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THE OBSERVATION OF TARGETS ACHIEVED DURING DISTRICT HEATING DEVELOPMENT IN RIGA CITY

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INTRODUCTION

A modern district heating company is a power utility whose operations are based on the use of cogeneration or even trigeneration technologies and which provides district heating services.
Improvement of efficiency of district heating systems plays the decisive role in securing the company competitiveness which, in turn, is a precondition for utilising the advantages of the district heating system in power generation, in minimisation of the environmental impact that finally improves the quality of life and comfort of heat consumers and presents the hidden reserve of the economic development related with re-distribution of free financial resources and introduction of modern production technologies.
JSC „RĪGAS SILTUMS" produces heat at 5 heat plants with the capacity ranging from 50 to 405 MW, two of which operate in a cogeneration mode, and at 38 automated gas fired boiler houses with the capacity ranging from 0.05 to 20 MW, two of which operate in a cogeneration mode. The total installed heat capacity of JSC „RĪGAS SILTUMS" equals 1082 MW.
The total length of heat networks in Riga is more than 800 km, of which JSC "RĪGAS SILTUMS" owns 684 km and more than 116 km belong to individual companies, cooperative societies of apartment houses, state institutions, etc.

METHODS

Joint Stock Company "RĪGAS SILTUMS" which is the biggest district heating company in Latvia and also in the Baltic countries is the operator of the district heating system in Riga. JSC "RĪGAS SILTUMS" was founded in 1996 by merging the Heat Supply unit of the state-owned JSC "Latvenergo" and municipal companies operating heat supply systems.
At the beginning stage of its operation JSC "RĪGAS SILTUMS" had 6 heat plants and 111 non-automated boiler houses, i.e. 18 gas-fired and 93 coal-fired boiler houses. Approximately 50% of the heat consumers connected to the district heating system in Riga received heat via central heat sub-stations operating on the basis of a four-pipe system. There were totally 185 central heat sub-stations in the district heating system of Riga. The length of heat networks equalled approximately 1000 km, including 135 km of networks for supply of hot water.
In order to secure the required amount of supply of heat at the appropriate quality level to heat consumers, improve safety and energy efficiency of heat supply, minimise heat losses in pipelines and thus reduce harmful emissions to the environment, the implementation of the project for renovation of the district heating system in Riga was launched in 1997.
The project for renovation of the district heating system in Riga was implemented in compliance with the requirements of the Energy Law and on the basis of the concept of heat supply development in Riga.
In the course of the implementation of the project for renovation of the district heating system in Riga priorities were set and it was decided to implement the modernisation of the district heating system in two stages. Taking into account that the biggest heat losses were found at central heat substations and in the four-pipe system, the elimination of central heat substations and reconstruction of individual heat substations was performed at the first stage. During the second stage heat networks and heat sources were upgraded. This program included the following measures: a) replacement and reconstruction of the existing heat networks in bad condition; b) closing of small and medium inefficient boiler houses and connection of consumers to the existing heat networks or construction of automated boiler houses; reconstruction of large heat sources and installation of cogeneration units at heat sources.

Elimination of central heat substations

The program of elimination of central heat substations included the following: a) installation of individual heat substations in houses which used to receive heat via central heat substations; b) transition from a four-pipe system to a double pipe system and elimination of hot water networks; c) reconstruction of individual heat substations in buildings connected to the heat networks.
In the result, all 185 central heat substations were eliminated until 2001, 3008 new modern automated individual heat

substations were installed, as well as 135 km of the networks of hot water supply were eliminated. 8138 out of totally 8147 individual heat substations were upgraded during the period until 2015 (see Figure 1).

Figure1. The number of constructed automated individual heat substations

Construction of individual heat substations will allow adjusting the temperature in premises and setting the required hot water temperature.
The equipment installed at individual heat substations provides the following: a) the possibility of maintaining comfortable heat supply to a building in compliance with customers' demand; b) the necessary temperature in the building irrespective of the incoming temperature to the individual heat substation; c) automation of the heat supply process to the building; d) the possibility of rational use of heat preventing inefficient consumption; e) the possibility of accurate adjustment of hydraulic regimes of the internal heat supply system in the building; f) stable hydraulic regime of the system of the building irrespective of the hydraulic regime of heat networks; g) minimum water leakage in cases of damage to the heat system.

Upgrading of heat networks
The security and continuousness of heat supply in Riga depends to a large extent of the technical condition of heat networks. In this regard, repairs and reconstruction of the sections of heat networks in a bad condition and where heat losses exceed the standard indices is performed every year. First of all, the sections of heat networks where a bad condition of insulation, internal or external corrosion of pipes was identified and where there were a high number of accidents which may cause interruptions of heat supply to consumers, are replaced.
Reconstruction of the sections of heat networks is performed by using non-channel pre-insulated pipelines the operation of which is not impacted by a high level of ground water.
Replacement (re-installation) of the sections of main and distribution heat pipelines has considerably reduced the company expenditure related with heat losses, elimination of leakages in pipelines, as well as considerably improved the security of the district heating system in Riga.
Development of replacement of heat networks during last ten years (see Figure 2).

Figure 2. Replacement of heat networks during last ten years

In order to secure continuous and secure supply of heat to consumers, a four year program (2002 – 2006) was developed for replacement of sleeve joints with expansion joints in all main heat networks and installation of new shut-off fittings in all main chambers. In the course of implementation of this program, 1111 expansion joints with diameter up to Dn1200 were installed and 2164 units of shut-off fittings with diameters up to Dn800 were replaced. Completion of this program provided the possibility: a)to disconnect sections of heat networks in a fast and secure manner; b) to change heat supply regimes, thus improving the efficiency of district heating; c) not to disconnect consumers and to provide heat during summer repair periods and in case of accidents of heat networks.
Minimisation of the amount of losses in heat transmission is among the most important directions for the improvement of efficiency of district heating systems. Complete elimination of these losses is not viewed as a feasible possibility and they have to be included in the final costs of the product. Expenditure related with the heat carrier transportation may also reduce the effect of the use of cogeneration.
Major measures which allowed reducing heat losses: a) Reconstruction of heat networks by using pre-insulated pipelines according to the non-channel technology; b) Replacement of insulation of above ground heat networks and the heat networks installed in building basements; c) Reconstruction of insulation in heat chambers; d) Installation of modern equipment and shut-off fittings (ball valves, expansion joints); e) Systematic monitoring of leakages and their elimination. f) Systematic analysis of the increase of return temperature in heat networks and at customers and elimination thereof; g) Periodic flushing of drainage systems in heat networks; e) Application of modern technologies for connection of consumers to heat networks - pressure cutting; d) Hydraulic testing of heat networks; c) The system of collection of heat meter readings which was implemented in JSC "RĪGAS SILTUMS" allowed introducing continuous control over the alarm system of heat networks.
Fulfilment of the above listed measures allowed JSC "RĪGAS SILTUMS" to reduce the proportional share of heat losses from 19.97% in fiscal year 1996/1997 to 12.43% in fiscal year 2014/2015 (see Figure 3).

Figure 3. Reduction of heat losses in fiscal year 1996/1997 to fiscal year 2014/2015

Minimisation of the level of feeding heat networks is among the main goals in the course of operation of heat networks. In order to identify the places of leakage, district teams prepare plans for surveying main and distribution heat networks and the Dispatch Service analyses the use of feeding into heat networks and causes of any change therein. At present the identified leakages of the heat carrier in heat networks are low and it is difficult to identify them even with the help of the existing devices. Air photography is used as an additional tool for searching for leakages in heat networks. This has presented the possibility of identifying leakages and heat losses in a fast manner.
In order to speed up the search for leakages in heat networks, heat carrier is coloured green by using fluorescent for this

purpose. This allows fast identification and elimination of a defect.
The set of the above described measures for searching and eliminating leakages has provided results which are demonstrated by the annual decrease of the amount of feeding. Thus, in 2014/ 2015, in comparison to 1996/ 1997, the total feeding decreased by 189.4 t/h in JSC "RĪGAS SILTUMS". Change in the annual consumption of feed water per fiscal years (see Figure 4).

Figure 4. Change in the annual consumption of feed water per fiscal years

Upgrading of heat sources
In the course of implementation of the project of renovation the district heating system in Riga, JSC "RĪGAS SILTUMS" eliminated inefficient small- and medium-scale boiler houses, including the ones fired with fossil fuel. Heat consumers of these boiler houses were connected to boiler houses with high operational efficiency or new automated gas-fired boiler houses were built, in the result of which the specific fuel consumption for production of 1 MWh of heat decreased and the environment pollution was reduced.
By utilising the advantages of the district heating system which allow securing the lowest possible harmful emissions to the environment, JSC "RĪGAS SILTUMS" has been gradually reducing the negative environmental impact of heat production sources. Among the most successful projects of the recent years there is the complete reconstruction of a boiler house, during which old steam units were replaced by modern, highly efficient water heating boilers equipped with condensation economisers providing for the rate of useful operation of the boiler house above 100% according to the calculations based on the lower heating value.
In 2010, in the course of continuing implementation of modern technologies improving energy efficiency, in heat plant "Imanta" a condensation economiser with the heat capacity 10 MW, which is the biggest one in the Baltics, was installed for the boiler KVGM-100. In the result of its operation the efficiency was considerably increased (up to 102%), and the use of produced condensate allows minimising expenditure (which had been quite high) for purchase of water.
In 2010 a unique project was implemented at the heat plant "Imanta" - installation of an industrial absorption heat pump/ cooler which allows efficient utilisation of approximately 2 MW of low potential heat emitted from the cooling system to the atmosphere during the operation of the cogeneration power unit with heat capacity 47 MW. During the heating season when the heating load is sufficiently high, the absorption heat pump allows increasing the operational efficiency rate of the cogeneration power unit by 2%, reducing the amount of harmful emission to the environment, as well as reducing the amount of water used for the needs of the cogeneration cycle.
Improvement of energy efficiency, saving of emission allowances, reduction of power consumption, considerable reduction of the volume of harmful emissions, minimising of the rick of icing, reduction of the consumption of cooling water by 48,000 tons per year – this is the list of the major advantages gained by the installation of the industrial heat pump at the cogeneration unit of the heat plant "Imanta".
The heat plant "Vecmilgravis" was commissioned at the end of the 1970-ies and supplies heat to residential buildings and industrial companies of Vecmilgravis district. As no reconstruction of equipment had been performed since the commissioning of the heat plant, it was decided to radically upgrade this heat plant. In 2011 the modernisation of the heat plant, which was implemented in several stages, was completed.
During the first stage the obsolete boilers KVGM-100 and PTVM-30 in the existing premises were replaced with modern highly efficient water heating boilers equipped with condensation economisers and with the total heat capacity of about 50 MW;
During the second stage, in the course of active introduction of biofuel at its heat production sites, thus contributing to the fuel diversification with the goal of intensifying the use of local renewable energy resources and contributing to the reduction of the emission of carbon dioxide, a completely new boiler house was constructed with wood-chips fired water heating boilers with the total capacity 14 MW;
Following the start of operation of the new highly efficient equipment at the heat plant "Vecmilgravis" the total operational efficiency increased from 92-94% to 107-110%.
In 2013 other two wood-chips fired plants were commissioned – a cogeneration plant with heat capacity of up to 22 MW and electrical capacity 4 MW and a water heating boiler house with capacity 20 MW, where the fluidised bed combustion technology is implemented allowing combustion of a broad range of biofuel, which allowed increasing the proportional share of heat produced on the basis of renewable energy sources from 4.4% to 19.4%.
For the purpose of improving the efficiency of production of heat on the basis of biofuel, flue gas condensers are being installed. Flue gas condensers are used for improving the operational efficiency of boilers by utilising the residual heat of flue gases by reducing their temperature which allows improving the environment and using fuel more efficiently. This allows increasing the efficiency of use of biofuel from 85% to 105% (based on the lower heating value).

Figure 5. Total operational efficiency of heat sources of JSC "RĪGAS SILTUMS"

Note: Operation of several heat sources within a single zone when, in compliance with hydraulic regimes or due to technical reasons, relevant units may be put into operation accordingly, can impact the total operational efficiency of heat sources.

System of collection of heat meter readings

Because of continuous fluctuations of the gas price, it was necessary to ensure accurate metering of sold heat to consumers on monthly basis. Therefore, JSC "RĪGAS SILTUMS", after having analysed technical possibilities, in 2011 introduced a two-way system of collection of consumers' heat meter readings.
The system of collection of consumers' heat meter readings implemented in JSC "RĪGAS SILTUMS" ensures two-way communication with metering sets of all the consumers connected to heat networks in Riga. Implementation of this large-scale project ensured collection of sufficiently complete information regarding the condition of and the problems in the heat supply system of the city.
The whole city (300 sq.km) is serviced by a minimum system infrastructure.
The whole system infrastructure consists of 41 base stations of transceivers and 45 retranslators (i.e. just one base station and one multiplicator per 5.5 sq. km of the system coverage area). The system of collection of heat meter readings is multifunctional and also provides functions like reading of an individual heat meter upon request, remote software updating of metering modules, parallel (asynchronous) collection of data from all the meters in the system, immediate transmission of an alarm signal regarding interruptions in the power network, immediate transmission of an alarm signal regarding attacks to the site, identification of accidents in the heat network and transmission of an alarm signal thereof. Among the most important achievements there is the fact that the system for communication with 7500 end units located in the area of more than 300 sq. km requires little resources.
The system of meter reading was integrated with the existing software of JSC "RĪGAS SILTUMS" allowing implementation of technological control and recording of various measurements, as well as performing their detailed analysis.
Taking into account the technical possibilities of the project, JSC "RĪGAS SILTUMS" collects data on daily basis at 9:00 a.m. This allows all the services to implement control over the consumption of heat by consumers. Control over consumers or consumer groups according to any time mode, as well as the possibility of individual inquiries of data from meters from any computer in the company network or from a mobile telephone has improved the efficiency of work of the heat inspection. The project which was implemented in Riga serves as the confirmation of technical achievements in the area of two wireless communications. The project success is based on the fact that the expanded system has demonstrated security, operationality and a high level of availability and communication. The system has turned out to be very secure also under extreme operational conditions. Successful communication is maintained in more than 99% of all 7500 installed measuring sets. With the help of developed software the employees of JSC "RĪGAS SILTUMS" ensure continuous control over the operation of individual heat substations and, in case of necessity, notify problems to the maintenance organisation.

Installation of allocators

Implementation of the program for renovation of the district heating system in Riga regarding installation of modernised heat substations provided the savings of approximately 8-10% of the total amount of heat consumed by a house. However, there were also buildings where heat bills increased. For example, after installation of heat substations circulation in the system of hot water supply and heating was improved. In the quarters where it used to be cold before, temperature increased to 18-20 degrees, thus the total heat consumption by a house also increased.
As heat supply is a very expensive service, JSC "RĪGAS SILTUMS" wants to ensure that customers continue saving heat also in future. We have reached a new level now and offer consumers to save not only on the level of a house, but also individually in their apartments. For this purpose allocators, which should be correctly referred to as distributors of payment for heating, may be installed in apartments and regulators on radiators allowing residents to change heating temperature in a room. The allocator is not a heat meter, it is the distributor of the payment for heat. For example, a water meter records how many cubic meters of water were received per month. The allocator cannot meter how many kilowatts were used for heating the apartment, however these devices record what proportional share of the total heat consumption of the house was used in the particular apartment. Thus, also heat bills in different apartments will differ.
This principle was invented 99 years ago in Switzerland, and in 1981 the mandatory installation of allocators in all the apartment houses in Germany was commenced, as the energy crisis started there at that time. According to the estimations by German experts, thanks to adjustment and individual metering of consumed heat it is possible to achieve savings of up to 20% and in some houses even more. In Latvia the use of heat payment distributors started in the beginning of the 2000-ies.
The efficiency of allocators was confirmed by our pilot project implemented in a municipal house.
In autumn 2014 we launched a project – research regarding the impact of allocators upon heat consumption in individual apartments of a municipal house. In the beginning we proposed this idea to residents in regular privatised houses, offered to test this system in their apartments, however in such houses it is difficult to come together for taking a decision. Due to this reason a new municipal house was selected for this pilot project (see Drawing 1).
We installed allocators on all the radiators in 168 apartments of this house. It is important to understand that in this house there was a modern two-pipe heating system, there were regulators on radiators allowing each resident to adjust heating temperature in rooms. However, earlier the residents of the building were not interested in changing the adjustments of

radiators because their heating bills were the same as those of their neighbours who were not saving heat. After the installation of allocators everything changed. People understood the main principle: one pays for what was actually consumed.

By implementing the pilot project we offered a full set of services, in particular, we installed allocators and covered the related costs, we were recording their readings and issued heat bills accordingly. For us it was important to understand for ourselves how the process of individual metering of heat should be correctly organised, in order to be able to offer the same service also in other houses in Riga.

We found a manufacturer of allocators whose devices not only allow to record readings of the proportional share of heat consumed in the particular room once a month, but also record the mean temperature in this room. It seemed important for us in order to see how the quality of life changed after people started adjusting their radiators and saving money paid for heat. Now, when somebody is complaining that heat bills are too high, we can check the data about this apartment and explain why the person pays for heating more than the neighbour.

Now once a month an employee of JSC "RĪGAS SILTUMS" remotely reads the data of all the allocators by using a mobile device. Then residents receive accurate heat bills for the share of heat consumed by each apartment.

Prior to launching the pilot project, the experts of JSC "RĪGAS SILTUMS" very carefully studied methodologies of assessing the payment for heat by using allocators applied both in Latvia and abroad. We also heard complaints from people that after the installation of allocators some of them have to pay for heat more than before. It turned out that the problem is not caused by the allocators, but by the assessment methodology used in each equipped house, as everything depends on the proportional share!

Payment for heat in such houses consists of two items, in particular: the payment for the proportional share of the total heat consumption of the house consumed by the particular apartment, and the payment for heating of the premises of common use, which amount is distributed among apartments, as well as heat provided by the heating system pipelines. Based on a decision of the general meeting of apartment owners, any proportions of the two above components may be applied. For example, residents may decide that 70% of heat will be accounted for by using allocators and 30% will be the fixed payment depending on the area of an apartment. Under the system of individual metering, by adjusting radiator settings residents can only impact the first component of the payment.

The proportion of 70/30 was borrowed in Latvia from the Western Europe and it was incorrectly accepted. First, because in Europe settlement is done once a year based on the mean annual consumption, but in Latvia this is done once a month. Second, in Latvia there is a high number of not reconstructed houses where the heating systems are in a bad condition. It is clear that the heat distributed among apartments, heat supplied from the heating system pipelines and heat consumption in premises of common use account for a much higher proportional share than 30% of the total payment for heat.

If the proportion of 70/30 is applied in such a house without further consideration, the residents who switch off their radiators completely for the sake of saving are winners. They will only pay for the "common heat" which is quite cheap according to this proportion. However, the residents who switch on radiators at least time from time will pay the biggest part of the total heat bill of the house. This situation can be easily corrected by introducing correct proportions for payment for heat in the house. We at JSC "RĪGAS SILTUMS" chose the mean outdoor temperature as the starting point for the methodology. For example, if the mean outdoor temperature during this month was-10, the proportion 70/30 is applied in the house for calculation the payment for heat by each apartment. If the mean temperature is 0, the applied proportion will be 50/50 and if the temperature is +10 we consider that the correct proportion would be 30/70.

On our scale there are several steps, which means that any outdoor temperature fluctuations impact the calculation of heat bills in the relevant month. Many service organisations have independently arrived to the same conclusion and are also changing the payment proportions depending on, for example, the season of the year. However, in houses where the administrator and apartment owners apply the same proportion all the time there are huge problems!

Moreover, in the course of calculation of the payment for heating we also apply the coefficient of the location of each apartment. We understand that if an apartment is located on the top floor or in the corner of the house, its owner will have to use more heat for heating the rooms than his/ her neighbours located in the central part of the house. Historically, people were privatising apartments and did not have much choice. Due to this reason the application of such coefficient of location is just fair. These coefficients for each house are defined by experts on the basis of the basic estimation of heat losses.

Recently the Cabinet Regulation has entered into force imposing an obligation upon energy auditors to estimate these coefficients and to provide recommendations regarding their application.

Drawing 1. Implementation of the pilot project of installation of allocators in a new municipal building.

Figure 6. Comparison of heat consumption prior to and after implementation of the pilot project of installation of allocators in a new municipal building.

The comparison of consumption of thermal energy before and after the pilot project implementation on installation of allocators to new municipal building shows that in comparison to heating season year 2013 /2014 the residents of building, where the installation of allocators took place, saved approximately 20% of thermal energy in heating season year 2014 /2015. In the same time the residents of similar new buildings, where allocators were not installed, consumed on the average 2% more heat in heating season year 2014 /2015 if compare with a year earlier (see Figure 6).

DISCUSSION

The assessment of the policy of the development of district heating system in Riga during the operation of the company leads to a justified conclusion that it has been successful. This is attested by the fact that the heat price in Riga is lowest among the capitals of the Baltic countries and even among the biggest cities in Latvia. JSC "RĪGAS SILTUMS" has managed to achieve this thanks to the invested effort for minimising heat losses. At present heat losses amount to less than 13% of the heat supplied to consumers, and in 1996/1997 heat losses amounted to approximately 20%.
In 2013, thanks to the launch of operation of biofuel-fired heat sources where wood chips which are cheaper than natural gas are used, the heat price was reduced by 3%.
Thinking about future plans, JSC "RĪGAS SILTUMS" is actively working towards maximum reduction of operational costs, which will allow offering even lower prices, at the same time providing high quality and security of heat supply, efficient use of natural resources, maximum reduction of the environmental impact. This means that long-term solutions for improving energy efficiency are required, including the use of the state-of-art technologies, minimisation of dependence on imported energy resources and broader use of local bio resources which is not only a more profitable solution for the company, but also contributes to the economic development.

REFERENCES