PROBLEMS OF THE HEAT PUMPS INTRODUCTION IN UKRAINE

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ABSTRACT: This report considers present difficulties of heat pumps sector and reasons of their introduction in economics of Ukraine. With respect to the Ukrainian climate heat pump systems will play an important role. Successful introduction of series of demonstration models is a key component for good future of heat pumps technology.

Key words: ***heat pump, status, market, trends, application***

INTRODUCTION

Runaway world price rise for scarce fossil fuels makes the issue of energy conservation and usage of the renewable energy sources not only relevant but also vital for Ukraine where its own fuel and raw material resources are sufficient only to meet 47% of the required amount.

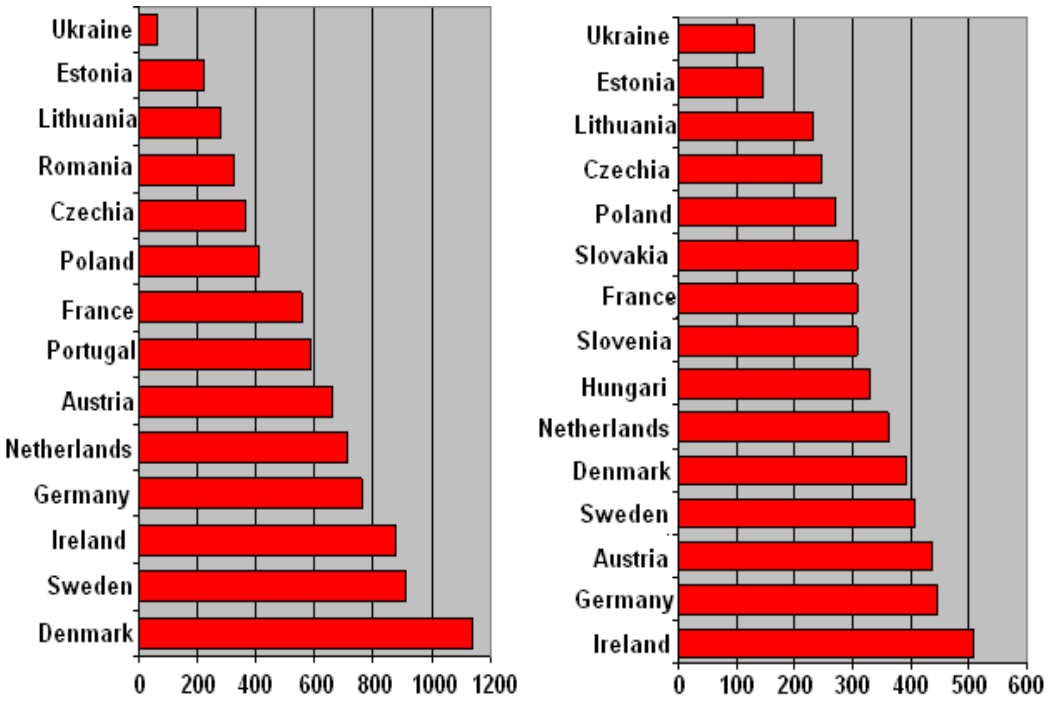
It is proven by the operational experience of millions of heat pump systems in the world that today one of the most energy-efficient technology of heat production that uses non-traditional renewable sources is the heat pump technology. Current situation in the world with pace and volume of heat pumps introduction in recent years gives grounds to believe that the International Energy Agency's forecast about 75% of replacement of conventional heat-generators by heat pump generators in housing sector is successfully realizing by 2020, and about the fact that it will be heat pump technology that will take a leading position in heat generation system processes in industry, agriculture and energy by the middle of the twenty-first century.

Unfortunately we must state that worldwide large-scale applied heat pump technology especially in recent years is just beginning to get used to in Ukraine (Matsevity Y. M. 2007). This lag is explained by a number of objective and subjective reasons that will be discussed below.

2 INTRODUCTION PROBLEMS

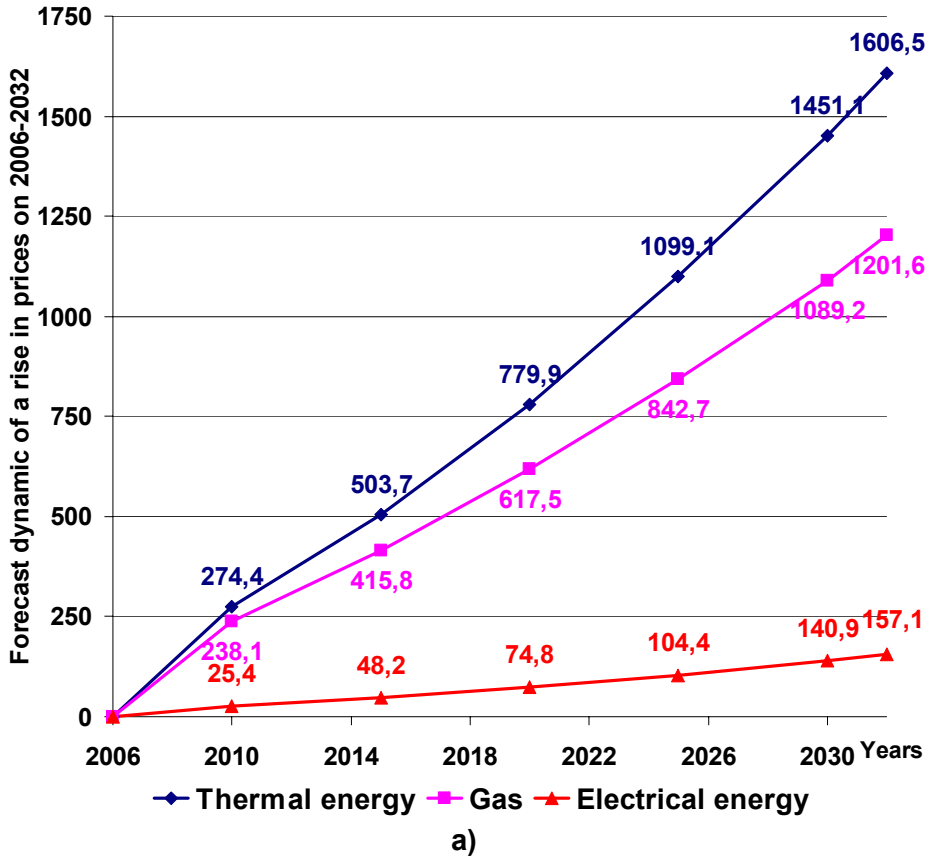
The main objective reason which hinders economical implementation of heat pumps is considered to be low price for all types of hydrocarbon fuels that was inherited from the times of former Soviet Union. As long ago as 2007 the gas price for private consumers in Ukraine was 11 times lower than the average European price (Fig. 1 a). For the industrial sector the difference was 2.7. Of course under such conditions projects with the use of expensive heat pump technology in terms of payback of the primary investment were not attractive neither for private investors nor for the government.

On the one hand changes in the fuel and energy sector of Ukraine in recent years favor to the use of heat pumps (HP). According to estimates of native and international experts the price for the fossil fuel in Ukraine is strictly increasing (Fig. 2a), significantly outpacing the growth of the prices for electricity.

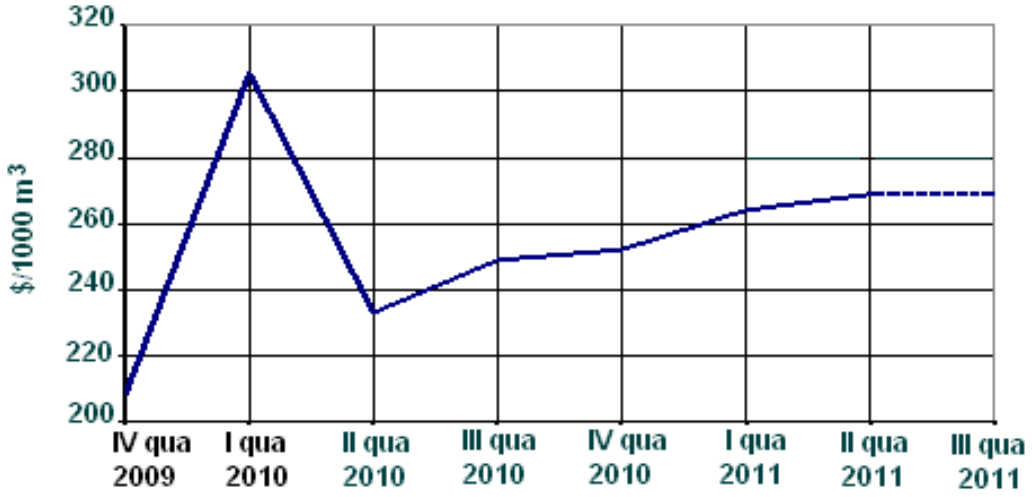


Source: Eurostat, NAK Ukraine

Fig.1. Cost of natural gas, €/1000 m^3, in a) domestic and b) industrial sector



a)



b)

Fig.2. a) forecast of gas prices for years 2007-2030 , b) the script of price changes over the past two years,

According to the forecast of the World Bank experts price for natural gas in Ukraine in 2011 was declared at the level of 250 US dollar/ thousand m3 and by 2017 should rise up to 312.5-438.0 US dollar/ thousand m3. On the other hand current negotiations with Russia on additional discounts for gas indirectly negatively affect the decision making to purchase heat pumps as it worsens correct realization of a feasibility study on the rationality of projects' implementation.

Another objective reason that caused difficulties with the introduction of energy-saving HP technology in Ukraine is the fact that the development of heat supply in cities of Ukraine is connected with central heating and central heating cogeneration. Financing of the individual heat and cold supply systems was realized by residual principle. Undoubtedly that combined production of both electric and heat energy on heat power plant or heat supply from the large modern boiler houses is thermodynamically the most efficient way of primary energy fuel use for municipal needs with minimal environmental impact. However up to 60% of Ukrainian population lives in rural areas, small towns, villages, remote from the district heating grids, and here for the purpose of heating and hot water supply individual low-powered heat-generators with solid or liquid fuels often are used. In order to use more convenient gaseous fuel people often have to pay for the permits and for the construction of local gas pipelines. These costs exceed the cost of HP implementation.

The third reason is the lack of a wide range of legal documents for HP including documents that regulate the interaction of the urban energy management structure, financial institutions (commercial banks, investment funds, etc.) and energy producers on issues of mutual payments for the produced heat with HP and financing implementation.

In Ukraine there is practically no public support for the application of heat pump technology. This is the fourth problem of the HP implementation.

Encouraging steps have been made recently in this direction when at the governmental, municipal and regional levels started to develop innovative projects on the application of HP in the heat supply system and hot water supply system of municipal sites, formation of the implementation incentives, discussion of the issues concerning the reduction of taxes on

imported products for energy-saving HP technologies and new status on the receipt and distribution of profits obtained from the implementation. Solution of these issues would make the heat pump technology more attractive for investors and customers. Realization of 20-30 pilot demonstration projects in different regions of the country with the government support would be the best advertisement for their widespread introduction.

The fifth reason of problematical introduction of HP in Ukraine is a lack of fair quantity of design, installation and service companies with sufficient experience. At that expected annual growth of the market introduction of HP is estimated as at least 70-80% in the next two - three years.

Hundreds of Ukrainian firms are ready to perform work on design, delivery and installation of heat pumps without much practical experience and skilled professionals in this field. According to the expert assessment of the author (Fig. 3) based on the number of actually implemented heat pump systems with installed thermal capacity of more than 20 kW, the number of firms declaring their desire to install heat pumps (based on Internet searching results) exceeds in more than 3-4 times the number of firms that have one or more operational completed projects. Such situation arises that may lead to the discredit of the idea of using heat pumps. Therefore relevant question for a competitive implementation of heat pump technology in the Ukrainian economy is an issue of scientific research connected with optimization of the circuit design of heat pump systems in the heat and cold supply systems with equipment selection and rational modes of its operation, development of manuals and recommendations for local designers, installation and service companies.

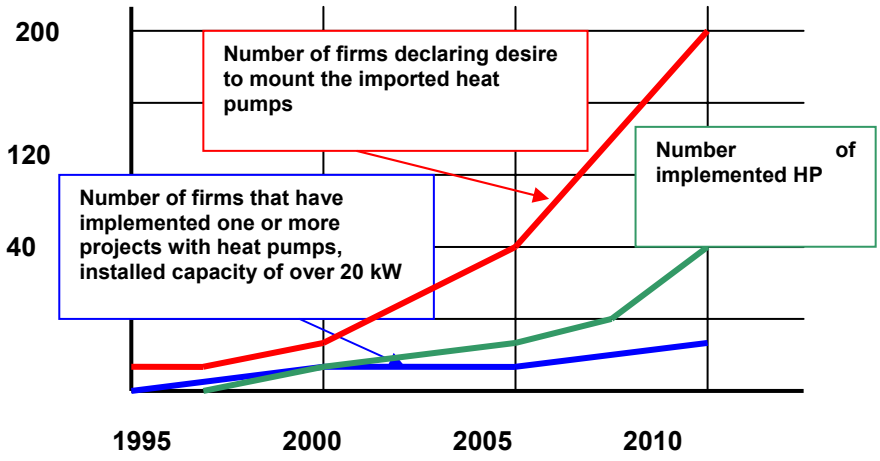


Fig.3. Number of firms that declare their participation in the implementation of HP technology.

3 BENEFIT FACTORS

Experts have common opinion: today favorable situation has being formed in Ukraine for the application of heat pump technology both in connection with approach of the Ukrainian energy prices to world prices, and in connection with increased attention to heat pumps from the government, public and investors. At the same time it should be emphasized that in view of advantages of heat pump technology it is not competent to make a tempting conclusion about the total replacement of traditional heat generators by them. There are areas of rational use of wood heating and zones of rational heat supply of the nuclear thermal power stations. And for a specific user a zone of expedient implementation of one or another form of heating is determined only on the basis of carefully performed technical and economic evaluation.

Comparison by operational costs of different types of public heat generation shows that the use of heat pumps at existing energy prices costs three to five times cheaper than electric boilers, and a half to two times cheaper than the solid and liquid fuel boiler houses. Almost equal to the price for gas boiler houses, and at further increase of gas prices will become more preferred.

Amount of fossil fuel that is replaced by thermal energy produced by heat pump is determined as

$$\Delta G = 0{,}1428\ Q_{TH}\ (\ 1/K_{тр}\ -\ 1/K_{тн}\ ), \qquad (1)$$

where ΔG - the difference of the fuel rate (t equivalent power) at the production of certain amount of heat Q_{TH} (Gcal) in accordance with the traditional technology and by using heat pump technology.

Ктр и Ктн - coefficients of primary energy use of traditional and heat pump methods of the heat generation. Determination of factors of primary energy use are specified (Kalnin I.M., 1966).

$$K_{тн} = COP_{д} \cdot \eta_{тт} \cdot \eta_{эс} \cdot \eta_{лэп} \cdot \eta_{ттп} \cdot \eta_{соб}. \qquad (2)$$
$$K_{рк} = \eta_{тт} \cdot \eta_{рк} \cdot \eta_{соб}^{рк}, \qquad (3)$$
$$K_{кв} = \eta_{тт} \cdot \eta_{тг}\ , \qquad (4)$$
$$K_{эл} = \eta_{эс} \cdot \eta_{лэп}\ , \qquad (5)$$

Here $COP_{д}$ is an efficiency of the actual HP cycle, $\eta_{тт}$ is transport fuel COP, $\eta_{эс}$ is net COP of the power station, $\eta_{ттп}$ is an efficiency of heat transport to the consumer and $\eta_{соб}=\sum N_{эл\ дв}/\ N_{ТН}$ is power consumption for own needs, thermal COP of district boiler house and housing heat generation $\eta_{рк}$ and $\eta_{тг}$ is taken into account. Obviously such fuel savings will be provided if $K_{тн} > K_{тр}$. Calculation results with formulas (2) - (5) are presented in Table 1.

Table 1: Rate of energy efficiency of heating systems

Element of the heat supply system	Indicator of the energy element efficiency	Traditional sources of heat generation				HP
		Electric heating	Housing heat generator	House boiler	District boiler	
Power station COP	$\eta_{эс}$	0,28- 0,33	-	-	-	0,28-0,33
Heat source thermal COP	$\eta_{рк}$, ($\eta_{тг}$)	1	0,4 – 0,6	0,5 – 0,6	0,6 -0,9	-
Transport fuel COP	$\eta_{тт}$	1	0,9	0,9	0,9	1
HP conversion COP	$COP_{д}$	-	-	-	-	3-4
Electric power transport COP	$\eta_{лэп}$	0,9	-	-	-	0,9
Heat transport COP	$\eta_{ттп}$	1	1	0.97	0,9	1
Coefficient of energy consumption for own needs	$\eta_{соб}$	-	-	0,9	0,96	0,9
Coefficient of primary energy use	K	0,25 – 0,32	0,36 – 0,54	0,39– 0,47	0,61-0,69	0,79-1,23

Analysis of the results shows that the use of electric heat pump systems allows to reduce fuel costs for the heat supply: compared with the large district boilers-houses in 1.2-1.8 times, compared with small boilers and individual heat generators in 2,0-2,6 times and in comparison with heaters in 3,2-3,8 times.

Cost savings for the electric driven HP is possible if:

$$(\xi_{эл} \cdot K_{тр}) / (\xi_{топ} \cdot COP) < 1, \quad (6)$$

where ξэл - electricity tariff, UAH. / (kW · h); ξтоп - cost of substitute fuel in conversion to its calorific value UAH. / (kW · h).

Express analysis dependence (6) graphically presented in Figure 4.

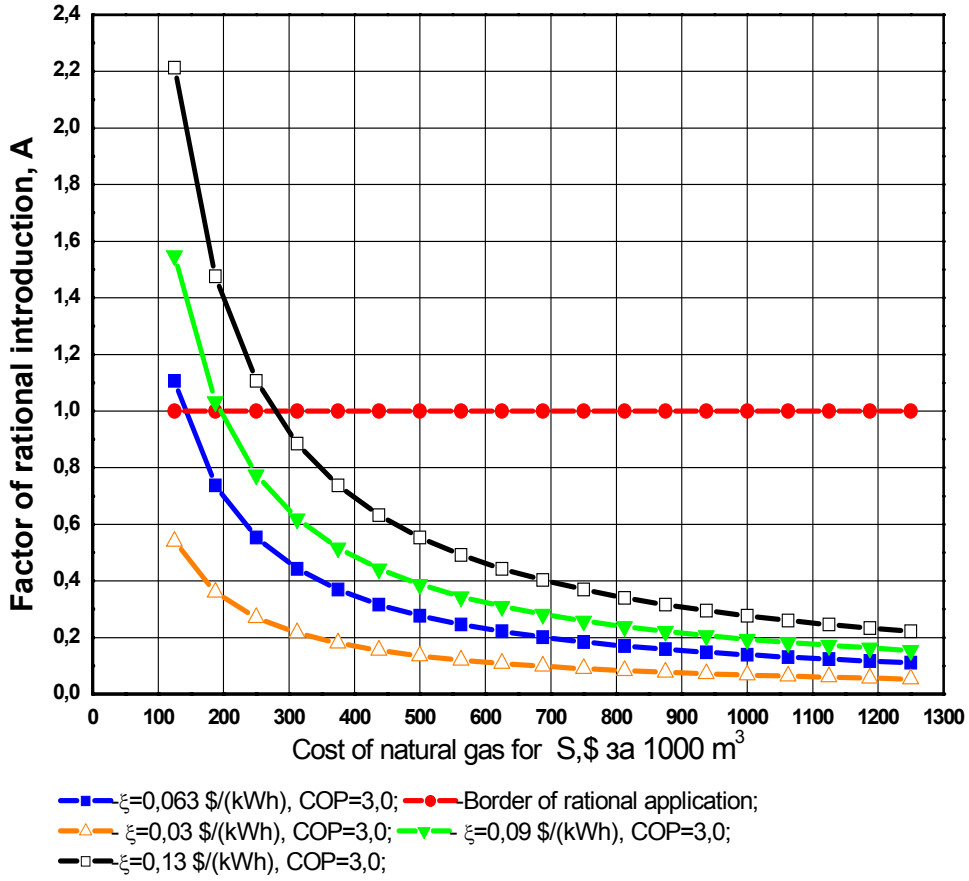


Fig 4. Area of rational implementation of heat pump

It should be taken into account that the competitiveness of HP depends on many factors of thermodynamic (circuit design, implemented cycle, temperatures of source and heating system, freon type, etc.), constructive (type of compressor and heat exchanger), economic (price for electricity and fuel, price for equipment). And in each concrete case only on the basis of technical-economic calculation the feasibility of heat pump implementation is determined.

4 APPLICATION OF THE HEAT PUMPS

Increased energy efficiency of heat pump systems in recent years allow us to find rational solutions of the introduction of heat pumps. Analysis of the developed projects allows us to highlight areas of competitive applications.

1. Primarily these are HVAC systems at the places with a lot of people (indoor pools, sports complexes, concert halls, shopping malls, large supermarkets.). Traditional schemes of heat and cold supply with separate use of boilers and air conditioners as a rule are power-consuming. Recovery of huge quantity of waste heat using heat pumps allows indoor pool, for example, to solve the problem of energy saving by heating and drying, ventilation air heating in winter and its cooling in summer, water heating in the pool. An example of such solution can serve a system designed and implemented in the indoor pool of sports club "Neftyanik, Ahtirka, Sumy region in 1998 (Fig.5).

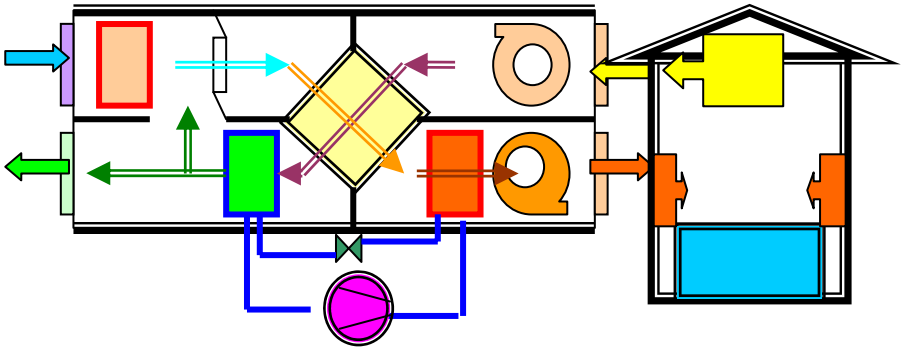


Fig. 5. Application of heat pump technology of low potential heat recovery in a typical indoor pool

Heat recovery of ventilation emissions with the use of “air to air " recuperator allowed to reduce to eight times the peak demand of heat power and to eliminate corrosive destruction of concrete and building structures. Period of successful system operation is more than 15 years; the primary investment payback period is 18 months. Using of heat pumps in the all-year-round air conditioning systems, heating and ventilation systems in shopping malls, including the use of recovery for hot water supply during the summer is very perspective. Such projects are now in implementation phase. At the same time preliminary calculations show that in winter only for heating and ventilation it is possible to achieve the reduction of the operating costs for 50-70% compared with conventional systems.

2. Individual heating, ventilation and air conditioning of residential, social, office buildings located away from centralheating systems and gas-main pipeline (houses, schools, kindergartens, hospitals, etc). The heating system of a suburban station at Zalyutino station, Kharkov was upgraded in 2006. Coal-fired boilers with total capacity of 50 kW were replaced by geothermal heat pump with the capacity of 38.6 kW with electric heater of 12 kW. The system successfully operates in automatic mode, reducing annual operating costs from 17 000 US dollars to 4.500 US dollars. In addition, installed equipment allows air conditioning during hot summer and provides hot water to the station all-year-round. There weren’t such benefits before the modernization. Modernization payback was 2 years and 6 months. In addition initial capital costs for the current system were alsmost 2 times lower compared with costs for planned installation of the gas heating system.

Fig. 6 Hot and cold water supply at Zalyutino station using geothermal heat pump a) station building, b) general form of heat pump boiler station.

3. Today heat pumps are in demand by a luxury cottage construction. Such implementations are increasing and they bring real savings to the owners. The main factor limiting the widespread implementation of heat pump at these sites is their high cost. Payback periods of heat pumps for domestic systems is from seven to nine years, for the industry systems is three or five years. For the owners of homes in the southern regions of the country where you can use relatively inexpensive and easy to mount heat pumps that use ambient air as a source will be the cheapest. Using them, for example, in the Crimean region will allow to produce the required amount of heat even in winter to ambient air temperatures minus 6 C according to the monovalent scheme. Residents of the cooler regions will have to choose between more expensive geothermal and water heat pumps or application of bivalent circuits with electric or gas boiler.

4. Today the use of heat pumps for the purpose of individual and centralized hot water supply is of practical interest for numerous industrial and municipal facilities in Ukraine. The actual gas consumption for hot water supply is estimated at 3 billion cubic meters of gas. As an example, by realization of the heat pump hot water supply system of the modern high-rise power efficient buildings due to the heat recovery of emissions, wastewater and heat of the soil or atmospheric air with heat pumps annual costs of power resource for water heating can be reduced by 45% (Vasiliev G.V., 2008).

5. Implementation of projects of heat pump heating systems using wastewater heat as low potential energy source for heat pumps in such cities as Zelenograd (more than six years of operation), Poltava, Kramatorsk indicate the possibility of obtaining the transformation coefficients COP 4-4,5 and higher. Currently a number of new projects is implementing in this direction in Ukraine

5 CONCLUSIONS

Ukrainian consumers of heat start to comprehend that the introduction of heat pumps is not just another upgrade of conventional heat generators but is the use of new, highly efficient conversion technologies and the use of low potential heat. Rising prices for scarce fossil fuels, problem solving of environment protection from products of combustion favor widespread implementation of heat pump technology, especially on housing sector of the national economy. This gives hope that within the next 10-15 years heat pump technology will enter to the Ukrainian way of life as well as today we use computers, televisions or washing machines.

6 REFERENCES

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