RIGA TECHNICAL UNIVERSITY

Normunds Talcis

DISTRICT HEATING SYSTEM MANAGEMENT AND CONTROL METHODOLOGY

Summary of the Doctoral Thesis

RTU Press
Riga 2018

RIGA TECHNICAL UNIVERSITY
Faculty of Civil Engineering
Institute of Heat, Gas and Water Technologies Institute

Normunds Talcis
Doctoral Student of the Study Programme "Heat, Gas and Water Technologies"

DISTRICT HEATING SYSTEM MANAGEMENT AND CONTROL METHODOLOGY

Summary of the Doctoral Thesis

Scientific Supervisor
Professor Dr. habil. sc. ing.
EGILS DZELZĪTIS

Professor Dr. math.
ANDREJS KOLIŠKINS

RTU Press
Riga 2018

Talcis N. District Heating System Management and Control Methodology. Summary of the Doctoral Thesis. Riga: RTU Press, 2018. 26 p.

ISBN 978-9934-22-200-9 (print)
ISBN 978-9934-22-201-6 (pdf)

DOCTORAL THESIS PROPOSED TO RIGA TECHNICAL UNIVERSITY FOR THE PROMOTION TO THE SCIENTIFIC DEGREE OF DOCTOR OF ENGINEERING SCIENCES

To be granted the scientific degree of Doctor of Engineering Sciences, the present Doctoral Thesis has been submitted for the defence at the open meeting of RTU Promotion Council on 13 December 2018, 12:00 at the Conference Hall of Riga Technical University, 6 Azenes street, floor 11.

OFFICIAL REVIEWERS

Professor Dr. habil. sc. ing. Namejs Zeltiņš
Riga Technical University

Dr. sc. ing. Gaidis Klāvs
Physical Energy Institute, Latvia

Dr. Anton Brin (Антон Бринь)
Energy Institute of the National Academy of Science of Belorussia

DECLARATION OF ACADEMIC INTEGRITY

I hereby declare that the Doctoral Thesis submitted for the review to Riga Technical University for the promotion to the scientific degree of Doctor of Engineering Sciences is my own. I confirm that this Doctoral Thesis had not been submitted to any other university for the promotion to a scientific degree.

Normunds Talcis ……………………………. (signature)
Date: ………………………

The Doctoral Thesis has been written in Latvian. It consists of Introduction; 4 chapters; Conclusions; 57 figures; 33 tables; 4 appendices; the total number of pages is 122. The Bibliography contains 111 titles.

ANNOTATION

The Doctoral Thesis " District Heating System Management and Control Methodology", where the subject of research is the district heating network of Riga City district heating system (DHS) in the heat supply area of CHPP-1 and CHPP-2, is focused on a DHS with subjective necessary needs of consumers to have comfortable indoor temperature in buildings under our climate conditions, as well as to have hot water, by ensuring safe and efficient production and transmission of heat at the same time. The topicality of the subject matter of the Doctoral Thesis is based on the necessity to improve the DHS efficiency, which is related to the guidelines of the UN Convention on Climate Change, to reduce emission of gases harmful to the climate into atmosphere and to reduce consumption of primary energy resources.

The objective of the Doctoral Thesis is to assess the interaction of all the DHS elements and to develop a methodological solution for management and control of DHS processes providing a higher contribution for reduction of CO_2 emissions and improvement of the DHS efficiency. By performing a study on changes of the return temperature in the transmission system it is possible to reveal deviations from the normal condition. This means that there are changes in the system that need to be identified by other practical methods, for example:

- examination of the consumers' systems by applying reading of heat meter data;
- survey of the consumers' systems, compliance with the return temperature regime;
- analysis of the results of monitoring of the control systems of transmission systems (heat pipelines without channels);
- survey of heat pipelines above the ground and in channels;
- inspection of the condition of shut-off fittings of heat chambers (verification of unauthorised interferences).

The study demonstrates that trend graphs can be prepared for each heat supply system by using historical data and the limits of deviations of the return temperature can be established. As the return temperature is reduced, heat losses decrease, electricity consumption for the network pumps decreases and energy consumption by the heat supply system decreases leading to reduction of CO_2 emissions and consumption of primary energy resources. The operator of each system can identify the deviation fast by following the return temperature and comparing it to the trend graph margins and respond fast in order to prevent deficiencies in the DHS management. For more efficient use of the developed system it is necessary to develop a technical data management system, which automatically follows and notifies deviations from settings.

The Thesis also reviews availability of DHS energy sources, including renewable energy resources (wood chips), and the possibilities of their future use, the possibilities of improving efficiency of the use of fuel, assesses the role of heat transmission in the DHS development and the impact of existing and perspective heat consumers on the DHS development in the area subject to study.

The Thesis consists of Introduction, four chapters reviewing the district heating system energy sources, the possibilities of improving efficiency of heat production, the role of heat transmission in the district heating system development and the impact of existing and perspective heat consumers on the district heating development, an experimental section, the result evaluation, conclusions, the list of references and annexes.

The first chapter describes the availability of and the demand for energy resources used in district heating systems, in particular, renewable energy resources and fossil energy resources. The potential of major renewable energy sources in Latvia, i.e. wood biomass, hydro energy and wind energy, and the possibilities of their use in energy are assessed.

The second chapter assesses the possibilities of improving fuel efficiency by using biofuel (wood chips) for heat production in the heat sources of Riga City district heating system. In this chapter the forms of heat production in district heating, namely, combined cycle natural gas fired cogeneration, cogeneration units using wood chips, natural gas fired water heating boilers and water heating boilers using wood chips as fuel, are compared. The study of the heat production units installed in the district heating system where wood chips are used as fuel leads to a conclusion that along with the development of technologies equal efficiency indices of fuel combustion to those of natural gas fired units can be achieved.

The third chapter contains an assessment of the role of heat transmission in the development of district heating system, the analysis of specific and absolute heat losses and various measures of reduction of heat losses has been performed.

The chapter summarises and analyses the results of an experiment identifying the link between the difference of the heat carrier temperature (T_1 and T_2) and the ambient air temperature in heat production sources CHPP-1 and CHPP-2 operating in Riga. The performed studies demonstrated that deviations from the normal condition upon the change of the temperature difference in the transmission system can be revealed by applying the developed methodology. The developed DHS management and control methodology defines the function of DHS at a particular difference of temperatures (ΔT). The curves above and below the regression curve correspond to the mean forecasted values of 95 % reliability interval and between them there is the optimum zone defining the operation of the district heating system.

The fourth chapter contains the study of impact of heat consumers upon the development of the district heating system, including the study of impact of change of the number of population, study of demand regarding the people's perceived quality of life, summarises information about housing development projects funded by the municipality and development territories, forecast of quantitative indices of living spaces, demand for non-residential areas and trends thereof. The chapter contains the study of impact of improvement of energy efficiency of heat consumers on the district heating system, including the assessment of the current level of energy efficiency of buildings, technical possibilities of securing improvement of energy efficiency of buildings, sufficiency and conditions of funding, forecasted specific heat consumption in residential buildings in Riga. Forecasting of effective heat consumption is done according to a particular sequence of assessment due to the impact of multiple factors and uncertainties: forecast of heat demand in the residential sector of Riga city, forecast of heat demand by the non-residential sector in Riga; forecast of heat demand in particular heat supply areas of Riga city.

CONTENT

INTRODUCTION

General

The topicality of the Doctoral Thesis is based on the following legislation:

- Kyoto Protocol to the United Nations Framework Convention on Climate Change of 11 December 1997 created as a means for fighting the global warming;
- Paris Agreement to the United Nations Framework Convention on Climate Change of 5 October 2016. This is the first generally binding global climate agreement aimed at restricting the global increase of the average temperature below 2 °C in comparison to the pre-industrial level and striving to restrict the temperature increase to 1.5 °C in comparison to the pre-industrial level;
- EU Directives set the new climate and energy targets to be attained by 2030, in particular, minimum 40 % reduction of greenhouse gas emissions, attaining that minimum 27 % of energy consumption is derived from renewable energy, attaining minimum 27 % improvement of energy efficiency.
- The Law of Latvia on "Paris Agreement to the United Nations Framework Convention on Climate Change", entered into force on 09.02.2017.
  Latvia will implement the conditions of Paris Agreement jointly with the other EU Member States – will reduce the GHG emissions in the EU by minimum 40 % until year 2030.
- National laws and Cabinet Regulations of Latvia.

The above mentioned documents are available at: http://www.lsua.lv/text.php?id=24&menu_id=9

Goal of the Thesis

The goal of the Thesis is reduction of CO_2 emission by improving efficiency of district heating (DH) by means of implementing its management and control with the help of the developed methodology.

DH is a large consumer of primary energy resources, and in the Latvian climate conditions the reduction of primary energy consumption by improving comfort in buildings is very important.

In order to secure DH efficiency, it is necessary to achieve that the T_2 return temperature in the heat network is lower and the temperature difference is higher. Research has been done on this subject in Sweden (Ph. D. Sven Werner, Ph. D. Justin N.W. Chin, Dr. Henrik Gadd), Denmark (Ph. D. Hakan Ibrahim Tol, Ph. D. Maksym Kotenko), and Poland (Ph. D. Sergey Anisimov). The impact of the return temperature to DH has not been sufficiently studied. Until now it has not been possible to describe the change of the return temperature at positive outdoor temperatures by application of a linear method. In Latvia this matter has been studied by Professor Dr. habil. sc. ing. N. Zeltiņš, Academician of the Latvian Academy of Science, Professor Dr. habil. sc. ing. P.Š ipkovs, Professor Dr. habil. sc. ing. J. Barkāns, Professor Dr. habil. sc. ing. E. Dzelzītis, Honorary Doctor of the Latvian Academy of

Science Dr. sc. ing. Ā. Žīgurs, Dr. sc. ing. A. Cers; socially responsible aspects of heat supply, considering the micro climate in residential premises, has been studied by Dr. oec. J. Kurovs.

The Doctoral Thesis investigates the link between ΔT and the outdoor temperature at heat production sources in Riga, Latvia. The industrial experiment described in the Doctoral Thesis was performed in the DH network of the right bank of Riga city, within the heat supply area of power plants CHPP-1 and CHPP-2.

The polynome of the 2nd stage more accurately approximates the relation between ΔT and $T_{outd.}$ by providing the highest value of the determination coefficient R^2. A regression equation has been developed by using the polynome of the 2nd stage and their graphical interpretation with 95 % probability is presented.

The impact of T_2 on the production process, the flue gas condenser and the operational efficiency of the condensation economiser have been researched.

Novelty of the Thesis

The development of methodology for complete transfer of heat from a DHS using bioenergy to the end consumer by adjusting it on the basis of the return temperature, by maintaining the return temperature within a determined deviation area.

Practical importance of the Thesis

The methodology can be applied in DHS of cities based on historical data. T_2 temperature can be reduced fast, by continuously following updated data resulting in reduction of heat loss in transmission, of electricity consumption for network pumps, of energy consumption by the heat supply system and more efficient operation of heat production equipment, and as a result reduce CO_2 emissions and the impact on the environment.

DHS provides wide opportunities for using renewable energy resources, at the same time reducing CO_2 emissions, for example, by wider use of wood, geothermal heat or sun radiation as a fuel. Improvement of efficiency of the DHS transmission system by reducing heat loss and the primary energy consumption allows improving the competitiveness of the heat transmission operator on the heat market.

Publications

1. Talcis, N., Dzelzītis, E., Līckrastiņa, A. Return Temperature in DH as Key Parameter for Energy Management. *International Journal Of Modern Engineering Research (IJMER).* 2018, vol. 8, issue 7, pp. 88–92. ISSN: 2249-6645.
2. Lickrastina, A., Talcis, N., Dzelzitis, E. Cogeneration unit with an absorption heat pump for district heating system. *HVAC&R Research.* 2014, pp. 404–410. ISSN: 1078-9669.
3. Grasmanis, Dz., Grekis, A., Talcis, N. Heat Consumption Assessment of the Domestic Hot Water Systems in the Apartment Buildings. *Construction Science.* 2013, vol. 14, pp. 38–43. ISSN 1407-7329.

4. Talcis, N. „Zaļā” koģenerācija Rīgā: atklāta siltumcentrāles „Ziepniekkalns” biokurināmā koģenerācijas stacija. *Enerģija un Pasaule.* 2013, Nr. 2, 54.–57. lpp. ISSN 1407-5911.
5. Ziemele, J., Blumberga, D., Talcis, N. Industrial Research of Condensing Unit for Natural Gas Boiler House. *Environmental And Climate Technologies*. 2012, vol. 10, pp. 34–38. ISSN 1691-5208.
6. Talcis, N., Dzelzitis, E. Use of biofuel in The District Heating system of Riga. *The REHVA European HVAC Journal*. 2012, vol. 49, iss. 6, pp. 28–33. ISSN 1307-3729.
7. Ziemele, J., Pakere, I., Talcis, N., Blumberga, D. Multi-criteria Analysis of District Heating systems in Baltic States. *Energy Procedia*. 2014, vol. 61, pp. 2172–2175. ISSN 1876-6102.
8. Ziemele, J., Pakere, I., Talcis, N., Cimdiņa, G., Vīgants, Ģ., Veidenbergs, I., Blumberga, D. Analysis of wood fuel use development in Riga. *Agronomy Research*. 2014, vol. 12, No. 2, pp. 645–654. ISSN 1406-894X.
9. Талцис Н., Церс А., Плискачев С., Дзелзитис Э. Опыт утилизации низкопотенциального тепла с использованием абсорбционного теплового насоса. *Новости Теплоснабжения.* 2011, №5 (129), 27.–31. с. ISSN 1609-4638.
10. Талцис Н., Дзелзитис Э. Оптимизация источников тепла в системе централизованного теплоснабжения. *Энергосбережение.* 2012, №2, 69.–72. с. ISSN 1609-7505.
11. Талцис, Н., Дубсон, М. Реализация программы повышения эффективности систем теплоснабжния г. Риги. *Новости Теплоснабжения*. 2013, №3 (151), 30.–35. с. ISSN 1609-4638.
12. Талцис, Н., Дубсон, М. Повышение эффективности использования систем автоматического считывания данных с коммерческих счетчиков тепловой энергии. *Новости Теплоснабжения*. 2015, №1(173), 46.–51. с. ISSN 1609-4638.
13. Dzelzītis, E., Jēgeris, A., Līckrastiņa, A., Talcis, N. Solid Particle Emission Abatement from Biomass-Fired Boilers in District Heating Plants. **In:** *Proceedings of REHVA Annual Conference 2015 „Advanced HVAC and Natural Gas Technologies”, May 6-9, 2015, Riga, Latvia.* Riga: RTU Press, 2015, pp. 155–161. doi: 10.7250/rehvaconf.2015.022.
14. Talcis, N., Līckrastiņa, A., Dzelzītis, E. The Observation of Targets Achieved during District Heating Development in Riga City. *Modern Enviromental Science and Engineering*. 2017, vol. 3, No. 4, pp. 237–248. ISSN 2333-2581.

Participation in conferences:

1. Siltuma avotu optimizācija centralizētajā siltumapgādes sistēmā. RTU 52. starptautiskā konference, 11 October 2011, Riga, Latvia.
2. Оптимизация источников тепла в системе централизованного теплоснабжения. Москва: проблемы и пути повышения энергоэффективности, 26–28 October 2011, Moscow, Russia.

3. Применение коденсаторов дымовых газов в производстве тепловой энергии, повышая эффективность использования биотоплива. Конференция и выставка „Москва - энергоэффективный город", 24–25 October 2012, Moscow, Russia.
4. Опыт по повышению эффективности работы системы централизованного теплоснабжения г. Риги. Московский Международный Форум „Современный мегаполис: ресурсосбережение и энергоэффективность", 3–4 December 2012, Moscow, Russia.
5. Ziņojums par SC "Ziepniekkalns" biokurināmā koģenerācijas energobloka ar siltumjaudu 22 MW un elektrisko jaudu 4 MW izbūvi. Pasaules Enerģijas padomes Latvijas nacionālās komitejas izbraukuma valdes sēde, 19 March 2013, Riga, Latvia.
6. Utilisation of the Latent Heat From Biofuel in the Heat Production Process. CLIMA 11th REHVA World Congress & 8th International Conference on IAQVEC, 16–19 June 2013, Prague, Czech Republic.
7. Повышение эффективности производства тела с использованием коденсаторов дымовых газов. Отраслевая Научно-Практическая Конференция „Теплоснабжение Росии: 110 Лет Развития", 11–12 September 2013, Moscow, Russia.
8. Kurināmā veidu diversifikācija Rīgas centralizētā siltumapgādē. ADVANCED HVAC & NATURAL GAS TEHNOLOGIES, 8–9 May 2015, Riga, Latvia.

1. PRIMARY ENERGY RESOURCES OF DISTRICT HEATING SYSTEMS

1.1. Renewable energy resources

Considering the climate conditions in Latvia (the length of the heating season being 6 months a year), heat production ranks first on the energy balance (64 %). At present gas prevails in heat production by cogeneration plants and district heating boiler houses, whereas wood is a prevailing fuel in households.

The growing demand for energy, restricted reserves of fossil fuel, as well as the environment pollution and the global climate change have caused increased interest in renewable energy sources during recent years. The potential of the local fuel (biomass) is not sufficiently used in heat supply in Latvia, its use can be increased because there are sufficient resources. Wood biomass, hydro energy and wind energy are major renewable energy sources in Latvia. The possibilities of use of geothermal energy are currently being investigated.

Wood is among most important renewable energy resources. The global demand for wood energy is continuously growing and its potential availability in future is important. According to the data of the State Register of Forests, the total area of forests in Latvia is 3.02 million hectares [1]. Further increase of the forest area can be forecasted because the natural overgrowing of areas not used in agriculture and their targeted forestation continues. The total reserve of forest lands in Latvia equals 677 mill.m^3 [2]. By-products, timber from forest, timber from lands outside forest lands, cutting remains can be used as wood energy. According to current studies the annual potentially available volume of wood is estimated to equal to 10 mill. solid m^3 per year.

Intensification of the use of wood biomass is a major precondition for attaining the new climate goals of the European Union, in particular, a 20 % reduction of greenhouse gas emissions in comparison to year 1990 in Europe as a whole. The package of climate and energy legislation provides for a 21 % reduction of CO_2 emissions by the industries participating in the emission trading scheme (ETS) by 2020 in comparison to year 2005. In the industries which are not included in the ETS, for example, energy, waste handling, transportation and agriculture, Latvia is allowed to increase emissions by 17 % by 2020 in comparison to year 2005. The actual forecasted emission increase reaches 50 % in comparison to year 2005. In the ETS sector, the increase of the use of wood resources for heat production will be important, and in the industries outside the ETC, it will be not only wood, but also the other biomass produced by agricultural operations for both heat production and electricity generation, as well as production of biogasoline for road vehicles. The discussion on the sustainability criteria of biomass has been started in the European Union taking into account the unassessed environmental impact of the first generation biogasoline, however, the progress of the discussion in the Council of Europe indicates that the criteria could be applied to biomass in general. The reduction of GHG emission by replacing fossil fuel with biofuel should be at least 35 % (after year 2017 – at least 50 %) [3].

2. POSSIBILITIES OF IMPROVING HEAT PRODUCTION EFFICIENCY

2.1. Use of heat produced in the combined cycle in the DHS

Combined heat production and power generation or cogeneration is one of the ways of most profitable use of primary energy. Cogeneration plants use up to 30–40 % less fuel than in separated heat production and power generation. The efficiency of cogeneration is usually 40 % higher in comparison to separated production of both types of energy if electricity is generated by a condensation plant and heat is produced by water heating boilers and the same fuel is used. Therefore, cogeneration is preferred when boiler houses or heat plants are modernised. According to Directive 2004/8/EC, cogeneration is simultaneous production of heat and generation of electricity in a single process.

In Riga, there are both large scale electricity and heat cogeneration plants (cogeneration plants CHPP-1 and CHPP-2 with more than 1000 MW_{th}), medium size (approximately 400 MW_{th}) and less capacity (up to 100 MW_{th}) boiler houses for heat production which correspond to the other three groups of classification. The possibility of producing heat and generating electricity within a cogeneration cycle with high total efficiency is among the main advantages of CHPP. The total efficiency is the ratio of the aggregate annual electricity generation and heat production to the total volume of fuel used for energy production within cogeneration (2.1):

$$\eta_{TEC} = \frac{E_{TEC}+Q_{TEC}}{B_{TEC}} \tag{2.1}$$

where E_{TEC} is electricity by cogeneration; Q_{TEC} is heat produced in the cogeneration mode; and B_{TEC} is fuel consumption in cogeneration equipment.

High efficiency cogeneration is the process providing more than 10 % savings of primary energy resources in comparison to separated production (see Fig. 2.1).

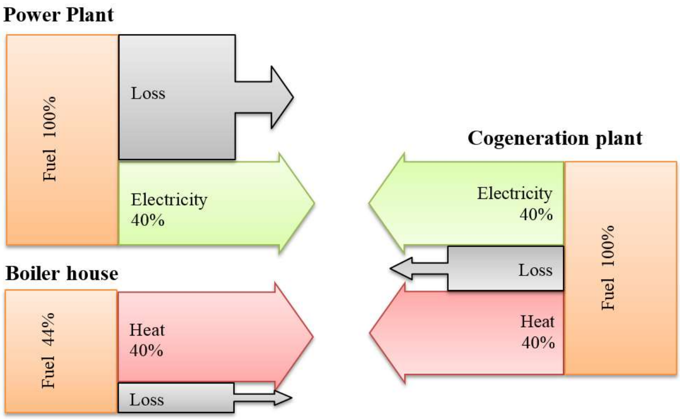

Fig. 2.1. Comparison of split production and cogeneration.

2.2. Impact of the use of wood chips on heat production

The study of the heat production units installed in the district heating system where wood chips are used as the fuel leads to the conclusion that, along with the development of technologies, equal efficiency indices of fuel combustion to those of natural gas fired units can be achieved. At the end of the last century, the efficiency rates of the plant using wood chips amounted to 80–90 %, however, now I can conclude that the efficiency rates exceed 100 % and equal up to 110 %, the assessment being based on the lowest combustion heat of fuel. If the calculation is based on the highest combustion heat of fuel, the efficiency rate ranges from 95 % to 98 %. Examination of the surveyed heat sources and boiler equipment where fuel wood chips are used (Fig. 2.2) clearly shows increase of the efficiency rate or so called efficiency of fuel utilisation.

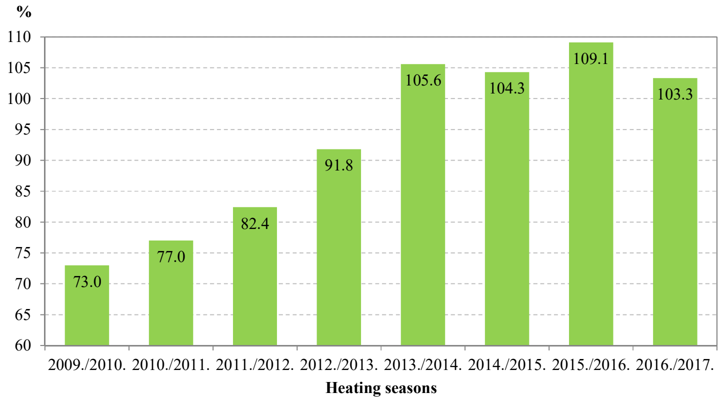

Fig. 2.2. Efficiency rates of fuel utilisation for wood chips fired boilers (%) [4].

2.3. Upgrade of heat production sources

2.3.1. Condensation economiser for a natural gas fired water heating boiler

The condensation economiser is among the most essential elements for securing the plant efficiency when natural gas fired boilers are used for heat production. The condensation economiser provides for utilisation of the latent heat of flue gas resulting in heat production without using fuel and 15−20 % improvement of total efficiency parameters of the boiler equipment. In the present Doctoral Thesis, the condensing economiser with the capacity of 10 MW installed in the heat plant "Imanta" for the natural gas fired water heating boiler KVGM-100 No. 3 was selected as the industrial experiment area.

During 2 years, in the course of performing the industrial experiment the efficiency of the condensing economiser depending on the heat network return temperature T_2 was evaluated.

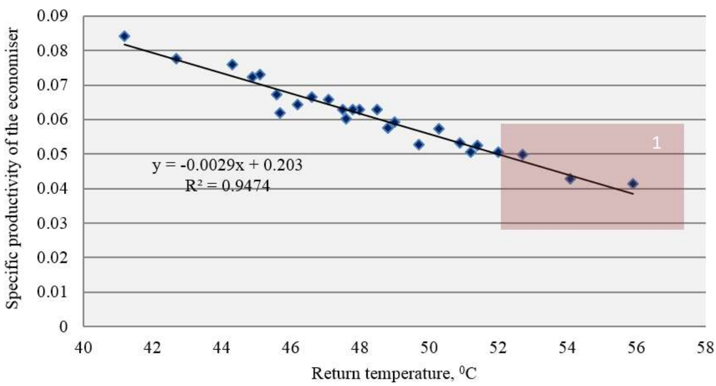

Fig 2.3. The specific economiser productivity depending on the return water temperature, January 2010 (experiment area 1 − there is no condensation process).

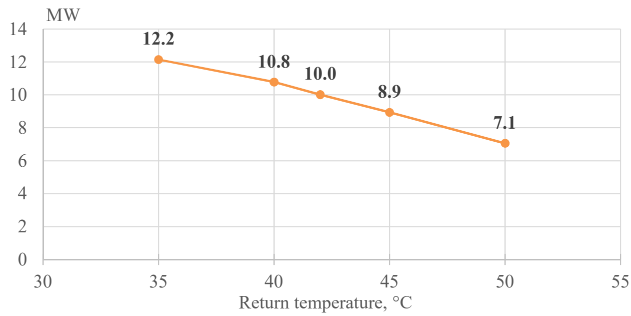

Fig. 2.4. Heat produced by the condensing economiser at the heat plant "Imanta" water heating boiler KVGM-100 No. 3 depending on the heat network return temperature at maximum load (116 MW).

As the return water temperature decreases by 1 °C, the productivity of the economiser will increase on average by 0.340 MW in relation to the full load of the condensing economiser 12.15 MW (the efficiency rate will increase by 2.8 %).

2.3.2. Flue gas condenser for a water heating boiler

In order to investigate which factors impact the operational efficiency of a flue gas condenser, an industrial experiment was carried out. The operation of the wood chips fired water heating boiler "Renewa OY" (Finland) 20 MW with a flue gas condenser 4 MW was analysed by using wood chips of various humidity and the impact of T_2 upon the operation of the flue gas condenser was investigated. During the experiment, the moisture content of wood chips and T_2 was analysed and the data was systematised.

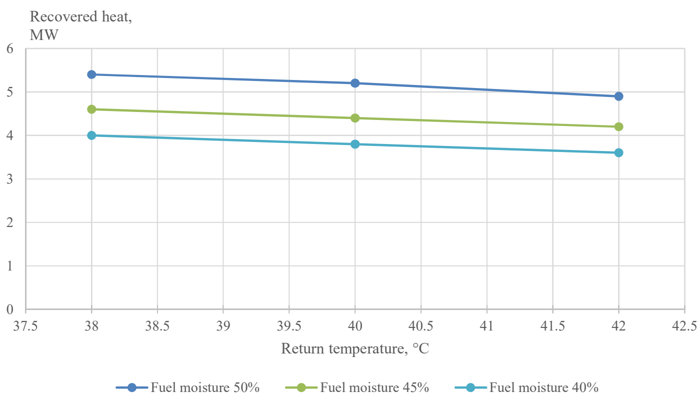

Fig. 2.5. Heat recovery.

The analysis of obtained data leads to the conclusion that the moisture content of wood affects the operation of the flue gas condenser, however, this is a factor to be solved with suppliers of wood chips. T_2, however, is a factor that affects the operational efficiency of the flue gas condenser, which in turn depends on the system operator and on the control of the DHS operation.

As the return water temperature decreases by 1 °C, the productivity of the flue gas condenser will increase on average by 0.100 MW, and the efficiency rate of the flue gas condenser will increase by 2.8 % accordingly.

3. THE ROLE OF HEAT TRANSMISSION IN DHS DEVELOPMENT

3.1. Analysis of specific and absolute heat loss in the DHS

Transportation of the energy transformed in heat carriers takes place along pipelines and is related to energy loss for overcoming hydraulic resistance. Energy loss also takes place in the form of heat during transportation of hot water, steam or air. Heat is supplied to consumers from heat sources via a heat supply system comprising heat sources, heat networks and consumer heat appliances such as heat exchangers, space heating radiators, water production devices, control automation and armature.

Heat networks comprise a system of pipelines along which a heat carrier, in particular, hot water or steam, delivers heat from a source to the consumer. The supplied heat is used for space heating of residential, public, administrative and industrial premises, technological needs, hot water production and ventilation. From the technical point of view heat networks are characterised by a high number of branches and the main lines are connected by connecting pipes to provide security of supply via scheme connections in emergency situations.

Part of old pipelines whose service time has expired should be replaced by more modern ones in order to prevent unexpected emergency situations and to minimise heat losses due to weaker heat insulation of the old mode. Pipelines of the new type can most often be laid in the soil without any channels and additional insulation, thus reducing the costs of construction works and shortening the work completion term. In the particular circumstances of city constructions, the necessity of laying pipelines in channels or installing pipelines on free standing fly-overs cannot be excluded.

For the purpose of reducing heat loss, the pipes and connections, the shut-off armature pits and various elements of pipelines should be insulated with great care.

Heat losses in outdoor environment from insulated pipelines depend on the temperature difference between the heat carrier and the outdoor temperature, the geometric dimensions of the pipeline, and the insulation quality. At present pipelines with different thickness of insulation are offered on the market of pre-insulated pipelines, therefore particular pipes for particular conditions are selected. The presence of ground water in the environment where e particular pipes will be laid should be taken into account.

The losses of above the ground heat networks can be calculated on the basis of the heat transfer equation by reference to the section length 1:

$$Q = q_{lin} l = k_{lin} \Delta t l \tag{3.1}$$

where

q_1 – density of the linear heat flow, W/(m·°C);

$\Delta t \cong (\bar{t}_s - t_v)$ – temperature drop, °C;

$\bar{t}_s$ – average temperature of the heat carrier in pipeline section l, °C;

t_v – outdoor temperature, °C.

The linear coefficient of heat transfer k_{lin} via the multi-layer wall of a pre-insulated pipeline is determined based on the following equation:

$$k_{lin} = \left(\frac{1}{\alpha_s \pi D_{iek\check{s}}} + \frac{1}{2\pi\lambda} ln \frac{D_{\bar{a}r}}{D_{iek\check{s}}} + \frac{1}{2\pi\lambda_{izol}} ln \frac{D_{izol}}{D_{\bar{a}r}} + \frac{1}{2\pi\lambda_{apv}} ln \frac{D_{apv}}{D_{izol}} + \frac{1}{\alpha_{gaiss} \pi D_{apv}} \right)^{-1} \tag{3.2}$$

where

α_s – the heat yield coefficient from the side of the heat carrier, W/(m^2·K);

α_{gaiss} – the heat yield coefficient from the side of the air, W/(m^2·K);

λ – the heat transfer coefficient of the pipeline, W/(m·°C);

λ_{izol} – the heat transfer coefficient of the insulation, W/(m·°C);

λ_{apv} – the heat transfer coefficient of the shell, W/(m·°C);

$D_{iek\check{s}}$ – the inside diameter of a steel pipeline, m;

$D_{\bar{a}r}$ – the outside diameter of a steel pipeline, m;

D_{izol} – the outside diameter of an insulation layer, m;

D_{apv} – the outside diameter of the shell, m.

$$k_{lin} = R^{-1} = \left(\frac{1}{2\pi\lambda} ln \frac{D_{\bar{a}r}}{D_{iek\check{s}}} + \frac{1}{2\pi\lambda_{izol}} ln \frac{D_{izol}}{D_{\bar{a}r}} + \frac{1}{2\pi\lambda_{apv}} ln \frac{D_{apv}}{D_{izol}} \right)^{-1}. \tag{3.3}$$

Heat transportation is associated with considerable heat loss. Due to unsatisfactory heat insulation and heat carrier leakage, losses reached even 50 % in the old systems. In the surveyed area heat loss amounted to 20 % and now it is 13 %. This could be afforded at the time when it was not necessary to pay such close attention to fuel consumption because the costs of energy resources were low. Particularly high heat loss can be found in technological heat pipelines where higher temperature differences prevail.

The following can be recommended for reduction of heat losses in the ambient environment:

- selection of heat pipelines with as efficient as possible heat insulation;

- reduction of the heat carrier supply temperature as far as it does not cause inconvenience for consumers;
- reduction of the return temperature T_2 by cooperating with and controlling the DHS users, by applying the management and control methodology developed within the present Doctoral Thesis;
- stop using steam as a heat carrier;
- fast elimination of leakages of the heat carrier;
- development and continuous improvement of rational systems for automation of heat distribution and supply [5−8].

Around pre-insulated pipelines, which are laid in the soil, there is a heterogeneous layer where the humidity differs and is in the form of both liquid and steam, as well as in a solid phase − frozen. Moreover, the composition of the soil layer along the length of pipelines can vary over a broad range. The soil density can increase following commissioning.

3.2. Analysis of various measures of reduction of heat loss in heat transmission

The evaluation of the operational efficiency of a district heating system is often defined by its efficiency ratio (specific heat loss in the transmission system): the ratio between the amount of heat consumed by consumers (effective energy) and the heat transmitted to the system (produced heat).

In order to save heat, ways and methods should be found for reducing heat loss without hindering provision of the needed heat regime to consumers.

The main issue for solving the task of reduction of heat loss is clarification of all the known loss components on the basis of their characteristics and numerical values in order to focus on optimum technological and economically permitted solutions that would allow improving the efficiency coefficient. In order to justify the selected way for reducing losses, prior to adopting a decision a detailed study of all the transmission systems should be done, eventual mutual impact of losses of various types, the economic characteristics of loss reduction methods and their technical stability, including automation possibilities, should be analysed. As heat supply systems differ by geographic layout of networks, length and diameter of individual sections, as well as the nature of connected consumers (density of consumer heat loads), the methodology of calculation of changes may turn out to be insufficiently accurate under the circumstances of changing variables and the theory of similarity of flows is difficult to be used. In this case, under suitable meteorological conditions it is useful to perform an actual technical experiment by obtaining needed input data for improving the selected technical solution. This is exactly the way we selected for testing eventual automated control risks by developing the temperature control methodology and the DHS operation or, in particular, T_2, which can be easily and accurately controlled by applying modern measurement equipment.

3.2.1. Heat supply transmission system control methodology

Supply and return temperatures play a very important role in setting the efficiency of a district heating supply system. Also heat losses in transmission are considerable. As it was described in the above sections, heat loss depends on ΔT, the heat carrier temperature and the outdoor temperature. Recent research [9], [10] confirms that even relatively low supply temperatures (slightly above 50 °C) can satisfy the consumer requirements in Central and Northern Europe countries. However, as the district heating systems in this country were designed and constructed in the 1970ies, the supply temperatures are much higher and attain the level of 120 °C, thus the consumer systems (insider heat supply systems of buildings) have been constructed according to this temperature schedule and reconstruction of consumer systems is almost impossible. Consumer systems are owned by consumers and reconstruction of the systems for a lower temperature schedule is a heavy financial burden for consumers. Taking into account that the system operates well at present, any changes are not possible. When new areas are designed in future, it will be possible to provide them with heat supply systems of the new generation with a lower supply temperature.

The difference of the supply and return temperature of the transmission system (ΔT) usually fluctuates over a year. The research [9] demonstrated that during the heating season in Denmark there is a correlation between ΔT and the outdoor temperature (T_{out}). The trend line, which presents reduction of ΔT if T_{out} increases at $T_{out} < 10$ °C, is presented in [9]. At higher T_{out} values (from 0 °C to 30 °C) data are scattered over a broad range of values and there is no correlation behind $T_{out} > 10$ °C. Considering that there are some differences in operation of the heat supply systems in Denmark and Latvia, it was decided to perform a study aimed at obtaining the link between ΔT and Tout at a heat production source in Riga, Latvia. Two heat production sources (CHPP-1 and CHPP-2) operating in Riga were selected. Data were classified per two years (2015/16 and 2016/17). The daily average supply and return temperatures were recorded during the whole year. Also the daily average outdoor temperature was recorded during the same time period. The dissipation graphs demonstrating the link between ΔT and T_{out} are presented in Fig. 3.1.

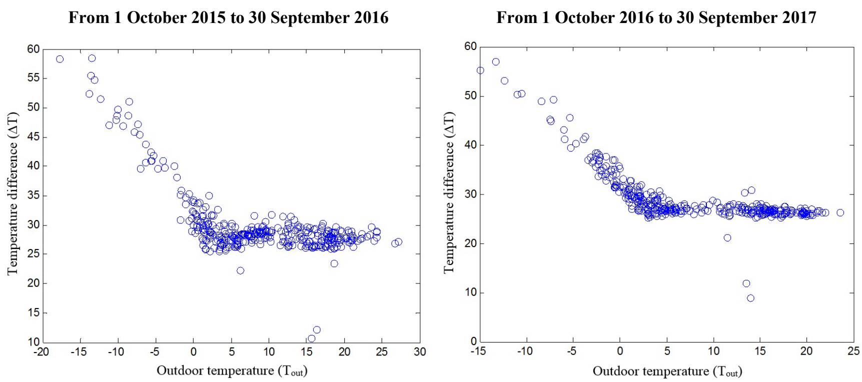

Fig. 3.1. Temperature difference (ΔT) to the outdoor temperature (T_{out}) at the heat supply plant CHPP-1, Riga, during two years.

The difference in the operation of the district heating systems in Latvia and Denmark can be seen by comparing Figures in the research [9] with Fig. 3.1 included in the Thesis. As it can be seen in Fig. 3.1, there is a correlation between ΔT and T_{out}, over a range of -20 °C < T_{out} < 10 °C. At higher outdoor temperatures ΔT is practically independent of T_{out}. As it has been demonstrated in [9], in case of T_{out} > 10 °C the temperature difference ΔT is broadly scattered over the range (0−50 °C).

As the correlation between ΔT and T_{out} exists within the range T_{out} < 10 °C, the regression analysis was performed on the basis of the data of heating seasons 2015/2016 and 2016/2017 (from 1 October 2015 to 1 May 2016 and from 1 October 2016 to 1 May 2017, accordingly) by using the first and second stage polynomes. Calculations were performed by applying Matlab software. The results of the regression analysis demonstrate that the second stage polynomes provide better approximation of the relation between ΔT and T_{out} (a considerably higher value of the determination coefficient R^2 corresponds to the second stage polynome). Figure 3.2 presents both, i.e. the best suited second stage polynome and the corresponding data points from the sample for the heat supply plant CHPP-1 for the heating season 2015/2016. Figure 3.2 presents the same data for the heating season 2016/2017.

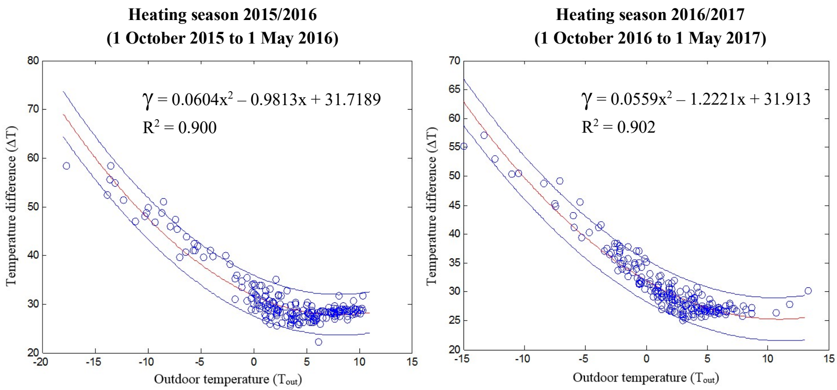

Fig 3.2. The second stage polynome and data points from the sample for the heat plant CHPP-1 are best suited.

Curves above and below the second stage polynome in the graph in Fig. 3.2 correspond to 95 % reliability range for the average forecasted values.

By using classified data from another heat plant in Riga (CHPP-2), calculations for the heating seasons 2015/2016 and 2016/2017 have been done and presented in Fig. 3.3, accordingly.

The 2nd stage polynome was used. We tried to do this by using the linear function, however, the 2nd stage polynome provides a higher value of the determination coefficient R^2. The above coefficient determines how big is the part of γ that can be explained by this model. The value of the coefficient R^2 should be closer to 1, then there is no error.

Some general conclusions can be drawn by analysing the graphs in Figs. 3.2−3.3. First, the second stage polynome is suitable for all the data (the determination coefficient ranges between 0.779 and 0.902). The corresponding p-values which are determined by Matlab software in all the reviewed cases are below 10^{-4}. Almost all the data points in Figs. 3.2−3.3 are between the top and bottom border of the 95 % reliability interval.

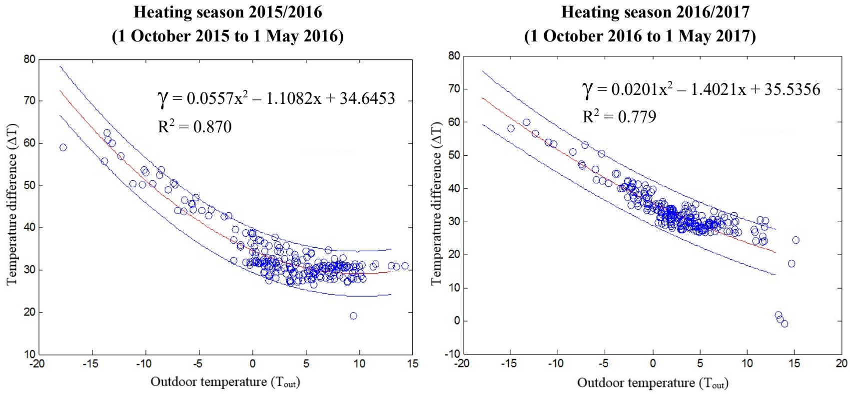

Fig. 3.3. The second stage polynome and data points from the sample for the heat plant CHPP-2 are best suited.

It should be taken into account that the trend line together with three standard deviation lines from the trend line is presented in research [9]. In the study [9] the typical temperature difference (ΔT) range between +/- three standard deviations equals approximately 25 °C. As it can be seen from Figs. 3.2 and 3.3, the typical difference between the top and bottom reliability interval borders is approximately 9 °C (thus 95 % reliability interval assessments provide considerably less uncertainty than the assessments based on three standard deviations from the trend line). By performing a study about changes of the return temperature in the transmission system we can find deviations from the normal condition, which means that there are changes in the system which need to be identified by other practical methods, for example the folowing ones:

- examination of the consumers' systems by applying reading of heat meter data;
- survey of the consumers' systems, compliance with the return temperature regime;
- analysis of the results of monitoring of the control systems of transmission systems (heat pipelines without channels);
- survey of heat pipelines above the ground and in channels;
- inspection of the condition of shut-off fittings of heat chambers (verification of unauthorised interferences).

The study shows that by using historical data the trend lines for each heat supply system are prepared and the return temperature deviation borders are defined. The operator of each system can identify the deviation fast by following the return temperature and comparing it to the trend graph margins and respond in order to prevent deficiencies in the district heating system transmission system.

For more efficient use of the developed system it is necessary to develop a technical data management system, which automatically follows and notifies deviations from settings. This means that for high quality management of a district heating system, it is necessary to organise automated return temperature data collection and entry to the common system where reports are generated on the system operation parameters, and the developed system would issue warnings of deviations from settings.

This is the only way for fast response management of a heat supply transmission system and identification of defects (functional deviations of the system elements from normal parameters).

Methodology calculation example

In order to verify the district heating system management and control methodology developed within the Doctoral Thesis, by reducing the return temperature of the heat carrier by 1 °C, heat losses were calculated and the changes of the productivity of the economiser were determined.

The heat loss calculation was performed in the heat network of the Right Bank of Riga City within the CHPP-1 heat supply area because the CHPP-1 operates during the whole year whereas the CHPP-2 operates only during the heating season.

The calculations indicated that as T_2 was reduced by 1 degree in the heat network return pipe, the heat transmission losses decreased by 1 %. As the T_2 was decreased by one degree in heat lines in the return pipeline, the efficiency coefficient of the flue gas latent heat utilisation devices increased by 2.5 to 2.8 %. Increase of the use of latent heat reduced the consumption of primary energy resources.

Table 3.1

Calculation of Heat Loss by Reducing the Return Temperature by 1 °C in the Heating Season 2015/2016 in the Industrial Experiment Area at CHPP-1

Average monthly temperatures														
	Depth, m	Months												Year
		10.	11.	12.	01.	02.	03.	04.	05.	06.	07.	08.	09.	
Soil	1.6	13.2	9.9	7.4	4.5	2.6	2.0	2.7	5.4	9.2	12.5	14.8	15.4	8.3
Air		6.9	5.1	3.7	-6.1	1.9	2.4	7.4	15.3	17.9	19.3	17.4	14.6	8.8

Network water temperatures			
Average actual		Reduced	
T_1	T_2	T_1	T_2
70.7	41	70.7	40.0

Heat loss increase, %			
Underground lines	−1.05	Average	−1.05
Above the ground lines	−1.06		

Table 3.2

Calculation of Heat Loss by Reducing the Return Temperature by 1 °C in the Heating Season 2016/2017 in the Industrial Experiment Area at CHPP-1

Average monthly temperatures														
	Depth, m	Months												Year
		10.	11.	12.	01.	02.	03.	04.	05.	06.	07.	08.	09.	
Soil	1.6	13.3	9.5	6.7	4.4	2.5	1.4	2.2	4.0	7.8	11.0	13.8	14.7	7.6
Air		5.7	1.6	1.8	-2.1	-1.5	3.1	5.2	12.1	15.5	17.4	18.1	13.7	7.6

Network water temperatures			
Average actual		Reduced	
T_1	T_2	T_1	T_2
73.3	42.4	73.3	41.4

Heat loss increase, %			
Underground lines	−1.00	Average	º1.00
Above the ground lines	−0.99		

4. HEAT CONSUMERS OF THE DISTRICT HEATING SYSTEM

4.1. Impact of current and potential heat consumers on DHS development

For the purpose of forecasting the heat loads and heat demand in Riga city until year 2024, the data of JSC "RĪGAS SILTUMS" regarding consumer heat loads, heat consumption and the data of Riga City Development Plan [11] have been used as input. In order to assess development of heat loads, the factors affecting heat demand were analysed. The following factors were included in the analysis:

a) outdoor temperature;
b) population size in Riga city;
c) characteristics of the housing sector;
d) development of the non-residential sector;
e) possibilities of improving energy efficiency.

Outdoor temperature in Riga can be referred to as one of the factors affecting heat demand. The heating season starts when the average day temperature is +8 °C or lower and this usually is from October to April. The length of the last five heating seasons in Riga (2012/2013 − 2016/2017) has been in the range from 194 to 218 days. The standard length of the heating season in Riga is 203 days with the average outdoor temperature 0 °C [12].

Change of the population size has a major impact upon the heat demand. According to the data of population census 2011 of the Central Statistics Bureau [13], the population of Latvia as of 1 March 2011 was 2 070 371. Since the last population census in 2000, the population in the country has decreased by 307 thousand or by 12.9 %. The population census data indicate that the population size has decreased most in comparison to year 2000 in Latgale (by 21.1 %) and in Vidzeme (by 17.5 %). In the Greater Riga area the population has increased by 3.2%. According to the information published by the Central Statistics Bureau, the population decrease in Latvia continued in 2017, however, the rate of decrease has become slower, and the number of permanent population was 1 950 116 as of 1 January 2017 [14]. Considerable decrease of the Latvian population during further years is forecasted in studies of Latvian, foreign and international organisations.

Since the attained top level in 1990, when the population of Riga was 916 thousand, it has decreased considerably and as of 1 March 2011 there were 658 640 permanent residents in Riga according to the data of the population census of 2011. The information on the status on 1 January 2018 as collected by the Central Statistics Bureau indicates that the number of permanent residents in Riga was only 637 971 [15].

The demand changes can be forecasted on the basis of the number of residential premises per person. In 2012, in Riga there were 1.30 residential premises and in developed Member States of the European Union (EU-15) it was 1.80 residential premises. Thus, it can be assumed that the difference indicates that there is a potential demand for purchase of new apartments. Considering social economic factors in Latvia, we can assume that this is the value of the long-term target index of housing comfort for Riga. Assuming that the average size of one room remains at the level of 2012 and the construction of new residential premises remains on average at the level of 2004-2012, the number of rooms per person in Riga could reach the level of 1.64 in 2024. From the above data it follows that in the surveyed period there is demand for new residential premises.

New shopping centre constructions can cause a major increase of heat load demand. Still, the development level of this sector and eventual progress during the survey period should be taken into account. In comparison to the European Union countries, in Latvia the trade area per person in shopping centres in 2012 exceeds the average EU-27 indices and is similar to Denmark where the GDP is twice as high as in Latvia based on the purchasing ability parity and the average net wage is five times higher than in Latvia. The above index (trade area per person) in Latvia is higher than, for example, in Great Britain, France, Spain, Italy, Germany and Belgium. This causes reasonable doubt regarding considerable growth possibilities of this sector during the survey period.

4.2. Study of the impact of improvement of energy efficiency of heat consumers on DHS

Energy efficiency of buildings where the average annual specific heat consumption is among the resulting criteria is among the factors determining the volume of heat consumption in both residential and non-residential buildings. The specific heat consumption of buildings is determined by both the energy efficiency of buildings and mental factors. Within the present research the impact of energy efficiency and its change on the specific heat consumption of buildings was analysed.

According to the data of the Central Statistics Bureau [16], the heated area of the residential sector of Riga receiving heat from external sources amounted to 12.6 mill. m^2. The average actual specific heat consumption of apartment houses included in the data base of Riga Energy Agency [17] in Riga in 2014 equalled to the following amounts:

- in houses with district hot water supply – 177 kWh/m^2/ year;
- in houses without district hot water supply – 136 kWh/m^2/ year.

The current average annual specific heat consumption of houses in Riga city is affected by the scope of annual building energy efficiency measures, which depends on financing sources and its volume. Implementation of these measures will be encouraged by the growth of prices of primary energy resources, as well as by relevant adopted regulatory enactments and development program documents in this area. Whereas the scope of measures in the non-residential sector (its public part) is determined by the state budget policy, in the residential sector, considering the low paying capability of people and unwillingness to undertake additional loan liabilities for implementing energy efficiency measures, an important precondition for implementing building energy saving measures is availability of the European Union structural funds. It can be assumed that the scope of energy saving measures is determined by the amount of the European Union funds targeted for energy efficiency improvement measures, the co-financing rate of the European Union funds and costs per unit of the volume of energy efficiency measures (m^2).

The Right Bank of Riga City has been in the leading position from the point of view of connecting new sites to the district heating system. As a result of successful cooperation with Riga City district heating operation, investors and project developers connect new apartment houses with the total area exceeding 1000 m^2 and business centres to the district heating system. During the last five heating seasons, sites with the total heat load of 86 MW have been connected on the Right Bank of the city.

Considering the size of heat loads of the new connected sites, it can be concluded that potential heat consumers trust the operation of the district heating operator and have appreciated it as a stable business partner from the point of view of both the technical offer and regarding favourable conditions of construction of heat networks. As the operator implements preventive measures by using the developed district heating system management and control methodology in heat transmission, it will provide the possibility of providing competitive heat supply on the heat market.

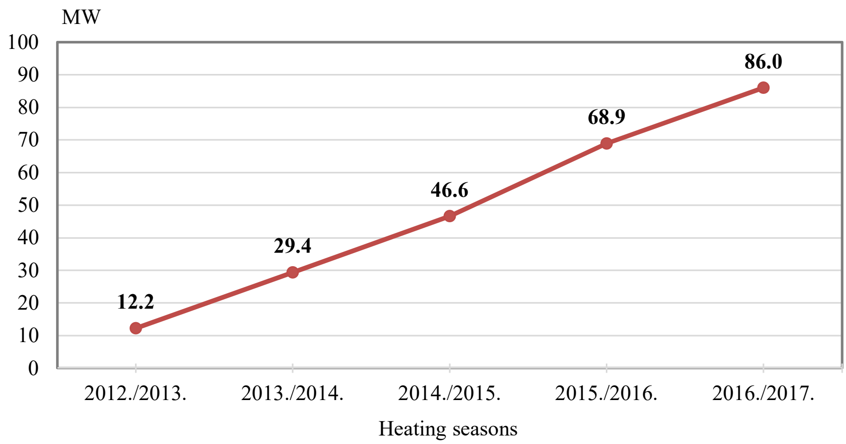

Fig. 4.1. Cumulative heat load of new connected sites on the Right Bank (5 years) [4].

CONCLUSIONS

Based on the experiments performed in the course of developing the Doctoral Thesis on the use of latent heat by using a condensing economiser, on the link between the transmission system supply and return temperature difference (ΔT) and the outdoor temperature ($T_{outd.}$) in the heat production sources in Riga and also as a result of assessing the application of renewable energy resources the following conclusions were drawn.

1. As T_2 is decreased by one degree in heat lines in the return pipeline, the heat transmission losses decrease by 1 % and the efficiency coefficient of the flue gas latent

heat utilisation devices increases by 2.5 to 2.8 %. Increase of the use of latent heat reduces the consumption of primary energy resources.

2. Before introduction of the DHS management and control methodology, the heat networks should be reconstructed by using pre-insulated pipelines.

3. It is recommended to review the proposal on including the DHS management and control methodology in "Energy Efficiency Law" of the Republic of Latvia aimed at rational use and management of primary energy resources in the DHS.

4. The DHS management and control methodology developed within the Doctoral Thesis will also help to perform social functions by allowing municipalities to reduce expenses for fuel, thus, being able to target the saved funds for financing social functions.

5. Long-term application of the DHS management and control methodology can provide the possibility for the heat supply system operator to reduce the heat rate and to secure improvement of competitiveness of the heat produced by the DHS on the heat market.

6. In the course of applying the DHS management and control methodology, sociological surveys among heat consumers should be performed in order to be able to continue developing this methodology and improving the comfort in apartment houses.

7. The DHS management and control methodology developed within the Doctoral Thesis will make reduction of CO_2 emissions faster in compliance with the Directives of the European Parliament and Council the requirements of which regarding improvement of energy efficiency and increase of the proportional share of renewable resources in energy are included in the Sustainability Strategy of Latvia for year 2030.

8. On the basis of the DHS management and control methodology the strategy of development of smart heat network in the cities of Latvia can be built.

9. The patent application "Automated control device and method for controlling the return temperature of a district heating system" is under preparation for submission to the Intellectual Property Commission of Riga Technical University.

REFERENCES

1. *2017.gada publiskais pārskats*. Rīga: Valsts meža dienests, 2018. 30 lpp.
2. *Meža nozare skaitļos un faktos 2018*. Rīga: Biedrība "Zaļās mājas", 2018. 52 lpp.
3. *Biomasas izmantošanas ilgtspējības kritēriju pielietošana un pasākumu izstrād*e. Rīga: SIA „Vides projekti", 2009.
4. Data of JSC "RĪGAS SILTUMS".
5. Лыков, А.В. *Тепломассообмен (Справочник)*, 2-е изд. Moscow: Энергия, 1978, 480 p.
6. Жуковский, В.С. *Основы теории теплопередачи*. Moscow: Энергия, 1969, 224 p.
7. Лыков, А.В., Михайлов, Ю.А. *Теория тепло - и массопереноса*. Moscow: Госэнергоиздат, 1963, 535 p.
8. Яковлев, Б. В., Кузнецов, Л. В., Терещенко, В. В. *Алгоритм расчета температурного графика теплосети*. Известия высших учебных заведений, 1982, pp.123−124.
9. Gadd, H., Werner, S. Achieving low return temperatures from district heating substations. *Applied Energy*. 2014, vol. 136, pp. 59−67. ISSN: 0306-2619.
10. Guidelines for low-temperature district heating. A deliverable in the project "EUDP 2010-II: full-scale demonstration of low-temperature district heating in existing buildings". 2014, 43 p.
11. *Rīgas teritorijas plānojums 2006.-2018.gadam. Paskaidrojuma raksts*. Riga: Riga City Council, 2015, 206 p.
12. *Ministru kabineta noteikumi Nr.338 Noteikumi par Latvijas būvnormatīvu LBN 003-15 "Būvklimatoloģija"* [Online]. Riga: Cabinet of Ministers, 2015 [Accessed on 1 March 2018]. Available: https://likumi.lv/ta/id/275013.
13. *Latvijas 2011.gada tautas skaitīšanas rezultāti*. Riga: Central Statistics Bureau, 2015, 230 p. ISBN 978-9984-06-482-6
14. *Latvija 2018. Galvenie statistikas rādītāji*. Riga: Central Statistics Bureau, 2018, 60 p. ISBN 978-9984-06-514-4.
15. Data bases of the Central Statistics Bureau. SG020. *Iedzīvotāju skaits un tā izmaiņas statistiskajos reģionos, republikas pilsētās, novadu pilsētās un novados* [Online]. Riga [Accessed on 1 March 2018]. Available: http://data1.csb.gov.lv/pxweb/lv/iedz/iedz__iedzskaits__ikgad/ ISG020.px/ ?rxid=d8284c56-0641-451c-8b70-b6297b58f464
16. Central Statistics Bureau [Online]. Riga [Accessed on 1 March 2018]. Available: https://www.csb.gov.lv/lv/ statistika.
17. Rīgas enerģētikas aģentūras datu bāze dzīvojamām mājām Rīgā [Online]. Riga [Accessed on 1 March 2018]. Available: http://www.rea.riga.lv/energoefektivitate/datu-baze-dzivojamam-majam-riga

Normunds Talcis was born on 13 July 1962 in Riga. He graduated from Riga Polytechnical Institute in 1987 and received the Diploma of Engineer-Constructor in Heat and Gas Supply and Ventilation. In 2006, Talcis obtained a Master degree in Engineering in Heat, Gas and Water Technology from Riga Technical University. Since 1998, he has been with AS "RĪGAS SILTUMS", first, taking the position of Head of Heat Department, then Head of the Dispatch Service, and the Technical Director. From 2003, Talcis has been a member of the Management Board of AS "RĪGAS SILTUMS", and from 2010 – the Chairman of the Management Board.

N. Talcis has been a lecturer with the Faculty of Civil Engineering and the Faculty of Mechanical Engineering, Transport and Aeronautics of Riga Technical University and also with the Higher Qualification Improvement Courses organised by AS "RĪGAS SILTUMS".