



TECHNICAL MEASURES TO DECREASE HEAT ENERGY CONSUMPTION OF FINAL CUSTOMER IN MULTI-APARTMENT BUILDINGS ACCORDING TO ENERGY EFFICIENCY DIRECTIVE

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Abstract. Energy consumption in the world increases, so the measures in order to improve energy efficiency must be found. The aim of 2012/27/EU Energy Efficiency Directive targets is to decrease energy consumption for a final energy consumer by 1.5% every year, but there is no definition how these targets could be achieved by an individual member state. This article presents the analysis how these targets could be achieved by the means of individual heat metering by heat cost allocators for every flat thus decreasing an energy consumption for a final consumer. Statistical analysis of identical buildings with individual metering by heat cost allocators and without them is presented. Heat cost allocators do not decrease energy consumption by themselves, so this article presents a technical solution and a set of additional equipment, i.e. thermostatic valves, balance valves, hot water meters and remote data collection system that must be installed. The final results show that the targets of 2012/27/EU Energy Efficiency Directive in Lithuania can be reached, because the buildings with individual heat cost allocators consume about 20–30% less of heat energy.

Keywords: multi-apartment buildings, energy efficiency, heat meters, smart metering, heat cost allocators, balance valves, hot water meters, distant remote data collection system, 2012/27/EU Energy Efficiency Directive.

Introduction. The role of final customer in energy efficiency process

World fuel prices have advanced and global warming still is increasing, so the attention is paid not to how to extract ever greater amounts of energy, but how to use extracted primary energy more efficiently. The European Union aims to deal with this problem, and to increase the efficiency of primary energy use, the European Parliament and of the Council on 25 October 2012 has approved the 2012/27/EU Energy Efficiency Directive which replaces Directives 2009/125/EC and 2010/30/EU and repealing Directive 2004/8/EC and 2006/32/EC. It aims to oblige Member States to introduce the energy sector in order to improve energy efficiency measures to help ensure the most effective use of produced energy.

Taking a view on a local situation, energy efficiency problem is particularly acute in Lithuania. The evidence of this is that for a heat energy a statistical Lithuanian resident spends a considerably higher part of income than in other European countries, so it may be concluded that the group of heat energy consumers is financially the most sensitive group of all consumers. This group of users is divided into two large segments – those who live in private houses and

those who live in multi-apartment buildings. As a private house has the possibility to select the free type of fuel and does not have a necessity to heat by expensive gas, can keep the desired temperature comfort level according to their income level, decrease temperature for the night, weekend or other desired time period of day, the multi-apartment buildings do not have such flexible options. In order to optimize the expenses for heat energy in residential buildings, in particular, reduction is possible in two main dimensions: the price of heat and amount of consumed heat. As practice shows, the heat price can be reduced by changing the structure of the balance of used fuel, i.e. reducing the use of expensive gas and increasing the use of local biofuel. In this case we have two main benefits: a) reduction of expenses for heating; b) instead of buying expensive imported fuel buying much cheaper local fuel, the expended money for these fuels remains within the country limits and do not crosses Lithuanian borders, that positively contributes to the economic welfare of the whole Lithuania. Municipalities which use the potential of local biofuel in the most intensive way, have a heat price range of 5–7 € cents/kWh and the

municipalities for heating using natural gas has from 7 to 10 € cents/kWh ranging price. Comparing the lowest 5 € cents/kWh local biofuel and the highest 10 € cents/kWh natural gas price, the difference is almost double.

The reduction of consumed heat energy is much more complex task. This task is more complex not from the point of view of technical or engineering solutions, but taking a look from our country's legal framework, which precisely and unequivocally does not identify the entities responsible for the heat consumption in buildings. However, this legal framework was made by the European Parliament in the Efficiency Directive, which aims that energy distributors and retail energy sales companies would get for end-consumers annual new energy savings equivalent to 1.5%. That must be done from 1 January 2014 to 31 December 2020 (Directive 2012/27/EU: 2012).

This article presents the analysis how 2012/27/EU Efficiency Directive targets can be achieved by the means of individual heat metering – by installing heat cost allocators for every final customer (flat) that decreases energy consumption for a final consumer. Heat cost allocators do not decrease energy consumption by itself – energy efficiency is obtained by the help of human factor and influence, so this article presents technical solutions that must be installed. This article presents a statistical analysis of identical buildings with individual metering by heat cost allocators and without them shows that the targets of 2012/27/EU Energy Efficiency Directive in Lithuania can be reached as the buildings with individual heat cost allocators consumes about 20–30% less of heat energy

The main targets of energy efficiency directive 2012/27/EU for a district heating sector

The European Union is facing with increased volume of imported energy resources, climate change and the economic crisis. This leads to draw extra attention to energy efficiency, because the reduction of primary energy consumption directly reduces dependence on imported energy resources and increases energy security. Development of energy-efficient economics is conducive to innovative technological solutions and enhances the European Union's industrial competitiveness, promotes economic growth and creation of a skilled workforce.

So great attention is paid to improve energy efficiency in the public sector. Even higher targets and obligations are provided for in order to enable the end user itself regulate his energy consumption, as buildings are responsible for 40% of total EU final energy consumption (Directive 2012/27/EU: 2012).

Energy efficiency directive 2012/27/EU section 7 of states that until 31 December 2020 must be reached a final energy consumption savings target to save annually 1.5% of end-user energy (Directive 2012/27/EU:2012). The aim is to ensure that all energy distributors and/or retail energy sales companies, as designated by obligated parties, from 1 January of 2014 until 31 December 2020 each year must save the new amount of energy equivalent to 1.5% of end user energy (Directive 2012/27/EU: 2012).

Energy efficiency directive 2012/27/EU section 9 states that in multi-apartment and multi-purpose buildings supplied from a district heating network individual consumption meters should be installed by 31 December 2016 to measure the consumption of heat or hot water for each unit where it is technically feasible and cost-efficient (Directive 2012/27/EU: 2012). Where the use of individual meters is not technically feasible or not cost-efficient, to measure heating, individual heat, cost allocators shall be used for measuring heat consumption at each radiator.

Energy efficiency directive 2012/27/EU Section 10 obligates that invoicing should be based on actual consumption. The final customer must be able to make a comparison of energy consumption during the current period and the same period of the last year. It should be done in graphic form. For a final customer provided information must be accurate and based on actual consumption. This obligation can be met by regular self-reading system that allows communicate readings from consumer meter to the energy supplier. Final customer must be able to obtain additional information on the previous consumption easily, which would allow the same end-user to make a detailed self-control.

The information on historical consumption must include cumulative data for at least the three previous years. The data shall include detailed data according to the time of use for any day, week, month and year and shall be made available to the final customer via Internet or the meter interface for the period of at least the previous 24 months. For a final customer must be offered the option of electronic billing information, a clear and understandable explanation of how their bill was derived.

At present moment main EU countries do not have a strong experience and confirmed technical means to reach Energy efficiency directive 2012/27/EU targets. Denmark applies energy efficiency measures in a wide way, but the technical solutions to obtain energy efficiency targets may have local significances so can't be applied for all countries in a blind way. Lithuania still does not have a confirmed solutions to increase energy efficiency for a final customer.

Actual energy consumption evaluation methodology

To assess not theoretical but actual energy consumption of each building for space heating, hot water preparation and hot water circulation, by R. Savickas defined actual energy consumption class (AECC) was used. AECC is used to evaluate real/actual supplied energy for premises heating. According to the energy consumption for space heating buildings are divided into 15 energy classes: the smallest and energetically most effective class is 1, the largest and energetically least effective buildings have 15 class. Numeric value of an AECC is the energy consumption amount for premises heating, from which by calculation procedure are eliminated various influencing factors – eliminated the factor of different heating season duration, the influence of different heating season outside air temperature and the influence of different buildings heated area. Results let to compare the energy consumption of the same or different types of buildings during different heating seasons. AECC lets to compare energy for premises heating of the same building during different time periods – years, months, etc. Also can be compared several buildings of different heating areas and so on. For AECC calculation energy balance of total consumed energy Q_{Σ} , MWh in building is used:

$$\sum Q = Q_h + Q_{hwp} + Q_{hwc}, \quad (1)$$

where: $\sum Q$ – total heat consumption in building, MWh; Q_h – heat energy for space heating, MWh; Q_{hwp} – heat energy for hot water preparation, MWh; Q_{hwc} – heat energy for hot water circulation, MWh.

For AECC calculation is eliminated actual hot water amount (not according to defined norms for all buildings):

$$Q_h = \sum Q - Q_{hwp} - Q_{hwc}. \quad (2)$$

Heat energy for hot water Q_{hwp} , MWh preparation is evaluated according to:

$$Q_{hwp} = G \cdot 0.051, \quad (3)$$

where: G – hot water consumption before hot water exchanger (this consumption is not the sum of declared hot water amount of all final customers/flats in building), m^3 ; 0.051 – heat energy to rise hot water temperature by 44 °C, kWh. If an actual raised temperature is known, it should be used instead of 44 °C.

After elimination of outside air temperature, heating season duration and heated area, the factor q_m , Wh/DD/ m^2 is obtained:

$$q_m = \frac{Q_h}{DD \times S}, \quad (4)$$

where: q_m – heat amount to rise 1 m^2 of premises heated area by 1 °C during 1 day (24 h), Wh/DD/ m^2 ; DD – Degree days (base temperature is 18 °C), DD; S – heated area of premises, m^2 .

Evaluated heat amount q_m is individual for every building. According to q_m , the AECC is prescribed in Table 1.

Table 1. Actual Energy Consumption Class and heat energy amount for premises heating q_m according to R. Savickas defined methodology

No	q_m , Wh/(DD× m^2)	AECC
1	$q_m < 5$	1
2	$5 \leq q_m < 10$	2
3	$10 \leq q_m < 15$	3
4	$15 \leq q_m < 20$	4
5	$20 \leq q_m < 25$	5
6	$25 \leq q_m < 30$	6
7	$30 \leq q_m < 35$	7
8	$35 \leq q_m < 40$	8
9	$40 \leq q_m < 45$	9
10	$45 \leq q_m < 50$	10
11	$50 \leq q_m < 55$	11
12	$55 \leq q_m < 60$	12
13	$60 \leq q_m < 65$	13
14	$65 \leq q_m < 70$	14
15	$q_m \leq 70$	15

Outcomes and results on implementation of energy efficiency means

Targets of 2012/27/EU directive on the energy efficiency in district heating sector can be implemented by application of technical energy efficiency means. Complete combination package allows to access it in the most energy efficient way. It is important to distinguish the minimal measures that enable to achieve energy efficiency at the minimum level. Performed analysis shows that the reconstruction of internal heating and hot water systems in multi-apartments buildings under 1992 and installing individual heat and hot water consumption meters for each final customer has a potential to decrease energy consumption for a final customer by about 25% (Fig. 1), (Savickas, Paulauskas 2014).

Mentioned potential savings for minimal energy efficiency can be achieved by in the Table 2 specified minimal technical means. Measures for larger energy efficiency can be described also, but they have a potential only of small saving percentage.

Minimal investment level to install minimal technical means (Fig. 2) for such individual heat metering is about 15 EUR/ m^2 or about 900 EUR for a typical apartment of

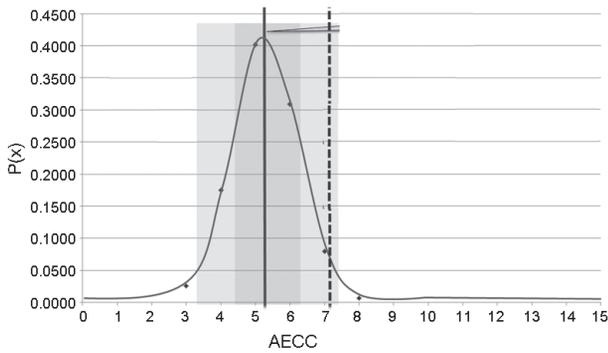


Fig. 1. Energy consumption in not reconstructed apartment buildings under 1992 with individual heat metering and without it (Savickas, Paulauskas 2014)

60 m². The reconstruction of one pipe heating system, installation of thermostatic valves and heat cost allocators for separate individual apartment can be performed in 1 day. The total reconstruction to have a potential of 25% energy savings also includes installation of automated balancing valves for heat and hot water systems, smart intelligent wireless monitoring and data collection system, hot water metering for each final customer.

Mentioned technical measures are applied and a potential of about 25% of energy savings is for buildings with independent heat substations with separate heat exchangers for heating and hot water. If the building does not have an independent type heat substation, the reconstruction of heat substation and installation of individual heat metering for every final customer in addition, gives savings much higher than 25%.

Heating system reconstruction does not preclude further renovation of the building envelope, as after additional building thermal insulation would be applied, the internal heating and domestic hot water systems still need to be

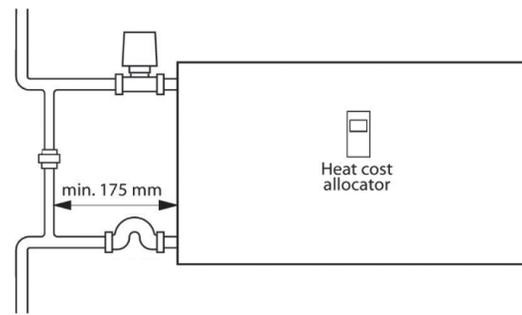


Fig. 2. The reconstruction of one pipe heating system for multi-apartment buildings

reconstructed according to a new heat demand. Once this is done before building envelope renovation, the savings due to heating system reconstruction can be obtained and get already before partitions insulation.

The optimal scenarios for the implementation of 2012/27/EU energy efficiency directive

For the implementation of the 2012/27/EU energy efficiency directive for centralized heat supply sector with the lowest costs, the potential to achieve the targets by different implementation scenarios must be evaluated for the Member State.

Obligations for Lithuanian electricity, heat and gas sectors are provided in the Table 3. Lithuania during 2012 has consumed 646.8 ktne of final energy. The total final energy consumption goal of all the electricity, heat and gas sectors by 2020 is 2639 GWh. Heat sector provides 33% or 870 GWh of final energy consumption. The annual savings during 2014–2020 years is 145 GWh.

Investments and cumulated savings for implementation of 2012/27/ES Energy efficiency directive are presented in Figure 3.

Table 2. Technical measures for energy savings

No.	Measure	Measures for minimal efficiency	Measures for larger efficiency
1.	Independent heat substation for heat and hot water preparation (the analysed buildings almost have reconstructed heat substations, so if heat substation is not reconstructed, the potential energy savings will be much more higher)	+	+
2.	Balancing of the heating system	+	+
3.	Hot water system balancing	+	+
4.	Thermostatic valves on the building heating system heating appliances	+	+
5.	Individual heat metering for each final customer of the building (heat meters or heat cost allocators)	+	+
6.	Hot water metering for each final customer of the building	+	+
7.	Smart intelligent wireless monitoring and data collection system	+	+
8.	Energy efficient heating and hot water pumps	–	+
9.	Replacement of heating appliances with more efficient	–	+
10.	Reflecting screens under heating devices	–	+

Table 3. Annual energy saving targets

No.	Name	Electricity	Heat	Gas
1.	Final consumption, ktne (2012)	767.2	646.8	548.1
2.	Final consumption, %	39.1	33.0	27.9
3.	Total 2020 target without buildings envelope reconstruction, GWh	2639		
4.	2020 targets for obligated countries 2020, GWh	1032	870	737
5.	Annual targets for obligated countries, GWh	172	145	123
6.	Investments for a measure, mln. Eur/GWh	0.579		
7.	Annual investment, mln. Eur	100	84	71
8.	Annual support for investment, mln. Eur (20 %)	20	17	14

Table 4. Implementation for 100% of the buildings, urgent investments on the year 2015

No	Name	2015	2016	2017	2018	2019	2020	Sum
1.	Target, GWh	145	145	145	145	145	145	870
2.	Target, ktne	12	12	12	12	12	12	75
3.	Target, Eur:	11 000	11 000	11 000	11 000	11 000	11 000	66 000
4.	Heated area, m ² :	30 000 000						30000000
5.	Reconstructed buildings, m ² :	30 000 000						30 000 000
6.	New annual savings, GWh:	0	858	0	0	0	0	858
7.	New annual savings, ktne:	0	74	0	0	0	0	74
8.	Savings, GWh:	0	858	858	858	858	858	
9.	Savings, ktne:	0	74	74	74	74	74	369
10.	Savings, Eur:	0	65 000	65 000	65 000	65 000	65 000	4292
11.	Investment, mln. Eur:	435	0	0	0	0	0	435

Different scenarios of 2012/27/ES Energy efficiency implementation are possible and directly depend on the investment lay down schedule and percentage of buildings will be selected. Table 4 shows implementation of technical means for 100% of the buildings with urgent investments on the year 2015, Table 5 shows implementation of technical means for 50% of the buildings with urgent investments on the year 2015, Table 6 shows implementation of technical means for 50% of the buildings when investments are set during the first three years (2015–2017).

Table 4 shows that implementation of technical means for 100% of the buildings then investments are instant on 2015 would lead to 4292 GWh savings then the obligation in heat sector is only 870 GWh. The obligation for all heat, gas and electricity sectors is just 2639 GWh, so the total savings for all sectors can be get only by heat sector. As it is difficult to implement all technical means during one year, the third scenarios (Table 6) is practicable and the savings of 1717 GWh is possible.

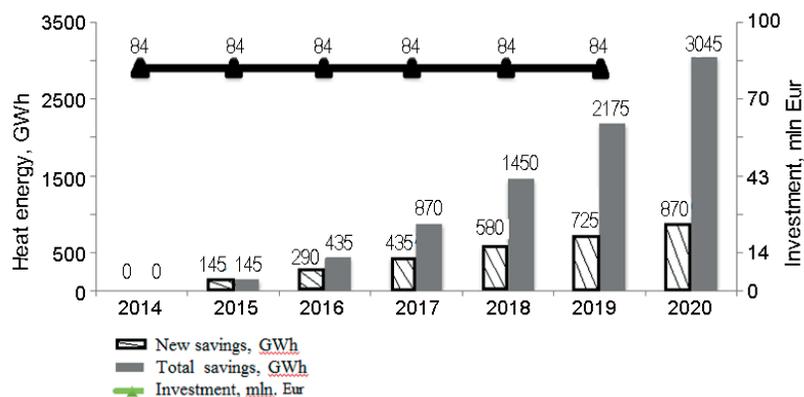


Fig. 3. Investments and savings for implementation of 2012/27/ES Energy efficiency directive

Table 5. Implementation for 50% of the buildings, urgent investments on the year 2015

Nr.	Name	2015	2016	2017	2018	2019	2020	Sum
1.	Target, GWh	145	145	145	145	145	145	870
2.	Target, ktne	12	12	12	12	12	12	75
3.	Target, Eur:	11 000	11 000	11 000	11 000	11 000	11 000	66 000
4.	Heated area, m ² :	30 000 000						30 000 000
5.	Reconstructed buildings, m ² :	15 000 000						15 000 000
6.	New annual savings, GWh:	0	429	0	0	0	0	429
7.	New annual savings, ktne:	0	37	0	0	0	0	
8.	Savings, GWh:	0	429	429	429	429	429	2146
9.	Savings, ktne:	0	37	37	37	37	37	185
10.	Savings, Eur:	0	32 500	32 500	32 500	32 500	32 500	195 000
11.	Investment, mln. Eur:	217	0	0	0	0	0	217

Table 6. Implementation for 50% of the buildings, investments (2015–2017)

Nr.	Name	2015	2016	2017	2018	2019	2020	Sum
1.	Target, GWh	145	145	145	145	145	145	870
2.	Target, ktne	12	12	12	12	12	12	75
3.	Target, Eur:	11 000	11 000	11 000	11 000	11 000	11 000	66 000
4.	Heated area, m ² :	30 000 000						30 000 000
5.	Reconstructed buildings, m ² :	5 000 000	5 000 000	5 000 000	0	0	0	15 000 000
6.	New annual savings, GWh:	0	143	143	143	0	0	429
7.	New annual savings, ktne:	0	12	12	12	0	0	37
8.	Savings, GWh:	0	143	286	429	429	429	1717
9.	Savings, ktne:	0	12	25	37	37	37	148
10.	Savings, Eur:	0	10 850	21 700	32 550	32 550	32 550	130 200
11.	Investment, mln. Eur:	72	72	72	0	0	0	217

Conclusions

As the Energy efficiency 2012/27/EU directive states the Member States are obliged to reach energy savings targets by 2020 year. Energy efficiency 2012/27/EU directive section 7 defines 1.5% annual savings for a final customer, section 9 and 10 defines the installation of individual heat metering for every final customer (flat) until 31 December of 2016 and requirements for invoices. Performed analysis shows that:

1. As the installation of individual heat meters for every flat for one and two pipe systems in multi-apartment buildings before 1992 year is technically and economically not possible, the obligations of Energy efficiency 2012/27/EU directive for 1.5% annual savings for a final customer can be reached by implementing technical means installing individual heat metering by heat cost allocators for every final customer (for every flat).
2. Performed analysis shows that the reconstruction of internal heating and hot water systems in multi-apartments buildings under 1992 and installing individual

heat metering by heat cost allocators and hot water consumption meters for each final customer has a potential to decrease energy consumption for a building by about 25%.

3. Energy efficiency 2012/27/EU directive targets for Lithuanian all sectors (Gas, Electricity and Heat) can be reached applying an above mentioned technical measures in heat energy sector. Implementation of technical means for 100% of the buildings then investments are instant would lead to 4292 GWh savings then the obligation in heat sector is only 870 GWh. The obligation for all heat, gas and electricity sectors is just 2639 GWh, so the total savings for all sectors can be get only by heat sector. As it is difficult to implement all technical means during one year and for 100% of buildings, the third scenarios (Table 6) implementing technical means for 50% of buildings during the first three years is practicable and the savings of 1717 GWh is possible.

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TECHNINĖS PRIEMONĖS, SKIRTOS MAŽINTI GALUTINIO VARTOTOJO ŠILUMINĖS ENERGIJOS VARTOJIMĄ DAUGIABUČIUOSE GYVENAMUOSIUOSE PASTATUOSE PAGAL ENERGIJOS EFEKTYVUMO DIREKTYVĄ

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Santrauka

Pasaulyje energijos vartojimas auga, todėl turi būti rastos energetinio efektyvumo pagerinimo priemonės. 2012/27/ES Energijos Efektyvumo Direktyvos tikslas yra sumažinti galutinio energijos vartotojo energijos suvartojimą kasmet po 1,5 %, tačiau nėra nurodyta, kaip kiekviena valstybė narė šiuos tikslus galėtų įgyvendinti. Šis straipsnis pristato analizę, kaip šie tikslai galėtų būti pasiekti, kiekviename bute įrengiant individualios šilumos apskaitos šilumos daliklius, kad sumažėtų energijos vartojimas atskiruose butuose. Pateikta statistinė identiškų pastatų su šilumos dalikliais ir be jų analizė. Šiluminei energijai taupyti neužtenka vien tik šilumos daliklių, todėl straipsnyje pateiktas techninis sprendimas – būtinų įdiegti techninių priemonių paketas, kurį sudaro tokios priemonės: termostatiniai ventiliai, balansiniai ventiliai, karšto vandens skaitikliai, belaidė reguliaraus duomenų nuskaitymo sistema. Galutiniai analizės rezultatai rodo, kad 2012/27/ES Energijos Efektyvumo Direktyvos tikslai Lietuvoje gali būti pasiekti, nes pastatai su individualia šilumos apskaita ir įrengtais šilumos dalikliais vartoja apie 20–30 % mažiau šiluminės energijos nei pastatai be tokios apskaitos.

Reikšminiai žodžiai: daugiabučiai pastatai, energijos efektyvumas, šilumos skaitikliai, išmanioji apskaita, šilumos dalikliai, balansiniai ventiliai, karšto vandens skaitikliai, belaidė reguliaraus duomenų nuskaitymo sistema, 2012/27/ES Energijos Efektyvumo Direktyva.