established in 1998. The Electricity Market Act (EMA) describes the obligation for grid operators to purchase electricity from the renewable sources. Up to May 2007 the rate of the feed-in tariff has been 51.77 EUR/MWh. In May 2007, amendments of the EMA came into force that established the subsidies for the high efficiency CHP of heat and electricity.

The new regulation supports the CHP with feed-in tariffs in the following cases:

- the CHP uses the renewable energy sources or fossil fuels such as peat or waste or oil or the shale gas;
- the CHP plant (up to 10 MW) has been started on the basis of a former heat only boiler (HOB) plant (See Table 1). Before that there was neither political nor financial support for the CHP in Estonia [10].

Table 1.

Support to electricity produced from the renewable energy sources and/or CHP in Estonia (EUR/MWh)

Energy source	Tariff alternatives (EUR/MWh)	
	Compulsory feed-in-tariff	Subsidized tariff
<i>Renewable energy sources (facilities < 100 MWe)</i>		
Other renewable energy sources	73,5	53,69
Renewable energy sources in efficient CHP	73,5*	53,69*
<i>Efficient CHP</i>		
Peat, waste, oil shale gas	51,77*	31,96*
CHP plant replacing heat-only boiler plant	51,77	31,96*

* A different tariff rate may be approved by the Energy Market Inspectorate.

On April the 3rd, 2009 the regulation draft regarding the grant payments to expand the renewable energy production and construction of CHP plants in Estonia was enacted. The regulation draft assumes the grant payments for the biofuel-based CHP plants under 2 MWe (except the Estonian islands) for up to 50% from expenses eligible for assistance. Enactment of this regulation is an extremely important for the small-scale biofuel-based CHP plants expansion. Latvia supports the CHP by means of the feed-in tariffs. The tariffs depend on the installed electrical capacity of the CHP units. The new Cabinet regulation Nr.221 regarding Electricity production,

price defining and producing electricity in CHP was adopted in 2009. The overview of the feed-in tariffs according to this regulation is presented in the Table 2 [11].

Latvian policy does not support industrial or auto-use of heat, produced in cogeneration.

As regards legislative basis, certain support is provided for the CHP development. There are still problems and the CHP projects are not very popular.

Table 2.

Support to electricity from CHP in Latvia

Installed capacity	Source type	
	Renewable sources or peat	Fossil fuel
More than 0,08 MW less than 1 MW	$0,51 \div 0,6 \cdot T_g^*$ (~ EUR 145÷190 /MWh)	$0,39 \div 0,45 \cdot T_g^*$ (~ EUR 110÷145 /MWh)
more than 1 MWe and less than 4 MWe	$0,47 \div 0,5 \cdot T_g^*$ (~ EUR 124÷133 /MWh)	$0,35 \div 0,38 \cdot T_g^*$ (~ EUR 90÷100 /MWh)
more than 4 MWe	Regulator approves the price	Regulator approves the price

* T_g - price of natural gas

Technological factors: Historically both Estonia and Latvia are the countries with district heating systems. This system is working both in big cities and in small towns. Usually heat is supplied by small-scale or middle scale boiler houses. This means, that there is enough heat load for the installation of new CHP equipment.

There are not so many small scale CHP plants in Latvia and Estonia and it means that there is a high potential for the new installations.

The overall summary of factors listed above and their influence is shown in Table 3.

Table 3.

Summary of factors, which influence the CHP development

Factors		Influence on the CHP development	
		Positive	Negative
Political	Dependence on Russian natural gas and oil sectors Baltic dependence on Russian electricity (Latvia)	Development of biomass CHP Local electricity production development, incl. CHP	Decrease of interest to install the internal combustion engine based CHP
Geographical-climatological	Low temperature and long winters Local energy wood resources Local hydropower resources (Latvia) Local oil shale resources (Estonia)	High heat load for CHP Bio-CHP development	 In wet years is no necessity for the CHP electricity Not possible to use in CHP
Legislative	Feed-in tariffs	CHP support	Bureaucratized procedures Restrictions and criteria for CHP operating
Technological	District heating High grid capacity	High heat load	Connection to the grid restriction, old grid

Small scale CHP potential calculation

According to the Cogeneration Directive the Small-scale CHP are the CHP units whose electrical generation output is less than 1MWe. [1]

We will analyze the potential of the small scale CHP. The small scale CHP is optimal for application in small cities. The CHP potential in certain places can be defined using information about the existing boiler houses and heat load.

Various alternatives for the CHP potential will be analyzed.

First alternative is the case when only the hot water is being taken into consideration. In this case the CHP can work with full load whole year round, because the heat load will not change. In this case the 13% from maximum heat load will be covered by CHP. For assessment $k=0,13$.

As a second alternative the optimum defined during previous research will be used. In this case the optimal relative heat load has been found for a small-scale CHP.

This optimum is 0,3 [12]. According to this optimum the CHP can produce more electricity working with full load than in the first case. But the CHP is not working during whole year.

The third scenario will show the situation for a small-scale CHP, when a half of the maximum heat load is covered by the CHP.

To define the maximum heat load a formula(1) has been used:

$$P_{th_{max}} = \frac{P_{el}}{k\alpha} \quad (1)$$

where

k is ratio between CHP heat capacity and maximum heat load,

α is power to heat ratio.

According to this formula the boiler house ranges for each alternative were defined for the CHP potential calculation (see Table 4.)

Table 4.

Boiler houses which can be used for the small-scale CHP in Latvia and Estonia [13, 14]

Alternative	Boiler houses range	Latvia	Estonia
		Total capacity MW th.	Total capacity MW th
$k_1=0.15$	1-20 MW	1547	3873
$k_2=0.3$	1-5 MW	791	1475
$k_3=0.5$	1-5 MW	791	1475

Data are not taken from the energy balance sheet because the corresponding transformation sector in the autoproducer heat plants includes only the heat produced for sale, however all of the heat load can be used for electricity production. That's why the specific boiler houses statistics for 2007 is taken for calculations. The amount of total heat capacity is higher in Estonia than in Latvia, no matter that Latvia is bigger than Estonia by the size of territory and by the amount of inhabitants. After an assessment of statistical data it has been concluded that the main reasons of such results are: the active heat use in the industry in Estonia, colder climate in Estonia and difference in approach for data collection and calculation.

The basics of data collection methodology are the same for the both states: data are collected from all the enterprises whose main or secondary activity is steam and hot water supply. But calculation basics in Latvia and Estonia can vary.

For calculation the two types of technology are used: an internal combustion gas engine for gaseous and liquid fuel types (natural gas, biogas, fuel oil, shale oil) and steam backpressure turbine for solid fuel (wood, peat and coal).

The number of boilers is difficult to define, because for Estonia there is a statistical data about the number of boilers [14], but for Latvia is given information about the number of heat plants [13].

For calculations the ratio between the boilers based on gaseous and liquid fuel and the boiler houses

based on solid fuel will be taken for range 1-5 MW $N_{g,l(1-5MW)} / N_{s(1-5MW)} = 1$, for range 5-20 MW $N_{g,l(5-20MW)} / N_{s(5-20MW)} = 2$. $N_{g,l}$ is number of boilers which are working on the basis of gaseous and liquid fuel and N_s is number of boilers, which are working on the basis of solid fuel. There is no exact statistical data, but for the calculation of potential this ratio for the both states can be used. According to the Cogeneration Directive the calculation of electricity from CHP must be based on the actual power to heat ratio. If the actual power to heat ratio of a CHP unit is not known the following default values may be used, notably for statistical purposes, for steam backpressure turbine $\alpha=0,45$, for internal combustion engine $\alpha=0,75$ [1].

Formula used for calculation of the CHP potential for each range is following:

$$P_{el} = \frac{P_{thKOG} N_{g,l} \alpha_{g,l} + P_{thKOG} N_s \alpha}{N_{g,l(1-5MW)} + N_{s(1-5MW)}} \quad (2)$$

where

P_{thKOG} - heat, which is covered by CHP ($P_{thKOG} = P_{th} k_n$, where n- alternative Nr);

$N_{g,l}$ is the number of boilers which work on the basis of gaseous and liquid fuel;

N_s is the number of boilers, which work on the basis of solid fuel.

The formulas and results for an alternative calculation are shown in Table 5(3,4,5).

Table 5.

Calculation of the small-scale CHP potential

Alternative	Formula	Latvia	Estonia
$k_1=0.13$	$P_e = \frac{k_1 P_{th(1-5MW)} N_{g,l} \alpha_{g,l} + k_1 P_{th(1-5MW)} N_s \alpha_s}{N_{g,l(1-5MW)} + N_{s(1-5MW)}} +$ $+ \frac{k_1 P_{th(5-20MW)} N_{g,l} \alpha_{g,l} + k_1 P_{th(5-20MW)} N_s \alpha_s}{N_{g,l(5-20MW)} + N_{s(5-20MW)}} =$ $= P_{th(1-5MW)} ((0,13 * 0,5 * 0,75 + 0,13 * 0,5 * 0,45) +$ $P_{th(5-20MW)} (0,13 * 0,66 * 0,75 + 0,13 * 0,33 * 0,45))$ $= 0,078 * P_{th(1-5MW)} + 0,083655 P_{th(5-20MW)}$ <p style="text-align: center;">(3)</p>	125 MWel	200 MWel
$k_2=0.3$	$P_e = \frac{k_2 P_{th(1-5MW)} N_{g,l} \alpha_{g,l} + k_2 P_{th(1-5MW)} N_s \alpha_s}{N_{g,l(1-5MW)} + N_{s(1-5MW)}} +$ $= P_{th(1-5MW)} ((0,3 * 0,5 * 0,75 + 0,3 * 0,5 * 0,45) = 0,18 * P_{th(1-5MW)})$ <p style="text-align: center;">(4)</p>	142 MWel	265,5 MWel
$k_3=0.5$	$P_e = \frac{k_3 P_{th(1-5MW)} N_{g,l} \alpha_{g,l} + k_3 P_{th(1-5MW)} N_s \alpha_s}{N_{g,l(1-5MW)} + N_{s(1-5MW)}} +$ $= P_{th(1-5MW)} ((0,5 * 0,5 * 0,75 + 0,5 * 0,5 * 0,45) = 0,3 * P_{th(1-5MW)})$ <p style="text-align: center;">(5)</p>	237 MWel	442,5 MWel

These alternatives for potential calculation show that the small-scale CHP potential is rather high in all cases, but in reality there are technological and economical restrictions and the features related with them:

- The economical calculation of every certain CHP plant is based on consumers' heat load duration curve. The consumer with constant heat consumption (mainly industrial consumers) is more preferable than the consumer with variable heat consumption. Both in Estonia and in Latvia the biggest part of consumers consists of households.
- Many boilers in Latvia and Estonia are the modern and effective boilers working on fossil and biofuels, which recently replaced the old boilers. Replacement of those boilers by CHP plants is not always the right decision, because the expenses for those boilers mainly are not covered.
- One of the problems is related to the industrial consumers. The experience shows that in such kind of industrial enterprises the heat supply is organized in a very cheap way. Taking into account the relatively high investment costs, an interest to the CHP plants construction is limited.

Conclusions

There are many factors influencing improvement of the CHP usage in each state: political (energy dependence), geographic-climatological (cold winters, long heating period duration), legislative (support, bureaucratic procedures), technological (district heating system). As regards Latvia and Estonia many of the factors are just the same for the both states. There are some specific factors, however, varying for each country, such as the local energy resources: high share of hydroenergy in electricity production in Latvia and oil shale in electricity production in Estonia. There are factors, which can be influenced by state policy to stimulate the CHP development: legislative and assistance to solution of the technological problems. Potential for the small scale CHP was calculated, taking into account the existing installed boiler houses. 3 alternatives were offered, where the ratio between the CHP heat capacity and the maximum heat load was 0,13; 0,3 and 0,5. The ratio 0,13 allows to be used in a wider consumer range for the small-scale CHP. The formulas for potential calculation for each of the alternatives and the results for Latvia and Estonia were given. For the first alternative when ratio is 0,13 the potential for Estonia is 200 MWel, for Latvia is 125 MWel. In the case of second

alternative when the ratio is 0,3, the potential for Estonia is 265,5 MWeI, for Latvia is 142 MWeI. For the third alternative when the ratio is 0,5, the small-scale CHP potential in Estonia is 442,5 MWeI, and 237 MWeI in Latvia. For all of the alternatives the small-scale cogeneration potential is higher in Estonia. It can be explained by the following: there are very few small-scale CHP in Estonia now; there are high heat loads in the industry sector and colder climate in Estonia. Concerning the methodology of statistical data collecting, the basics are the same for the Latvian and Estonian Statistical bureaus, as it has been defined in the methodology description. However, the calculation methodology can be different what may have an influence on the result. Final conclusions regarding the small-scale CHP potential can be made only after an additional research.

According to the calculations made in this paper there are high perspectives for the small-scale CHP development in Latvia and Estonia. The small-scale CHP potential is partly used, more in Latvia than in Estonia, but there are still big possibilities to enlarge the share of electricity produced by the small-scale CHP in both countries.

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Anna Volkova, Eduard Latišev, Andres Siirde, Mazas jaudas koģenerācijas potenciāls Latvijā un Igaunijā

Izpētes laikā tika noteikts mazas jaudas koģenerācijas staciju potenciāls Latvijā un Igaunijā. Rakstā analizēti faktori, kuri ietekmē koģenerācijas attīstību, iekļaujot politiskos, ģeogrāfiskos, klimatoloģiskos, likumdošanas un tehnoloģiskos faktorus. Mazās jaudas koģenerācijas potenciāla noteikšanai tika izvēlētas trīs alternatīvas. Pirmā alternatīva ņem vērā tikai karstā ūdens izmantošanu. Šajā gadījumā koģenerācijas stacija var strādāt ar pilno slodzi visa gada periodā tāpēc, ka siltuma slodze netiks mainīta ($k=0,13$). Otrajai alternatīvai tika izmantoti iepriekšējo pētījumu rezultāti. Šajā gadījumā autori noteica, ka mazas jaudas koģenerācijas stacijai optimāla relatīva slodze ir 0,3 ($k=0,3$). Attiecībā uz šo optimumu koģenerācijā var saražot vairāk elektroenerģijas, strādājot ar pilno slodzi, nekā pirmajā gadījumā, bet koģenerācija strādās ne visu gadu. Trešā alternatīva parāda koģenerācijas potenciālu, kad puse no maksimālās slodzes tiks nodrošināta ar koģenerāciju. Ir izstrādātas formulas un piedāvāti rezultāti katrai alternatīvai.

Anna Volkova, Eduard Latosev, Andres Siirde, Small-scale CHP potential in Latvia and Estonia

In the research the small-scale CHP potential of Latvia and Estonia has been defined. Factors, which influence the CHP development, were analyzed in this paper, including political, geographic, climatological, legislative and technological factors. For the small-scale CHP potential assessment the three alternatives were chosen. The first alternative is the case, when only the hot water is taken into account. In this case the CHP can work with full load during the whole year because the heat load will not change ($k=0,13$). For the second alternative the results of the previous research were used. In this case an optimal relative heat load has been found for a small-scale CHP. This optimum value is 0,3. According to this optimum value the CHP can produce more electricity working with full load than in the first case. However, the CHP does not work whole year round. The third alternative shows the situation for the small-scale CHP when a half of the maximum heat load will be covered by the CHP. The formulas and the results for each case were provided.

Анна Волкова, Эдуард Латышев, Андрес Сиирдеб, Потенциал малых когенерационных станций в Латвии и Эстонии

Во время исследования был определен потенциал малых когенерационных станций в Латвии и Эстонии. В статье были проанализированы факторы, которые влияют на развитие когенерационных станций, включая политические, географические, климатические, законодательные и технологические факторы. Для определения потенциала малых когенерационных станций были выбраны три альтернативы. Первая альтернатива это случай, когда берется во внимание только нагрузка нагрева горячей воды. В этом случае станция может работать в течении всего года, потому что тепловая нагрузка не будет меняться ($k=0,13$). Для второй альтернативы были использованы результаты предыдущих исследований. В этом случае было определено, что для малых когенерационных станций оптимальная относительная тепловая нагрузка 0,3 ($k=0,3$). Касательно данного оптимума, можно произвести больше электроэнергии в когенерации, чем в первом случае, но станция не будет работать весь год. Третья альтернатива показывает когенерационный потенциал, когда половина максимальной мощности обеспечивается когенерацией. Разработаны формулы и предложены результаты для каждой альтернативы.