Determination of gas consumption rate using the thermo technical calculations

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Abstract. At present time the problem of energy efficiency in field of housing and utilities infrastructure is very actual. Gas fuel consumption by population is the main factor influenced on achievement of high values in energy efficiency. One of the stage of optimization and efficiency upgrading of gas consumption is introduction of gas-meter containing smart-cards. This device allows optimization as well as monitoring gas consumption according to real data (not according to data of consumption rate)

1 Introduction

At present time gas-meters generally are absent with consumers. For determination of norm of gas consumption the Building regulations, manuals and recommendations are used. Norms of gas consumption for cooking and water heating when application of gas-stoves and boilers in house buildings should be determined according to SP 42-101-2003 presented in Table 1.

Table 1. nnual gas fuel consumption for house buildings

Gas customers	Gas consumption index	Heat consumption rate, MJ
House buildings 1. In case, the gas-stove and centralized hot-water supply system present	For a one person per a year	4100
2. In case, the gas-stove presents but centralized hot-water supply system absents	For a one person per a year	6000
3. In case, the gas-stove and gas water heater present but centralized hot-water supply system absents	For a one person per a year	10000

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Methodology

Calculation of gas consumption in house and public buildings is based on methods of heat losses determination those depend on building type, number of floors and climate conditions.

Gas consumption rates for heating of house buildings are determined taking into account calculated heat losses recovered by local gas heating systems.

Main part. Heat consumption in house building depends on some parameters. The ones of the most important are followings: building type, number of floors as well as realization degree of energy-efficiency procedures when construction process. Calculation of heat consumption it is necessary to accomplished taking into account the followings building types:

1) Buildings constructed before 1985

a) without considering of energy-saving procedures application (1-2-storied, 3-4-5-storied buildings and higher buildings);

b) taking into account of energy-saving procedures application (1-2-storied, 3-4-5-storied buildings and higher buildings);

2) Buildings constructed after 1985 (1-2-storied, 3-4-5-storied buildings and higher buildings).

There is a building type, where local heating systems are set up. In this case the heat loss calculation and gas consumption are determined by following eq.:

$$Q_0^{an} = 24 Q_{max} \frac{t_{ext} - t_{av0}}{t_{av-in} - t_0} n_0, \tag{1}$$

where Q_0^{an} is annual heat consumption for house buildings, W;

Q_{max} is maximum heat flow for house buildings with calculated external temperature for heating process design (text), W;

t_{av}-in is average internal temperature in heated buildings, ^{o}C;

t_{av0} is average external temperature for average daily temperature up to 8 ^{o}C (heating season), ^{o}C;

n_0 is duration of heating season, days.

Maximum heat flow for house buildings Q_{max} is determined by the following eq.:

$$Q_{max} = q_0 A \tag{2}$$

where q_0 is integrated value of maximum heat flow for house buildings for 1 m^2 of total area, W;

A is total area of house buildings determined as a sum of all apartment areas in these buildings, m^2.

According to SNiP2.08.01-89 «House buildings» the total apartment area is a sum of their areas taking into account the followings decreasing coefficients: built-in closets – 0.5; recessed balconies and balconies and verandas – 0.3; terraces and refrigerating chambers – 0.1.

Total area is determined by internal measurement of all rooms at floor level without considering a baseboard. At the same time, area occupied by heating stove is excluded of total area.

When heating systems design the value of tav-in is determined according to SNiP 2.04.05-91 «Heating, ventilation and conditioning».

In this case the real average internal temperature can be used.

Values of t_0, t_{av0}, n_0 are determined according to SNiP 2.01.01-82 «Building climatology and geophysics» or according to data of meteorological service.

Annual gas consumption for heating of house buildings is determined by following eq.:

$$G = \frac{3,6Q_0^{r0n}}{Q_0^n * n}, \tag{3}$$

where G is annual gas consumption for heating of house buildings, m^3;

Q_0^n is minimum of calorific value of gas fuel, kJ/m^3 (kkal = 4,1868 kJ);

n is coefficient of efficiency for heating system.

For heating stove the parameter n= 0.7–0.75; for heating equipment the parameter n is determined according to machinery certificate.

To simplify the payment procedure for customers the annual gas consumption rate for heating process is equidistributed monthly during a year.

In this case the average monthly of gas consumption rate is determined by follow eq.:

$$P_{im} = \frac{G_i}{12a_i}, \tag{4}$$

where P_{im} is average monthly of gas consumption for heating of house buildings in i-group (m^3) per 1 m^2 of heated area;

G_i is annual gas consumption for heating of house buildings in i-group, m^3;

a_i is heated area of of house buildings in i-group, m^2.

Gas consumption for local heating systems is determined using average values of heated area by following:

$$P_m = \sum_{i=1}^{re} P_{im} * d_1, \tag{5}$$

where P_{im} is average monthly gas consumption in oblast (region or republic in Russian Federation), m^3 per 1 m^2 of heated area;

d_1 is part of heated area for heating of house buildings in i-group generally in oblast (region or republic in Russian Federation) vs. area heated with local heating systems;

m is number applied groups of buildings.

Calculation of gas consumption rates realized with selected measures (for exp. the first group of apartment).

According to previously selected 10 proxy objects (n`=10) the followings real gas consumption for a one person are recognized: 9,6; 9,2; 7,8; 8,5; 6,7; 7,0; 6,6; 6,8; 7,5 и 8,3 nm^3 (Table 2).

Using the eq. (2) the parameter σ_E^2 is calculated.

Table 2. Determination of universe variance

Number of proxy objects (i)	Real gas fuel consumption for a one person per a month, nm^3	$(x_1 - x^{\sim})^2$
1	9,6	$(9,6 - 7,8)^2 = 3,24$
2	9,2	$(9,2 - 7,8)^2 = 1.96$
3	7,8	$(7,8 - 7,8)^2 = 0$
4	8,5	$(8,5 - 7,8)^2 = 0,49$
5	6,7	$(6,7 - 7,8)^2 = 1,21$
6	7,0	$(7,0 - 7,8)^2 = 0,64$
7	6,6	$(6,6 - 7,8)^2 = 1,44$
8	6,8	$(6,8 - 7,8)^2 = 1,00$
9	7,5	$(7,5 - 7,8)^2 = 0,09$
10	8,3	$(8,3 - 7,8)^2 = 0,25$
n`=10	x=7,8	$\sum_{i=1}^{n`} (x_1 - {\sim}x)^2 = 10,32$

3

$$O_x^2 = \frac{10,32}{10} = 1,032 \tag{6}$$

According to eq. (4) the parameter O_x^2 is determined by following:

$$O_x^2 = \frac{1,032*10}{1 - \frac{10}{280000}} = 10,32 \tag{7}$$

where 280000 is total apartment number in the first group.

Then, with eq. (1) the calculation of minimum required apartment sample number in this group is calculated by following:

$$n = \frac{280000*1,645^2*10,32}{280000*0,8^2 + 1,645^2*10,32} = 44,$$

where 0,8=10 % of tentative average gas consumption rate that is equal to 8,0 nm^3 for a one person per a month.

Real number of selected proxy objects is 86 (44 at least). Effective gas fuel consumption is based on application of gas-meters with max coefficient of efficiency.

Targeted indicators represented change in measures are calculated relatively to current year vs. previous year. Targeted indicators represented gas-meter availability are calculated according to objects connected with gas-supply system.

Determination of targeted indicators for gas-supply systems as well as efficiency upgrading under equal conditions the variation in structure and volume of requirement in resources those are extra of efficiency upgrading procedures are should be taken account.

Table 3. Calculation of efficiency of gas fuel consumption

№	Parameters	Unit measure	Year		
			2010	2011	2012
2	Gross Regional Product in Moscow oblast	trillion.rub.	2	2,1	2,2
	Total volume of costumed gas fuel	103 m3	450 812,65	443 973,30	324 135,39
4	Volume of costumed gas fuel, taking into account with gas-meter	103 m3	330 808,86	375 849,30	303 822,96
5	Pipeline rates according to gas-meter	rub/103 m3	2,75	3,3	3,795
6	Efficiency of gas fuel consumption	%	73,38	84,66	93,73

The data in Table 3 are actual as at October, 2012.

Conclusions

According to the above data, the volume of gas fuel, consumed by «Odintsovomezhregiongas» (branch of «Mosoblgas» company), taken into account with gas-meters grows annually. At the same time, efficiency of gas fuel consumption also grows by 10 % averagely.

In compliance with it we can conclude the efficiency of gas fuel consumption is significantly increased vs. 2010 due to application of gas-meters with smart-cards.

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