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Potential for Efficient Cogeneration of Heat and Power in Estonia

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Foreword

This report has been prepared at the request of the Ministry of Economic Affairs and Communications, with the Department of Thermal Engineering of the Tallinn University of Technology undertaking to carry out an analysis of efficient heat and power cogeneration in Estonia in accordance with the requirements established in Article 6(2) of Directive 2004/8/EC.

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1. Heat demand suitable for the application of efficient heat and power cogeneration

1.1. Current situation in heat and power cogeneration

Estonia is a small country (with an area of approximately 45.2 thousand km^2 and a population of 1.36 million). The uniqueness of Estonia from an energy point of view is the relatively high importance of local fuel among the resources of primary energy (approximately 68%). Oil shale accounts for the largest share of domestic fuel, but peat and firewood also take up a significant part of the supply. Figure 1 indicates the proportions of different fuel types used for power and heat production in 2005. In 2005 the total fuel consumption for power and heat production was 141 481 TJ.

Fuel consumed in 2005 for heat and power production
Oil shale 68.0%
Natural gas 15.3%
Firewood 7.0%
Other 9.7%

Figure 1

In recent years the production of power and heat in Estonian power stations and boiler plants has amounted to 10 200-10 600 GWh without major changes (Figure 2), with approximately 73% of the heat produced being sold to consumers in district networks. The end-use of heat and power amounted to 32 217 TJ and 21 680 TJ, respectively, in 2005. Power production in Estonia is mainly based on oil shale. In 2005, 9289 GWh of power was produced from oil shale, which makes the share of power produced from oil shale approximately 91.5%. 545 GWh of power was produced from gas and the respective share was approximately 5.4%. The amount of power produced from renewable resources – by wind power, hydro energy, oil shale gas and shale oil – amounted to 33 GWh, 53.9 GWh, 21.5 GWh, 217 GWh and 28 GWh respectively.

Power production in power stations and boiler plants in 2005

In boiler plants
In power stations

Electric power Heat production

Figure 2

Different types of fuel are used for heat production in boiler plants, with both natural gas and firewood contributing a relatively big share (Figure 3). Shale oil also accounts for a significant share.

Fuel consumption for producing heat in 2005

Natural gas 43%
Firewood 32%
Fuel oils 19 %
Other 6%

Figure 3

Figure 4 describes the power production balance, transition and distribution to consumers per fuel input.

Power production balance in Estonia in 2005

[left to right]
Oil shale
Natural gas
Production losses
Internal consumption of power stations
Import
Export

Figure 4

The average efficiency of power production in power plants is approximately 34%, with network losses amounting to approximately 17%.

The volumes of heat and power production and also consumption of fuel have been relatively stable in the recent years (since 2003). A slight reduction has been observed in the use of solid fuels, which have been replaced by increased import of natural gas. Since 2000 there has been an increase in the production and consumption of shale oil, which has reduced the use of heavy fuel oil.

1.2 Heat consumption

Figure 5 describes the heat production balance, transition and distribution to consumers per fuel input.

Heat production balance in Estonia in 2005

[left to right]
Natural gas
Local renewables
Peat
Other local
Other local
Total
Production losses
Heat production
Distribution losses
District heating
Local heating

Figure 5

The average efficiency of heat production is 82% and the average distribution loss of heat in district heating networks is 15%. The majority of heat produced is utilised in the energy sector and in industry (Figure 6).

Produced heat per branches of economy in 2005

[left to right]
Energy sector
Industry
Commercial and public service sector
Transport
Agriculture

Figure 6

1.2.1 District heating

Although there are 43 towns in Estonia, there are only 2 – Tallinn and Tartu – with the number of inhabitants exceeding 100 000 (396 193 and 101 740 respectively). The number of inhabitants in the other 33 towns ranges between 1 000 and 17 000 people. There are district heating networks in towns and smaller settlements but their unit outputs are relatively small. This is characterised by the fact that of the aggregate number of boilers (3 924) used for producing heat, approximately 80% are smaller than 1 MW (Figure 7).

Number of boilers used for heat production and their shares in the production of power in 2005
Boiler output

Figure 7

In addition, the majority of heat (almost 50%) is produced by boilers with an output of up to 5 MW (Figure 7).

The share of district heating in heat supply has been relatively high, accounting for approximately 70% of all heating. The preservation and development of heat networks is a national priority, enabling heat and power cogeneration to be implemented. For the purpose of the stabile development of the heat supply, the State supports the formation of optimal district heating regions in cities (city districts), which basically means the harmonised development of district heating and various types of local heating. The formation of district heating regions must take into account the interests of consumers and the city (city district) as a whole, the principles of sustainable development, the need to minimise requisite investments, and social aspects.

2. Heat and power cogeneration

2.1 Current situation in heat and power cogeneration

In Estonia, heat and power cogeneration plants of different outputs are used (irrespective whether they qualify as 'efficient' or 'not efficient' within the framework of Directive 2004/8/EC of the European Parliament and of the Council. Oil shale, natural gas, peat, oil shale gas generated in the process of oil shale production and landfill gas are used as fuels. Various technologies are implemented – steam power units (back-pressure turbines, industrial and fuel extraction steam turbines) as well as units operating on internal combustion engines. Figure 8 indicates the heat and power production of cogeneration plants per power unit types and their overall output in 2005.

Production of cogeneration plants per plant types in 2005

Power Heat

Back-pressure turbine
Extraction turbine
Internal combustion engine

Figure 8

Electricity produced in heat and power cogeneration plants accounts for approximately 11% of the overall power production, while heat produced in cogeneration plants forms approximately 30% of the total heat produced in Estonia.

2.2 Technologies used for cogeneration of heat and power

In 2005, 150 MW of the overall electrical output of 2662 MW available in Estonia was installed in cogeneration plants, which, according to technical data and possible operation modes, qualify as ‘efficient cogeneration’.

2.2.1 Internal combustion engine-based plants

Fourteen cogeneration internal combustion engine-based units have been installed and are used in Estonia. The cogeneration units are relatively new and modern and their overall power output is almost 19.3 MW and heat output 21.3 MW. Annex 1 contains general data on cogeneration plants based on internal combustion engines in Estonia as at December 2006. According to their technical parameters and subject to the use of appropriate operation modes these cogeneration units qualify as ‘efficient cogeneration units’.

2.2.2 Cogeneration plants based on steam turbines

Iru Thermal Power Plant

The Iru cogeneration plant operates on the basis of steam power units; it is fuelled by natural gas and connected to the district heating network of Tallinn. General data on the Iru Thermal Power Plant are presented in Annex 2. The choice of operation mode depends on the heat load, as well as the self-cost and selling price of the heat and power produced. It would be more efficient to produce power in a block containing a back-pressure turbine, but the possibility of using turbines at the Iru Thermal Power Plant are limited due to a lack of the necessary heat load. The calculated overall efficiency of a cogeneration unit based on a back-pressure turbine is approximately 85% and subject to the use of appropriate operation modes qualifies as an efficient cogeneration unit (power output 110 MW and heat output 220 MW).

AS Narva Elektrijaamad Baltic Thermal Power Plant

The Baltic Thermal Power Plant of AS Narva Elektrijaamad runs on oil shale and supplies heat to the district heating network of Narva. The entire length of the district heating network of Narva is 68.5 km. The designed heat output for consumption is 312 MW. In addition, the Baltic Thermal Power Plant sells industrial steam with the following parameters: 16.0 bar, 300.0°C, with a maximum output of approximately 16.1 kg/s.

As a result of reconstruction works at Narva Elektrijaamad (Narva Power Plants), the technological solution for heat output at Baltic Power Plants changed considerably in 2006. Heat output is possible via three gas-operated NSTB-87-16-300 steam boilers or a K-200-130 steam boiler, reconstructed by means of boilers operating on oil shale (regulated extraction was reconstructed). The designed maximum heat output is 160 MW and the electrical output (excluding heat output) is 215 MW. Qualifying the Baltic Power Plant as ‘efficient’ is questionable. The estimated overall efficiency is less than 70%. At the same time the selling price of heat originating from Baltic Thermal Power Plant is more competitive than possible alternatives. The sale of heat to Baltic Thermal Power Plant is economically justified. The reconstructed energy unit is efficient from the point of view of power efficiency and meets all environmental conditions.

Small-scale cogeneration plants operating on steam turbine units

In Estonia, there are cogeneration plants which are historically related to industry that operate on generator gas generated in the process of pulverised combustion of oil shale or production of shale oil, the general data of which are set out in Annex 3 (Tables 1-5). The overall installed power output of these heat and power cogeneration plants is 75 MW. The thermal power plants are outmoded, including in technical terms, and over-dimensioned considering the current heat consumption. It is intended to close down or completely overhaul the power plants in the coming years. Qualification as ‘efficient cogeneration’ is unlikely, but the renovation of these power plants should be viewed as a possibility for the potential application of efficient cogeneration in the years to come.

The general data on cogeneration plants related to pulp, paper and peat industries are presented in Annex 3 (Tables 6-8). Several reconstruction works and modernisation of equipment have been carried out in the thermal power plants and they will qualify as efficient cogeneration units subject to the use of appropriate operation modes.

3. Fuels and energy sources used in cogeneration and the security of supply thereof

3.1 Natural gas

Natural gas is the cleanest fossil fuel and its extensive use would help to reduce air pollution (incl. greenhouse gas emissions) to a significant extent. Using this fuel in power production will practically eliminate the generation of solid waste. In Estonia, natural gas is the most considerable alternative to oil shale. Pipelines and border metering stations enable 8-10 million m³ of gas to be transported per day, depending on the supply mode. Currently no more than 5-5.5 million m³ of gas are used per day during the winter months.

There are approximately 15 companies in Estonia engaged in natural gas distribution, the biggest of which is AS Eesti Gaas.

The main fields of activity of AS Eesti Gaas include the importing, distribution and sale of natural gas. Other activities include the maintenance of gas systems, the construction of new gas pipelines and the management of gas network development. AS Eesti Gaas is a public limited company which is owned by three large European gas companies – OAO Gazprom, Ruhrgas AG Fortum Oil & Gas OY – and minority shareholders (private persons and legal entities).

Other companies are considerably smaller and are mainly active in Tallinn: Fortum Termest, Water Ser, Bingonet, Tallinngaas, Gaasienergia, Kakumäe võrgud, Eurogaas, Esmar.

Gas is imported to Estonia from Russia and the In•ukalns underground gas deposit located in Latvia. AS Eesti Gaas owns two metering stations on the Estonian border, where the amounts of gas imported to Estonia are measured (Figure 9).

Figure 9. Natural gas supply to Estonia

Natural gas is then distributed to consumers via transmission gas pipes, gas distribution stations and gas pressure control stations (Figure 10).

Figure 10. Natural gas distribution in Estonia

All of the gas is imported from Russia. The competitiveness of natural gas in energy production is largely affected by environmental taxes and the security aspect. The formation and stability of the price of natural gas is important. Estonia will be able to improve the stability of gas supply if it participates in the development of the underground storage facilities of Latvia and establishes its stocks in these facilities. The natural gas supply risks could also be reduced by the construction of another gas pipeline from Russia to Europe and connecting the Estonian gas system to that gas pipeline. In addition, the stability of gas supply in Estonia would improve significantly if the Nordic Gas Grid project were implemented and a gas pipeline built between Tallinn and Helsinki.

The gasification process continues in Estonia. From the point of view of stable supply, it is important that Estonia is able to switch to the supply from St. Petersburg, which is not used at present but has occasionally been relied upon in winter months in order to mitigate supply risks. A developed and completed gas network represents a potential for developing heat and power cogeneration based on natural gas. Considering the distribution of heat loads in smaller towns in Estonia, it would be appropriate to use internal combustion engines. Subject to the existence of sufficient heat loads, the implementation of a gas-steam turbine cycle in the cogeneration could be considered.

3.2 Biofuels and peat

In 2002, biomass accounted for over 99% of all renewable energy sources used. Firewood accounted for 17.2% of the total fuel used in heat production. Approximately 80% of the wood was used in domestic households (59%) and in the business sector. Wood used in district heating accounted for 20% and its share is increasing. In the business sector, wood was used as the main fuel in about 900 boilers with an overall output of 798 MW.

The Long-Term Energy Sector Development Plan sets the objective of increasing the share of renewable energy resources to 13-15% in primary energy. It is not intended to increase the share of biomass, since a significant amount of the primary energy from cut firewood and wood-processing waste is already used in the energy conversion processes, primarily for producing heat. The use of logging waste may increase to some extent. Estonia is exporting almost 500 000 tonnes of wood chips per year, mainly as a raw material for the pulp industry. Wood briquettes and pellets are produced (in total 210 000 tonnes per year), the majority of which (83%) is exported.

There are large peat reserves in Estonia – 1.7 billion tonnes – with usable peat reserves amounting to 775 million tonnes. It is permitted to use 2.78 million tonnes per year. In 2003, 1 million tonnes of peat was produced, of which peat used as fuel amounted to 362 000 tonnes (248 000 tonnes of milled peat and 114 000 tonnes of peat pellets). 27% of milled peat and 98% of peat pellets were used in district heating. Of the 120 000 tonnes of peat briquettes manufactured from peat, 84% was exported.

Factors facilitating the implementation of biofuels include the long traditions of power production based on wood fuels and the availability of the relevant know-how in Estonia. Other factors include the sufficient availability of natural forest resources and other biofuel types, the increasing demand for biofuel as an environmentally-friendly fuel and the continuing increase in the price of fossil fuels.

Biofuel and peat are considered as suitable fuel types for the introduction of cogeneration plants in Estonia. The construction of cogeneration plants in Tallinn and Tartu are in the design phase. The plants are planned to be operated on the basis of combined use of biofuel and peat.

3.3 Shale oil

Shale oil is a domestic fuel produced in Kohtla-Järve, Kiviõli and the Estonian Power Plant in Narva. The parameters of total oil produced in Narva: ash content 0.3%, moisture content 0.5% and lower calorific value 10.5 MWh/t, which is a result of higher oxygen content compared to black oil. The calorific values of shale oils produced in Kohtla-Järve and Kiviõli are even higher, ranging up to 10.8-11.4 MWh/t. Oil with the calorific value of 11.4 MWh/t can also be used in small boilers. The viscosity of shale oil is lower than that of black oils, which makes it easier for boiler plants to use it. Approximately 400 boilers are fuelled by shale oil. These boilers supply approximately 14% of all heat produced in Estonian boiler plants and use 15% of the fuel energy used in boiler plants. The average output of boilers is 2.4 MW. The annual operation hours of boilers operating on shale oil is approximately 1 000 hours, which is a relatively small number compared to boilers operating on wood and peat. Boilers operating on shale oil are used in a wide continuous capacity range, as well as to cover peak loads. Subject to the existence of a sufficient heat load and with economic justification, it is possible, in principle, to put cogeneration plants into operation to replace boilers fuelled by shale oil.

3.4 Oil shale

Oil shale is a domestic fossil fuel which now accounts for more than a half of the primary energy resources in Estonia. Oil shale can be found in a large area from Northern Estonia to the St. Petersburg–Moscow railway in Russia. The best part of the area is the deposit in Estonia, with 1.5 billion tonnes of oil shale worth mining. Today over 90% of electric power is generated from oil shale. Oil shale is a strategic energy source of Estonia and it is viewed as the main energy resource in the areas of its application (power industry and chemical industry). However, the proportion of oil shale in the balance of the primary energy is decreasing. Oil shale could be regarded as potential fuel to be used in the cogeneration of heat and power only after the renovation of active and obsolete power plants (Kohtla-Järve, Kiviõli, etc.) related to industry. The co-combustion of oil shale with waste products generated in the energy industry during shale oil production, such as generator gas and semi-coke, is an appreciable option.

3.5 Coal

Coal consumption is relatively small in Estonia. In 2005 coal accounted for just 0.22% or 478 TJ in the total supply of primary energy in Estonia. Consumers of coal include industrial enterprises, households (for heating) and small boiler plants (for the production of heat). Coal is not used for the production of electricity in Estonia. However, given the large coal resources in the world, the production of electricity on the basis of coal might become feasible in the long-term, depending on the development of different factors (such as environmental taxes). This will not happen, however, until 2015 and even then on the basis of new clean technologies.

4. Approaches to the application of the cogeneration potential in the national energy policy

4.1 Decisions taken by the Republic of Estonia regarding fuel and energy sectors, incl. from the viewpoint of developing cogeneration

The National Long-Term Development Plan of the Fuel and Energy Sector up to 2015 was adopted by the Decision of the Parliament of the Republic of Estonia of 15 December 2004.

This document states that the fuel and energy sector is a strategic infrastructure of the State, which must ensure that Estonia has an uninterrupted supply of high-quality fuel, electric energy and heat at optimal prices. At the same time, the fuel and energy sector must be as efficient as possible and must comply with safety and environmental requirements. The sustainable fuel and energy sector is one of the bases for national security.

The strategic objectives of the Estonian fuel and energy sector presented in the development plan which directly or indirectly concern the cogeneration of heat and power are as follows:

- to ensure fuel and energy supply with the required quality and at optimal prices;
- to ensure the existence of local generating capacity to cover the domestic electricity consumption needs and the reserve of liquid fuel in accordance with the law;
- to ensure that renewable electricity accounts for 5.1% of gross consumption by 2010;
- to ensure that by 2020 electricity produced in heat and power cogeneration plants accounts for 20% of gross consumption;
- to ensure that the power network is completely modernised approximately every thirty years;

- to ensure that the competitiveness of the domestic market of oil shale energy production is preserved in the open market conditions and its efficiency is increased, while applying modern technologies which reduce harmful environmental impact;
- to ensure compliance with the environmental requirements established by the State;
- to improve the efficiency of energy consumption in the heat, electricity and fuel sectors;
- to maintain the volume of primary energy consumption at the level of the year 2003 until 2010.

Movement towards these strategic objectives is based on the principles set out below. The Minister of Economic Affairs and Communications is required to submit a report to the Government concerning adherence to the principles every two years:

- to enhance cooperation between energy enterprises, the public sector and research and educational institutions;
- to base the formation of the national fuel policy on the need to increase the relative importance of domestic renewable fuels in the energy balance, while taking account of the principles of economic rationality and security of supply;
- when setting up new power plants, to give preference to the principle of distributed production and cogeneration of heat and power, while ensuring the optimal use of existing heat networks;
- to appoint a person in every county government whose task is to analyse the development of the fuel and energy sector of the given county, and to ensure the implementation of the national objectives at county level and administer fuel and energy-related information and activities of the local government;
- when establishing various environmental objectives related to the energy sector and acceding to international agreements, to analyse the cost of the obligations assumed;
- when using investment support and operating aid, to accord preference to projects which are important from a regional aspect or for environmental protection purposes.

In order to achieve these objectives, the development plan prescribes the cogeneration of heat and power to the maximum extent so as to cover the load curve of the power system.

Factors limiting the further growth of the proportion of cogenerated electricity include the lack of a necessary heat load which could be increased mainly through the creation of large industrial consumers, the construction of new district heating networks and, in the more distant future, through the development of microenergetics. In developing the cogeneration of heat and power, priority should be given to the consumption of local renewable fuels. The development plan prescribes that by 2010 the proportion of renewable electricity in Estonia should increase to 5.1% of gross consumption, which is equivalent to 300-360 GWh of electric power. In order to achieve that objective, EEK 2-4 billion must be invested in renewable energy production facilities, and EEK 90-144 billion must be paid on the basis of the commitment to purchase renewable energy. The proportion of renewable electricity continues to grow and by 2020 the proportion of renewable electricity will account for up to 10% of gross electricity consumption in Estonia.

Based on the National Long-Term Development Plan of the Fuel and Energy Sector up to 2015, the Government of the Republic of Estonia established the Development Plan for the Estonian Electricity Sector for 2005-2015 by its Order No 5 of 3 January 2006.

The strategic goal of the Development Plan for the Electricity Sector until 2015 is to ensure the optimal functioning and development of the Estonian power system under market economy conditions and the adequate long-term supply of consumers with electricity at as low prices as possible. All the requirements concerning service and supply security as well as environmental requirements must be observed, the domestic power consumption load will be covered by local power production capacity, the efficiency of power production, transmission, distribution and consumption will be promoted and developed, support will be provided to research activities and to the development and transfer of technology by ensuring the existence of national expertise, and international cooperation will be promoted to facilitate the best possible implementation of the activities listed above. When moving towards the objectives and directing the development of the power sector, the obligations assumed by Estonia at both the national and international level must be taken into account. The main obligations are related to environmental issues and internal electricity market rules of the European Union, with Estonia being required to follow the provisions stipulated in the European Union accession treaty for the transitional period. In connection with the non-conformity of environmental pollution, Estonia has to close down the majority of its power production capacity and establish new production capacities under the conditions of the opening electricity market. In addition, Estonia must create conditions for placing alternative production technologies on the market based on the EU directives on renewable energy and cogeneration of heat and power.

4.2 Cogeneration and renewable energy sources based on the Development Plan for the Electricity Sector 2005-2015

When developing various electricity production scenarios several limitations have to be considered, which were taken into account as a default agreement when making calculations under the electricity production scenarios. According to the agreements made under Directive 2001/77/EC of the European Parliament and of the Council and the objectives set forth in the National Long-Term Development Plan of the Fuel and Energy Sector up to 2015, Estonia must ensure certain shares of electricity produced from renewable energy resources and in heat and power cogeneration plants in the domestic gross consumption. Based on these commitments, the following objectives for developing the electricity sector have been established:

- The proportion of renewable electricity must account for 5.1% of the gross domestic electricity consumption by 2010 and at least 8% by 2015. The proportion of renewable energy sources in the gross domestic consumption must ensure the possibility of using oil shale as a national energy resource in the production of electricity for as long period as possible. Therefore, the proportion of electricity produced from renewable energy sources in the gross domestic consumption in 2015 will depend on the definition of the National Strategy for Use of Oil Shale by the Ministry of the Environment, the Ministry of Economic Affairs and Communications and the Ministry of Finance in the first half of 2006. The estimated resource-based proportions of renewable electricity are set out in Table 1.

Estimated resource-based proportions of renewable electricity production from 2005 to 2015

Table 1

	2005	**2010**	**2015**
Wind	1.0%	2.2%	4.5%
Biofuels	0.2%	2.5%	3%
Other	0.3%	0.4%	0.5%

- The proportion of electricity produced in heat and power cogeneration plants in the gross domestic consumption will increase to 20% by 2020 and to at least 18% by 2015. Iru Power Plant will continue its production activities in a slightly increased volume, Narva will be supplied with heat by the new energy unit of the Baltic Power Plant, and it is planned to construct cogeneration plants in Tallinn, Tartu, Pärnu and Kuressaare by 2010 as well as to ensure that the Ahtme Power Plant will be fuelled by biomass. Table 2 indicates the possible capacity of heat and power cogeneration plants based on the consumption forecast for 2015.

Table 2

Possible capacity of heat and power cogeneration plants by 2015

	Heat demand in 2015, GWh_s	Heat production potential based on CHP, GWh_s	Power production potential based on CHP, GWh_e	Power output, MW_e
District heating	5 453	4 916	1 475	280
Local heating	5 355	979	440	83
Technology	1 916	605	180	34
Total	14 739	6 500	2 095	397

New heat and power cogeneration plants would operate on gas or biofuels. When using gas it would be possible to implement technologies which enable a heat and power ratio of 1:1 to be achieved.

Installing cogeneration gas turbines would enable the load peaks of the energy system and the hot reserve demands to be covered. The use of cogeneration gas turbines for covering peak loads requires the use of heat storage devices. The use of these facilities will level the load curve of Narva Power Plants (improving the operation efficiency), create an alternative to the importation of the regulating capacity, considerably increase the security of supply of the power system, reduce investments in Narva Power Plants and the transmission network, and provide an opportunity for participation in the reserve market of the neighbouring countries.

5. Evaluation of the potential of technologies upon the implementation of cogeneration possibilities

Considering that heat consumption (approximately 10 500 GWh) is not expected to increase in Estonia and approximately 3 750 GWh of heat is produced by existing heat and power cogeneration plants, it is estimated that it would additionally be possible to set up cogeneration plants for approximately 2 000....4 000 GWh of heat in Estonia. Heat produced in cogeneration plants could be doubled by the years 2015-2020 (Figure 11).

This assessment conforms to the objectives established in the National Long-Term Development Plan of the Fuel and Energy Sector up to 2015 (see section 4.)

Existing cogeneration plants
Boiler plants
Total district heating
Households
Industry
Agriculture
Construction
Other
Losses
Heat production and consumption
Cogeneration potential 2 000...4 000 GWh

Figure 11

As the majority of heat is produced in small boiler plants, it is estimated that the output capacity of the cogeneration plants would be relatively small (heat output <10 MW). It is possible to set up larger (10....30 MW) cogeneration plants either for the district heating networks of Tallinn or following the renovation of the old cogeneration plants in Tartu, Pärnu or Eastern Estonia which operate on the basis of steam turbine cycles. The potential electricity production will amount to 600....750 GWh or 1 800....3 800 GWh, depending on whether cogeneration would be based on steam cycles of peat or biofuel or on natural gas. The technology to be used would depend on the choice of fuel. The choice of fuel depends on what is considered more important – environmental conditions, CO_2 emission volumes or independence from exported fuel. The use of biofuel and peat depends on the amount and availability of the resources. Investments will be affected, to a significant extent, by the opening of the Estonian electricity market: to the extent of 35% by 2009 and fully by 2013. The implementation of the Large Combustion Plants Directive by 2015 will also have an impact, as a result of which Estonia would have to close down all condensation steam units based on pulverised combustion.

6. Barriers which might prevent the realisation of national potential for high-efficiency cogeneration of heat and power

6.1 Barriers relating to the prices and costs of and access to fuels

The main fuel used for heat production in Estonia is natural gas. In 2005, 43% of all heat was produced from natural gas, 100% of which was imported from Gazprom in Russia. In recent years Gazprom has significantly raised the price of natural gas sold to Estonia, which is increasingly nearing the price level in Nordic countries.

There is no competition on the Estonian gas market, since all gas sold in Estonia is supplied by Gazprom. This means that consumers of natural gas depend on one supplier. In addition to the risk arising from the single monopolistic supplier, the availability of natural gas is also influenced by the inadequate investments in gas infrastructure in Russia. Although the Estonian gas network has relatively strong connections with the networks of neighbouring countries, in winter 2005 the gas supply significantly reduced during cold weather due to a lack of gas in north-west Russia. The security of supply could be significantly improved by connecting the Estonian gas network to the gas route of the Baltic Sea and the gas network of Finland.

Bigger settlements in Estonia are connected to the gas network, which creates the necessary technical preconditions for using gas. However, the lack of a gas network is preventing gas from being used for cogeneration in Central and Western Estonia as well as in Hiiumaa and Saaremaa.

Peat and biofuel are local fuels with significant energetic potential which could be used sustainably in small-scale cogeneration plants. By a carefully planned national peat policy, it is possible to make peat and biofuel a significant and sustainable part of heat and power cogeneration.

The most remarkable negative aspect of using peat is its relatively high CO_2 content when burning gases (0.37 tonne/MWh). The distribution plan of greenhouse gases and the trade system cause significant risks to the users of peat for heat and power cogeneration. The uncertainty regarding the distribution principles of emission quota for 2008-2012 creates an uncontrollable risk to the companies that plan to use peat as the main source of fuel.

6.2 Barriers relating to grid system issues

Access to the power network is regulated by the Electricity Market Act and the Grid Code, which stipulate requirements applicable to all market participants. A network operator is obliged to ensure that all market participants are treated equally.

According to the current regulation, network charges are paid by the market participants who receive electric energy from the network, i.e. by consumers. Network charges are not applied to producers. Distributed cogeneration plants would facilitate the efficient use of the power network and reduce network losses. Differentiated network charges applied to producers would enable distributed production to be better directed and promoted in comparison to concentrated production. That way, a part of a larger unit investment of small-scale plants could be compensated compared to large power plants. However, such a principal change would have to be made in coordination with neighbouring markets so as to avoid placing Estonian power producers in a worse competition position.

6.3 Barriers relating to administrative procedures

The regulation of the Estonian power market, which gives priority to electric power generated from oil shale, sets significant barriers to investments in the cogeneration of heat and power. According to the treaty of accession to the European Union, Estonia has the right to fully open its electricity market to competition by 2013. The current regulation obliges consumers (with the exception of those who consume at least 40 GWh per year) to buy all the electric power from the network operator with whose network the consumers are connected to. This hinders independent producers from entering the market as access to the end customer is limited by the market regulation.

7. Summary

There is a relatively big cogeneration potential in Estonia and the necessary economical and technical preconditions are present:

- functioning district heating in towns and bigger settlements;
- local industry is relatively energy-intensive;
- the availability of gas fuel and a developed gas network;
- possibility to use biofuels;
- increasing power consumption in the region, the need for investments and technology upgrades in existing condensation plants;
- stricter requirements regarding environmental protection.

In order to set up a cogeneration plant, a technical and economical analysis for each selected location has to be carried out, including:

- determining an actual durable heat load curve of the specific region (consumers);
- determining the internal power need of the potential heat and power cogeneration producer, and drawing up a precise load curve;
- investigating the trends of heat and power consumption from previous years, preparing a consumption forecast for the coming years on the basis of the trends as regards both heat consumption and the electricity to be consumed by the company;
- investigating the financial situation of the current heat producer (cash flow, loans, debts, other financial liabilities) and deciding which assets and liabilities should transfer to the new producer;
- deciding who will cover the loans, debts and other liabilities (if any) of the current heat producer;
- investigating the possibilities and conditions for raising a loan;
- deciding on what to do with the equipment and buildings of the current heat producers upon introduction of cogeneration and on the future of personnel employed by the current heat producers (redundancy and compensation issues);
- determining whether, how and under which conditions the electric power to be produced could be sold, which reconstruction works are needed as regards the power production business of the company (network connections) and which reconstruction works are needed as regards the heat production business of the company;
- choosing the fuel type to be used, determining its availability for the coming years and preparing a fuel price forecast for the years to come;

- preparing a forecast for the possible price of heat energy upon its production with existing equipment; predicting changes in purchase and selling prices of electric power in the region in the coming years;
- ascertaining the technical condition of heat networks, deciding on whether they need to be reconstructed (rebuilt) in the coming years and estimating the amount of investments needed for this;
- deciding on how to cover the heat peak load (this might require additional investments); it is reasonable to design cogeneration units only to cover basic loads;
- if possible, enquiring about the future of the local power network (privatisation?);
- carrying out feasibility studies.

Potential locations of possible cogeneration plants:

- new real estate development areas;
- new energy-intensive companies;
- cogeneration plants in larger buildings (hospitals, building complexes, swimming pools, spa centres, etc.);
- existing district heating networks.

It is estimated that it would be possible to set up district heating-based cogeneration plants with an electrical capacity of 2...3 MW in such towns as Viljandi, Kuressaare (project feasibility study carried out), Võru, Haapsalu, Paide, Rakvere, Valga, Jõgeva, Viljandi. District heating-based cogeneration plants with a larger capacity (approximately 10 to 20 MW_{el}) could be set up in Tartu and Pärnu. In addition, feasibility studies have been carried out regarding the establishment of cogeneration plants based on district heating in Mustamäe and Õismäe city districts in Tallinn. Reconstruction works are planned to be carried out at inefficient and depreciated oil shale chemicals plants and at Sillamäe Thermal Power Plant.

According to the development plans and decisions approved by the government bodies of the Republic of Estonia, it is possible to ensure that electricity produced in heat and power cogeneration plants will account for 20% of the domestic gross consumption by 2020 and at least 18% by 2015. New heat and power cogeneration plants would operate mainly on gas or biofuels.

Annex 1. Heat and power cogeneration plants operating on internal combustion engines

Name of the cogeneration plant	Installed capacity, MW		Year of introduction	Fuel input
	Electricity	Heat		
AS Kunda Nordic Tsement	3.1	3.3	1998-1999	Natural gas
AS Eraküte Põlva	0.922	1.253	1999	Natural gas
AS Grüne Fee (4 units)	Total 4	Total 4.8		Natural gas
AS Narva Vesi	0.5	0.7	1999	Natural gas
AS Kristiine Kaubanduskeskus	0.5	0.7	2000	
AS Terts (2 units)	Total 1.68	2	2002-2003	Landfill gas
Sillamäe SEJ	5.95	6.7	2004	Natural gas
ELME AS (BLRT Grupp AS (2 units)	Total 2.4	2.8	2002 -2003	
AS Tallinna Vesi	0.65	0.86	2002 -2003	Natural gas

Annex 2. Large-scale cogeneration plants operated on a steam turbine

Iru Power Plant

Table 1

Years of construction	1980-1982
Maximum installed electricity and heat capacity, MW_{el}/MW_{th}	Energy Unit No 1 80/120 Energy Unit No 2 110/220
Technology used	Extraction turbine, back-pressure turbine (*note:* in 2002 turbine No 2 (T-110/120-130) was modernised and transformed into a back-pressure turbine)
Fuel input	Natural gas (*note:* in 1998 black oil was totally replaced by gas (gasification) in the Iru Power Plant)
Possible modes for producing heat and power	Both condensation and cogeneration modes

Annex 3. Small-scale cogeneration plants operating on a steam turbine

General data on VKG Energia Northern Power Plant (Kohtla-Järve Power Plant)

Table 1

Name of the cogeneration plant	Kohtla-Järve Power Plant
Years of construction	1954-1958
Maximum installed electricity and heat capacity, MW_{el}/MW_{th}	27/70
Technology used	Extraction turbines, back-pressure turbines (in total four turbines)
Fuel input	Oil shale, oil shale generator gas
Possible modes for producing heat and power	Both condensation and cogeneration modes

General data on VKG Energia Southern Thermal Power Plant

Table 2

Name of the cogeneration plant	VKG Energia
Years of construction	1997 (a second-hand unit was installed)
Maximum installed electricity and heat capacity, MW_{el}/MW_{th}	8/12
Technology used	Back-pressure steam turbine
Fuel input	Generator gas
Possible modes for producing heat and power	Cogeneration

Thermal Power Plant of Kiviõli Oil Shale Processing and Chemicals Plant

Table 3

Name of the cogeneration plant	Thermal Power Plant of Kiviõli Oil Shale Processing and Chemicals Plant
Years of construction	~1958
Maximum installed electricity and heat capacity, MW_{el}/MW_{th}	Usable ~ 8/20
Technology used	Extraction turbine, back-pressure turbine
Fuel input	Generator gas, oil shale
Possible modes for producing heat and power	Both condensation and cogeneration modes

General data on Sillamäe Thermal Power Plant

Table 4

Name of the cogeneration plant	Sillamäe Thermal Power Plant (the oil shale-based part)
Years of construction	1954-1965
Maximum installed electricity and heat capacity, MW_{el}/MW_{th}	Two steam power units, 6/12 each
Technology used	Extraction and back-pressure turbines
Fuel input	Pulverised combustion of oil shale
Possible modes for producing heat and power	Both condensation and cogeneration modes

General data on Ahtme Power Plant

Table 5

Name of the cogeneration plant	Ahtme Power Plant
Years of construction	1953
Maximum installed electricity and heat capacity, MW_{el}/MW_{th}	30/ (to be specified)
Technology used	Back-pressure turbines (to be specified)
Fuel input	Pulverised oil shale
Possible modes for producing heat and power	Cogeneration

General data on Horizon Pulp and Paper Ltd. Thermal Power Plant

Table 6

Name of the cogeneration plant	Horizon Pulp and Paper Ltd. Thermal Power Plant
Years of construction	1953, 1983
Maximum installed electricity and heat capacity, MW_{el}/MW_{th}	Overall capacity 10/125* *) heat output also includes possible heat production from boilers
Technology used	Back-pressure steam turbine and condensation turbine
Fuel input	Natural gas, heavy fuel, black alkali, wood waste
Possible modes for producing heat and power	Cogeneration regime, condensation regime

General data on AS Sangla Turvas Power Plant

Table 7

Name of the cogeneration plant	AS Sangla Turvas Power Plant
Years of construction	Reconstructed in 1998
Maximum installed electricity and heat capacity, MW_{el}/MW_{th}	2.5/7
Technology used	Back-pressure steam turbine
Fuel input	Peat
Possible modes for producing heat and power	Cogeneration

General data on AS Tootsi Turvas Power Plant

Table 8

Name of the cogeneration plant	AS Tootsi Turvas Power Plant
Years of construction	(to be specified)
Maximum installed electricity and heat capacity, MW_{el}/MW_{th}	5/14
Technology used	Back-pressure steam turbine
Fuel input	Peat
Possible modes for producing heat and power	Cogeneration

References

1. 1. Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004 on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC. Official Journal of the European Union L 52, 21.2.2004, p. 50.

2. Eesti elektrimajanduse arengukava 2005–2015 (Development Plan for the Estonian Electricity Sector for 2005-2015). Tallinn 2006. RTL, 18.01.2006, 7, 134.

3. Eesti energeetika arvudes 2005 (Estonian Energy Sector in Figures 2005). Ministry of Economic Affairs and Communications. Tallinn 2006.

4. Energiabilanss 2005 (Power balance 2005). Statistics Estonia. Tallinn 2006.

5. Igor Krupenski. Maagaas kui konkurentsivõimeline kütus Eestis (Natural Gas as Competitive Fuel in Estonia). Tallinn University of Technology. Department of Thermal Engineering. Master's Thesis. Tallinn 2006.

6. Kütuse- ja energiamajanduse pikaajalise riikliku arengukava aastani 2015 kinnitamine (Approval of the National Long-Term Development Plan of the Fuel and Energy Sector up to 2015). Tallinn 2004. RTI, 23.12.2004, 88, 601.

7. National Report on State of Small-scale CHP Policy and Sector Situation. Tallinn University of Technology, Estonia. European Commission (Directorate-General for Energy and Transport) Contract No NNE5/2002/52: OPET CHP/DH Cluster. May 2004.

8. Peeter Raesaar, Latest Development on RES Policy, Implementation and Planning in Estonia. Tallinn Technical University. Workshop "Data Gathering on Renewable Energies for New Member States and Candidate Countries" jointly organised by DG JRC IES RE-Unit and the Energy Institute Hrvoje Pozar, Cavtat-Dubrovnik, Croatia, 15-16 Nov 2006.

9. Reference Values of Efficient Cogeneration and Potential of Efficient Cogeneration in Estonia. Tallinn University of Technology. Department of Thermal Engineering. Report. Tallinn 2006.