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Economic dependence of the consumer on the feasibility to regulate the heat supply system

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The paper explores the issue of cost-effectiveness of the transition from existing one-pipe, unregulated heating systems to two-pipe regulated apartment systems, with the possibility of installing thermostatic controls on each heater as well as heat meters in each apartment. Four residential buildings with the same specific heat load, which have central regulation, group regulation, local regulation and combined regulation, were selected. The actual heat consumption has been analysed and conclusions drawn as to the possible savings with combined control. One of the main conclusions is that renovation of existing in-house heating systems is an objective necessity

Keywords: heat supply system, heating system, control valves, heat meter

Економічна залежність споживача від можливостей регулювання системи теплопостачання

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Розглянуте питання економічної ефективності переходу існуючих однотрубних, нерегульованих систем опалення на двотрубні поквартирні, регульовані, з можливістю встановлення терморегуляторів на кожному опалювальному приладі, а також теплोलічильників у кожній квартирі. Для проведення аналізу було обрано чотири житлові будинки, з однаковим питомим тепловим навантаженням, які мають центральне регулювання, групове, місцеве та комбіноване регулювання. Проведено аналіз реального теплоспоживання, згідно до показів теплових лічильників, цих будинків за 2021-2022 опалювальний період. При центральному регулюванні фактична питома спожита тепла енергія склала: 0,106 ГКал/год·м²; при груповому регулюванні фактична питома спожита тепла енергія склала: 0,094 ГКал/год·м²; при місцевому регулюванні фактична питома спожита тепла енергія склала: 0,085 ГКал/год·м²; при комбінованому регулюванні фактична питома спожита тепла енергія склала: 0,054 ГКал/год·м². Якщо розглядається трьохкімнатна квартира площею 67 м², то економія теплоспоживання при комбінованому регулюванні, в порівнянні з централізованим становить 5364 грн. за опалювальний період, тобто 49%. До основних висновків статті можна віднести: лише наявність реальної технічної можливості регулювання виробітку, транспортування та, головне, споживання тепла дає дійсне зниження витрат палива на джерелах та відповідно зменшення грошових витрат споживачів на опалення; Існуюча більшість внутрішньобудинкових систем опалення житлових та цивільних будівель України не мають індивідуального регулювання споживання тепла кожною квартирою та приміщенням; Реконструкція існуючих внутрішньобудинкових систем опалення є об'єктивною необхідністю, без якої реальний вплив абонента на своє теплоспоживання неможливий. Така модернізація диктується і всіма нормативними термінами капітальних ремонтів, систем опалення, які у більшості випадків перевищені більш ніж вдвічі.

Ключові слова: система теплопостачання, система опалення, регулююча арматура, теплोलічильник

Introduction

Saving energy resources is a crucial objective for any country. Currently in Ukraine energy saving is the key to energy security, and is therefore more important than ever.

The issue of heat energy saving is very multifaceted and consists not only in the well-known directions: insulation of buildings; modernization of heat source equipment; replacement of existing heat network pipelines with pre-insulated pipes; replacement of obsolete mixing units (elevator units) with mixing units with mixing pumps and automation.

Undoubtedly, the implementation of all these measures improves the heat supply systems and brings significant economic effect in the form of reduced fuel consumption for the heat source and reduced heat consumption costs.

However, the consumer himself, i.e. the person to whom the comfort conditions for work and relaxation are created, can in no way affect the consumption of heat in his apartment, office, etc.

Review of the research sources and publications

The existing stock of twentieth-century residential and civic buildings is equipped with vertical single-pipe unregulated heating systems (Figure 1).

Analysis shows that in the majority of all buildings in Ukraine we have unregulated in-house heating systems, which should be regarded as a "single heater" for the entire building. Regulation of such a "single heater" is actually impossible.

In [1-4] issues related to the inability to regulate existing single-pipe heating systems have been addressed.

Reconstruction of existing single-pipe heating systems to two-pipe or single-pipe regulated systems can be found in the articles [5-9].

Reconstruction of single-pipe, unregulated heating systems into two-pipe, horizontal, regulated heating systems is carried out to allow each individual consumer can to affect the heat consumption of their premises. In this case, you can regulate with the thermostat on the heater. And an installed heat meter would allow the consumer to clearly see how much heat he consumed, how to regulate it, and how much he has to pay for it.

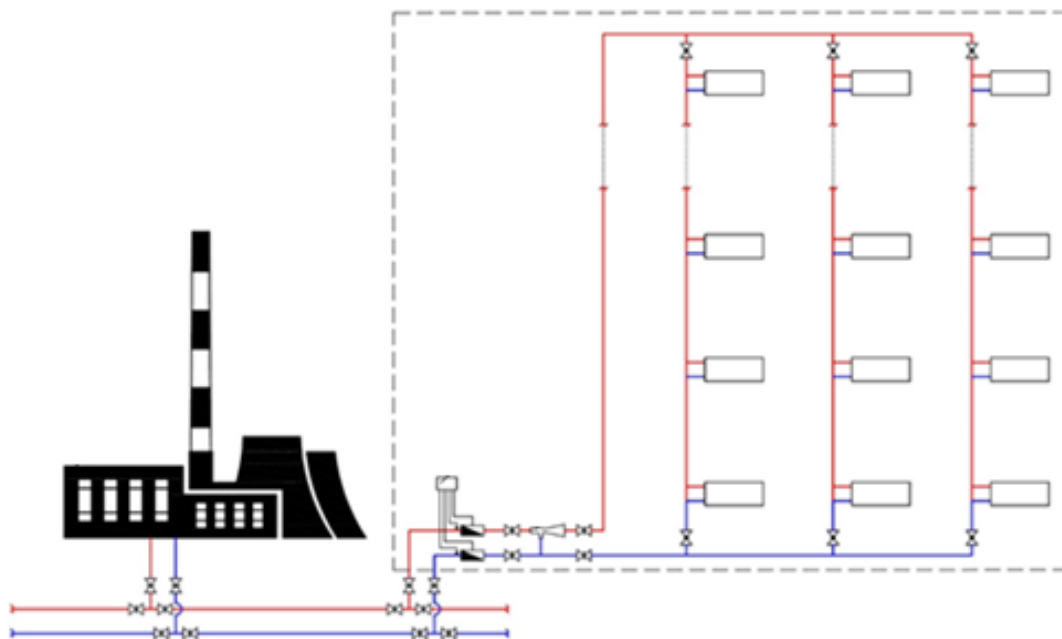


Figure 1 – One-pipe heating system for twentieth-century buildings

The electricity, water and gas supply systems in Ukraine, as well as throughout the civilised world, are built on such principles. For a long time now, these systems have allowed the consumer to independently meter, calculate and regulate his or her own consumption.

And only the regulation of heat consumption, the most expensive utility service, remains inaccessible to the consumer, the consumer simply has no real technical feasibility to do so.

Even having a whole-building heat meter does not solve the issue of heat savings by each individual consumer. This requires a heat meter in every apartment, office, hospital treatment block, etc.

Definition of unsolved aspects of the problem

All previously published papers have considered the technical feasibility of reconstructing existing heating systems, but have not analyzed the actual heat consumption of consumers under different types of regulation.

Problem statement

In this article we consider the issue of saving by each consumer and, as a consequence, the entire heating system as a whole, based on the actual technical capabilities of the existing heating systems of multi-storey buildings.

Most of Kharkiv's buildings and their heating systems date back to the 20th century. They were all built according to different designs and standards, with different materials, and in completely non-comparable social conditions. Why is this housing development not in line with European norms? Let historians and sociologists talk about it. We, as specialists in our field, must proceed from the actual situation and, based on it, give our recommendations, draw conclusions and make decisions.

Basic material and results

The purpose of any heat supply system is to cover the load of the heating system, to ensure a comfortable thermal environment at all times of the day and throughout the entire heating season. Only if this task is carried out one hundred percent can the system be said to be running stably, meeting all the required technical and economic parameters. To perform the task of heat supply the system must have the appropriate technical equipment (pumps, valves, sensors, etc.) in all its components: heat energy source, heat networks, equipment for heating substations, in-house piping and heating apparatus. Without such technical equipment along the entire chain: heat generation, transportation and consumption from the heat source to the heater, effective regulation is impossible. The lack of real regulation of any of the elements in this chain leads to overconsumption and consumer discomfort.

According to [10-11], there are the following main generally accepted types of regulation of heat supply systems:

- *central regulation*: carried out at the heat source (boiler-house or combined heat and power plant, CHPP), according to the predominant type of load characteristic of the entire heat consumption area from the given source;
- *group regulation*: carried out at the district heating substations according to the predominant load type of a certain group of subscriptions (residential quarter or neighbourhood, plant site)

The group heating substations are usually constructed for the centralized preparation of hot water for an entire group of buildings.

After using the heat transfer fluid from the heat source at the district heating substation, regulation is carried out according to the predominant heating load:

- *local regulation*: carried out at the individual heating substations of each building according to the average temperature for all rooms in the building
- *individual regulation*: carried out directly on each heating device of each room by the consumer himself, according to his wishes

The types of regulation mentioned above and laid down in [10] correspond to the regulatory principles long accepted and strictly observed in European countries.

In Ukraine, these principles began to be strictly observed only in the 21st century in all newly designed and built facilities, including in-house heating systems of residential and civil buildings.

All heat sources in Ukraine, regardless of their design, capacity and location, practically perform only qualitative regulation of heat supply to the consumer. They are regulated automatically or manually by adhering to a "design temperature schedule".

In all modern individual heating substations there is also a technical capability to perform qualitative-quantitative regulation of heat consumption of the entire object as a whole by setting a certain "average temperature" for this object.

Naturally, with this averaging of temperature, each placement, whether it is a room in a residential building, a ward or operating theatre in a hospital, group rooms and bedrooms in a kindergarten, classrooms in a school, receive an "average" amount of heat, not the amount they need at a given moment.

Only modern two-pipe in-house horizontal heating systems in residential and public buildings by design (Figure 2) allow the user to regulate the amount of heat transfer fluid to each heater by means of a thermostat on each heater.

Thus, the design of modern heating systems in residential and public buildings ensures individual heat consumption in each room. The presence of individual meters in each apartment of a residential building and a building-wide meter at the house inlet provides one hundred percent economy of the whole heat supply system, as each consumer is interested in taking the minimum amount of heat for his comfort, and the system as a whole generates the required amount of heat with minimum consumption of fuel and energy resources.

Today, however, no more than fifteen percent of heat consumers have modern two-pipe horizontal in-house heating systems with thermostat on each heater and heat meter in each apartment.

The remaining more than eighty-five percent of buildings that consume heat were built in the second half of the 20th century, during the period of mass housing construction, and are equipped with unregulated vertical single-pipe systems without thermostat on each heater.

As more than half a century of experience with these heating systems has shown, their design makes it virtually impossible for the consumer to perform any heat regulation.

Moreover, their actual condition precludes even the possibility of one particular heater or riser being switched off completely without significantly affecting the entire heating system.

The result of this ratio of unregulated to regulated in-house heating systems is that heat sources cannot be regulated in any way other than a qualitative regulation based on the "average temperature of the whole district of heat supply".

In buildings constructed in the second half of the 20th century and equipped with vertical single-pipe heating systems, only qualitative regulation is possible also because any change in the amount of heat transfer fluid in the riser pipes with heating devices leads to an arbitrary vertical deregulation of the entire system.

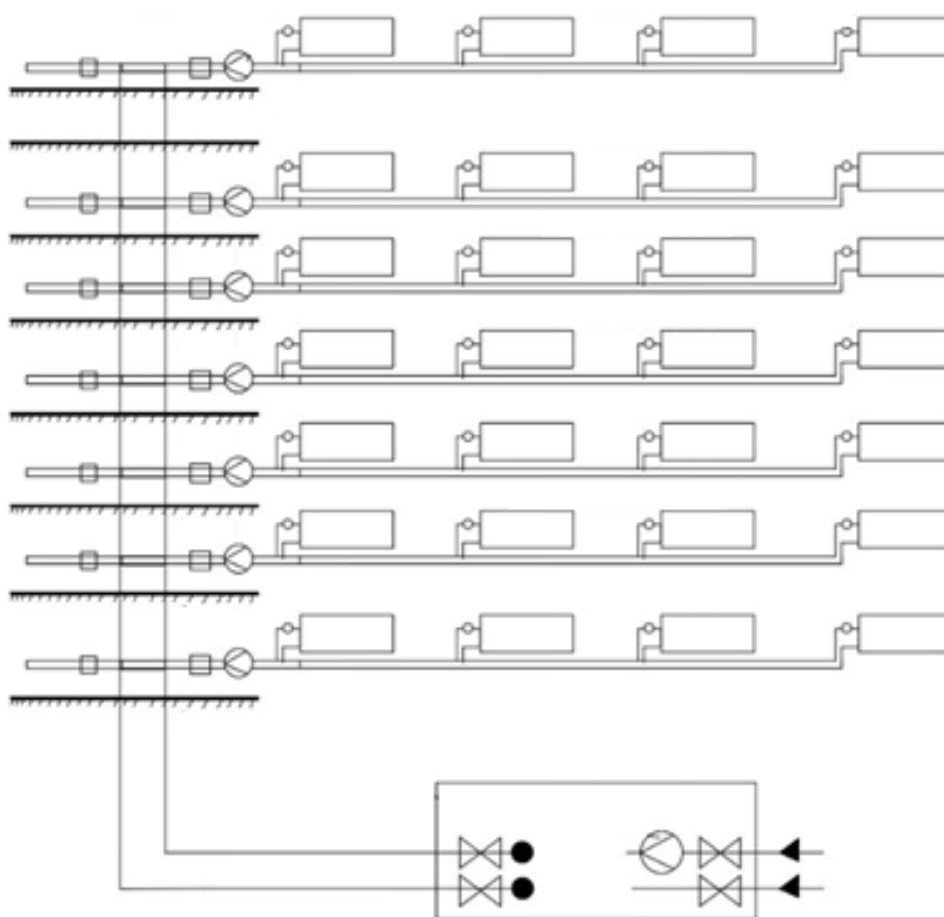


Figure 2 – Two-pipe horizontal apartment heating system

Therefore, even in the utterly new individual heating substations, which are now being installed in old buildings, we still only have the possibility of qualitative regulation.

In other words, equipping old buildings with new individual heating substations, we do not solve the problem of comfort of each consumer (tenant) because we only correct the "average temperature of the entire district or neighborhood" to the "average temperature of this building".

Only in modern houses built in the 21st century, which are equipped with horizontal apartment heating systems with meters and thermostats on each heater, does the consumer (tenant) really make the quantitative and qualitative regulation himself to create the comfort conditions he needs, regardless of the needs of other consumers. In doing so, each consumer creates a comfortable environment only for himself, at his own discretion, without preventing other consumers from doing the same.

Technical calculations, confirmed by the actual practice of heat supply companies, show that due to the technical impossibility of regulating heat consumption by each subscriber in each room of his flat, hospital ward or classroom, more than twenty percent of all fuel intended for heat generation in Ukraine is wasted, and each subscriber (a three-room flat with an average area of 70 m²) overpays thirty percent each month.

The results of the analysis of the current state of the heat supply from the point of view of heat consumption regulation are given below. All figures are based on actual data from heat supply companies in the Kharkiv region. This article shows the results of a study carried out on houses with both old single-pipe vertical heating systems and old houses with retrofitted new horizontal apartment heating systems with temperature controllers on each appliance.

We have studied the heat consumption of several residential buildings, with the following characteristics:

- regulation of heat supply only at the source, i.e. combined heat and power plant (CHPP) or boiler-house;
- group regulation at the district heating substation;
- local regulation at the individual heating substation;
- combined local regulation at the individual heating substation and individual regulation for each resident.

All residential buildings in question are equipped with heat meters.

The heat consumption analysis is compiled for the 2021-2022 heating season. Due to the fact that all buildings have different heating areas and different maximum heat loads, it was decided to make comparisons based on specific loads, which theoretically all approximately the same (Figure 3).

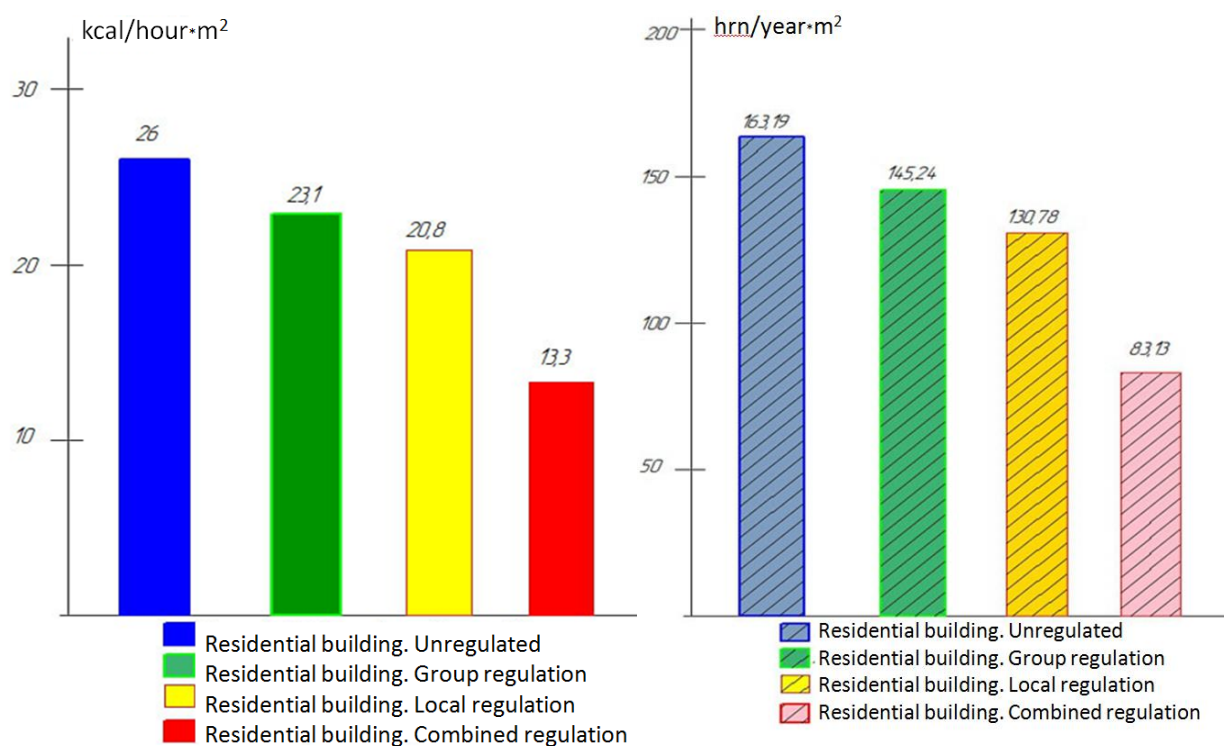


Figure 3- Plots comparing the actual specific heat loads averaged over the year (amount of heat consumed) and the specific cost of heat consumed over the heating period by residential buildings

The data for each type of building surveyed are shown below.

1. Residential building equipped with a heat meter, but no regulation. The actual specific heat load averaged over the year (amount of heat consumed) is 26 kcal/year·m². The heating period of 2021-2022 is 4084 hours. The specific heat consumption for the heating period is 0.106 Gcal/year·m². At the cost of 1 GCal in the amount of 1539 UAH 50 kopecks, the unit cost per year is 163.19 UAH/year·m².

2. Residential building equipped with a heat meter, regulation is group. The actual specific heat load averaged over the year (amount of heat consumed) is 23.1 kcal/year·m². The heating period of 2021-2022 is 4084 hours. The specific heat consumption for the heating period is 0.094 Gcal/year·m². At the cost of 1 GCal in the amount of 1539 UAH 50 kopecks, the unit cost per year is 145.24 UAH/year·m².

3. Residential building equipped with heat meter, regulation is local. The actual specific heat load averaged over the year (amount of heat consumed) is 20.8 kcal/year·m². The heating period of 2021-2022 is 4084 hours. The specific heat consumption for the heating period is 0.085 Gcal/year·m². At the cost of 1 GCal in the amount of 1539 UAH 50 kopecks, the unit cost per year is 130.78 UAH/year·m².

4. Residential building equipped with a heat meter, regulation is combined - local and individual. The actual specific heat load averaged over the year (amount of heat consumed) is 13.3 kcal/year·m². The heating period of 2021-2022 is 4084 hours. The specific heat consumption for the heating period is 0.054 Gcal/year·m².

At the cost of 1 Gcal in the amount of 1539 UAH 50 kopecks, the unit cost per year is 83.13 UAH/year·m².

The following are the results of the study on cash savings on heating costs for a three-room apartment of 67 m² in the case of real means of regulation.

In the first case, with regulation at the boiler house only, the cost to be paid by the consumer for the heating period is 10933.73 UAH.

In the second case, with the group regulation, the cost to be paid by the consumer for the heating period is 9731.08 UAH. The saving compared to the first case is 1202.65 UAH or eleven percent.

In the third case, with the local regulation, the cost to be paid by the consumer for the heating period is 8762.26 UAH. The saving compared to the first case is 2171.47 UAH or twenty percent.

In the fourth case, with the local and individual regulation, the cost to be paid by the consumer for the heating period is 5569.71 UAH. The saving compared to the first case is 5,364.02 UAH, or forty-nine percent.

If we consider a residential nine-storey building of three entrances with an area of 7220 m², the savings per year due to combined regulation compared to no regulation is 578033.20 UAH.

To summarize the issue of cash savings to consumers, it should be clearly understood that the heating organization has the same proportional fuel savings.

Conclusions

1. Only the presence of a real technical possibility to regulate the generation, transportation and, most importantly, consumption of heat provides a real reduction of fuel consumption at sources, and the corresponding reduction of cash costs of consumers for heating.

2. The vast majority of in-house heating systems in residential and civil buildings in Ukraine do not have individual control of heat consumption by each apartment and room.

3. The originally flawed technical design and the actual condition of the in-house heating systems of the vast majority of multi-storey buildings in Ukraine, contradict modern requirements and do not allow for cost-effective heat consumption.

4. Reconstruction of existing in-house heating systems is an objective necessity, without which the subscriber cannot really influence his or her heat consumption. Such modernization is also dictated by all the regulatory terms of major repairs of heating systems, which in most cases are exceeded by more than two times.

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