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SETTLEMENTS OF INDIVIDUAL HEATING COSTS IN MULTIFAMILY BUILDINGS – POLISH EXPERIENCE

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Abstract
European Directive on energy efficiency requires the settlement of energy consumers according to the actual consumption. The use of properly operating and socially acceptable settlement systems of individual heating costs contributes to energy savings in the residential sector. The paper presents the national legal requirements in this field and the possibility of using different settlement systems of heating costs. The main causes of irregularities in settlements of individual heating costs using heat cost allocators in housing sector in Poland are listed and described. There are presented proposals of existing irregularities elimination, in order to obtain adequate quality of the heating cost division in building into individual apartments.

Streszczenie
Dyrektywa dotycząca efektywności energetycznej nakłada obowiązek rozliczania odbiorców energii według faktycznego zużycia. Stosowanie właściwie działających i akceptowalnych społecznie systemów rozliczeń indywidualnych kosztów ogrzewania przyczynia się do oszczędności energii w sektorze mieszkaniowym. W artykule przedstawiono krajowe wymagania prawne w tym zakresie oraz możliwości stosowania różnych systemów rozliczeń kosztów ogrzewania. Wyszczególniono i opisano najważniejsze przyczyny występowania nieprawidłowości w rozliczeniach indywidualnych kosztów ogrzewania przy zastosowaniu podzielników kosztów w budownictwie mieszkaniowym w Polsce. Podano również propozycje usunięcia występujących nieprawidłowości, w celu uzyskania odpowiedniej jakości podziału kosztów ogrzewania budynku na lokale mieszkalne.

Keywords: **Energy efficiency; Energy saving; Heating; Heat cost allocators; Heating costs.**

1. INTRODUCTION

Actions aiming at reducing gradually the energy consumption in buildings have been introduced in Poland for more than 20 years in order to fulfill Polish energy policy and EU commitments. Settlement of consumers according to the actual consumption of energy is one such action.

Settlement systems of individual heating costs in Poland operate already in more than 50% of the total number of multifamily buildings. The experience shows that the installation of devices enabling the settlement of heating costs of individual apartments stimulates energy-efficient behavior of tenants. The result is a reduction in energy consumption for heating the building, estimated at approx. 10 to 20% of current consumption. This does not necessarily mean reducing of heating cost relevant to the energy-saving behavior

of tenants and respectively to reduced energy consumption.

Nowadays, this matter is of particular importance due to the requirements of the Directive on energy efficiency [1]. This is connected with obligation of metering the energy use in premises and apartments in multi-purpose and multifamily buildings. Devices enabling the settlement of individual heating costs according to the actual consumption and ensuring the proper billing accuracy should be installed in such buildings.

2. LEGAL REQUIREMENTS CONCERNING THE NEED FOR SETTLEMENTS OF INDIVIDUAL HEATING COSTS

General rules of settlements of heat costs between administrators or owners of buildings and energy companies, as well as between an owner or an administrator of multifamily building and its occupants are set out in regulations like: Energy Law Act [2] and Regulation on technical conditions for buildings [3] (which is the executive act to Building Law Act [4]). According to the above regulations, in multi-family buildings supplied with heat from a district heating network or using their own boiler is necessary to apply energy consumption measurement in whole building and in every dwelling as well.

According to the Energy Law [2] the basis for settlements of individual heating costs in multifamily building should be:

a) for residential and commercial premises:
- indications of heat meters
- indications of devices enabling settlements of individual costs, which are not measuring devices in the meaning of metrological rules,
- the surface area or the volume of these premises,

b) for common parts of multifamily building – the area or the volume of these parts accordingly in proportion to the surface area or the volume of occupied dwellings.

According to the Regulation [3] devices enabling settlement of individual heating costs should be used in a building with more than one dwelling or a commercial premise. The Regulation does not define a type of device and it is not required that it should be a measuring equipment.

The Act [2] requires an owner or an administrator of the building to use such a method of settlement of individual heating costs that meets the following requirements:

a) ensures the correct operating conditions of the building,
b) takes into account handicap factors resulting from the location of premises within the building,
c) stimulates energy-efficient behavior of users,
d) provides fees for heat corresponding to its consumption,
e) takes into account the amount of heat delivered to the premises by heating risers,
f) takes into account the amount of heat connected with heat transfer through partitions between premises.

There have not been developed yet detailed guidelines on the method in order to ensure transparency and accuracy of settlement of individual costs of heat consumption in the premises.

3. CONNECTION BETWEEN THE METHOD OF SETTLEMENT OF HEATING COSTS AND TYPE OF CENTRAL HEATING SYSTEM

Settlements of individual heating costs in multifamily building are carried out by dividing the total cost of heating the building into the costs of heating K_i individual units of account (premises). The total cost of heating the building is the sum of the fixed cost K_{sb} (independent of heat consumption) and the variable cost K_{zb} (cost of heat used for heating the building).

The cost of heating a single apartment K_i also includes two parts: the fixed cost K_{si} as a part of the cost K_{sb} proportional to the surface area (or volume) of a premise and the variable cost K_{zi} as part of the cost K_{zb} proportional to the amount of heat used for heating an apartment. In order to determine the cost K_{zi} of a single apartment it should be extracted the amount of heat for heating this apartment from the summary heat consumption, measured for the entire building.

The choice of the method of individual heating costs settlements for residential premises in multifamily building depends on the solution of central heating system.

Settlement systems based on indications of heat meters can be used for "the horizontal installation system", with horizontal distribution network in apartments, in which all radiators within a single

premise are supplied from one riser (Fig. 1). Settlement systems of individual heating costs based on indications of heat cost allocators are used for "the vertical installation system", with several risers in each apartment, in which different radiators within a single premise are supplied from different risers (Fig. 2). Such a system is dominant in existing multifamily buildings in Poland.

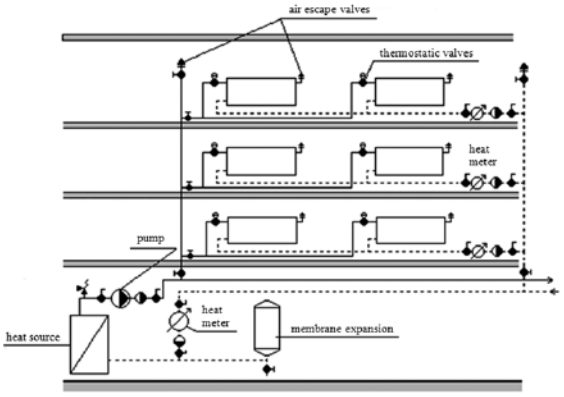

Figure 1.
Scheme of double-pipe central heating installation with horizontal distribution in apartments [5]

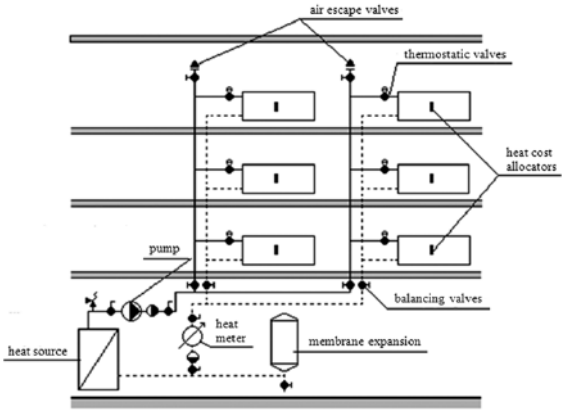

Figure 2.
Scheme of double-pipe central heating installation with several risers in each apartment [5]

3.1. Division of heating costs according to indications of heat meters in premises

Direct measurement of heat consumption using heat meters is possible in new buildings or thoroughly modernized ones equipped with central heating system supplied from one riser in each apartment. It is noteworthy that in such buildings heat consumption of individual premises is so small that volume flows of the heating medium during the average operating conditions of installation are very small. The correct measurement of very small flow rates is not possible if it is within inaccuracy or even deadband range. This causes problems in settlement of heating costs. In fact, these heat meters play a role similar to heat cost allocators.

3.2. Division of heating costs based on heat cost allocators

The method of division of heating costs using heat cost allocators is currently the most widespread in Poland, due to the dominant structure of central heating systems with radiators in each dwelling supplied from many risers. This method involves estimating the amount of energy supplied to the premises by individual heating surfaces. Auxiliary devices called heating heat cost allocators are used for this purpose. They are mounted on heating surfaces (on radiators) in the manner specified in the standards [6, 7].

The method assumes that an indication of a heat cost allocator in the billing period is proportional to amount of energy transmitted by a radiator to a room during the heating season.

Two types of heat cost allocators are used in heating costs settlement systems in Poland:

- without electrical energy supply, based on the evaporation principle – called evaporative heat cost allocators (only single-sensor allocators),
- with electrical energy supply, devices for the registration of the temperature integral with respect to time – called electronic heat cost allocators (single- or two-sensor allocators).

Single-sensor allocators register the temperature of the room heating surface or heating medium (assuming a constant air temperature in the room). In two-sensor allocators one sensor registers the temperature of the room heating surface or heating medium, the second sensor registers the room temperature or a temperature in a defined relation to it [8].

In settlement algorithms using heat cost allocators, it is assumed that the energy Q transmitted by the radiator in the accounting period is determined by the equation:

$$Q = C \cdot \int_{\tau=0}^{\tau=\tau_g} (\Delta t_m)^n \, d\tau = C \cdot \int_{\tau=0}^{\tau=\tau_r} \left(\frac{t_H - t_L}{1 - C_T} \right)^n d\tau \quad (1)$$

where: C – constant for the radiator, n – exponent of the characteristic equation of the radiator,

Δt_m – logarithmic excess temperature of the heating medium with respect to temperature t_L, t_L – air temperature in the room (for evaporative or electric single-sensor allocators it is assumed that $t_L = t_i = idem$, for two-sensor electronic allocators this is temperature of the room temperature sensor), τ_g – the duration of the heating season, τ_r – the duration of the settlement period, t_H – temperature of the radiator surface (for evaporative allocators this is a temperature of measuring liquid in ampoule, for single- or two-sensors electronic allocators this is a temperature of the radiator sensor), C_T – thermal coupling coefficient (equation 2).

$$C_T = \frac{t_m - t_H}{t_m - t_L} \tag{2}$$

where: t_m – mean heating medium temperature.

C_T coefficient is determined experimentally under so called "basic conditions" in accordance with the standards [6, 7], and is assumed as a constant value.

4. NATIONAL EXPERIENCE RELATED TO THE USE OF SYSTEMS OF SETTLEMENT OF INDIVIDUAL HEATING COSTS USING HEAT COST ALLOCATORS

Used for over 20 years heating costs settlement systems in Poland are in most duplication of systems used in the countries of western Europe. The critical evaluation of these systems is practically observed throughout this period. The main reason are the specific national circumstances creating different operating conditions in central heating systems, which are not included in the settlement algorithms taken from western countries. The next reason is inappropriate preparation of the buildings for the introduction of settlement systems and the improper behavior of building users.

Research [9, 10] on the improvement of methodology and system of heat costs division using heat cost allocators showed that the operating conditions for radiators and heat cost allocators adopted in the standards [6, 7] do not reflect the actual, variable operating conditions for allocators in typical Polish heating systems during the heating season. The actual operating conditions for radiators, which differ from the standard assumptions, influence on the indication errors of allocators, and cause the problems related to determining the correct cost of heating premises in multifamily building.

The temperature distribution on the surface of the radiator has the greatest importance for indications of the heat cost allocator. The surface temperature at the mounting location of the allocator has a direct influence on the temperature of measuring fluid in an ampoule of the evaporative allocator or on the temperature of the radiator sensor in electronic allocator.

In the method of division of heating costs using allocators, the heat flux emitted by the radiator is estimated on the basis of the static model of radiator-heated room. Such a model assumes stable standard heat-flow conditions. Such conditions in the actual central heating systems usually do not occur at all or are very rare. Heat fluxes exchanged between radiator and the heated room are transient because of qualitative and quantitative control of central heating system and changes of heating water mass flow caused by operation of thermostatic radiator valves. In addition, during most of the heating season, heating water mass flow flowing through the radiator is much smaller than the one in designing conditions. Throttling effect of the heating water mass flow changes temperature field on the radiator surface, which influences on operating conditions of heat cost allocators and contributes to errors of allocators' indications and heating costs' division.

The most important causes of irregularities in the settlements of individual heating costs using heat cost allocators are described in chapters from 4.1 to 4.7.

4.1. Oversizing of the central heating installation

Oversizing of the heating surfaces of radiators in relation to the heat demands of rooms causes the necessity of throttling the mass flow of heating water in radiators. Heating surfaces of radiators are oversized both during the design and operating phase of central heating system.

The reasons of radiators' oversizing connected to designing are following:

- the use of factors that increase the thermal power of radiators; these factors are required in installations with thermostatic valves because of the need for rapid heating rooms after periods of weakening or breaks in operation of a heating system,
- assuming power excess during the dimensioning of radiators; power excess is required in order to compensate the effects of weakening of heating

power in adjacent dwellings, according to the Standard [11],

- the presence of additional heat sources which are not taken into account during the dimensioning of radiators – eg. the internal heat gains and gains from not isolated risers of central heating installation.

Radiators are also often oversized after incorrect thermomodernization of a building, when a thermal insulation of a building envelope is made but the size of radiators is not adjusted to reduced heat demand of rooms after the renovation.

Figure 3 shows the impact of changes in the mass flow rate of water in the radiator in the range of $\dot{m}^* = \dot{m}/\dot{m}_o = 1 \div 0.1$ and the thermal load coefficient of the room $\varphi_{room} = (t_i - t_{e,x})/(t_i - t_{e,o})$ on the temperature distribution of heating water in the radiator and location of mean heating water temperature in the radiator. Mass flow rate $\dot{m}_o$ is value under design conditions.

If the radiator size is adjusted to the heat demand of the room and the supply temperature of radiator is in accordance with the required for the room qualitative control program, the state of thermal equilibrium is determined by the mass flow of heating water in the radiator equal to the one under design conditions $\dot{m} = \dot{m}_o$. Under real conditions, the thermal equilibrium state in the room is determined at the mass flow of heating water in the radiator $\dot{m} \neq \dot{m}_o$ (most commonly $\dot{m} < \dot{m}_o$).

The temperature distribution on the surface t_w of various radiators is different due to varied throttling of the water mass flow rate occurring in each radiator in the building. Therefore, there is different temperature at mounting location of allocator for each radiator.

On the Fig. 3 we can see that linear temperature distribution of heating medium occurs only at the mass flow rate of water under design conditions $\dot{m}_o$. Then the average temperature of heating water is located at the height slightly above half the height of the radiator.

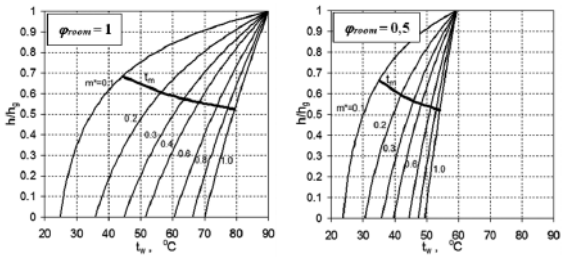

Figure 3.
The temperature distribution of heating water t_w and the location of mean heating water temperature t_m in the radiator at nominal parameters of 90/70°C and at thermal load coefficient of the room $\varphi_{room} = 1$ and $\varphi_{room} = 0.5$ [9]

The good correlation between the indication of the allocator and the amount of heat emitted by the radiator throughout the heating season is required in order to obtain the correct settlement of individual heating costs by using cost allocators. Irregularities in the division of heating costs are caused by the diversity of the temperature distribution on the surface of the radiators in individual rooms belonging to the same area settlement. Only if changes in the mass flow of heating water are the same in all radiators, it is possible to neglect their impact on the division of heating costs. Therefore, the correction of the size of the radiators with the assumption of constant temperature drop of the water in each radiator is the most appropriate method to adjust the power of radiators in buildings after theromorenovation (with the simultaneous introduction of heat cost allocators). It allows to maintain the similarity of the temperature distribution on the surface of radiators under the actual conditions to the temperature distribution on radiators under the basic conditions. This method eliminates many negative phenomena that generate errors in the division of heating costs, but it is rarely used because of technical difficulties and lack of consent of tenants.

4.2. Assumption about the constant coefficient of thermal coupling C_T

Thermal coupling coefficient C_T is an indicator of the thermal relationship between the temperature of the measuring fluid in an evaporative allocator or a radiator sensor in the electronic allocator and the temperature of heating water. According to the standards [6, 7] the value C_T is assumed as constant for the radiator-allocator couple (regardless of operating conditions) in settlement algorithms using heat cost allocators.

Theoretical analysis and laboratory tests described in works [9, 10, 12], have shown that the value of the thermal coupling coefficient is not constant and varies considerably within the building for the defined set radiator-allocator.

Fig. 4 shows the tests results of relationship between thermal coupling coefficient and relative mass flow rate $C_T = f(\dot{m}^*)$ for panel radiator and heat cost allocator installed at the height of the radiator equal to $h=0.75h_g$, for three values of supply temperature $t_1=42°C, t_1 = 62°C, t_1 = 72°C$, in the range of relative mass flow rate $\dot{m}^* = 0.2 \div 1.0$ [9].

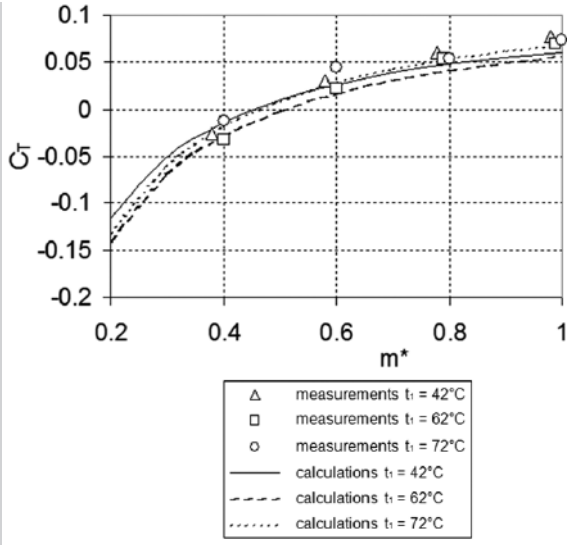

Figure 4.
Relationship between thermal coupling coefficient and relative mass flow rate for panel radiator and heat cost allocator installed at the height of the radiator $h=0.75\ h_g$ [9]

As can be seen from the graph in Fig. 4, the thermal coupling coefficient is not a fixed value ($C_T = var$) and depends on thermal and flow conditions in the radiator. For all tested allocator-radiator couples, it was found that the coefficient C_T decreases with decreasing mass flow rate of heating water and it depends slightly on the supply temperature of the radiator t_1. In other studies [9, 10], has also been shown that the coefficient C_T depends on the installation height of the allocator on the radiator.

Therefore, taking in the algorithms of division of heating costs the assumption that $C_T = idem$ causes poor correlation between the indication of the allocator and the total amount of heat emitted by the radiator to the room during the heating season. Such an approach generates errors in the calculation of the individual heating costs of premises.

In order to improve this correlation, it is necessary to determine the function $C_T = f(\dot{m}^*)$ and to introduce C_T coefficient as a variable and not a parameter for settlement algorithms. Such an approach was developed and presented in the works [5, 9, 10].

4.3. Immeasurable gains heat from the central heating system

In multi-family buildings in Poland, built in the last century, dominate double-pipe systems. Risers are not insulated and conducted by walls (usually external) in the apartments. On the ground floor, especially in high-rise buildings, where the diameters of risers of central heating system are the greatest (eg. DN 40), the rooms are heated mostly by heating surfaces – vertical ducts (risers). The heat emitted from these surfaces is not measured. Depending on the pipe diameter and the temperature of heating medium, part of heat supplied by the risers to rooms is varied. Radiators cover only part of the heat demand of premises, which causes low indications of heat cost allocators or even no indications (especially in insulated buildings). This fact consequently contributes to errors in the division of heating costs.

There are no specific rules in Poland for taking into account the amount of heat supplied by heating risers to premises. Settlement systems within 20 years of their functioning mostly did not take into account the heat emitted by uninsulated heating risers. The legal requirements in this area have been introduced in Poland only in 2016 by the Act [2], but criteria or methods of considering this issue in settlements of heating costs are not specified.

In existing buildings insulation of risers in residential premises is practically impossible for technical reasons and due to the possible opposition of tenants. In newly constructed buildings pipes of heating installation in heated rooms should be insulated and conducted in grooves inside building partitions. Appropriate changes in the Regulation [3] should be introduced.

There are guidelines in Germany [13], since 2009, giving the criteria that should be met within the premise in relation to taking into account or skipping heat gains from uninsulated risers in settlement systems. Three calculated indicators establish criteria for assessing the significance of the share of heat gains from heating risers in settlements of heating costs. Calculation of these indicators is based on the analysis of indications of heat cost allocators within one unit of settlements [13].

4.4. Heat flows between apartments

The desire to reduce the cost of heating after introducing cost settlement systems in the building, incline tenants to reduce the supply of heat to the rooms and the ventilation air flow or even turn off the heating (eg. during tenants' trips). This leads to decreasing the room temperature below the assumed design value. Therefore, heat flow between the premise heated to a higher temperature, and the adjacent premise with a lower temperature occurs. Such a problem exists because building partitions between apartments in multi-family buildings are not insulated. In Polish Regulation [3] there are no requirements regarding an insulation of partitions between apartments. This situation causes difficulties in proper settlement of heating costs and tenants may pay costs not only related to heating of their own apartment, but also of neighboring premises.

In the analyzes carried out in [5] it has been shown that the important factor relevant for the heat flow between premises is the number of external partitions or adjacent to unheated spaces. Heat losses in apartments with only one exterior wall are the most dependent on the users' behavior in neighboring apartments. In case of premises with three external walls and situated on the top floor, the energy consumption for heating is mainly due to heat losses to the external environment, so heat flows between the premises are less important. In addition, it should be noted that in buildings with a well-insulated envelope (new or after renovation) share of heat transmitted between different flats in the total heat losses of building increases. This means that heat flows between apartments have greater significance. Due to the fact that the behavior of tenants is varied with time and it is difficult to predict, so any computational method cannot take into account the actual amount of heat exchanged between premises in the heating season.

In 2016, in the Act [2], there was introduced the requirement that the method of settlement of heating costs should take into account the amount of heat delivered to premises as a result of heat transfer between premises. According to the Act, the amount of heat delivered in this way to premises should be estimated on the basis of registration of the air temperature in premises, if it is technically possible. It does not seem, however, technically possible and economically justified because of the lack of reliable methods of temperature measurement in premises, that would not be vulnerable to manipulation of tenants.

It would be better to use the insulation of walls separating individual premises in order to prevent heat flows between apartments.

4.5. The use of inappropriate compensatory factors

Polish legislation does not specify any relationship between the amount of rent and the energy quality of apartment in residential building. According to the Act [2], differences in energy quality of apartments should be corrected (compensated) during the settlement of heating costs in multifamily building. It should be assumed that in all premises operating conditions are the same and correct, which means that the design internal air temperature and the required ventilation airchange are preserved.

Location of apartments situated unfavorably within the building (corner premises or on the highest or the lowest floor) is the reason for higher heat demand, which is due both to their lower energy performance and to the usage conditions. The purpose of application of compensatory factors is to compensate for the increased energy consumption in such premises. Unfortunately, there are no appropriate guidelines about the way of calculating factors required by law.

In Poland, compensatory factors determined in accordance with the recommendations of 1996 [14] are mostly used. Recommendations provide two methods for determining the values of these factors: simplified – based on the tabular values and computational – taking into account the varied demand for thermal power of premises under design conditions (related to their surfaces). Both of these methods are not correct because they do not have connection with the seasonal heat consumption for heating of premises, as required by the Act [2]. Unfortunately, as the practice shows, the coefficients determined using the above methods, and especially using the simplified method are still preferred and applied by companies performing the settlement of heating costs.

The method of determining of compensatory factors which are connected to the seasonal heat consumption for heating of premises is presented in the work [5]. It requires the performing of calculations of the annual energy demand for the heating system in each premise, related to the unit area. The proposed method of determining compensatory coefficients allows for the achievement of the same amount of final energy demand for heating for the each premise, expressed in kWh/(m^2.rok), regardless of the location of the apartment within the building. In this case, differences in the energy consumption

depend only due to the usage conditions of premises. Thus, the use of such factors entirely compensate for the impact of the location of premises within the building on the settlement of individual heating costs.

4.6. Inappropriate division of variable costs into the part dependent and independent of indications of allocators

Variable heating costs for the whole building K_{zb} are determined on the basis of main heat meter in the building or on the basis of measurement of the amount of fuel in the boiler room. Then they are divided into individual premises as costs K_{zi} including two components:

- "dependent variables" – part of the variable cost K_{zi} divided on the basis of indication of heat cost allocators,
- "independent variables" – part of the variable cost K_{zi} including the charge for heating spaces of shared use, not equipped with allocators (eg. staircases, drying rooms, utility rooms) and other chambers not equipped with allocators (eg. bathrooms and kitchens in apartments); this part is divided proportionally to the area (or volume) of the premises.

Division of the costs of "dependent variables"" and "independent variables" of heat cost allocators' indications is usually determined arbitrarily in the settlement system and is embodied in the rules of heating costs. Such an imposed division of costs generally do not take into account the actual share of heat delivered by the "metering surfaces" (ie. radiators with heat cost allocators) in the total amount of heat delivered to individual rooms in the building. Because of this, unwarranted differentiations of the calculated heating unit cost for individual apartments may occur.

The division of the costs of "dependent variables" and "independent variables" should be considered individually in each building in order to achieve correct settlements. It should be noted that heat cost allocators are usually not mounted on radiators in bathrooms. In some buildings allocators are also not mounted on the radiators in kitchens equipped with gas cookers. Application of allocators in these rooms could be an encouragement for sparing tenants to turn off the radiators and reduce ventilation. Such action is a serious threat to the safe operation of gas appliances and could result in fungal attack.

In extreme cases only radiators in rooms are equipped with allocators, and the charge for the heat supplied for radiators in kitchens and bathrooms is then included in the part of the cost of "independent variables" of consumption (i.e. of indications of allocators).

4.7. Lack of verification of heating costs related to individual premises

A very important issue in settlements of individual heating costs is to control and analyze results of the division of heating costs in terms of "theoretically possible" heat consumption values by residential unit in order to ensure proper indoor temperature. Unreal costs, calculated in this way, can be detected. According to the practice, companies often charge to tenants such high, unreal heating costs. In addition, the heat consumption lower than minimal may indicate a significant reduction in indoor temperature (or even turning off radiators), as well as the lack of ventilation in rooms or excessive reduction of ventilation airflows. The result of such actions is the increase of heat flow between the premises or destruction of a structure of the building (moisture, fungal attacks).

Furthermore analysis of the results of settlements in apartments adjacent to the premises with impossibly low heat consumption would detect any manipulation of users wishing to diminish indications of allocators.

This implies establishing the requirements for settlement companies with regard to the verification of accrued heating costs of premises in terms of possibility of their occurrence. Companies should specify the maximum and minimum heat consumption for each apartment, assuming permissible deviations of the normative indoor temperature. These values cannot refer to reference climatic conditions and should be calculated taking into account actual external temperatures that have occurred in the considered heating season.

5. SUMMARY

The article discusses the most important issues in relation to settlements of individual heating costs based on the use of heat cost allocators in Poland. Despite more than 20 year period of their application there are many complaints of tenants of multi-family buildings concerning irregularities in settlements of individual heating costs.

In the near future it is planned the significant increase in the number of objects, in which will be used settlement systems of individual heating costs according to energy consumption in premises, including the ones on the basis of indications of heat cost allocators. Irregularities connected with division of

heating costs are well diagnosed through research studies and experience (often negative) of users of these systems. Therefore settlement systems should be introduced to properly prepared buildings and installations in order to improve their accuracy and reliability and to avoid well known errors. Whereas in buildings where these systems have already been introduced and systems do not function properly, it is necessary as soon as possible to revise their operating conditions and to make appropriate changes.

Eventual rejection of such settlement systems, in the absence of alternative solutions, can cause negative economical and energetic effects for the economy of our country.

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