Comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling, and cost-benefit analysis in accordance with the requirements of Directive 2012/27/EU

Customer:
Ministry of the Economy
55 Brīvības Street
Riga, LV-1519
Latvia

Executor:
PricewaterhouseCoopers SIA,
Reg. No 40003142793
21 Kr. Valdemara Street, Room 21
Riga, LV-1010
Latvia

Institute of Physical Energetics
21 Aizkraukles Street
Riga, LV-1006
Latvia

Telephone: +371 67094400
Fax: +371 67830055
pwc.riga@lv.pwc.com
www.pwc.lv

Study

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General information and limitations

This study was carried out by "PricewaterhouseCoopers", SIA (hereinafter "PwC") in cooperation with the Institute of Physical Energetics (hereinafter "the IPE") for the Ministry of the Economy (hereinafter "the Ministry") under an agreement concluded between the Ministry and PwC on 23 December 2015 (hereinafter the "Agreement").

The study was carried out in accordance with the requirements of Article 14 of Directive 2012/27/EU of the European Parliament and of the Council, which stipulates that each Member State should carry out a comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating (DH) and cooling. Thus, the results presented should be viewed from the Directive's perspective as an indicator of the technical and economic potential that has been identified for the future introduction of high-efficiency cogeneration technologies in Latvia. This study cannot be used as a basis for any investment decisions.

Our study includes information that has been obtained from various sources which are described in detail in the present study. PwC has not endeavoured to ascertain the reliability of such sources or to verify the information thus provided. Therefore, PwC does not make any promises or guarantees (neither express nor implied) to any persons, except the Ministry under the Agreement concluded, as to the correctness or completeness of the study.

The information included and the estimates and conclusions made in the study cover all of the data provided regarding energy consumption forecasts, which are at the disposal of the Ministry of the Economy of the Republic of Latvia up until the year 2030, as well as data regarding heating in municipalities, including information about the energy efficiency thereof. Where such information was not at the Ministry's disposal, publicly accessible data sources from the Environment and Energy Database of the Central Statistical Bureau of Latvia, statistical reports "Air-2" of the Latvian Environment, Geology and Meteorology Centre, Eurostat database, and energy planning documents of Latvian cities and municipalities were used.

Our conclusions are based on the information that had been provided to us as of the date of the present report. The report does not describe the effect of such events and circumstances that may have occurred after that date, nor does it include information that might have been disclosed after that date.

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In case of any inquiries regarding this study, please contact Baiba Apine, Director of PwC Consulting, by e-mail: baiba.apine@lv.pwc.com.

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Summary

In Latvia, heating is provided by district, local and individual heating systems. In the case of a district heating system, most of the heat energy (72.6 %) is produced by combined heat and power (cogeneration) plants. In 2014, there were 175 cogeneration plants operating in Latvia which primarily used natural gas (86 %), but also biogas, wood chips, biofuel and coal as a fuel. Natural gas is used to produce about four fifths of the total heat energy consumption in Latvia.

Article 2 in Chapter I of Directive 2012/27/EU states that an "efficient district heating and cooling system" means a district heating or cooling system using at least 50 % renewable energy, 50 % waste heat, 75 % cogenerated heat or 50 % of a combination of such energy and heat. "High-efficiency cogeneration" means cogeneration meeting the criteria set out in Annex II of Directive 2012/27/EU. In accordance with these requirements, Latvia has already ensured that the majority of the heat energy in a district heating system is produced by a high-efficiency cogeneration process[1]. In Latvia there is a high level of coverage of district heating.

Taking into account the high levels of cogeneration and DH coverage and the low heat density in most of the territory of Latvia, our study identified only a marginal potential for introduction of additional cogeneration technologies (by increasing the share of energy produced by DH in the total heat demand by about 3 % by 2020).

Currently, the total heat demand in Latvia is 20 217 GWh/year, which is low as compared to other European Union Member States, except in the case of individual, more densely populated cities (Riga, Daugavpils, Jekabpils, Liepaja, Ventspils, etc.)[2] By 2030, with the introduction of energy efficiency measures, a further decline in heat demand can be expected.

The scope of the present study does not include an assessment of the potential impact of investments in connection with the high-efficiency cogeneration and efficient district heating system on the heat and power tariffs for the individual and industrial final consumer. Such an impact should be assessed separately alongside with the potential impact on the behaviour of market participants.

The potential for increasing the share of cogeneration through the use of indigenous energy resources

The economic benefits of cogeneration which uses natural gas as a fuel (a gas turbine with heat recovery) are mainly proceeds from the sale of additional electricity. Cogeneration plants which use renewable energy provide additional benefits, such as less dependence on imported natural gas, lower fuel costs, and less negative environmental impact. Hence, during the course of the study it was analysed whether there is an additional potential for the introduction of cogeneration in Latvia and what type of fuel should be used. The analysis did not take account of State subsidies (the mandatory electricity procurement component) and used the market (Nord Pool Spot) price as the electricity price.

In accordance with the EU methodology, during the study, the analysis was carried out on the basis of geographical division. When analysing the share of cogeneration at the regional level — in municipalities and local governments —, the economic potential for the introduction of additional high-efficiency cogeneration was identified and analysed for only three cities in Latvia (Daugavpils, Liepaja and Jurmala). The economic potential for the application of cogeneration in district heating also exists in cities with a comparatively high heat demand which is currently satisfied solely by boiler houses which use natural gas or other fossil fuel in heat production. Since no increase in heat demand is expected in the future, renovation of the existing boiler houses with a capacity similar to that of cogeneration plants would be the most rational way of facilitating cogeneration. The scenarios analysed provide for additional electricity amounting to 18 GWh which could be generated by all of the new cogeneration units during the first year from their installation.

The cost-benefit analysis in which the scenarios were evaluated consists of a financial analysis in which their financial autonomy was evaluated by taking into account the financial indicators only, and a socio-economic analysis in which the costs and benefits for the public were assessed in a theoretical scenario. In the cost-benefit analysis the following financial and socio-economic results were obtained:

[1] https://em.gov.lv/lv/nozares_politika/energoefektivitate_un_siltumapgade/siltumapgade/

[2] The analysis was only carried out for regions with the housing unit density above 0.3 %. The regions analysed are representative of 79 % of heat demand in district heating in Latvia.

Table 1. Potential for cogeneration

City	Scenario description	Financial net present value (FNPV), thsd. EUR	Economic net present value (ENPV), thsd. EUR
Daugavpils	Replacement of the boiler house by a wood chip cogeneration plant for connection to DH	- 9 661	9 701
Jurmala	Establishment of a wood chip cogeneration plant to produce 35 % of the necessary heat in DH	2 069	6 788
Liepaja	Merger of five DH boiler houses into a single natural gas cogeneration plant	- 2 556	- 1 233

The results of the economic potential estimate showed that the Daugavpils scenario has a socio-economic potential from the Latvian economy perspective in general, as its overall benefits outweigh the costs. However, the introduction of this scenario requires financial support, as the financial analysis shows a negative financial net present value (FNPV).

The scenario that was applied for Jurmala showed a positive economic potential even without additional financial support. The Liepaja scenario showed an insufficient economic potential. A description of the scenarios considered and the main assumptions are provided in Chapter 3 of the present study. The results of the economic estimate are highly sensitive to changes to the main assumptions, such as changes to the amount of electricity generated and its sale price, as well as fuel prices and amount of investments.

The potential for using waste heat

Taking into account the small number of plants in Latvia which produce a large amount of heat, the study identified only a marginal potential for using waste heat and introduction of cogeneration. The study considered the possibility of establishing a cogeneration plant in Ventspils that would use biogas as a fuel. However, the analysis showed a low economic potential for this scenario, mainly due to insufficient revenue from the generation of additional electricity against the cost of investments.

The potential for increasing the share of district heating

The largest technical potential of energy efficiency could be achieved in the residential sector which is currently the largest energy consumer. In 2014, of the total final district heat consumption 69.5 % was used by households, 25.0 % by the services sector, 4.2 % by the industrial and construction sectors, and 1.3 % by the agricultural sector.

There is an economic potential for increasing the coverage of the district heating system in regions with the highest heat density, i.e. a large heat demand concentration in a comparatively small territory. The economic benefits arise mainly from primary energy savings as a result of the higher efficiency of DH as compared to individual heat generation solutions; district heating provides economic benefits only in the regions with a high use of cogeneration and renewable sources in the heating system. Since we had no information about the actual efficiency indicators, we based our assumptions on the regulatory efficiency indicators set forth in the Guidelines for Assessing the Efficiency of District Heating and Cooling, published by ECOHEATCOO. The results are highly sensitive to those assumptions.

Our study identified an economic potential for expanding DH in the territories where the average heat network intensity is above 2 MWh/year per metre of the heat network. Our study took into account the entire territory of the cities selected, but disregarded the specific conditions of each territory (e.g. roads, architectural conditions, etc.). It was found that an important factor in each city is the competition between individual and district heating, which is highly affected by the availability of a gas network in the city. Thus, the results represent only the overall economic potential in the territories considered, so any investment decision should be based on the specific provisions of additional detailed evaluations on a case-by-case basis.

The potential for trigeneration

In Latvian climatic conditions, the need for cooling is considerably lower than for heating. Currently, there are no district trigeneration plants in Latvia. Due to the low demand for trigeneration, its potential was assessed as being low.

1 Introduction

1.1 Purpose and scope of the present document

The present document was prepared on the basis of the Agreement concluded on 23 December 2015 between the Ministry of the Economy of the Republic of Latvia (hereinafter “the Ministry”) and “PricewaterhouseCoopers”, SIA (“PwC”) on carrying out a comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling and a cost-benefit analysis in accordance with the requirements of Directive 2012/27/EU; the Customer's procurement contract No EM 2015/82, procurement identification No EM 2015/82.

The work was performed in three stages:

1. ***Assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling in Latvia,***
2. ***Cost-benefit analysis,***
3. ***Recommendations on the necessary policy measures.***

The users of the study are energy, heat and energy-efficiency policy-makers.

1.2 Definitions and abbreviations

Explanations of the definitions, units of measurement and abbreviations used in the study are given in Table 2.

Table 2. List of explanations

Abbreviation	Explanation
HEC	High-efficiency cogeneration
RES	Renewable energy sources
BIO	Biomass
DH	District heating, district heat
NG	Natural Gas
EC	European Commission
Ministry	Ministry of the Economy of the Republic of Latvia
EU	European Union
IPE	Institute of Physical Energetics
GWh	Gigawatt hours
CP	Cogeneration plant
BH	Boiler house
RL	Republic of Latvia
MWh	Megawatt hours
MWh_{el}	Electricity megawatt hours
MWh_{th}	Thermal megawatt hours
MPC	Mandatory procurement component
PE	Primary energy
PEF	Primary energy factor
PwC	“PricewaterhouseCoopers”, SIA

1.3 *Data acquisition and processing methodology*

In order to carry out a comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling, and cost-benefit analysis in accordance with the requirements of Directive 2012/27/EU, the available information was summarised and the steps described in the present Section were taken.

The study "Heat supply data acquisition, analysis, methodology development and preparation of a manual for local governments on energy planning in their administrative territories" from the Ministry of the Economy of the Republic of Latvia, which includes information on heat production, consumption, production plants, etc., was the most important source of information. In addition, data from the following sources were used: the Environment and Energy Database of the Central Statistical Bureau of Latvia, statistical report "Air-2" of the Latvian Environment, Geology and Meteorology Centre, Eurostat database, and energy planning documents of the Latvian cities and local governments.

In the preparation of the present study the following steps were taken in accordance with Annex VIII of Directive 2012/27/EU:

Step 1:

At the beginning of the study, heat demand in Latvia was assessed, including the total heat demand and the demand that is satisfied by the district heating (DH) system. The existing heat demand in the DH system was analysed by sectors (households, services and industrial), and the potential of the cooling system in Latvia was described in accordance with the requirements of Directive 2012/27/EU.

At the end of Section 2.1 a forecast of changes in the heat demand in Latvia for the period up to 2030 is included. The heat demand forecast was made on the basis of energy forecasts provided by the Ministry of the Economy from the MARKAL model it had prepared.

In accordance with the requirements of Directive 2012/27/EU a business-as-usual scenario was identified where, on the basis of energy forecasts provided by the Ministry of the Economy from the MARKAL model it had prepared, heat demand for the regions analysed for the period of time up to the year 2030 was forecast.

Step 2:

In Section 2.2 of the study, the share of heat demand, which can be satisfied by DH and HEC, of the total heat supply in Latvia was discussed in detail. The boiler houses and cogeneration plants involved in DH as well as their number, capacity, amount of heat produced and the share of cogenerated heat of the total generated DH were considered. In addition, the main types of fuels that could be used were analysed and described in short.

The conclusions in this Section form the basis of Section 3.3.5 of the present study, where the economic potential for increasing the share of DH in the Latvian regions analysed is evaluated.

Step 3:

In order to identify the energy efficiency potential, in accordance with the requirements of Annex VIII to Directive 2012/27/EU, the regions of Latvia — municipalities and conurbations — in accordance with the geographic principle of a plot ratio of at least 0.3 were identified. Based on this requirement, a heat demand map of municipalities and cities of Latvia showing the heat demand intensity was prepared.

In order to provide a comprehensive assessment of the heating and cooling demand by municipalities, information from the Ministry of the Economy's study "Heat supply data acquisition, analysis, methodology development and preparation of a manual for local governments on energy planning in their administrative territories" was used. The purpose of the study was to summarise the most important representative data on heating systems, which are presented according to administrative territorial structures.

On the basis of this analysis, Chapter 2.3 of the present study was prepared, which analyses the existing heating systems in the cities and municipalities which meet the housing unit density requirements, as well as the technical potential for DH and cogeneration.

Step 4:

Further in the study, based on the technical potential identified in Section 2, an alternative scenario was calculated. Forecasts of heat energy produced by 2030 in the case of an alternative scenario, i.e. cogeneration units/plants in the selected regions, were summarised.

Step 5:

On the basis of the results of the analysis in Chapter 2.3, a cost-benefit analysis was carried out in order to assess the socio-economic and financial costs and benefits of the technical potential, and a sensitivity analysis was performed to assess the dependence of the results on various factors (heat demand, fuel prices, and the amount of the necessary investments).

Step 6:

On the basis of the results of the cost-benefit analysis, conclusions were drawn and recommendations were given regarding the necessary policy measures pursuant to Annex VIII to Directive 2012/27/EU.

1.4 *Limitations*

The results of this type of study depend heavily on the quality of the input data. The main drawbacks identified in the course of the present study were related to fuel consumption data by sectors (households, industrial and services sectors), especially in the industrial sector. Information on the energy consumption by industrial companies was only included in the form of aggregated statistics, since more precise data are protected under Section 19 of the Commercial Law.

For the data analysis the report from 2014 was used, and if any additional information needed for the given year was lacking, reliable data for the closest available year were used. All results are based on the data acquisition and processing methodology which meets the requirements of Article 14 and Annexes VIII and IX of Directive 2012/27/EU of the European Parliament and of the Council.

In accordance with those requirements the study did not take account of the heat and power tariffs for final consumers. Before any investments in district heating or cogeneration are made, it is necessary to analyse in detail how they might affect the heat demand depending on the possible changes to tariffs in each individual region.

The potential was calculated theoretically, without considering each individual case in detail and by leaving aside such factors as the number of debtors and the culture of payments, the heat demand within the framework of a given city, as well as the condition and efficiency of the heating system. When considering the costs specific to each case, the result may differ from the assessment of the potential in the cost-benefit analysis.

2 Assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling in Latvia

2.1. Description of the heat and cooling demand in Latvia

2.1.1 Heating in Latvia

The climate of Latvia makes thermal energy one of the most important energy sectors in the country. Latvia is located on the 57th parallel north where the duration of the heating season exceeds half a year (200 to 210 days), so heating is an important component of the quality of life for the population of Latvia. Accordingly, almost each household has local, individual district heating.

Since 1991, heating in Latvia has been the responsibility of local governments and municipalities which, within their competence, carry out local forecasting and planning of energy, develop and implement projects for continuous heat supply to consumers and the development of energy systems in their administrative territories, as well as ensure local implementation of the provisions of the European Energy Charter Treaty.

The transfer of the heating business to municipalities took place at a time when in the cities and densely populated areas of Latvia, a comparatively high ratio of district heating had been achieved (40-80 %); however, due to the collapse of the national economy which emerged in the late 1980s and ended in the early 1990s, alongside with the regaining of the country's independence and the reorientation of society from the regulatory to the market economy, the heat demand decreased substantially, and for a long time insufficient resources were provided for the maintenance of heating systems. Heating systems functioned with high heat losses and low economic indicators. Accordingly, since 1998 the renovation and upgrading of heating systems has been ongoing, and the condition of district heating is improving.

Currently, the heat supply to consumers in Latvia is ensured by using district heating systems[3], local heating[4] and individual heating[5]. Most of the thermal energy produced by district heating systems is produced in Riga, of which 90 % is produced by a high-efficiency cogeneration process. Local heating is ensured by using electric heaters and boilers, and in last decade heat pump, solar collector and micro-cogeneration systems have become increasingly popular, as these have proved to be cost-effective local heating technologies[6].

2.1.2 The existing heat demand

There are very few territories with high heat demand/high heat density in Latvia. After summarising the information on the current heat demand across all the sectors, a heat demand map was drawn up (Figure 1). The highest heat demand is in Riga (24.2 GWh/km²) and eight cities of republic significance (5.4 to 14.3 GWh/km²).

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[3] A technologically unified system of a heat source/several heat sources, main and distribution heat networks and internal consumer systems which ensures heat supply to consumers in a given territory by transporting thermal energy at large distances.

[4] A technologically unified system of a heat source and a customer's/the customers' internal heat-consuming systems where no main networks are needed for the heat supply; i.e. the heat is distributed and supplied to the consumers from the heat source by, or without, using heat distribution networks.

[5] (Household) — heating of an individual household (apartment, private house).

[6] *"Siltumsūkņu izmantošanas pieredze un perspektīvas dzīvojamo ēku un sabiedrisko objektu sektorā LR"*[Experience and prospects of using heat pumps in the residential and public facilities sectors in the Republic of Latvia] (D. Turlajs, S. Jaundālders, N. Zeltiņš)

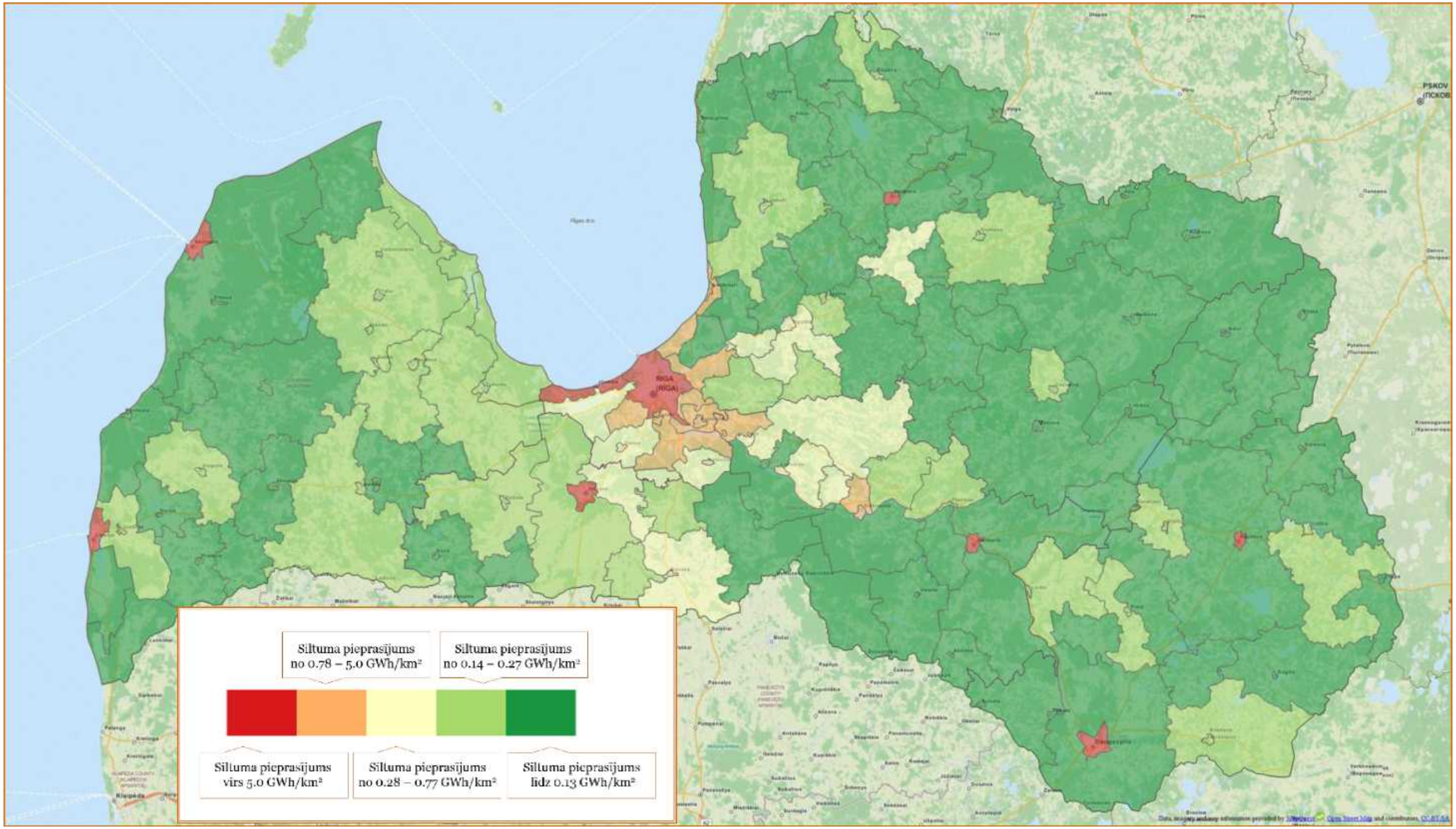

Figure 1. Heat demand analysis across municipalities and cities (carried out by the authors using the data supplied by the Ministry)

Siltuma pieprasījums no 0.78 – 5.0 GWh/km^2	Heat demand 0.78–5.0 GWh/km^2
Siltuma pieprasījums virs 5.0 GWh/km^2	Heat demand above 5.0 GWh/km^2
Siltuma pieprasījums no 0.14 – 0.27 GWh/km^2	Heat demand 0.14–0.27 GWh/km^2
Siltuma pieprasījums no 0.28 - 0.77 GWh/km^2	Heat demand 0.28–0.77 GWh/km^2
Siltuma pieprasījums līdz 0.13 GWh/km^2	Heat demand up to 0.13 GWh/km^2

In the rest of the territory the national heat demand is up to 0.27 GWh/km^2, while in Riga suburbs it ranges from 0.78 to 5.0 GWh/km^2. It can be seen that there are not many areas where the potential for a district heating system exists, since in the largest part of the territory the heat demand does not reach even 1 GWh/km^2.

Local and individual heating systems in Latvia produce 65 % of all the thermal energy in Latvia. The population and merchants in Latvia ensure individual heating by using various types of fuels, including natural gas and diesel fuel, and in the smaller villages people provide fuel individually — by purchasing it from merchants or acquiring it on their own. Thermal energy is obtained by various means, e.g. by using the latest technologies (including micro-generation), as well as electric heaters boilers and individual stoves.

2.1.3 Sectoral analysis

The heat demand is grouped according to the largest consumer groups — households, the services sector and the industrial sector. In accordance with the European Commission Guidelines, a correlation was used in order to comprehensively assess the heat demand and to exclude the impact of any deviations of the climatic conditions from the average norms on the heat demand. By applying the Building Code (LBN) 003-01 “Construction Climatology”, the climatological indicators were determined that are applied in construction, engineering research, construction design and in the performance of construction work, as well as the repair, renovation and reconstruction of construction works. The climatological indicators of any geographic point for the needs of construction in the territory of Latvia should be determined in accordance with Annex 1 of the above-mentioned Building Code.

In accordance with the European Commission Guidelines, the Central Statistical Bureau's data on the number of inhabitants and the area of the particular municipality/city were used, and the values from the ENTERANZE study on the average floor area per capita were applied[7],[8]

The district heating consumer structure in 2014 remained unchanged; the share of district heat amounted to 65–70 %, and the hot water supply amounted to 30–35 %. In 2014, of the total final district heat consumption, 69.5 % was used by households, 25.0 % by the services sector, 4.2 % by the industrial and construction sectors, and 1.3 % by the agricultural sector. Due to the poor availability of data the agricultural consumer sector will not be considered further in this document.

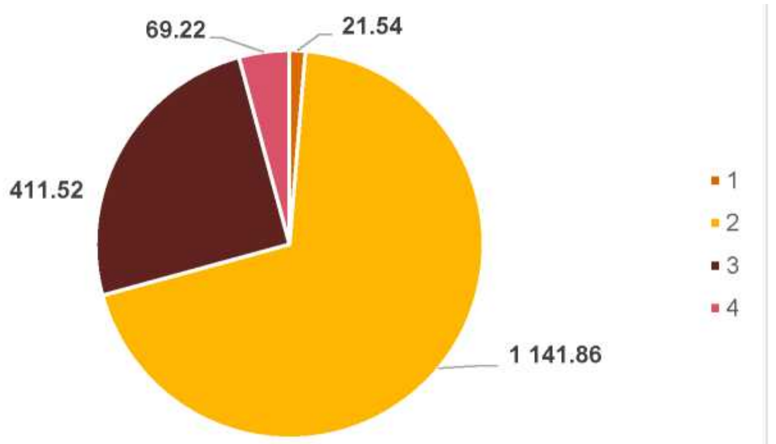

Figure 2. Structure of the final heat consumption in the country in 2014, GWh (source: the CSB data)

2.1.3.1 Households

It is established that in Latvia the heat demand of the household sector is 15.5 TWh, of which 36 % is satisfied by the district heating system. There are 1 993 782[9] inhabitants in Latvia, of which 1 341 390 (67 %) live in various cities (more than 56 % (1 123 054) live in nine cities of republic significance); the rest live in villages and rural areas dominated by

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[7] “Enteranze” study report, http://www.entranze.enerdata.eu/average-floor-area-per-capita.html
[8] Energy Efficiency Trends and Policies in the Household and Tertiary Sectors, http://www.odyssee-mure.eu/publications/br/energy-efficiency-trends-policies-buildings.pdf
[9] Office of Citizenship and Migration Affairs

country estate buildings where district heating is not an issue.

According to data from the Latvian household surveys, in 2010[10] the distribution of energy resources by types of use was the following: heating —80 %, cooking — 11 %, other needs — 9 %. The thermal energy distribution in households is as follows: 70 % for heating and 30 % for hot water.

2.1.3.2 Services sector

The Latvian services sector is made up mainly of tourism and recreation/servicing. By using the National Real Estate Cadastre Information System (NRECIS)[11], the area of the services sector according to groups of buildings was determined (see Figure 3). By applying the specific heat demand per m^2 of the area in each group of buildings, the heat demand for 2014 was established which amounted to 3.9 TWh.

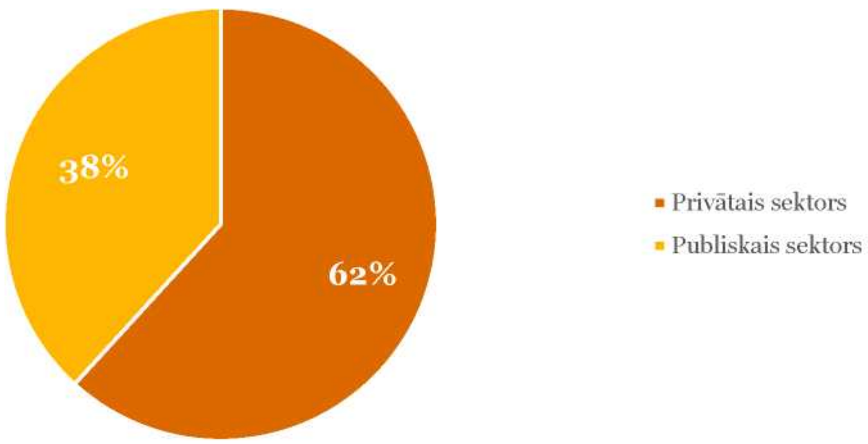


Figure 3. Total heat consumed by the services sector in 2014, by types of buildings (source: the Ministry's data)

Privātais sektors	Private sector
Publiskais sektors	Public sector

Most of the heat is necessary in the private sector which consists mainly of office buildings (819 GWh), wholesale and retail buildings (476 GWh) and hotels (319 GWh). In the public sector, however, most of the energy is required by schools (794 GWh) and hospitals (253 GWh).

2.1.3.3 Industrial sector

The largest manufacturing sector in Latvia is the wood processing sector (49 %); the non-metallic mineral products sector is the second largest manufacturing sector (18 %), while construction is the third (12 %). The three sectors account for 79 % of energy consumption in the industrial sector. Since Section 19 of the Commercial Law prohibits the public disclosure of information on commercial operations, with limited information about the heat consumption of industrial companies for technology and heating purposes the heat demand of 0.8 TWh was determined which may not reflect the whole of the demand.

[10] CSB data

[11] The areas of the residential houses registered in the NRECIS differ from the Central Statistical Bureau's (CSB) data on the housing stock, since the NRECIS records the total area of the residential houses, while the housing stock records the total or useful area of apartments (excluding the area of corridors, stairways, basements and other premises shared by all the owners of the residential or non-residential house).

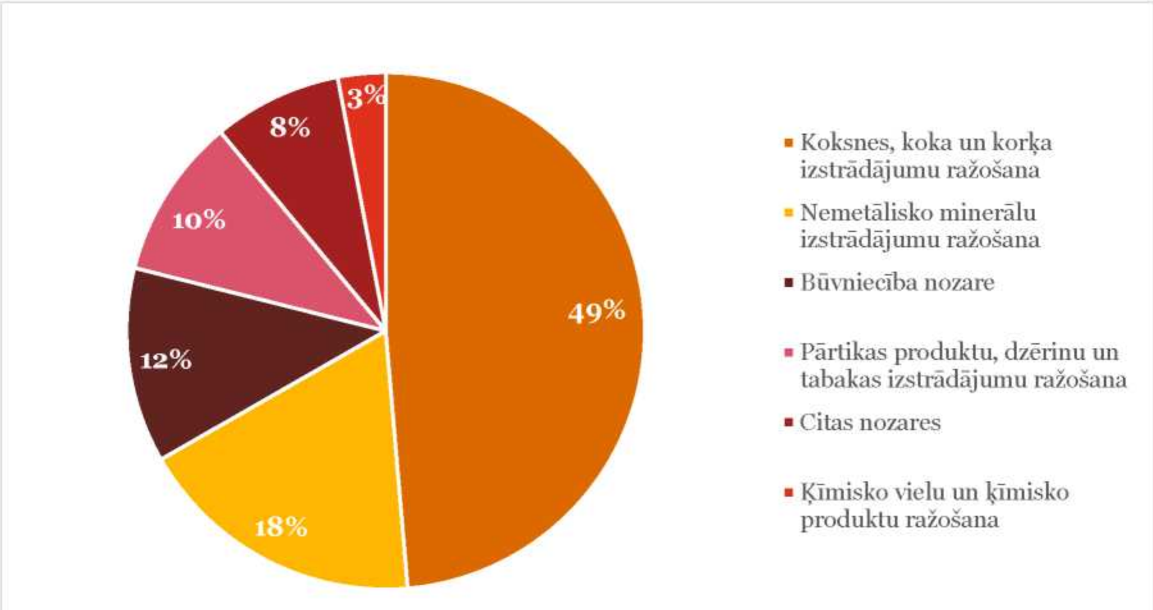


Figure 4. Distribution of energy consumption in the industrial sector in 2014 (source: the Ministry's data)

Koksnes, koka un korķa izstrādājumu ražošana	Manufacture of wood and of products of wood and cork
Nemetālisko minerālu izstrādājumu ražošana	Manufacture of non-metallic mineral products
Būvniecības nozare	Construction sector
Pārtikas produktu, dzērienu un tabakas izstrādājumu ražošana	Manufacture of food, beverages and tobacco products
Citas nozares	Other sectors
Ķīmisko vielu un ķīmisko produktu ražošana	Manufacture of chemicals and chemical products

2.1.4 Cooling

In the Latvian climate the cooling of premises would require up to 1 500 degree-hours. There are no trigeneration district plants installed in Latvia. For the cooling of premises, traditional cooling equipment is used which, like any other energy equipment, puts extra load on the urban infrastructure and, in the case of local solutions, creates unnecessary ecological load in the form of additional CO_2 emissions, fire effluents and noise.

Due to its consumer concentration and the construction specifics, Riga is the only city with the potential for the introduction of district cooling. Energy suppliers are interested in the establishment of a district cooling infrastructure in order to increase the share of energy produced by cogeneration, especially during the summer when heating is cut off and heat consumption falls substantially. The technical solution of district cooling which is most suitable for the Latvian climate is based on the combined operation of cogeneration units and absorption cooling units. An active transition from local to district cooling may increase the summer cogeneration potential by up to 30 % and relieve the urban electrical communications from pronounced summer peak loads, as well as provide the possibility to connect additional electricity consumers without increasing the supply loads. For Riga this could allow the cogeneration of 50 MW of additional electricity during the summer and 2-5 MW during the winter.

It should be noted that it is only worth installing district cooling in the territories where the introduction of cogeneration is planned, since in the case at hand it is only the energy producer that has the necessary incentive to introduce it. The parties interested in the introduction of district cooling are energy producers and suppliers, real estate and infrastructure owners, and public and municipal authorities. Attracting European funds for the establishment of pilot projects may provide positive momentum in this regard. It is important to implement only highly energy-efficient projects and to prevent the development and implementation of local cooling projects which have a negative impact on the environment. In the future, taking into account the resources available, Riga is planning to develop a pilot project for the integration of district cooling into the existing heating system.

Since currently the potential for cooling is in Riga only and it has not yet been tested in a pilot project and is based only on theoretical assumptions, this study does not analyse cooling in Latvia in further detail.

2.1.5 Forecast of changes in heat demand in Latvia until 2030

The heat demand forecast was made on the basis of energy forecasts provided by the Ministry of the Economy from the MARKAL model it had prepared. The model forecasts the final energy consumption in Latvia in three national economy sectors from 2010 to 2030 and was prepared taking into account the report of Latvia to the European Union “Guidelines on State aid for environmental protection and energy 2014-2020”.

Table 3. Forecasts of heat demand by consumption sectors by 2030

Sector	2015[12]	2020	2025	2030
Households, GWh	15 087	14 863	14 312	13 952
Industrial, GWh	828	832	845	860
Services, GWh	3 911	3 903	3 854	3 825
Total heat demand, GWh	**19 826**	**19 598**	**19 011**	**18 637**

As can be seen, in the household sector it is planned to continue the promotion of energy efficiency measures that gradually decrease the amount of heat consumed. In the industrial sector the increase in heat consumption is forecast by assuming that the establishment and growth of industrial companies will be promoted. The situation is similar in the case of the services sector — business growth is forecast which will exceed the energy efficiency measures by 2015.

Table 4. Forecast of heat demand by types of heat production

Heat produced, GWh	As % of total	2014[13]	2015	2020	2025	2030
Boiler houses, total	9.70 %	1 976	1 923	1 901	1 844	1 808
Cogeneration plants, total	25.80 %	5 231	5 115	5 056	4 905	4 808
Heat produced by DH, total	35.50 %	7 207	7 038	6 957	6 749	6 616
Individual heat production	64.50 %	13 072	12 788	12 641	12 262	12 021
Total heat demand	**100 %**	**20 279**	**19 826**	**19 598**	**19 011**	**18 637**

Based on the Ministry's forecasts, a heat demand forecast was prepared by types of heat production. The forecast shows the amount of heat energy that will be produced by each of the producers, provided that the ratio remains at the level of 2014.

[12] Guideline scenario from the developed MARKAL model in accordance with the report of Latvia to the EU “Guidelines on State aid for environmental protection and energy 2014-2020”.
[13] Data from the CSB and the Ministry

2.2. *The existing heat demand that could be satisfied by HEC and DH*

2.2.1. DH in Latvia

In 2014, the heat for DH in Latvia was produced in 175 cogeneration plants and 638 boiler houses. The heat produced by cogeneration plants amounted to 72.6 % of the total heat produced for DH in Latvia (see Figure 5). In general, DH accounts for 35 % of the total heat demand in Latvia. The remaining 65 % is heat produced locally and individually. As can be seen from Figure 1 in Section 2 of the present study, the heat demand in Latvia is concentrated in the largest cities, while outside the cities the heat density is very low. This is one of the reasons why it would be more complicated to connect the major part of the Latvian population to DH for the investments to be economically feasible. This possibility is analysed in Sub-section 5.3.6 of the study.

Figure 5. Production of district heat (source: the CSB data)

Katlu mājas	Boiler houses
Koģenerācija	Cogeneration

Overall, DH in Latvia is well-developed. Especially good coverage is in Riga and its suburbs where most of the Latvian population lives and hence the heat density per km² is the highest. In Riga, most of the heat is produced in the CHP and CHP-2 plants. The CHP was built in the 1950s but was completely reconstructed at the beginning of the century. In 2014, the CHP produced 945 GWh of heat, and CHP-2 produced 1 291 GWh of heat. This amounts to 31 % of the total DH production.

2.2.2. Cogeneration plants and boiler houses

District heating in Latvia is ensured by cogeneration plants and boiler houses. In recent years, the share of the heat produced by boiler houses of the total DH production has decreased. In the case of cogeneration plants, the opposite has been observed (Figure 6 shows the trend from 2010 to 2014).

In 2014, district heat for sale was produced in 631 boiler houses and 175 cogeneration plants. This means that about 34 % of the heat demand is satisfied by district heating. In accordance with the requirements of Article 2 in Chapter I of Directive 2012/27/EU, Latvia has ensured that most (72.6 %) of the heat energy produced by the district heating system is produced in a high-efficiency cogeneration process[14].

[14] https://em.gov.lv/lv/nozares_politika/energoefektivitate_un_siltumapgade/siltumapgade/

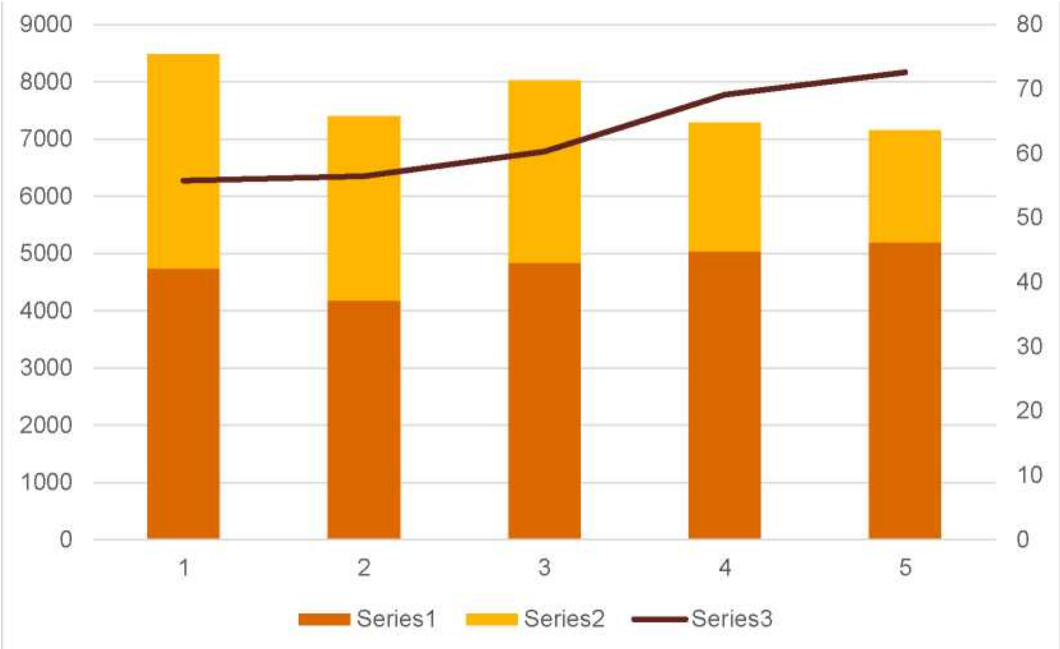


Figure 6. Development of heat production in DH boiler houses and the cogeneration cycle (source: the CSB data)

The total amount of DH production has seen a downward trend during the period from 2010 to 2014, while the share of heat produced by cogeneration has increased by 17 %. This can be explained by the fact that in 2010, heat in Latvia was produced in 668 boiler houses and 71 cogeneration plants. By 2014 the number of boiler houses had fallen to 631, while the number of cogeneration plants increased to 175. Accordingly, the share of cogenerated heat of the total DH production increased. Combined with the reduction in the number of boiler houses and the introduction of energy efficiency measures in Latvia, the total amount of heat produced in this period decreased slightly.

2.2.2.1. Boiler houses

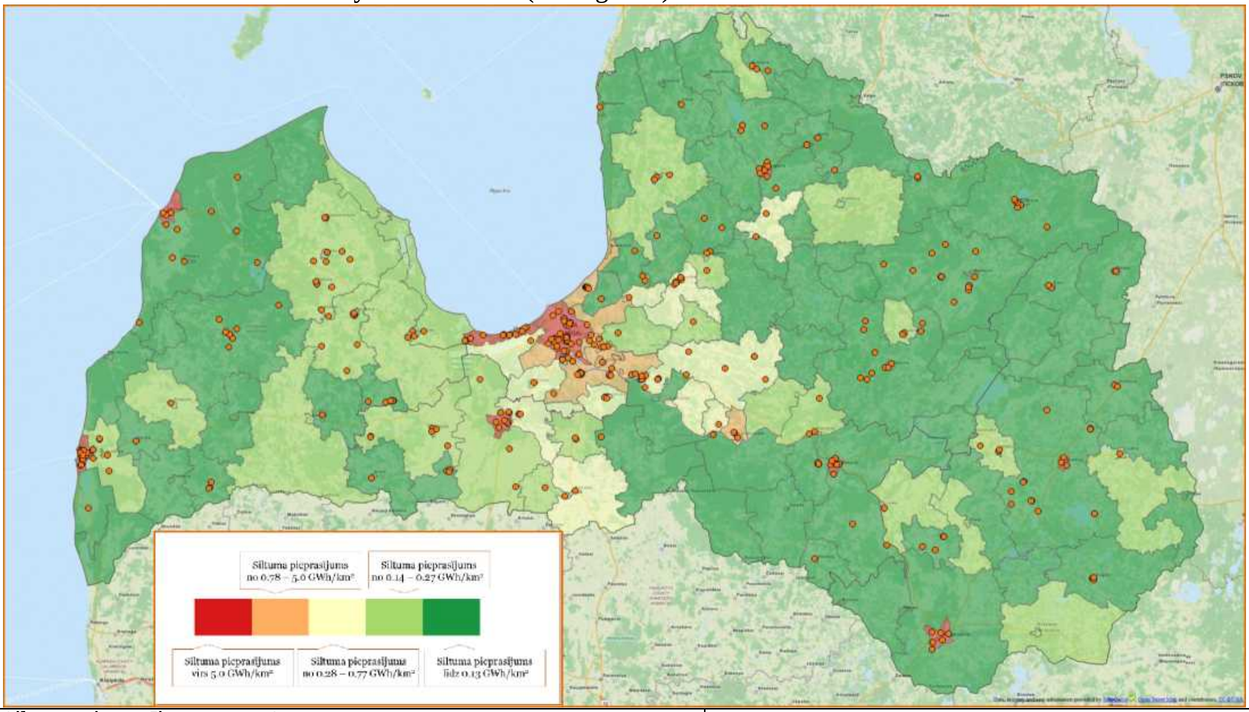
Boiler houses produce 27.4 % of the DH production in Latvia. In 2013, there were 638 boiler houses in Latvia, while in 2014 the number decreased slightly to 631. The DH boiler house network is evenly spread across Latvia; only 6.5 % of the heat is produced in low-capacity (up to 1 MW) boiler houses. More than 25 % of the heat in conversion process is produced in high-capacity boiler houses. The total installed heating capacity of boiler houses in 2014 was 2 589 MW, from which 1 962 MW of heat was produced.[15]

Table 5. The number of boiler houses, heating capacity and heat produced (2014)[15]

MW	Number of boiler houses	Installed heat capacity, MW	Heat produced, GWh
Total	631	2 589	1 962
< = 0.2	110	15	18
0.2 < MW < = 0.5	98	35	35
0.5 < MW < = 1	101	82	75
1 < MW < = 5	235	577	493
5 < MW < = 20	67	654	549
20 < MW < = 50	13	368	289
> 50	7	860	502

[15] CSB data

Figure 7 below shows the location of DH boiler houses in the territory of Latvia (orange dots). The largest number of boiler houses is in Riga and its suburbs, where the heat density is the highest, as well as in the largest cities of Latvia (red areas). In the areas with lower heat density (light green) there is a comparatively smaller number of boiler houses, while in the areas where heat density is the lowest (dark green) the number of boiler houses is the smallest.



Siltuma pieprasījums no 0.78 – 5.0 GWh/km²	Heat demand 0.78–5.0 GWh/km²
Siltuma pieprasījums virs 5.0 GWh/km²	Heat demand above 5.0 GWh/km²
Siltuma pieprasījums no 0.14 – 0.27 GWh/km²	Heat demand 0.14–0.27 GWh/km²
Siltuma pieprasījums no 0.28 - 0.77 GWh/km²	Heat demand 0.28–0.77 GWh/km²
Siltuma pieprasījums līdz 0.13 GWh/km²	Heat demand up to 0.13 GWh/km²

Figure 7. Location of boiler houses in Latvia (source: the CSB and the Ministry)

Figure 8 “Industrial zones with a total annual heating and cooling consumption of more than 20 GW (source: the CSB and the Ministry)” below shows the heating and cooling demand points for the industrial areas where the total heating and cooling consumption exceeds 20 GWh.

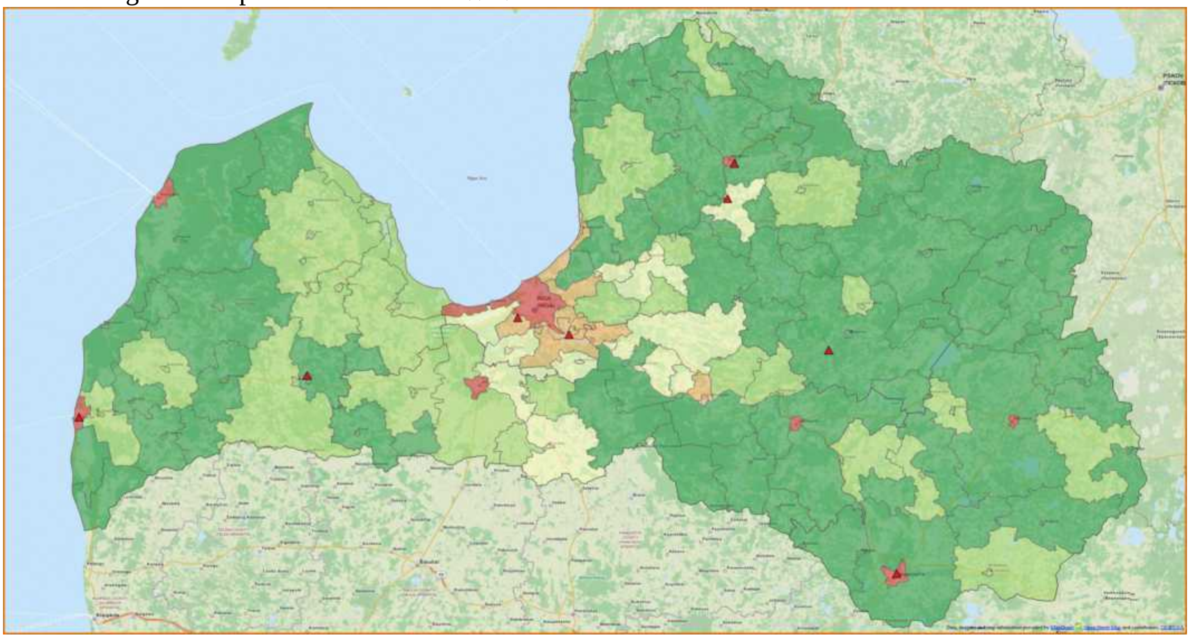


Figure 8. Industrial zones with a total annual heating and cooling consumption of more than 20 GW (source: the CSB and the Ministry)

2.2.2.2. Cogeneration units

Steam and gas turbines, as well as internal combustion engines, are the most common cogeneration technologies in Latvia. Steam turbines are the energy technology that is most widely used for district heat production/heat cogeneration. This system consumes less electricity per fuel unit than gas turbines, but its overall performance is higher and may reach 84 %. Steam turbines require a source of heat for steam generation, as the fuel energy in the turbines cannot be directly converted into mechanical or electrical energy. There are three types of steam turbines: back-pressure steam turbines, branch steam turbines and condensing steam turbines.[16] In Latvia the most effective steam turbines, back-pressure steam turbines, are primarily used since they ensure that all of the steam used in the generation of electricity by the turbine is used for technology or heating purposes.

Gas turbines are the second most common cogeneration technology. Natural gas, as well as biogas, is normally used as fuel. Equipment with a capacity of less than 1 MW is not economically feasible in cogeneration plants, as it requires rather high capital investments. During the last three years the share of natural gas consumption in boiler houses and cogeneration plants has decreased; this is due to the fact that cogeneration plants and boiler houses using biomass (wood chips, pellets) as fuel have been put into operation. The share of the boiler houses using natural gas decreased from 75 % to 65 %, while the share of the boiler houses using biomass increased from 18 % to 28 %.

Table 6. The number of cogeneration plants, heat capacity and heat produced (2014)[17]

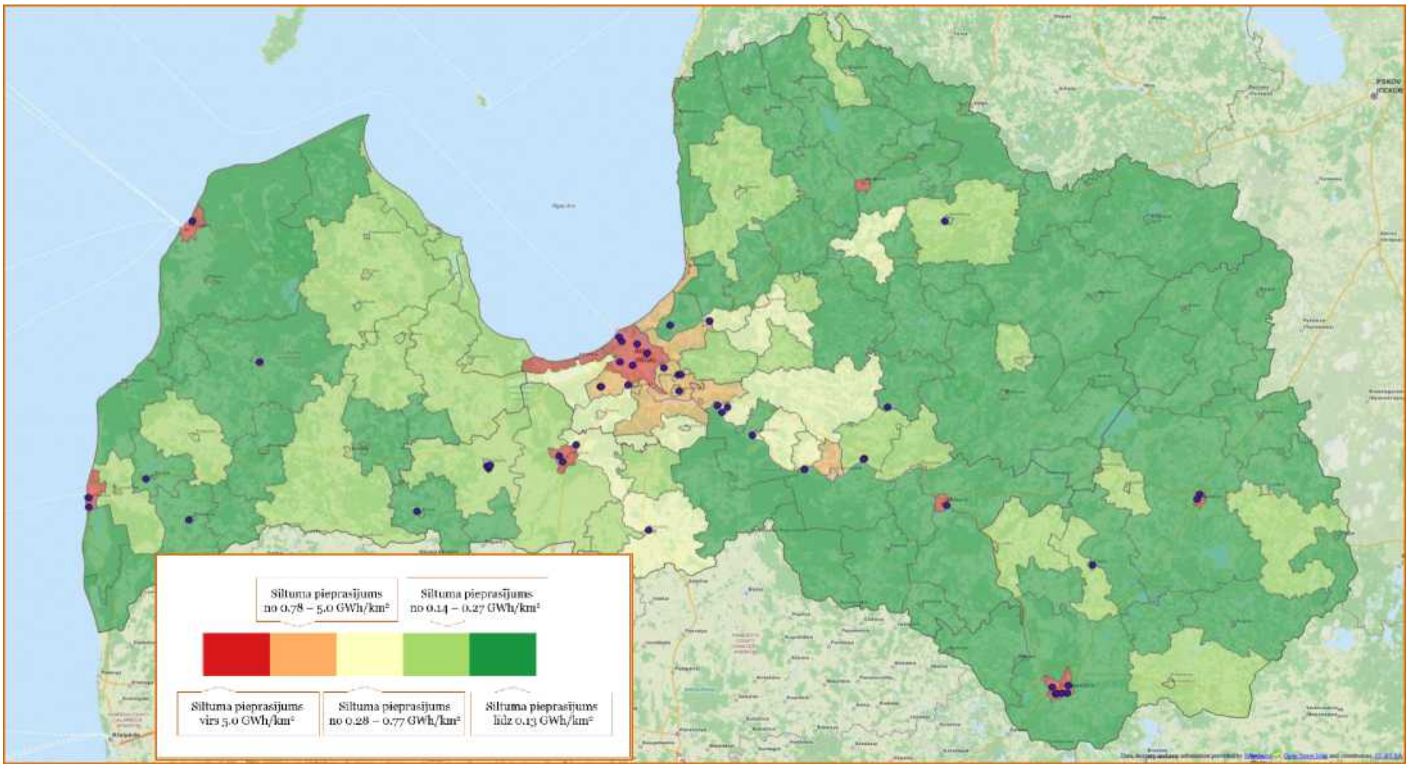
MW	Number of cogeneration plants	Installed electrical capacity, MW	Electricity produced, GWh	Heat produced, thsd. MWh
Total	175	1 265	3 005	5 190
< = 0.2	21	3	18	38
0.2 < MW < = 0.5	36	14	74	127
0.5 < MW < = 1	56	45	286	511
1 < MW < = 5	55	128	709	1 512
5 < MW < = 20	3	28	107	21
> 20	4	1 048	1 811	2 981

Table 6 summarises information from the CSB data on the number of cogeneration plants in Latvia, their breakdown by capacity and their installed electrical capacity and amount of electricity and heat produced. The largest groups consist of cogeneration plants with a capacity of 0.5 to 1 MW and 1 to 5 MW; their number represents 63 % of the total number of cogeneration plants in Latvia.

Figure 9 below shows the location of cogeneration plants in the territory of Latvia (blue dots). As can be seen on the map, the largest number of cogeneration plants is in Riga and the region of Riga, where the heat demand is the highest.

[16] R. Šeļegovskis "Siltuma ieguves tehnoloģijas" [Heat Production Technologies], Book 1, Latvia University of Agriculture, Jelgava, 2007;

[17] CSB data



Siltuma pieprasījums no 0.78 – 5.0 GWh/km²	Heat demand 0.78–5.0 GWh/km²
Siltuma pieprasījums virs 5.0 GWh/km²	Heat demand above 5.0 GWh/km²
Siltuma pieprasījums no 0.14 – 0.27 GWh/km²	Heat demand 0.14–0.27 GWh/km²
Siltuma pieprasījums no 0.28 - 0.77 GWh/km²	Heat demand 0.28–0.77 GWh/km²
Siltuma pieprasījums līdz 0.13 GWh/km²	Heat demand up to 0.13 GWh/km²

Figure 9. Location of cogeneration plants in Latvia (source: the CSB and the Ministry)

Figure 10 "Electricity generation installations with a total annual electricity production of more than 20 GWh" shows the potential heating and cooling supply points where electricity generation installations with a total annual electricity production of more than 20 GWh are installed. Figure 11. Waste incineration plants

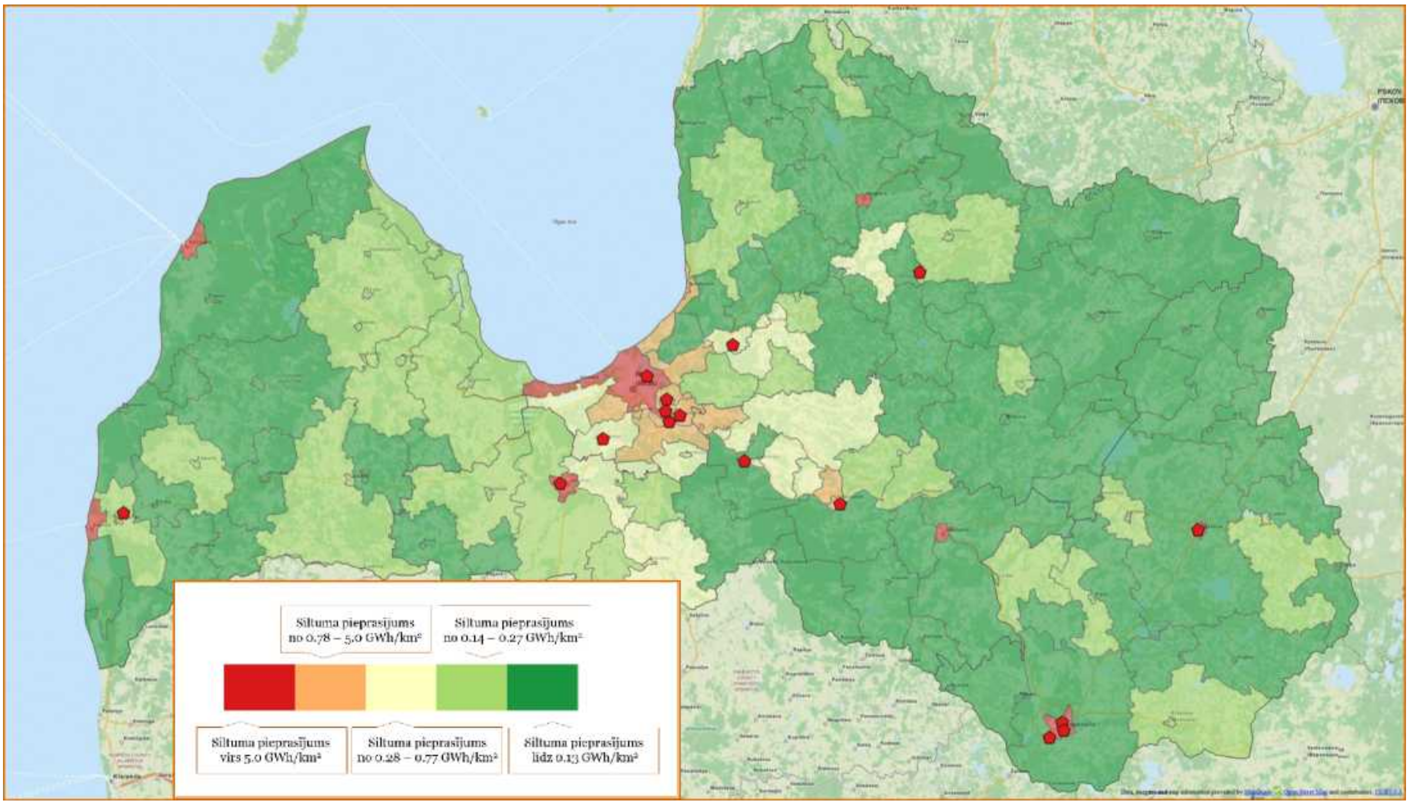
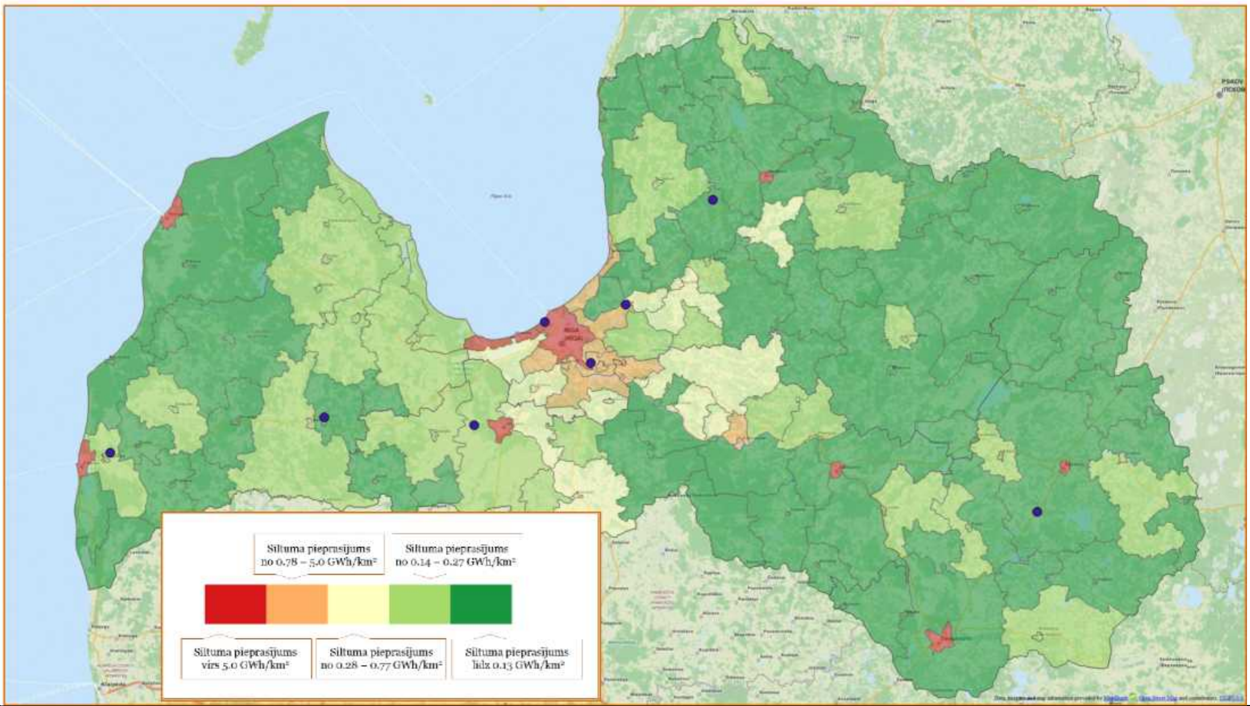


Figure 10. Electricity generation installations with a total annual electricity production of more than 20 GWh (source: the CSB and the Ministry)

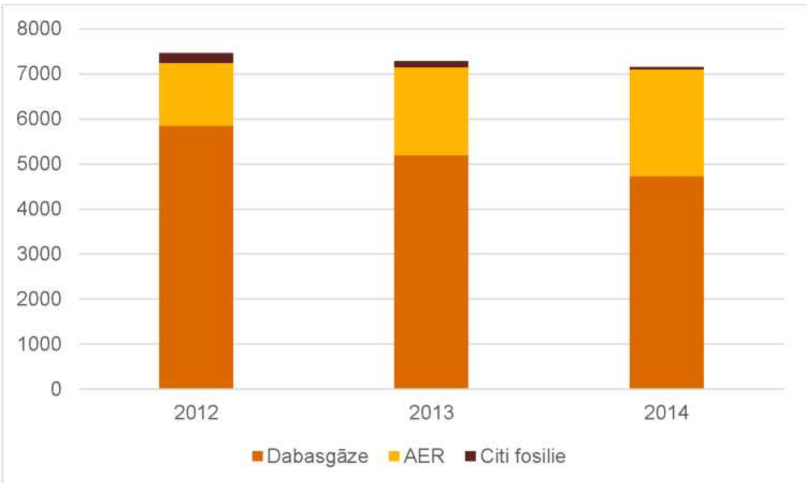


Siltuma pieprasījums no 0.78 – 5.0 GWh/km²	Heat demand 0.78–5.0 GWh/km²
Siltuma pieprasījums virs 5.0 GWh/km²	Heat demand above 5.0 GWh/km²
Siltuma pieprasījums no 0.14 – 0.27 GWh/km²	Heat demand 0.14–0.27 GWh/km²
Siltuma pieprasījums no 0.28 - 0.77 GWh/km²	Heat demand 0.28–0.77 GWh/km²
Siltuma pieprasījums līdz 0.13 GWh/km²	Heat demand up to 0.13 GWh/km²

Figure 11. Waste incineration plants (source: the CSB and the Ministry)

2.2.3. Fuel

Latvia's supply of indigenous energy resources is not particularly diverse; moreover, fossil fuels are imported. Therefore, taking into account the wide coverage of the natural gas infrastructure, natural gas and wood are the main fuels used for district heat production. Developments in recent years show that the share of RES in the heat production process is increasing and reached 33 %[18] in 2014. Fuels such as diesel fuel and liquefied petroleum gas are used mainly for covering the peak loads.



Dabasgāze	Natural gas
AER	RES
Citi fosilie	Other fossil fuels

Figure 12. Types of fuels used for heat production, GWh[19]

[18] CSB data

[19] CSB data

Figure 12 shows that the total amount of fuels consumed also slightly decreased from 2012 to 2014.

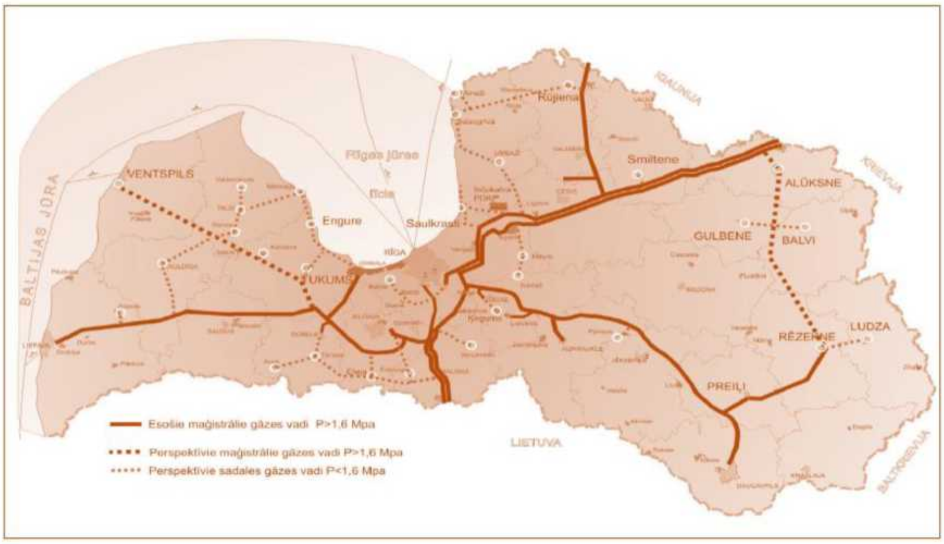
Table 7. Fuels consumed by boiler houses and cogeneration plants and the heat produced, 2014[20]

Heat produced, GWh, 2014				
In boiler houses	**Fuel consumed**	**As % of total**	**Heat produced**	**As % of total**
Wood fuel	1 628	12.6 %	1 113	15.4 %
Natural gas	923	7.1 %	838	11.6 %
Other	33	0.3 %	25	0.3 %
In boiler houses, total	**2 584**	**20.0 %**	**1 976**	**27.4 %**
Cogeneration plants				
Natural gas	7 550	58.4 %	3 932	54.6 %
Wood fuel	1 976	15.3 %	1 055	14.6 %
Biogas	778	6.0 %	213	3.0 %
Coal and diesel fuel	50	0.4 %	31	0.4 %
Cogeneration plants, total	10 354	80.0 %	5 231	72.6 %
DH TOTAL	**12 938**	**100.0 %**	**7 207**	**100.0 %**

Table 7 shows the fuel pattern of boiler houses and cogeneration plants in 2014. In boiler houses wood fuel is mainly used as a fuel (63 %), while cogeneration plants use mainly natural gas (73 %). Overall, natural gas is the most important type of fuel which is used both by boiler houses and cogeneration plants, and, by using this fuel, 66.2 % of the DH production is produced. Using wood fuel, BHs and CPs together produce 30.1 % of the total DH production. Other types of fuel (diesel fuel, oil fuel, coal, straw and liquefied petroleum gas) are used to produce only 3.7 % of the DH production (for covering the peak loads, as mentioned above). Since cogeneration plants use biogas as a fuel as well, which is not used by boiler houses, the share of this type of fuel is very small and accounts for only 3 % of the total DH production.

2.2.3.1 Natural gas and its infrastructure

Natural gas is a resource of strategic significance for the Latvian national economy and energy sector. Latvia receives all of its natural gas from Russia. The natural gas infrastructure is very well-developed in Latvia (see Figure 13); therefore, many consumers use natural gas for local and individual heating. In 2014, 47.5 % of the households used network gas for heating and cooking. Taking into account the well-developed infrastructure in the region of Riga, natural gas is used by 76.7 % of the households.



Esošie maģistrālie gāzes vadi P>1,6 Mpa	Existing main gas pipe-lines P>1.6 Mpa

[20] CSB data

Perspektīvie maģistrālie gāzes vadi P>1,6 Mpa	Prospective main gas pipe-lines P>1.6 Mpa
Perspektīvie sadales gāzes vadi P<1,6 Mpa	Prospective gas distribution pipelines P<1.6 Mpa

Figure 13. Gas supply plan for Latvia[21]

High-quality gas supply infrastructure is available (or is planned to be available) in all major cities in Latvia and other densely populated areas. Due to the highly combustible nature of natural gas, 73 % of cogeneration plants use natural gas as a fuel. In Jurmala, for example, the natural gas infrastructure is very well-developed, so it is very convenient to use natural gas as a fuel there. In Ventspils, there is currently no gas infrastructure, but it is planned to establish one in the future; therefore, the city uses only renewable energy sources as a fuel.

In the long term, the amount of natural gas sold is influenced mostly by such factors as the development of business activity in the industrial customer sector, the improvement of heat production and consumption efficiency and the growth of alternative (including subsidised) types of energy production. These factors combined have had a negative impact on the average consumption of natural gas over the last five years.

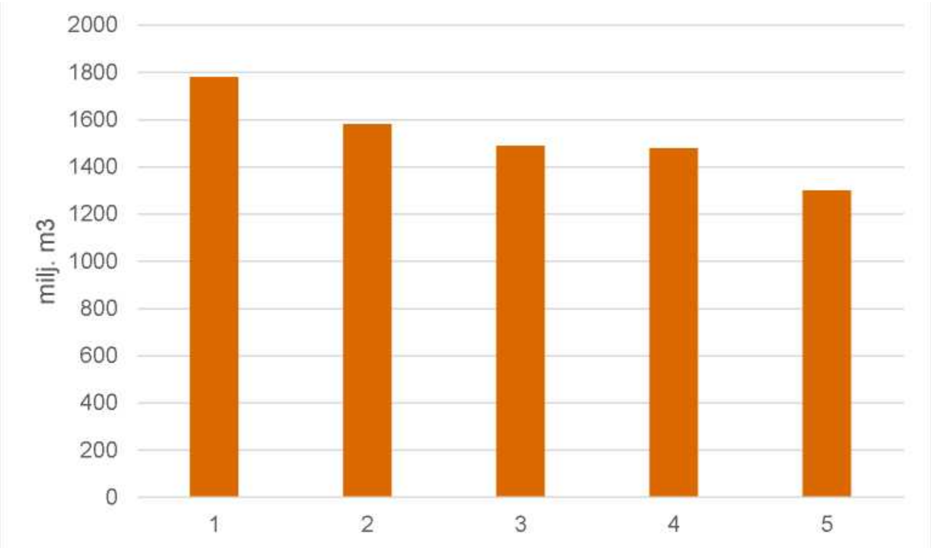


Figure 14. Decrease of the natural gas consumption

2.2.3.2. Wood chips

Wood chips are the most common type of fuel from renewable sources in Latvia. Both boiler houses and cogeneration plants use wood ships as fuel. Since wood chips are produced from waste wood and overgrowth, the cost of this type of fuel is comparatively lower (as compared, for instance, to natural gas). Their price ranges from EUR 8.00/bulk m^3 to EUR 9.82/bulk m^3 in various regions of Latvia. Taking into account the relative moisture content in wood chips (about 45 % on average) and their calorific value, more wood chips are needed in terms of volume than natural gas. However, wood chips are more environmentally friendly and cheaper (natural gas: EUR 24.2/MWh, wood chips: EUR 12.4/MWh in 2014); hence, many boiler houses and cogeneration plants use wood chips. According to the Ministry's data, in 2014, 1 796 GWh of wood chips were used for DH, which makes wood chips the second most widely-used type of fuel in terms of volume (the consumption of natural gas was 7 382 GWh).

2.2.3.3. Waste

According to the information available to the State Environmental Bureau (SEB), there are no direct waste incineration plants in Latvia. However, the SEB has data on permits received by at least five industrial waste co-incineration plants which, in combination with natural gas or waste wood, incinerate construction waste, slaughterhouse waste, technical liquids, smuggled goods and sorted municipal waste of various categories. The use of waste landfill site products and other agricultural or manufacturing by-products for the production of biogas is developing in Latvia. In five landfill sites, biocells or ecocells are used for producing biogas which is then burnt in a cogeneration plant that produces electricity and feeds it into the grid, while the by-product, heat, is used for the plant's own needs (heating or technological). "Getliņi EKO", where 300 000 to 400 000 tonnes of waste are deposited each year, is the largest landfill gas production plant. With the continued construction of new landfill sites the gas production has increased as well; the generation of electricity

[21] I. Laube "*Gāzes sadales sistēmu parametru aprēķinu metodoloģija*" [Methodology for Calculation of Gas Distribution System Parameters]

reaches 30 000 to 35 000 MWh/year. The heat produced by the power unit is used fully: for heating the infiltration reactor, office and household buildings, water heating, as well as for heating the newly-constructed greenhouse complex (3 625 m^2). In Riga there is an active sludge biogas cogeneration plant used for waste-water treatment, containing two units with a nominal heat capacity of 1.34 MW each and an electrical capacity of up to 1.05 MW each.

2.2.3.4. Biogas

As cogeneration plants develop, the number of biogas cogeneration plants which use biogas that has been obtained by the process of the incineration of municipal and agricultural waste as fuel has increased in Latvia. In most cases, cogenerated electricity is fed into the grid, while heat is used for self-consumption or technology purposes, without providing a significant contribution to the district heating system. In 2009, after the adoption of the Cabinet Regulation No 262 Regarding the Production of Electricity Using Renewable Energy Resources and the Procedures for the Determination of the Price, a rapid development of biogas projects began, which continued until 2012. In September 2015, Cabinet Regulation No 567 Regarding the Concept Report “Complex Measures for the Development of the Electricity Market” entered into force, which was drawn up to deal with relevant issues in the electricity market, including the issue of maintaining the level of the mandatory procurement component (MPC) and support to energy-intensive companies. According to the Ministry of the Economy's data, at present there are 22 biogas cogeneration plants operating in Latvia which, in accordance with the provisions of Cabinet Regulation No 221 of 10 March 2009 Regarding Electricity Production and Price Determination upon Production of Electricity in Cogeneration, have obtained the right to sell the generated electricity within the framework of the mandatory procurement with a total installed electrical capacity of 19 MW and heat capacity of 20 MW (as of 24 August 2015).

2.3. Description of the energy-efficiency potential of the existing DH infrastructure and assessment of the additional potential of HEC and the share of HEC in the energy balance of Latvia

In order to carry out a comprehensive analysis of the potential of the existing district heating infrastructure, a detailed assessment of the present situation was performed in accordance with the available information. The assessment criteria comply with Annex VIII of Directive 2012/27/EU:

- identification of the heating and cooling demand that could be satisfied by high-efficiency cogeneration, including residential micro-cogeneration, and by district heating;
- identification of the potential for additional high-efficiency cogeneration, including from the refurbishment of existing and the construction of new generation and industrial installations or other facilities generating waste heat;
- identification of energy efficiency potentials of district heating infrastructure.

For the purpose of the description of the heating and cooling demand, in accordance with the requirements of Annex VIII to Directive 2012/27/EU the regions of Latvia — municipalities and conurbations — in accordance with the geographic principle of a plot ratio of at least 0.3 were identified. Nine cities of republic significance (Riga, Daugavpils, Jelgava, Jekabpils, Jurmala, Liepaja, Rezekne, Valmiera, Ventspils) and four Riga suburban municipalities (Stopini, Salaspils, Marupe, Kekava) meet this criterion.

According to the information available regarding the amount of heat produced and consumed in Latvia in 2014, the cities and municipalities selected for the study account for about 48 % of the heat consumed by DH.

Table 8. Geographic limitation (source: the CSB and the Ministry)

	Area, km²	Number of inhabitants	Dwelling floor space per inhabitant, m²	Residential area, m²	Housing unit density
Riga	304	642 188	25.6	16 440 013	5.408
Liepaja	68	71 525	29.2	2 088 530	3.071
Daugavpils	72	86 919	22.5	1 955 678	2.716
Jelgava	60	57 256	25.1	1 437 126	2.395
Jurmala	101	49 698	28	1 391 544	1.378
Ventspils	58	36 476	24.9	908 252	1.566
Rezekne	18	29 633	23.9	708 229	3.935
Valmiera	18	23 544	23.5	553 284	3.074
Jekabpils	25	23 144	23.6	546 198	2.185
Kekava Municipality	275	22 482	29	651 978	0.237
Salaspils Municipality	123	22 148	29	642 292	0.522
Marupe Municipality	104	17 345	29	503 005	0.484
Stopini Municipality	53	10 207	29	296 003	0.558
Saulkrasti Municipality	48	5 762	29	167 098	0.348
Latvia, total	**64 573**	**1 993 782**	**27.2**	**54 230 870**	**0.084**

Table 9. Amount of heat demand and consumption in 2014 (source: the CSB and the Ministry)

City	Population density, %	Heat produced by CPs, MWh/year	Heat produced by BHs, MWh/year	Total heat productio n, MWh/ year,	Heat consumption in the industrial sector, MWh/year	Heat consumption in the household sector, MWh/year	Heat consumption in the services sector, MWh/year	Local and individual heating consumption in the household sector, MWh/year	Local and individual heating consumption in the services sector, MWh/year	Heat network losses, MWh/ year,	MWh/ year, total	km^2	GWh/km^2
Riga	5.4	3 919 104	341 714	4 260 818	643 408	3 135 159	1 056 895	1 922 908	648 233	574 644	7 406 603	304	24.4
Liepaja	3.071	208 431	42 812	251 243	4 230	165 246	32 076	345 433	67 052	36 240	650 275	68	9.6
Daugavpils	2.716	151 035	133 744	284 779	4 279	287 091	61 455	286 016	61 225	67 887	767 952	72	10.7
Jelgava	2.395	280 138	11 410	291 548	2 544	136 678	26 769	232 439	45 525	38 495	482 449	60	8.0
Jurmala	1.38	0	121 852	121 852	915	100 098	24 344	390 381	94 942	24 361	635 041	101	6.3
Ventspils	1.566	84 196	88 391	172 587	1 397	116 848	25 364	123 794	26 872	20 226	314 501	58	5.4
Rezekne	3.935	144 185	5 986	150 171	1 386	103 616	23 959	88 236	20 403	20 065	257 665	18	14.3
Valmiera	3.074	35 695	62 287	97 982	1 220	104 143	34 547	47 290	36 840	17 637	224 040	18	12.4
Jekabpils	2.185	29 558	17 815	47 373	1 220	44 545	8 916	107 871	21 592	12 262	196 406	25	7.9
Kekava Municipality	0.2	46 252	0.0	46 252	2 097	41 189	2 569	194 717	12 143	3 124	252 715	275	0.9
Salaspils Municipality	0.522	30 059	4 748	34 807	1 493	57 434	6 762	130 484	15 362	8 490	211 535	123	1.7
Marupe Municipality	0.484	9 286	0	9 286	1 841	49 479	6 476	129 507	16 949	2 527	204 252	104	2.0
Stopini Municipality	0.588	12 037	3 529	15 566.0	1 185	20 547	2 661	89 332	11 568	2 213	125 294	53	2.4
Saulkrasti Municipality	0.348	0	4 176	4 176	154	866	47	132 746	7 280	820	141 093	142	2.9

Table 9 shows the consumption of the heat supplied, by conversion sector technologies — cogeneration plants or district heating boiler houses — and also reflects the distribution of heat energy by national economy sectors in the selected conurbations, municipalities and cities.

2.3.1 Riga

Heat demand	- Households: 4 458.07 GWh/year - Industry: 643.41 GWh/year - Services: 2 305.13 GWh/year
Share of district cogeneration	- In the district heating system: 4 835.46 GWh/year - In local and individual heating: 2 571.14 GWh/year 56 % of the heat is ensured by DH
District heating infrastructure and its potential	46.2 % of the heat for Riga City is provided by CHP-1 and CHP-2. The DH in Riga undergoes gradual infrastructure improvements and upgrading, including the replacement of heating boilers and the use of new technologies in energy generation plants, i.e. the recovery of flue gasses and cooling flows (absorption heat pumps), as well as condensing economizers. Innovative technologies for heat recovery from waste water are used, and biogas production from waste water sludge is carried out. The length of heat network is 756 km. By renovating 502.39 km of the heat network, it would be possible to achieve energy savings of 66.96 GWh/year and primary energy savings of 69.9 GWh/year.
Share of cogeneration	In 2014, 91.98 % of the DH production through a conversion process was produced by cogeneration. The cogeneration potential is achieved fully.
Share of RES in DH	67 % natural gas, 33 % RES
Potential for connecting new consumers	Taking into account the infrastructure available, there is a high potential for integrating new consumers into the existing DH.

The natural gas infrastructure and the geographical location of Riga affect the share of energy resources in the city's heating system. Considering the transportation distances and the location of the DH infrastructure in the urban environment, assessment of the biomass potential is not cost-effective. It is necessary to carry out an in-depth study of innovative technologies regarding recovery of various types of energy from the environment, technological processes and various types of waste and industrial by-products.

2.3.2 Liepaja

Heat demand	- Households: 541.03 GWh/year - Industry: 4.23 GWh/year - Services: 105.02 GWh/year
Share of district heating	- In the district heating system: 237.8 GWh/year - In local and individual heating: 412.48 GWh/year DH covers 40 % of the total heat demand.
District heating infrastructure and its potential	There are 18 boiler houses and two cogeneration plants in Liepaja. The required heat load is close to 80 % of the total installed capacity of the units; this means that the installed capacities are fully used. Taking into account the number of boiler houses and their small capacities, it is necessary to evaluate the possibility, based on past practice, of a transition to a single large cogeneration plant, achieved by merging several plants. Considering the location of the boiler houses, in the prospective area five boiler houses could be merged in which the units were installed in 2000 to 2006 with a total heat capacity of 27.44 MW, by replacing them with one cogeneration plant. The total length of the heat network is 97 km. Heat distribution losses in Liepaja during the last five years have substantially decreased (by 26.2 % in 2009 and by 15.4 % in 2013). Reconstruction of the heat transmission and distribution networks in Liepaja will also continue in the coming years, thereby reducing heat losses. By renovating 26.48 km of the heat network, it would be possible to achieve energy savings of 11.33 GWh/year and primary energy savings of 12.2 GWh/year.
Share of cogeneration	The two cogeneration plants provide 82.95 % of the DH production in Liepaja. One is a natural gas generation plant with an installed capacity of 4 MW_{el}, and the other is a wood chip CP with an installed capacity of 6 MW_{el}.
Share of RES in DH	At the end of 2013 a wood chip boiler house with a capacity of 30 MW was brought into operation. With the start of operation of the biomass boiler house, about 65 % of heat is produced by the company using the local renewable resource, wood chips. At the same time, the share of imported biogas in the fuel balance has decreased by ~40 %. The BH produces about 90 GWh of heat per year, which is roughly 35 % of the total heat produced by plants in Liepaja.

Potential for connecting new consumers	The DH system of Liepaja is planning to maintain the current level and to connect new consumers gradually.
Waste energy potential	From biogas deposited by two landfill sites in two cogeneration plants with nominal electrical capacity of 584 KW_{el} and maximum heat capacity of 861 KW_{th} each, 1 390 030 kWh of electricity were generated in 2015. A small part of the heat is used by the company for heating the landfill site buildings, while the major part — at least 740 KW_{th}/h — of the heat produced is offered for the development of business activity. Since the regional waste management centre "Liepājas RAS" is located 8 km far from Liepaja City, and taking into account that the amount of heat energy is not large, construction of an infrastructure would not be cost-effective.
Industrial heat recovery potential	The heat recovery potential of the metallurgical plant in Liepaja was evaluated by taking into account the limited information on the future development scenario of the company and the existing infrastructure, and it was found that it is impossible to carry out the technical and economic evaluation of this potential.

Considering the large share of RES and of the high-efficiency cogeneration system in the DH system of Liepaja, the latter meets the definition of a district heating system, and there is more potential for increasing the number of consumers and evaluating the possibility of using recovered heat from the industrial heat energy for technology purposes. Liepaja's local government is planning to raise the efficiency of the district heating system by using local energy resources and by continuing the reconstruction of heating mains[22].

2.3.3 Daugavpils

Heat demand	- Households: 629.02 GWh/year - Industry: 4.28 GWh/year - Services: 134.65 GWh/year
Share of district heating	- In the district heating system: 420.71 GWh/year - In local and individual heating: 347.24 GWh/year DH satisfies 47 % of the heat demand.
District heating infrastructure and its potential	The city's DH system consists of three heating plants, eight local boiler houses, one boiler house integrated in a residential building, and a heat network with a length of almost 122 km. The three large heating plants and their heat networks, which are interconnected, make up the city's DH area. About 15 % of the heat necessary for district heating is purchased from other heat producers. The configuration of the heat networks allows for each heat plant's heat supply area to be quite flexible. Taking into account its heat production (92 000 MWh in 2014), Daugavpils DH plant with an installed capacity of 248.9 MW (natural gas) is not cost-effective and is only operated during the heating season. There is a potential to install a wood chip cogeneration plant with a boiling-layer boiler and a steam turbine with a heat capacity of about 40 MW and an electrical capacity of about 6-7 MW. This technology would allow all types of forest and industrial waste wood to be used as fuel. Currently this plant purchases an additional 76.8 thousand MWh of heat — the new plant would be able to also cover this amount of heat. With the load in the city increasing, it is also possible to install a flue gas condenser thereby increasing the total heat capacity of the plant. By renovating 95.21 km of the heat network, it would be possible to achieve energy savings of 24.11 GWh/year and primary energy savings of 28.17 GWh/year.
Share of cogeneration	There are six CPs which produce 52.55 % of the DH production.
Share of RES in DH	For 97 % of the heat production, natural gas is used as a fuel.
Potential for connecting new consumers	It is offered in the city's DH area to connect to the district heating system instead of establishing individual heat production sources. Despite the continuous development of the heat network, very few new heat users connect to the DH system, since the value of heat depends heavily on price fluctuations of natural gas. Less than half of the city's consumers are connected to DH networks.

[22] LIEPAJA CITY DEVELOPMENT PROGRAMME 2015–2020

Waste energy potential	There are no waste landfills or dumps in the territory of Daugavpils; the municipal waste landfill is located in Demene Parish of Daugavpils Municipality. Waste from other parishes in Daugavpils Municipality is transported to this landfill. Considering the amount of waste in the landfill and the landfill's distance from the city, the potential was not evaluated.
Industrial heat recovery potential	In the centre of Daugavpils there is a food company which has heat production units with nominal capacity of 3.72 MW. The company uses 1 086.85 MWh of heat for own needs and 10.025 MWh of heat for technology needs by using natural gas as a fuel. Due to the insufficient information on the infrastructure and technological possibilities and the quite low heat energy potential, this potential was not evaluated in more detail.

In order to diversify the range of fuels in heating by introducing renewable fuels in energy production[23], there is the potential for technological renovation of an outdated boiler house by converting it into one that uses waste wood for heat production.

2.3.4 Jelgava

Heat demand	- Households: 401.31 GWh/year - Industry: 2.54 GWh/year - Services: 78.60 GWh/year
Share of district heating	- In the district heating system: 204.49 GWh/year - In local and individual heating: 277.96 GWh/year 42 % of the heat demand is produced by DH.
District heating infrastructure and its potential	In Jelgava, district heating of residential houses, public buildings and industrial companies is ensured by the city's district heating system and autonomous (local) heat sources that have been built for supplying heat to a building or a small group of buildings. DH consists of two independent district heating systems located on the right and the left banks of the Lielupe river, and four low-capacity heating systems of local significance. There are seven boiler houses in total; in two of them cogeneration units are installed. In recent years significant measures for upgrading the district heating systems and raising energy efficiency have been implemented. The length of the heat network is 74.6 km. By renovating the heat network, it would be possible to achieve energy savings of 17.98 GWh/year and primary energy savings of 20.18 GWh/year.
Share of cogeneration	97 % of the DH production is cogenerated.
Share of RES in DH	The use of local biofuel, i.e. wood chips and waste wood, will reduce the dependence on imported fossil fuel and ensure a more stable heat tariff. Thus, beginning with the 2013/2014 heating season, 85 % of the DH production will be provided from one heat source that uses renewable energy resources as a fuel.
Potential for connecting new consumers	It is planned to integrate the autonomous boiler houses into the common DH network, which will increase the energy efficiency of the heating system. There are also plans to build a new DH infrastructure in prospective building territories, including the construction of a heating main running from Rupniecibas to Dambja Streets.
Waste energy potential	Several kilometres from Jelgava there is a landfill site that has biodegradable municipal waste storage cells for biogas production and a biogas cogeneration plant with installed electrical capacity of 0.18 MW_{el}, heat capacity of 0.205 MW_{th} and the amount of electricity production of 426 053 kWh/year. Due to the small amount of waste — 2 700 tonnes/year — no potential for connecting to the Jelgava DH system by building a corresponding infrastructure was identified.

Taking into account the share of renewable energy resources and of high-efficiency cogeneration in the DH system of Jelgava, the system meets the definition of an efficient district heating system. There is a potential for connecting new consumers in order to fully use the capacity of the installed infrastructure.

2.3.5 Jurmala

Heat demand	- Households: 510.07 GWh/year - Industry: 0.91 GWh/year - Services: 124.05 GWh/year

[23] DAUGAVPILS CITY DEVELOPMENT PROGRAMME 2014–2020

Share of district heating	- In the district heating system: 149.72 GWh/year - In local and individual heating: 485.32 GWh/year 21 % of the consumers are connected to district heating networks.
District heating infrastructure and its potential	Information on 13 boiler houses is available. The total installed capacity: 123 MW; average capacity: 14 MW; average summer capacity: 2 MW. The district heating system of Jurmala is divided locally between the most densely populated regions of the city, i.e. Kauguri, Sloka, Dubulti, Majori, Bulduri, Lielupe and Kemeri. There are also local boiler houses which supply heat to one or two objects and whose heat production is not fed into the shared district heating network scheme. They are located mainly in Kemeri, Lielupe and other areas which are located far away from the main district heating networks and whose connection to these networks is currently unprofitable. Most of the natural gas boilers installed are outdated, so there is a high energy efficiency potential. The length of the heat network is 59 km. The condition of the heat network in the city is satisfactory, since a part of the mains have been replaced. By renovating 19.9 km of the heat network, it would be possible to achieve energy savings of 8.87 GWh/year and primary energy savings of 9.7 GWh/year.
Share of cogeneration	There are no cogeneration plants in Jelgava. Boiler houses use only natural gas as a fuel. There is a potential for installing a cogeneration plant with a capacity of 6-10 MW, which would use wood chips as a fuel in order to reduce dependence on natural gas.
Share of RES in DH	100 % natural gas. In 2014, the boiler houses of Jurmala consumed about 14 thousand m^3 of natural gas to produce 121.85 GWh of heat. The natural gas network is easily available in the city; therefore, natural gas is used as the primary energy resource. In individual cases, diesel fuel is also used for heat production in Jurmala. Local and individual heating is ensured using other energy resource as well; however, precise data on the consumption of other energy resources in Jurmala are not available. There is a potential for conversion of the outdated boiler houses of Jurmala into biomass cogeneration plants to produce 35 % of the heat from RES. This could be achieved by constructing a new cogeneration plant with installed heat capacity of 10 MW and electrical capacity of 2 MW. In order to gain additional capacity, it is possible to install a flue gas condenser with a capacity of 2 MW.
Potential for connecting new consumers	It is planned to connect new heat consumers to the Jurmala DH system. This would result in reduction of the natural gas consumption by 0.5 % per year. Some of the potential consumers are located close to energy sources and/or heating mains, so their connection to the Jurmala DH system would be technically possible.

In order to ensure that the Jurmala DH system is able to meet the EC requirements concerning efficient district heating, investments for using the cogeneration potential in Jurmala City are required. Taking into account the depreciation of the natural gas boilers, it would be justified to carry out not only renovation of the boiler houses but a transition to cogeneration as well. It is also necessary to substantially increase the share of RES in DH. Even though no potential for waste heat or heat recovered from industrial objects was identified, it is important to fully utilise the existing and the planned DH infrastructures and to attract new consumers.

2.3.6 Ventspils

Heat demand	- Households: 257.26 GWh/year - Industry: 1.4 GWh/year - Services: 55.84 GWh/year
Share of district heating	- In the district heating system: 163.84 GWh/year - In local and individual heating: 150.67 GWh/year 52 % of the heat is provided by the DH system.
District heating infrastructure and its potential	Information on five boiler houses, one of which operates in cogeneration, has been summarised. The length of the heat network is 45.3 km. By renovating 0.3 km of the heat network, it would be possible to achieve energy savings of 2.5 GWh/year and primary energy savings of 2.8 GWh/year.
Share of cogeneration	In 2014, the amount of heat produced by DH cogeneration was 49 %.
Share of RES in DH	Reconstruction of several district heating sources of Ventspils city has already been carried out by switching to another fuel, wood biomass. In 2014, 80 % of DH production was produced from wood.
Potential for connecting new consumers	It is planned to expand the district heating infrastructure. The construction of a new district heating infrastructure, including new local heat sources, in building territories is planned in accordance with the territorial planning. The development of networks in production areas is intended.

Waste energy potential	Located at a distance of about 8 km from the city is the landfill site "Pentuļi", where biogas produced from waste is used to produce heat for the operation of the landfill, while the surplus is burnt in an incinerator. In the future, improving gas technology is possible which would allow the generation of electricity, which is necessary for the landfill. For the burning of biogas a "Wiesman" boiler with a nominal input heat capacity of 0.7 MW has been installed. The incineration plant operates continuously for 8 760 hours a year. Biogas is burnt to heat water that is used to maintain the process temperature in fermentation units and to supply heat to the technical building. The amount of waste arriving at the landfill site is 14 392 tonnes/year. There is a possibility of improving an existing biogas plant that produces biogas from waste with electrical capacity of up to 0.2 MW, which could generate electrical capacity of 600 MWh and heat from by-products; however, with this amount of heat, investing in a heat network infrastructure would be unprofitable, so the heat could only be used for the plant's own needs.

There is no natural gas infrastructure in Ventspils; therefore, alternative solutions for the integration of high-efficiency cogeneration systems into DH should be considered. Taking into account the technical condition of the existing infrastructure, it is necessary to carry out efficiency improvements and upgrade the district heating sources of Ventspils. The district heating network coverage is insufficient to connect new consumers more effectively.

2.3.7 Rezekne

Heat demand	- Households: 208.15 GWh/year - Industry: 1.4 GWh/year - Services: 48.13 GWh/year
Share of district cogeneration	- In the district heating system: 149.03 GWh/year - In local and individual heating: 108.64 GWh/year 58 % of the heat is provided by the DH system.
District heating infrastructure and its potential	Data on three boiler houses, two of which operate in cogeneration, have been summarised. The required heat load is 52 % of the total installed capacity of the units; this means that the installed capacities are not used fully. The total length of the heat network is 38 km. By renovating 25.9 km of the heat network, it would be possible to achieve energy savings of 4.13 GWh/year and primary energy savings of 5.4 GWh/year.
Share of cogeneration	In 2014, 94.35 % of the DH energy was cogenerated.
Share of RES in DH	For 99 % of the DH production natural gas is used, as well as diesel fuel as an alternative fuel.
Potential for connecting new consumers	It is not planned to expand the city's district heating network. For heating purposes the gas infrastructure will be developed alongside alternative energy supply solutions.
Waste energy potential	The nearest landfill site that has energy potential (including biogas production) is located 14 km away, which makes the construction of power generation installations and infrastructure unprofitable.
Industrial heat recovery potential	The heat recovery possibilities in the food company which is located in the centre of the city and has an installed nominal heat capacity of 1.8 MW were evaluated, yet it should be taken into account that for heat production, liquefied gas, which was not considered as a potential source of heat, is used.

All boiler houses in the city of Rezekne are operated using natural gas. In order to increase energy independence, it is necessary to look for potential heat sources. However, taking into account the low heat demand, no new capacities can be planned, so the only option is to consider a gradual integration of alternative resources into DH.

2.3.8 Valmiera

Heat demand	- Households: 151.43 GWh/year - Industry: 1.2 GWh/year - Services: 71.39 GWh/year
Share of district heating	- In the district heating system: 139.91 GWh/year - In local and individual heating: 84.13 GWh/year DH satisfies 62 % of the heat demand.

District heating infrastructure and its potential	Information on four boiler houses (two cogeneration plants) has been summarised. 161 apartment houses, or 93 % of the total apartment houses, are connected to the city's district heating system. Individual building areas are not connected to central heating. Central heating in the city is provided by four boiler houses which were built in the second half of the 20th century. The length of the heat network is 32.94 km.
Share of cogeneration	There are two cogeneration plants with installed electrical capacity of 3.98 MW_{el}. In 2014, 36 % of the DH energy was cogenerated.
Share of RES in DH	The share of RES is 30 % (it planned to achieve 81 % in 2016).

Taking into account that in May 2015 a biomass boiler house was opened in Valmiera, there has not been a full heating season from which to collect precise data; however, it is forecast that in Valmiera 81 % of heat will be produced from RES, which makes the DH system in Valmiera efficient. Accordingly, no potential is seen at present, yet in the future it would be necessary to study the actual situation and to compare it against the forecast 81 % share of RES.

2.3.9 Jekabpils

Heat demand	- Households: 162.63 GWh/year - Industry: 1.22 GWh/year - Services: 32.55 GWh/year
Share of district heating	- In the district heating system: 66.94 GWh/year - In local and individual heating: 129.46 GWh/year DH satisfies 34 % of the heat demand.
District heating infrastructure and its potential	Information on seven boiler houses, one of which operates in cogeneration, has been summarised. In the recent years fragmented investments in reconstruction of the district heating system have been made. In order to substantially reduce heat losses, heat consumers should continue energy efficiency measures. Also, large investments are necessary for the heat production infrastructure which is outdated and, taking into account that once there were large industrial objects operating in Jekabpils, exceeds the capacity demand several times. In the autumn of 2011 the CP of Jekabpils began generating electricity from wood processing waste. The electricity generated by the new plant is fed into the "Latvenergo" power grid, while the heat produced is used for the plant's own needs and is also sold to the heat supply system of Jekabpils, thereby providing heat for up to 2 000 households. The total length of the heat network is 51.6 km. By renovating 28.9 km of the heat network, it would be possible to achieve energy savings of 5.5 GWh/year and primary energy savings of 7.9 GWh/year.
Share of cogeneration	In 2014, 62 % of the necessary heat in the DH network will be cogenerated.
Share of RES in DH	District heating in Jekabpils is mainly provided by using renewable energy resources, namely, chips. Irrespective of the existence of the natural gas infrastructure, 54 % of DH production will be produced using RES.
Potential for connecting new consumers	There is a potential for connecting new consumers to DH.

The share of high-efficiency cogeneration and renewable resources in Jekabpils DH system proves the efficiency of the district heating system. It is necessary to connect new consumers. No industrial heat recovery potential was identified in Jekabpils City.

2.3.10 Kekava Municipality

Heat demand	- Households: 235.91 GWh/year - Industry: 2.1 GWh/year - Services: 14.71 GWh/year
Share of district heating	- In the district heating system: 45.86 GWh/year - In local and individual heating: 206.86 GWh/year 18 % of the heat consumption is provided by DH.

District heating infrastructure and its potential	Information on 25 boiler houses is available. District heating is available in housing sites in populated areas. A decentralised heat supply — local boiler houses located close to or near heat consumers (apartment houses, schools) — exists in housing sites in the populated areas of Kekava and Daugmale. In Kekava Municipality, most of the inhabitants (72 %) live in apartment houses — all of them are involved in a central waste management system. Also, most of the inhabitants from agricultural holdings and individual houses are involved in a central system. The length of the heat network is 6.3 km.
Share of cogeneration	13 % of the DH production is cogenerated.
Share of RES in DH	100 % natural gas.

The territorial specifics of Kekava Municipality does not allow for building of a heat network infrastructure. Gas availability lowers the potential for the integration of RES into the DH system. There is a potential for cogeneration development; however, considering the low existing heat capacities, it is economically unjustified to invest large resources in the low-capacity generation of electricity that is assumed to be unprofitable.

2.3.11 Salaspils Municipality

Heat demand	- Households: 187.92 GWh/year - Industry: 1.5 GWh/year - Services: 22.12 GWh/year
Share of district heating	- In the district heating system: 65.69 GWh/year - In local and individual heating: 145.85 GWh/year DH provides about 31 % of the heat consumption of the municipality.
District heating infrastructure and its potential	There is information on three boiler houses, including one CP. The length of the heat network is 18.1 km. The condition of the heat network in the municipality is satisfactory, since most of the mains have been replaced. By renovating 0.33 km of the heat network, it would be possible to achieve energy savings of 1.4 GWh/year and primary energy savings of 1.7 GWh/year. The only possibility is to build a new heat main. Riga CHP-2 is about 6 km from Salaspils. With the construction of a heat main, its length could reach about 8 km. It would be possible to connect the new heat main to the existing heat supply system of Salaspils only at the places where the diameter of the heat pipelines is 400 mm or more. Hence, the heat main could be connected to the heat supply system of Budeskalni village. However, taking into account the low heat demand, investments in the construction of an infrastructure are unprofitable.
Share of cogeneration	There is one CP with an installed heat capacity of 4.59 MW and electrical capacity of 3.99 MW_{el}. 86.4 % of the heat is produced by cogeneration.
Share of RES in DH	DH is fuelled by roughly 16 % RES.
Industrial heat recovery potential	Energy consumption at Knauf's dolomite extraction and processing company “Saulkalne S” for technology needs is 12 GWh/year. Natural gas/coal is used as a fuel. After evaluating the possibilities for heat energy recovery, it was found that in the vicinity there is no DH boiler house which could use the recovered heat. The heat energy consumption of “AEROC Saulkalne” for technology needs is 11 GWh/year, with an installed capacity of 6.5 MW. Considering the load of the equipment, which is 3 000 h, there is no information on the specifics of operation of the equipment and on whether the heat recovered as a result of its operation could be sold. In the neighbourhood there are no potential boiler houses which could consume the potential heat.

In Salaspils Municipality, 86.4 % of heat is produced by high-efficiency cogeneration which is above the average level in Latvia and meets the definition of efficient district heating. In Jekabpils, DH provides 31 % of the total energy consumption, which is not much; therefore, it would be necessary to consider the possibilities of connecting more consumers to DH.

2.3.12 Marupe Municipality

Heat demand	- Households: 178.99 GWh/year - Industry: 1.8 GWh/year - Services: 23.42 GWh/year
Share of district heating	- In the district heating system: 57.8 GWh/year - In local and individual heating: 146.46 GWh/year 28 % of heat is provided by DH.
District heating	District heating systems operate in all four villages of the municipality. There are five boiler houses and one biogas cogeneration plant (which allows using the generated heat for greenhouses and apartment houses).
infrastructure and its potential	Inhabitants heat their private houses individually by using wood, pellets, electricity (heat pumps), gas and diesel fuel. The length of the heat network is 6.78 km.
Share of cogeneration	There is one CP with installed heat capacity of 0.035 MW, which uses biogas as a fuel.
Share of RES in DH	95 % natural gas, 5 % RES.

The DH system of Marupe Municipality meets the definition of an efficient heating system. After evaluating the natural gas infrastructure in the municipality and the consumer specifics (private houses), no potential for expanding the DH networks can be seen.

2.3.13 Stopini Municipality

Heat demand	- Households: 109.88 GWh/year - Industry: 1.2 GWh/year - Services: 14.23 GWh/year
Share of district heating	- In the district heating system: 24.39 GWh/year - In local and individual heating: 100.9 GWh/year DH provides about 20 % of the heat consumption of the municipality.
District heating infrastructure and its potential	Information on ten DH boiler houses, four of which operate in cogeneration, was summarised. The condition of the heat network in the municipality is satisfactory, since most of the mains have been replaced. There is a natural gas infrastructure, and accordingly, most of the heat consumers have individual heating systems installed. The length of the heat network is 8.3 km.
Share of cogeneration	There are three cogeneration plants with installed electrical capacity of 1.24 MW_{el}. 77.3 % of the heat is produced by cogeneration.
Share of RES in DH	Taking into account the natural gas infrastructure in the municipality, only one boiler house operates on pellets, which equals only 0.17 % share of RES in DH.
Potential for connecting new consumers	Considering the territorial fragmentation of the municipality, there is no potential for expanding the DH network.
Industrial heat recovery potential	On pig farms, the issue of using manure is relevant. Some years ago the farm was equipped with heat pumps producing heat from manure, and later this energy complex was supplemented by a cogeneration plant. Its maximum capacity is 190 kWh. Electricity generated from biogas is sold to “Latvenergo”, while heat remains on the farm. Digestate, which is what remains from manure after cogeneration, would be used as fertiliser. No changes are planned in the near future.
Waste energy potential	In the territory of the municipality there is a municipal waste landfill site and an organic material, or biological waste, composting field. 300 000–400 000 tonnes of waste per year are deposited in the landfill site. Construction of new landfill sites is ongoing, and at the same time gas production increases. Generation of electricity reaches 30 000 to 35 000 MWh/year. The heat produced by the power unit is used fully: for heating the infiltration reactor, office and household buildings, water heating, as well as for heating the newly-constructed greenhouse complex (3 625 m^2). There are six gas motors with an installed capacity of 5.24 MW_{el}. Electricity production amounts to 15 929.63 MWh/year. Capacity utilisation rate: 88.5 %. No changes are planned in the near future.

A large portion of the energy in Stopini Municipality is cogenerated; therefore, DH in the municipality is considered to be generated efficiently (more than 75 % is cogenerated). No additional potential for HEC has been identified.

2.3.14 Saulkrasti Municipality

Heat demand	- Households: 134.43 GWh/year - Industry: 0.15 GWh/year - Services: 7.33 GWh/year
Share of district heating	- In the district heating system: 1.07 GWh/year - In local and individual heating: 140.03 GWh/year - DH provides about 1 % of the heat consumption of the municipality.
District heating infrastructure and its potential	The heat supply is provided from four boiler houses. 20 % of consumers in the municipality are provided with district heating; this is due to the fact that most of the households in the municipality are private houses and summer cottages. Local and individual heating is ensured using other energy resources; however, precise data on the consumption of other energy resources in Saulkrasti Municipality are not available.
Share of cogeneration	There is no information on CPs.
Share of RES in DH	81% RES, 19% coal.

Due to the limited information a comprehensive evaluation of potential for Saulkrasti Municipality is impossible.

2.3.15 Conclusions

In general, the existing district heating network in Latvia can be described as developed, with a high proportion of cogeneration. Also, the use of renewable energy sources is considerable, and as stated in Section 2.2.3, increases each year. From city development plans and heat network statistics it can be concluded that it is necessary to carry out the renovation of heat networks — which is what the cities are planning to do in the future — in order to reduce heat losses and thus heat tariffs as well. From the RES share analysis it was concluded that theoretically, there is the potential to implement cogeneration projects in only four cities in Latvia (three of which are connected to district heating), i.e.:

- in Liepaja: to merge five boiler houses into a single gas turbine cogeneration plant,
- in Daugavpils: to replace the outdated 248.9 MW boiler house with a modern and efficient biomass cogeneration plant,
- in Jurmala: at present, 100 % of heat is produced by boiler houses that use natural gas, so there is the potential to replace some of the boiler houses and to produce 35 % of energy in one biomass cogeneration plant, which would bring the share of cogeneration in DH closer to the average in Latvia,
- in Ventspils: there is the potential to install in the existing waste landfill site biogas plant a gas cogeneration turbine with a heat capacity of 0.7 MW and an electrical capacity of 0.2 MW.

By implementing the above cogeneration projects, the share of cogeneration in DH could rise from the present 72.6 % to 75.5 % in 2020, thereby meeting the provisions of Article 2, Chapter I of Directive 2012/27/EU concerning an efficient district heating and cooling system in the entire territory of Latvia.

Table 10. Heat produced in the DH system and forecasts based on implementation of the theoretical potential

Heat produced, GWh	2014*	2015	2020	2025	2030
In boiler houses, total	1 975.96	1 969.9	1 737.8	1 730.3	1 729.1
% of DH, total	27.4 %	27.4 %	24.3 %	24.4 %	24.5 %
Cogeneration plants, total	5 231.24	5 215.2	5 416.7	5 351.0	5 338.0
% of DH, total	72.6 %	72.6 %	75.7 %	75.6 %	75.5 %
Heat produced by DH, total	**7 207.2**	**7 185.1**	**7 154.5**	**7 081.3**	**7 067.1**

3 Cost-benefit analysis

3.1 Assumptions

In the analysis of the energy efficiency potential of the district heating infrastructure, four cities were identified in which there is the potential to take measures to increase the share of high-efficiency cogeneration, as well as eight cities in which there is the potential to increase the share of district heating. That potential will be evaluated in detail in the cost-benefit analysis accordingly.

In order to provide the necessary recommendations and measures, the results of the following two indicators were analysed:

- Technical solutions for which the financial result is negative (FNPV<0), while from the public point of view it is positive (ENPV>0), are the solutions for which socially justified public support is necessary.
- Technical solutions for which the financial result is positive (FNPV>0), and from the public point of view as well (ENPV>0), are the solutions for which no additional support is necessary.
- Technical solutions for which the result from the social point of view is negative (ENPV<0) are generally not economically viable.

This cost-benefit analysis takes into account the costs and benefits to the Latvian national economy in general rather than to any individual market participant. At the same time, the costs and benefits to any individual market participant (e.g. an investor or consumer) may differ substantially. Notably, this study did not consider the specific costs and benefits from the perspective of the final consumers of heat and energy.

In order to assess the economic viability of the scenarios and identify the need for financial support, the scenarios were based on market assumptions. No subsidies were taken into account. Especially, revenues from the additional amount of energy produced were calculated on the basis of the average energy market price. The mandatory procurement component provided for in the Latvian laws and regulations was not taken into account for the purpose of this study.

The cost-benefit analysis carried out is based on the requirements of Directive 2012/27/EU and the European Commission document “Best practices and informal guidance on how to implement the Comprehensive Assessment at Member State level”[24]. Based on this Guidance, the following assumptions were made:

- Reference year: 2014 (the most recent complete data on heat supply in Latvia)
- Price basis year: 2015
- Present value year: 2015
- Real financial discount rate: 6 %[25]
- Real social discount rate: 7 %[26]
- The cost-benefit forecasts were expressed in real values
- Value added tax was not taken into account

The data and investment assumptions were taken from the above-referred EC Guidance, as well as from the Danish Energy Agency's study “Technology data for energy plants. Individual heating plants and energy transport.”[27]

- The natural gas forecast up until the year 2025 was taken from the World Bank's study on energy and raw material prices.[28]
- The wood chip price in Latvia was taken from the price set by the JSC “Latvia's State Forests”, and it was assumed that it would increase in the future by 1 %.
- As regards the energy price, the average price at “Nord Pool Spot” in Latvia in 2015 was taken, and it was assumed

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[24] Best practices and informal guidance on how to implement the Comprehensive Assessment at Member State level, JRC Science for policy report, 2015

[25] “Numeric values of macro-economic assumptions and forecasts”, the Ministry of Finance, 2015

[26] “Numeric values of macro-economic assumptions and forecasts”, the Ministry of Finance, 2015

[27] “Technology data for energy plants”, Energinet.dk, 2013

[28] World Bank Commodities Price Forecast, 2015

that the price would fall on average by 1 % per year, based on the European Commission report “EU energy, transport and GHG emissions trends to 2050”.

The forecasts include the new heat supply technology costs and benefits to all market participants. The cost and benefit forecast includes the new production infrastructure installation and operation costs (including cogeneration plant and network costs), cost savings of introduction of the new technologies, and environmental benefits.

The cost-benefit analysis considers the economic net present value for each alternative scenario against the business-as-usual scenario under which the use of the existing technologies continues in order to satisfy the existing and expected heat demand. This net present value expresses net benefits of the adoption of these technologies to the economy as a whole.

3.2 Summary of the business-as-usual and the alternative scenarios

The business-as-usual scenario describes the existing situation and its potential evolution during the selected time period, i.e. it is a reference scenario against which the alternative scenarios will be considered and their net present value will be established.

The calculation and analysis of the existing heat demand and its potential changes until 2030 are included in Chapter 2 of this study. On the basis of the analysis carried out, the following business-as-usual scenario was identified:

Table 11. Summary of the business-as-usual scenario

Cities and municipalities with population density >0.3 as against the rest of the territory	Type	2014		2020		2025		2030	
		Distribution	Produced energy (MWh)	Distribution	Produced energy (MWh)	Distribution	Produced energy (MWh)	Distribution	Produced energy (MWh)
	Boiler houses, total	7.29 %	829 795	7.5 %	845 549	7.5 %	808 579	7.0 %	731 703
	Cogeneration, total	43.04 %	4 896 821	43.5 %	4 904 187	44.0 %	4 743 666	44.5 %	4 651 541
	Additional purchased	5.87 %	667 492	5.5 %	620 070	5.0 %	539 053	5.0 %	522 645
	Individually produced	43.79 %	4 982 081	43.5 %	4 904 187	43.5 %	4 689 760	43.5 %	4 547 012
	Selected cities and municipalities, total	**100 %**	**11 376 189**	**100 %**	**11 273 993**	**100 %**	**10 781 058**	**100 %**	**10 452 900**

The Table reflects the overall data on the regions considered for which the actual information on 2014 has been aggregated, and forecasts for the period to 2030 have been made.

Table 12 summarises the forecasts of heat energy produced by 2030 in the case of an alternative scenario, i.e. installation of cogeneration units/plants in the selected regions. The calculations were made taking into account the existing heat production infrastructure and the types of fuel used in the selected regions, the Ministry's forecasts of heat demand until 2030 and the amount of heat produced by new cogeneration plants in case of their installation. The following Sub-sections provide a more detailed analysis.

Table 12. Forecasts for the alternative scenario

Cities and municipalities with population density >0.3 as against the rest of the territory	Type	2014		2020		2025		2030	
		Distribution	Produced energy (MWh)	Distribution	Produced energy (MWh)	Distribution	Produced energy (MWh)	Distribution	Produced energy (MWh)
	Boiler houses, total	7.29 %	829 795	5.79 %	653 294	5.61 %	604 408	5.09 %	531 535
	Cogeneration, total	43.04 %	4 896 821	45.98 %	5 183 547	47.92 %	5 166 299	50.16 %	5 243 473
	Additional purchased	5.87 %	667 492	5.01 %	564 578	4.23 %	455 619	3.45 %	361 032
	Individually produced	43.79 %	4 982 081	43.22 %	4 872 573	42.25 %	4 554 733	41.30 %	4 316 858
	Selected cities and municipalities, total	**100 %**	**11 376 189**	**100 %**	**11 273 993**	**100 %**	**10 781 058**	**100 %**	**10 452 900**

3.3 *Alternative solutions*

The analysis of the energy efficiency of the DH infrastructure and the additional potential for HEC identified four cities for which an alternative solution is possible, which would improve the energy efficiency of the DH system and increase the share of HEC in the city. The potential for increasing the share of district heating was identified and analysed in detail for eight cities.

In defining the alternative scenarios, the existing infrastructure, number of boiler houses and cogeneration plants, share of cogeneration of the total heat production, type of fuel used, and the district heating system connected to the heat consumers' share of the total heat production were considered.

The cost-benefit analysis consists of two parts: the financial analysis which considers only the financial data, and the economic analysis which takes into account the costs and benefits to the public in general, which, in the present case, is environmental damage depending on the heat production technology applied and the fuel used. Within the framework of the analysis the costs and benefits of the alternative scenario were compared to those of the business-as-usual scenario, or the existing situation. All of the alternative scenarios were analysed for the period from 2014 to 2030, since the data analysed for the existing situation refer to 2014. It is also assumed that in 2015, investments and a simulation of the alternative scenarios will occur.

Table 13. Environmental damage in monetary terms by technologies and fuels used[29]

Technology/ fuel	Environmental damage (EUR/MWh_{th})
Cogeneration plant — Biomass	4.3
Cogeneration plant — Natural gas	11.7
Boiler house — Natural gas	17.9
Boiler house — Biomass	11.2

3.3.1 Daugavpils

In the analysis it was found that one of the Daugavpils natural gas boiler houses with an installed capacity of 248.9 MW, which was established in 1970s, is unprofitable, is only operated during the heating season and is purchasing additional energy from other heat producers in the amount of about 70 % of its total heat production. By replacing this outdated BH with a new, efficient cogeneration plant it would be possible to reduce the costs of fuel, gain income from power generation and limit the environmental impact. A wood chip cogeneration plant with a boiling-layer boiler and a steam turbine with a heat capacity of about 40 MW_{th} and electrical capacity of about 8 MW_{el} would allow using not only chips but all types of forest and industrial waste wood as fuel as well. This heat capacity would be enough to efficiently produce the necessary heat energy to avoid purchasing additional heat from other producers. With the load in the city increasing, it is also possible to install a flue gas condenser thereby increasing the total heat capacity of the plant.

Alternative solution: a wood chip cogeneration plant with a boiling-layer boiler and a steam turbine with heat capacity of about 40 MW_{th} and electrical capacity of about 8 MW_{el}, which would replace the existing 248.9 MW boiler house.

Table 14. Main technological and economic assumptions (Daugavpils)

Parameter	Value	Unit of measurement	Source
Heat capacity	40	MW_{th}	Scenario assumption
Electrical capacity	8	MW_{el}	Scenario assumption (MW_{el} = 1/5 of MWth)
Fuel/heat production ratio	1.30		Source: Technology data for energy plants
Investment costs	kEUR 4.000	MW	Source: Technology data for energy plants (Medium CHP Biomass)

29 Subsidies and costs of EU energy. An interim report, 2014.

Variable operating costs	kEUR 0.0039	MWh	Source: Technology data for energy plants (Medium CHP Biomass)
Fixed operating costs	kEUR 29	MW	Source: Technology data for energy plants (Medium CHP Biomass)
Technology life-cycle	25	years	Source: Best practices and informal guidance on how to implement the Comprehensive Assessment at Member State level; Table A1
Heat demand, 2016	163 169	MWh/year	Calculated energy demand that would have to be satisfied by the existing boiler house
Heat produced, 2016	32 634	MWh/year	Scenario assumption based on the amount of electricity produced

The costs in the alternative scenario are made up of investments in the establishment of a cogeneration plant, annual variable and fixed operating costs, as well as fuel costs. The benefits are the sale of electricity produced in addition to heat, reduced fuel costs and the residual value of the new assets at the end of the simulation in 2030.

This technology was selected as most optimal, since (1) in Daugavpils, the use of wood chips as fuel is virtually non-existent, despite the fact that, according to information provided by JSC "Latvia's State Forests", in the Eastern region the price of wood chips is the lowest; (2) the share of heat in district heating, produced by cogeneration plants in Daugavpils, is 53 %, which is below the average in Latvia, i.e. 73 %; (3) the boiling-layer boiler technology allows using not only wood chips but all other types of wood as fuel as well; (4) the environmental damage is the lowest for biomass cogeneration plants (EUR 4.3/MWh_{th}), but the highest in the case of natural gas boiler houses (EUR 17.9/MWh_{th}).

Table 15. Results of the financial analysis (Daugavpils)

Indicator	Value
Financial net present value (FNPV), kEUR	- 9.661
Financial rate of return (FRR), %	0 %

The financial indicators show a negative FNPV, which means that the project is incapable of being independent and that financial support is required for its implementation.

Table 16. Results of the socio-economic analysis (Daugavpils)

Indicator	Value
Economic net present value (ENPV), kEUR	9.701
Economic rate of return (ERR), %	9 %

The economic net present value which includes the evaluation of environmental damage is EUR 9.7 million with a return rate of 9 %. These results show how considerably the values change when the socio-economic benefits and costs are included, which in the present case is the benefit of the much lower environmental damage achieved by replacing the natural gas boiler house with a wood chip cogeneration plant. Such a result shows that this project, although financially unstable, is beneficial for the public and would be worth supporting financially.

Table 17. Sensitivity analysis (Daugavpils)

Factor	Factor change, %	Effect on the FNPV, %	Effect on the ENPV, %	Sensitivity
Electricity market price	- 10	- 14	-13	High
Amount of investments	- 10	+ 26	+ 27	High
Heat demand	- 10	- 19	-39	High
Natural gas market price	- 10	- 33	- 31	High

The sensitivity analysis shows variations in the financial result indicators when the values of the key factors are changed. In this case, the factors were changed downwards by 10 %. If the results differ by more than 12 %, the sensitivity is defined as high; when they differ by less than 12 %, the sensitivity is low. In the cases where one of the results of the analysis (FNPV or ENPV) is above 12 %, while the other is below 12 %, the sensitivity is defined as medium.

For Daugavpils, the natural gas price and heat demand are the most critical factors. If the natural gas market price falls by 10 %, the potential benefit of not using natural gas also decreases and makes the financial net present value fall by 33 %. All of these factors combined may substantially affect the results of the financial and economic analysis.

3.3.2 Jurmala

At present there are no cogeneration plants in Jurmala, and the city is very dependent on natural gas. The alternative scenario should accordingly be evaluated by establishing the potential benefit if 35 % of DH was produced by one chip cogeneration plant which, from the technological point of view, is the same as in the above scenario for Daugavpils, i.e. a back-pressure steam turbine using chips as a fuel, yet with less heat and electrical capacity. In this way, the share of high-efficiency cogeneration plants in Jurmala could be brought closer to the average level in Latvia, and the energy efficiency of district heating could be increased as well.

Alternative solution: 35 % of heat produced by the district heating system comes from a chip cogeneration plant.

Table 18. Main technological and economic assumptions (Jurmala)

Parameter	Value	Unit of measurement	Source
Heat capacity	10	MWth	Scenario assumption
Electrical capacity	2	MW_{el}	Scenario assumption (MW_{el} = 1/5 of MWth)
Fuel/heat production ratio	1.30		Source: Technology data for energy plants
Investment costs	kEUR 4.000	MW	Source: Technology data for energy plants (Medium CHP Biomass)
Variable operating costs	kEUR 0.0039	MWh	Source: Technology data for energy plants (Medium CHP Biomass)
Fixed operating costs	kEUR 29	MW	Source: Technology data for energy plants (Medium CHP Biomass)
Technology life-cycle	25	years	Source: Best practices and informal guidance on how to implement the Comprehensive Assessment at Member State level; Table A1
Heat demand, 2016	42.517	MWh/year	Calculated energy demand that would have to be satisfied by the existing boiler house
Heat produced, 2016	8.503	MWh/year	Scenario assumption based on the amount of electricity produced

Investment costs in the alternative scenario are based on the same assumptions as in Daugavpils scenario; only the heat capacity and plant capacity changed, which reduced its investment costs. In Jurmala, there is not a great demand for district heating — this could be explained by the fact that the city has a developed natural gas infrastructure and a major portion of the households in the city are private houses which are connected to the natural gas network. This scenario accordingly assumed that a heat capacity of 10 MW would be necessary to satisfy 35 % of the DH demand.

Table 19. Results of the financial analysis (Jurmala)

Indicator	Value
Financial net present value (FNPV), kEUR	2.069
Financial rate of return (FRR), %	7 %

The financial net present value is EUR 2 million with a 7 % rate of return, which shows that the project is financially stable and does not require external financial support. This result is most likely due to the fact that the chip price per MWh is almost three times less than the present natural gas price and the fact that there is also additional income from the sale of cogenerated electricity.

Table 20. Results of the socio-economic analysis (Jurmala)

Indicator	Value
Economic net present value (ENPV), kEUR	6.788
Economic rate of return (ERR), %	15 %

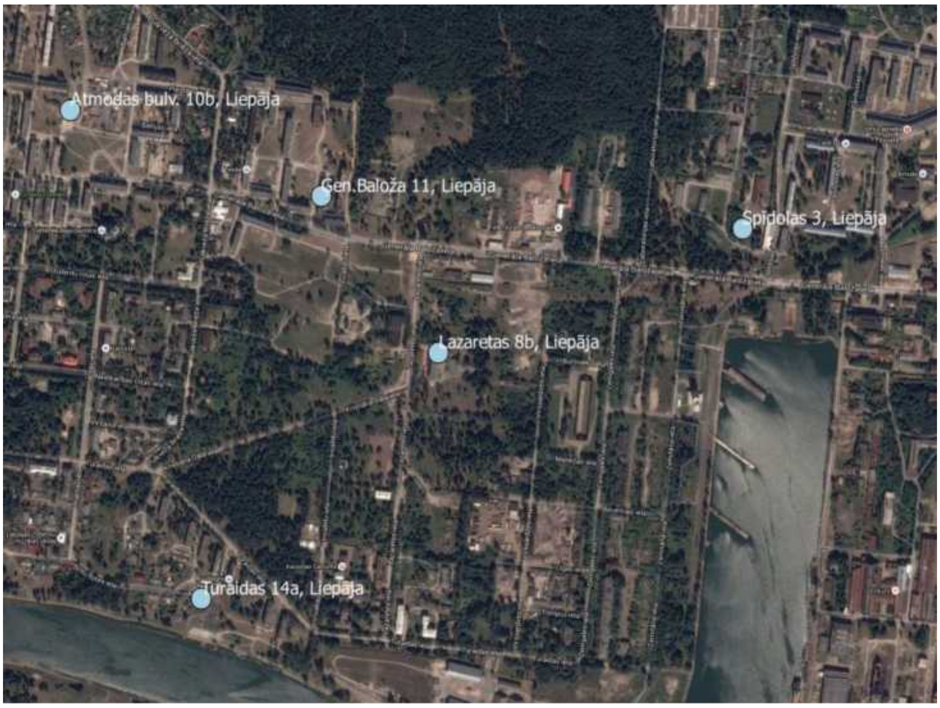
The economic net present value which includes an evaluation of environmental damage shows rather positive socio-economic benefits in case of the implementation of this alternative scenario by proving the public benefit of a chip cogeneration plant in the form of reduced environmental damage.

Table 21. Sensitivity analysis (Jurmala)

Factor	Factor change, %	Effect on the FNPV, %	Effect on the ENPV, %	Sensitivity
Electricity market price	- 10	-17 %	-5 %	Medium
Amount of investments	- 10	31 %	9 %	High
Heat demand	- 10	-44 %	-20 %	High
Natural gas market price	- 10	-69 %	-19 %	High

The trends in the sensitivity analysis for Jurmala are similar to the analysis for Daugavpils, except that the results of the financial analysis are more sensitive to changes, especially as regards the natural gas market price. This shows that a more detailed analysis of the Jurmala scenario is needed by including and evaluating all the factors and their forecasts that affect the final result, so that it is possible to precisely determine if financial support for Jurmala is necessary. The present analysis only shows that theoretically, there are grounds to believe that a biomass cogeneration plant would potentially be beneficial to Jurmala's DH system.

3.3.3 Liepaja



The analysis found that there are five low-capacity boiler houses which are located not far from one another in the Karosta district of the city. The amount of heat produced is low compared to the total capacity, which most likely means that heat production is inefficient and has a comparatively high maintenance cost.

Table 22. Description of the boiler houses under consideration

Address:	Installed capacity, MW	Year of installation	Heat produced, MWh
10b Atmodas Blvd., Liepaja	10	2001	9 282.10
11 Gen. Baloza Street, Liepaja	5.2	2001	3 602.80
8b Lazaretes Street, Liepaja	0.8	2001	365.60
3 Spidolas Street	10	2001	7 695.10
14a Turaidas Street	1.44	2007	1 701.90
Total:	**27.44**		**22 647.50**

Since the present amount of heat is low and the amount of electricity produced depends on the number of hours of full-capacity operation of the cogeneration plant, a chip cogeneration plant, which is more costly than other technologies, would not pay off in this scenario unless it is operated for at least 4 000 hours per year. Consequently, assuming that the amount of heat generated remains the same as it is currently, the optimum technology that was selected is a combined-cycle gas turbine with heat recovery which uses natural gas as a fuel. The required initial investments are almost four times less than for a chip cogeneration plant of the same capacity.

Alternative solution: to combine the heat capacity of the existing five boiler houses into a single natural gas cogeneration plant.

Table 23. Main technological and economic assumptions (Liepaja)

Parameter	Value	Unit of measurement	Source
Heat capacity	10	MW_{th}	Scenario assumption
Electrical capacity	2	MW_{el}	Scenario assumption (MW_{el} = 1/5 of MW_{th})
Fuel/heat production ratio	1.30		Source: Technology data for energy plants
Investment costs	kEUR 1.350	MW	Source: Technology data for energy plants (Gas turbine, combined cycle, back-pressure)
Variable operating costs	kEUR 0.0025	MWh	Source: Technology data for energy plants (Gas turbine, combined cycle, back-pressure)
Fixed operating costs	kEUR 30	MW	Source: Technology data for energy plants (Gas turbine, combined cycle, back-pressure)
Technology life-cycle	25	years	Source: Best practices and informal guidance on how to implement the Comprehensive Assessment at Member State level; Table A1
Heat demand, 2016	22.578	MWh/year	Calculated energy demand that would have to be satisfied by the existing boiler house
Heat produced, 2016	4.516	MWh/year	Scenario assumption based on the amount of electricity produced

The financial net present value is negative (EUR -2.6 million), with a negative 11 % rate of return, and the economic net present value, which includes an evaluation of environmental damage, is negative as well (EUR -1.2 million), with a negative 2 % rate of return. The cost-benefit analysis shows that at such a low capacity (2 300 to 2 000 hours/year), there can be no financial stability and that external aid is necessary.

Table 24. Results of the financial analysis (Liepaja)

Indicator	Value
Financial net present value (FNPV), kEUR	- 2.556
Financial rate of return (FRR), %	- 11 %

The negative financial results show that the existing boiler houses operate inefficiently, since the assumptions are based on the existing heat capacity and the amount of heat produced. Accordingly, for this scenario to yield positive financial results, the most appropriate ratio of heat capacity and amount of heat produced should be examined. It is also possible that with a larger amount of heat produced, there would be a financially stable solution, just as there is for Jurmala, i.e. a chip cogeneration plant which would substantially improve the results of the economic analysis.

Table 25. Results of the socio-economic analysis (Liepaja)

Indicator	Value
Economic net present value (ENPV), kEUR	- 1.233
Economic rate of return (ERR), %	- 2 %

Although the negative results of the economic analysis can be explained by the low results of the financial analysis (as they are also included in this analysis), there is not, however, a great benefit from natural gas cogeneration plants as there is from chip cogeneration plants, due to the fact that they use fossil fuels. In general, this shows that the merging of the natural gas boiler houses in a single natural gas cogeneration plant in Liepaja would bring no socio-economic benefit to the public.

Table 26. Sensitivity analysis (Liepaja)

Factor	Factor change, %	Effect on the FNPV, %	Effect on the ENPV, %	Sensitivity
Electricity market price	- 10	-7 %	-14 %	Medium
Amount of investments	- 10	8 %	18 %	Medium
Heat demand	- 10	- 1 %	- 12 %	Low
Natural gas market price	- 10	6 %	11 %	Low

In the Liepaja scenario the financial results were minimally affected by changes in external factors, which shows that even after an in-depth cost-benefit analysis the combination of this technology and fuel would most likely bring a negative result in both the financial and the socio-economic analyses. At the currently forecast prices and the capacities assumed in this scenario and their utilisation, it is unprofitable to replace the natural gas boiler houses with a natural gas cogeneration plant from the financial and socio-economic points of view.

3.3.4 Ventspils

As was already concluded in Section 5, there is the potential for establishing a biogas cogeneration plant in Ventspils. Heat which is produced by burning methane obtained from waste is used for their own needs, and since the landfill site is 8 km away from the city, it would be unprofitable to build a heat network in order to connect to district heating, because there is not a great amount of heat produced. Since the waste heat is burnt in an incinerator, there is the potential to convert this excess energy into electricity and sell it to an electricity trader. The existing heat boiler operates throughout the year; therefore, by installing a 0.2 MW gas turbine, it would be possible to generate about 600 MWh of electricity per year.

Alternative solution: conversion of the landfill site's biogas boiler house into a cogeneration plant with a capacity of 0.2 MW_{el}.

Table 27. Main technological and economic assumptions (Liepaja)

Parameter	Value	Unit of measurement	Source
Heat capacity	0.7	MW_{th}	Scenario assumption
Electrical capacity	0.2	MW_{el}	Scenario assumption (MW_{el} = 1/5 of MW_{th})
Investment costs	kEUR 1.350	/MW	Source: Technology data for energy plants (Gas turbine, combined cycle, back-pressure)
Variable operating costs	kEUR 0.0025	/MWh	Source: Technology data for energy plants (Gas turbine, combined cycle, back-pressure)

Fixed operating costs	kEUR 30	/MW	Source: Technology data for energy plants (Gas turbine, combined cycle, back-pressure)
Technology life-cycle	25	years	Source: Best practices and informal guidance on how to implement the Comprehensive Assessment at Member State level; Table A1
Heat produced, 2016	600	MWh/year	Scenario assumption based on the amount of electricity produced

Since heat is produced for their own needs, the only costs are gas turbine investment costs and the variable and fixed operating costs arising therefrom. The only benefit is the sale of the additional electricity produced to an electricity trader for a market price.

Table 28. Results of the financial analysis (Ventspils)

Indicator	Value
Financial net present value (FNPV), kEUR	- 42
Financial rate of return (FRR), %	2 %

The financial net present value is negative (EUR -42 000), with a 2 % rate of return. The cost-benefit analysis shows that this type of use of the technology and fuel would be profitable if the green energy subsidy were to be applied to it, which is also supported by the positive results of the economic analysis.

Table 29. Results of the socio-economic analysis (Ventspils)

Indicator	Value
Economic net present value (ENPV), kEUR	86
Economic rate of return (ERR), %	9 %

Similarly, the heat produced in this way is in one of the most environmentally-friendly forms, which means that the results of the economic analysis are positive. Such a project and alternative solution are not relevant from the general perspective of the country; however, they show that there is the potential for the conversion of landfill sites into small power plants, which are nonetheless cost-efficient with respect to fuel.

Table 30. Sensitivity analysis (Ventspils)

Factor	Factor change, %	Effect on the FNPV, %	Effect on the ENPV, %	Sensitivity
Electricity market price	- 10	-61 %	-27 %	High
Amount of investments	- 10	52 %	25 %	High

The financial results are very sensitive to the electricity price and amount of investments, which means that the results of the financial analysis would change substantially in case a subsidy for the electricity sold were to be received. This also shows that in the present case, it is necessary to carry out an in-depth cost-benefit analysis by considering all of the possible factors which might affect the results of the financial and socio-economic analyses.

3.3.5 The economic potential for increasing the share of district heating in the regions being analysed

For each region being analysed, an assessment was carried out regarding the economic potential to ensure that 10 % of the annual individual heat consumption is provided by district heating. The economic costs of this scenario include investments in an additional heat supply network, as well as annual maintenance costs. The established benefits are primary energy savings as a result of more efficient heat production in district heating as compared to individual heating. The residual value of the heat supply network is included in the latest forecast period on the basis of an expected useful life of 30 years.

The calculations were based on the following assumptions:

Table 31. Assumptions regarding increasing the share of heat supply

Parameter	Value	Unit of measurement	Source
Average heat supply network investment costs	EUR 500	m	The Ministry of the Economy's study “Heat supply data acquisition, analysis, methodology development and preparation of a manual for local governments on energy planning in their administrative territories”, Swedish District Heating Association
Fixed maintenance costs	EUR 0.9	MWh/year	Danish Energy Agency, “Technology data for energy plants. Individual heating plants and energy transport.” October 2013
Normative losses of the eat supply network	15 %		Danish Energy Agency, “Technology data for energy plants. Individual heating plants and energy transport.” October 2013

One of the most important assumptions in calculating the investment costs is the heat network’s heat intensity per metre. It shows the amount of heat that is delivered during the year to heat consumers in a DH system per metre of the heat network. The heat network’s heat intensity per metre in a district heating system is calculated on the basis of the available information regarding energy delivered to end users during the year, as well as the length of the heat network in each region. In Jurmala and Jelgava the average normative heat intensity of 2.5 MWh/m was applied due to the lack of reliable information on the length of heat networks in these regions. The primary energy savings were assessed on the basis of Primary Energy Factor (PEF) assumptions for the individual and the district heating systems.

Table 32. Primary energy factor assumptions

Primary energy factor assumptions	Value	Source
PEF for individual heating (an individual gas heating boiler)	1.3	ECOHEATCOOL WP3 Guidelines for Assessing the Efficiency of District Heating and Cooling
PEF for the district heating system (gas cogeneration)	0.5	

The socio-economic analysis also takes into account the environmental benefits provided by the energy-efficient solutions of district heating. The environmental impact assessment was carried out on the basis of assumptions on primary energy savings achieved in the district heating system, and assumptions on the environmental damage.

Table 33. Environmental damage factor assumptions

Environmental damage factor assumptions	Value	Source
Cogeneration (natural gas)	11.7	EU energy subsidies and costs. ECOFYS, 2014
Internal natural gas heating boiler	17.9	

The results of the analysis show that district heating has economic potential in the regions where the average heat network heat intensity exceeds 2 MWh/year per metre. In the regions with lower heat intensity (e.g. in Jekabpils) the investment costs and heat supply network maintenance costs exceed the economic benefits from energy savings.

In implementing the district heating expansion project the specifics of the city and the region should also be taken into account. It should also be considered whether it is possible to construct heat networks, taking into account architectural peculiarities. For example, the existence of architectural monuments and protected objects in the region may substantially increase investment costs and the repayment period.

The results of the economic analysis which reflect the connection of 10 GWh of individual heat consumption to the DH system are described below.

Table 34. Summary of results of the economic analysis (connection of 10 GWh)

	Heat network intensity in DH	Financial net present value	Financial rate of return (FRR)	Economic net present value	Economic rate of return (ERR)
	MWh/m/year	thsd. EUR	%	thsd. EUR	%
Riga	3.80	935	11 %	1 194	15 %
Jurmala	2.50	459	7 %	698	9 %
Liepaja	2.06	165	5 %	393	7 %
Daugavpils	2.89	647	8 %	894	11 %
Rezekne	3.39	823	10 %	1 077	13 %
Ventspils	3.17	753	9 %	1 005	12 %
Jelgava	2.50	459	7 %	698	9 %
Jekabpils	1.06	(1 429)	0 %	(1 268)	2 %

The individual heat demand that could be connected to the district heating system should be determined taking into account the detailed analysis and heat network intensity for the respective territories. Assuming that 5 % of the existing individual heat consumers would be connected, the following economic results could be achieved:

Table 35. Result summary of the economic analysis (5 % district heating)

	Heat network intensity in DH	5 % of the individual heat demand	Financial present value	Financial rate of return (FRR)	Economic net present value	Economic rate of return (ERR)
	MWh/m/year	**MWh/year**	**thsd. EUR**	**%**	**thsd. EUR**	**%**
Riga	3.80	128 557	12 018	11 %	15 349	15 %
Jurmala	2.50	24 266	1 113	7 %	1 694	9 %
Liepaja	2.06	20 624	341	5 %	810	7 %
Daugavpils	2.89	17 362	1 123	8 %	1 552	11 %
Rezekne	3.39	5 432	447	10 %	585	13 %
Ventspils	3.17	7 533	567	9 %	757	12 %
Jelgava	2.50	13 898	637	7 %	970	9 %
Jekabpils	1.06	6 473	(925)	0 %	(821)	2 %

3.3.5.1 Sensitivity analysis

The sensitivity of the primary assumptions to the present value of a result was analysed. The analysis showed that the present value is extremely sensitive to changes in assumptions regarding primary energy savings. If the expected primary energy savings were reduced by 10 % (due to a decline in fuel prices or changes to PEF assumptions), the minimum heat network intensity would drop to 2.2. Due to the aforementioned reasons, district heating is not regarded as efficient in Liepaja due to the lower heat network intensity in the city.

Table 36. Sensitivity analysis summary (reduction of PE by 10 %)

	Reduction of primary energy savings by 10 %			
	Financial net present value, thsd. EUR	Changes, %	Economic net present value, thsd. EUR	Changes, %
Riga	738	-21 %	968	-19 %
Jurmala	262	-43 %	472	-32 %
Liepaja	(32)	-119 %	167	-58 %
Daugavpils	450	-30 %	668	-25 %
Rezekne	625	-24 %	851	-21 %
Ventspils	556	-26 %	779	-22 %
Jelgava	262	-43 %	472	-32 %
Jekabpils	(1 627)	14 %	(1 494)	18 %

Investment costs, which might be very different depending on the technical condition in each individual territory, is another critical assumption. The sensitivity analysis shows that economic efficiency is most sensitive to this parameter in regions with low heat network intensity.

Table 37. Sensitivity analysis summary (increase in investments by 10 %)

Increase of investment costs by 10 %				
	Financial net present value, thsd. EUR	Changes, %	Economic net present value, thsd. EUR	Changes, %
Riga	844	-10 %	1 099	-8 %
Jurmala	320	-30 %	553	-21 %
Liepaja	(3)	-102 %	217	-45 %
Daugavpils	527	-19 %	769	-14 %
Rezekne	720	-12 %	970	-10 %
Ventspils	644	-15 %	891	-11 %
Jelgava	320	-30 %	553	-21 %
Jekabpils	(1 757)	23 %	(1 609)	27 %

4 Recommendations on the necessary policy measures

The goal of the cost-benefit analysis is to identify technical solutions with total economic benefits which exceed their costs. The result of the analysis is the financial net present value (FNPV which shows the financial return to the investor) and economic (social) net present value (ENPV which also takes into account non-financial costs and benefits to the public in general). The summary of the alternative scenarios considered in the CBA is provided in Table 38.

Table 38. Summary of the cost-benefit analysis

Scenario	City	FNPV, kEUR	ENPV, kEUR
Replacement of the boiler house with a wood chip cogeneration plant for connection to DH	Daugavpils	- 9.661	9.701
Establishment of a wood chip cogeneration plant to produce 35 % of the necessary heat in DH	Jurmala	2.069	6.788
Merger of five DH boiler houses into a single natural gas cogeneration plant	Liepaja	- 2.556	- 1.233
Establishment of a biogas cogeneration plant at the waste incineration plant	Ventspils	- 42	86

Taking into account the results of the cost-benefit analysis, all of the potential policy measures referred to in Annex VIII, point (1)(g) of Directive 2012/27/EU were considered in the study. The results are summarized below.

4.1 *Policy measures to facilitate cogeneration*

Increasing the share of high-efficiency cogeneration in the district heating system

In general, the share of cogeneration in the DH system of Latvia is already high (72.6 %); on top of that, in some of the regional DH systems in Latvia the maximum share of cogeneration is nearly achieved in heat production, and there is a high share of renewable resources in the fuel usage patterns of those regions (e.g. in Jelgava, with 97 % of heat produced by cogeneration and an 85 % share of RES in the fuels used). As a result of the potential analysis it was found that there is no potential for increasing the share of RES at the national level; however, an analysis carried out also identified that in some individual cities (Daugavpils, Liepaja and Jurmala) there could be the potential for the introduction of high-efficiency cogeneration in district heating.

In the Daugavpils scenario a positive socio-economic potential was identified, while the negative financial results in this scenario point towards the need for support. It can be concluded that there is only a theoretical potential for increasing the share of RES, since the conclusion which was reached in the CBA was that there is a socio-economic benefit to the public, but at the same time a more in-depth financial analysis of this particular case is needed in order to establish the necessary amount of financial support to implement the project.

The Liepaja scenario shows negative results both from the financial and the socio-economic points of view, mainly due to the low heat capacity usage, since the scenario was based on the ratio of the existing heat capacity and the amount of heat produced. If the installed heat energy is adjusted from 10 MW to 3 MW, the Liepaja scenario shows some positive results, which means that the conversion of the natural gas boiler houses into natural gas cogeneration plants is unprofitable at the current natural gas and electricity prices. However, to obtain more precise results in this case, a more detailed analysis of the heat demand in Liepaja and a cost-benefit analysis of this scenario should be carried out. The final conclusion is that the theoretical potential for increasing the share of RES in Liepaja is very low or non-existent.

In Jurmala, the construction of a new wood chip boiler house is already planned. However, the Jurmala scenario included in the analysis (35 % of heat produced by a wood chip cogeneration plant) showed positive results for both the financial and the socio-economic indicators. Hence, it can be concluded that theoretically there is the potential for increasing the share of RES in Jurmala, perhaps even without the need for additional support. However, in this case it is necessary to carefully examine all of the potential factors that could lead to additional benefits as well as costs.

Our calculations are based on electricity and heat market prices. The tariffs for final consumers should not increase as a result of the implementation of the projects, as this may have a negative impact on the share of heat consumers which are connected to DH.

Develop an efficient district heating infrastructure to accommodate the development of high-efficiency cogeneration and the use of waste heat and renewable energy sources

Our heat demand analysis showed a limited demand for heat produced by DH systems due to the economic conditions for heat consumers. Thus, there is currently a limited potential for developing the DH infrastructure, except for the possibility to attract a large number of consumers to DH via a favourable heat tariff.

Even though additional investments in the DH infrastructure are needed, any effect on the final tariff for the consumer must be examined very carefully, and measures should be taken to reduce such effect.

The necessary policy measures

1. **As regards the development of cogeneration potential for Daugavpils and Liepaja, the cost-benefit scenarios show that without attracting external sources of financing, the financial net present values are negative. Therefore, the country should attract EU Funds for the implementation of these projects.**
2. **In Jurmala, it is possible and would be more effective to build a cogeneration plant instead of the boiler house currently planned. The results of the scenario show a positive net present value without the need for additional financial support, so the state should implement the plan for the construction of a cogeneration plant in Jurmala.**

4.2 Policy measures to facilitate district heating

Encourage residential zones and industrial plants which consume heat in their production processes to be connected to the local district heating network

As compared to individual heating solutions, DH is characterised by a high level of efficiency, as it includes a higher share of efficient cogeneration. At the same time, DH requires substantial investments in the infrastructure and has high operation and maintenance costs. The efficiency of DH is also reduced by energy losses in the network. These considerations make DH economically viable only in the territories with a comparatively high heat demand density.

The heat density in the territories analysed mainly shows a sufficient heat demand for the expansion of the existing DH system to be economically viable. The highest potential for district heating is in the household sector. At the same time, we observed only limited demand for DH from households and industries, since most of them prefer individual heating solutions due to economic reasons.

The necessary policy measures

In order to realise the potential for DH, it is necessary to develop economic incentives for final consumers to ensure that **the costs of DH do not exceed the costs of alternative individual heating**. Such incentives mainly represent measures to achieve a reduction in the total heat tariff in the DH system and should be the following:

3. **It is necessary to attract EU financial support for investments in the establishment of new regional DH networks and renovation of the existing (old) networks in the municipalities where the existing or planned heat network intensity exceeds 2 MWh/m.**
4. **In addition, review and optimisation of DH operation and maintenance processes as well as the related costs should be carried out.**

4.3 Political measures for more efficient use of waste heat

Encourage new (thermal) electricity generation installations and industrial plants producing waste heat to be located at sites where a maximum amount of available waste heat will be recovered

Our assessment did not identify the economic potential for new electricity generation installations and industrial plants producing waste heat to be located in the proximity of heat consumers. In the case of any such scenario an additional cost-benefit analysis should be carried out at the level of the particular installations and the project. Such an analysis should consider the social costs to households which are located near the industrial plants, and the potential impact on the real estate market.

Encourage new residential zones or new industrial plants which consume heat in their production processes to be located where available waste heat can contribute to meeting their heat demands

As was mentioned above, such options should be assessed on a case-by-case basis, taking into account the potential implications for health and market conditions, since location of residential houses close to industrial plants may affect their market value.

Encourage thermal electricity generating installations, industrial plants producing waste heat, waste incineration plants and other waste-to-energy plants to be connected to the local district heating network

A limited potential for heat recovery was identified in the study, due the small number of industrial plants producing waste heat. Thus, the use of such incentives should be assessed on a case-by-case basis by taking into account the economic conditions for the specific industrial plants.

The potential for a cogeneration plant in Ventspils which would convert waste into biogas that is burnt, while the heat obtained would be used only for their own needs, was identified and assessed. The analysis found that the landfill site is located 8 km far from the city and is not sufficiently large to justify the costs of connecting to the local DH system, while also assessing the possibility of installing a cogeneration plant to divert the waste heat for generating electricity that could be fed into the common electricity grid. From a financial perspective, the project has a negative value, while from a socio-economic perspective it is positive, which shows that with the help of subsidies it would be possible to generate small amounts of electricity from waste.

The necessary policy measures

5. **In their territorial planning the municipalities should take into account waste heat produced during the production process and in the existing heat supply infrastructure/capacities. At the level of each municipality the location and capacities of the existing heat sources as well as the possibility of connecting them to DH should be assessed. By doing so, it is possible to ensure that waste heat is used in a district heating system. The direction of the political process should be assumed by the Ministry of the Economy in order to ensure uniform process management and an assessment of the results achieved.**