

# **The error in determining thermal characteristics and energy classification of buildings**

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Standards that establish the energy characteristics of buildings

**1 Construction heating engineer. Construction norms of design** TKP 45-2.04-43-2006. – Minsk: Interstate Council for standardization, metrology and certification: Belarusian. State Institute of standardization and certification, 2006. – 35 p. (rus)  
**Establishes the requirements for the reduced resistance to heat transfer of the enclosing structures of buildings:**

**External walls:** **not less than  $3.2 \text{ m}^2\text{K} / \text{W}$ ;**

**Windows:** **not less than  $1.0 \text{ m}^2\text{K} / \text{W}$ ;**

**Overlapping of the upper floor:** **not less than  $6.0 \text{ m}^2\text{K} / \text{W}$ ;**

**Overlapping above the basement:** **not less than  $2,5 \text{ m}^2\text{K} / \text{W}$ ;**

**2 Thermal protection of buildings. Heat power characteristics. Rules of definition:** TKP 45-2.04-196-2010– Minsk: Interstate Council for standardization, metrology and certification: Belarusian. State Institute of standardization and certification, 2010. (rus)  
**Establishes requirements for the specific consumption of heat energy for heating and ventilation of buildings**

**3 Standard of the Republic of Belarus 2409-2015 The Definition of an indicator of energy efficiency of the operated buildings**

The number of storeys of the building	Specific consumption value for classes of buildings, kWh/m2
Class D	
1 - 3	153 - 112
4 -6	89 - 66
7 and more	81 - 60
Class C	
1 - 3	111 - 92
4 -6	65 - 53
7 and more	59 - 49
Class B	
1 - 3	91 - 65
4 - 6	52 - 35
7 and more	48 - 30
Class A	
1 - 3	64 - 55
4 - 6	34 - 28
7 and more	30 - 24
Class A <sup>+</sup>	
1 - 3	<55
4 - 6	<28
7 and more	<24

# **The EN standards in Republic of Belarus**

ГОСТ EN 15217:2007 Energieeffizienz von Gebäuden — Verfahren zur Darstellung der Energieeffizienz und zur Erstellung des Gebäudeenergieausweises

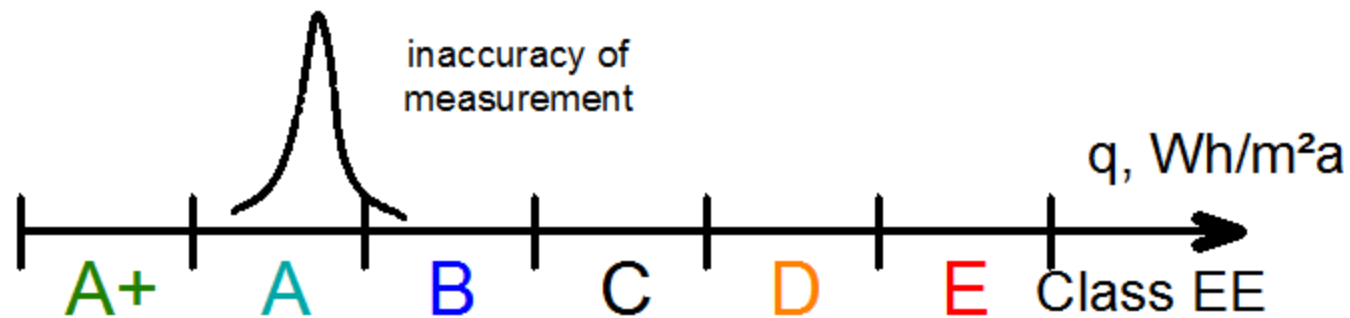
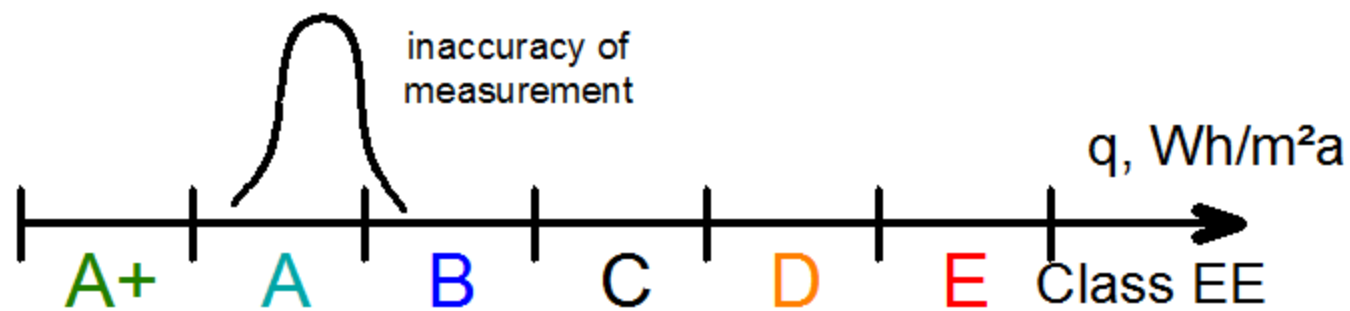
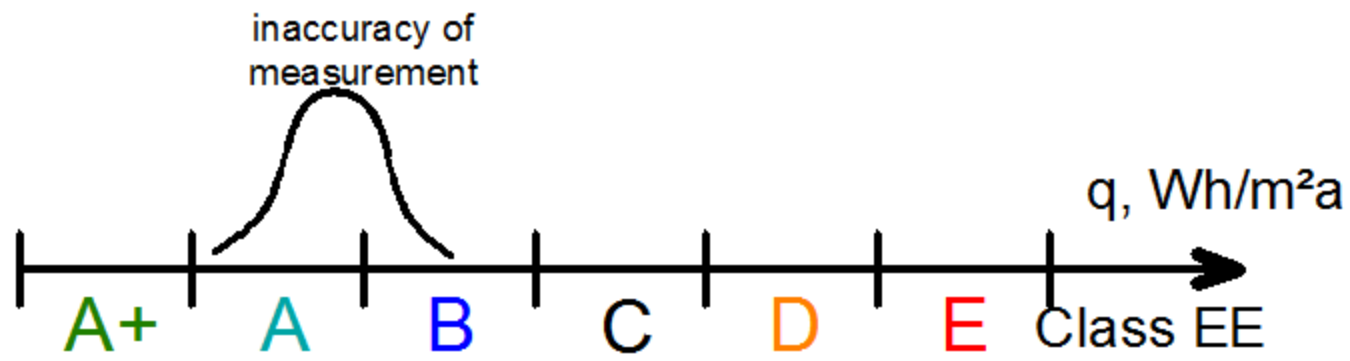
СТБ EN 15603-2014 Energy performance of buildings — Overall energy use and definition of energy ratings

There is a problem: definition of a class of the operated building on an indicator of specific consumption of energy on heating

indications of the counter of thermal energy in the building correspond to specific climatic conditions, air temperature in the building and size of household thermal emissions behavior of inhabitants

the class of the building is defined for the settlement service conditions set by standards

**classes of buildings on a specific  
indicator have to be appointed taking  
into account the possible accuracy of  
definition of an indicator**



# Classes of buildings and accuracy of measurements

Classes of buildings with more than 7 levels	Range of values of indicator, kWh/m <sup>2</sup>	Reasonable range of indicator, kWh/m <sup>2</sup>	Accuracy of definition of kWh/m <sup>2</sup>							
			±2		±4		±6		±8	
			Quantity of ranges For two ranges of indicators		Quantity of inter-vals For two ranges of indicators		Quantity of intervals For two ranges of indicators		Quantity of intervals For two ranges of indicators	
			range 1	range 2						
<b>D</b>	<b>81 - 60</b>	<b>89 - 69</b>	<b>10</b>	<b>10</b>	<b>5</b>	<b>5</b>	<b>3</b>	<b>3</b>	<b>2</b>	<b>2</b>
<b>C</b>	<b>59 - 49</b>	<b>69 - 49</b>	<b>5</b>	<b>10</b>	<b>3</b>	<b>5</b>	<b>2</b>	<b>3</b>	<b>2</b>	<b>2</b>
<b>B</b>	<b>48 - 30</b>	<b>49 -29</b>	<b>10</b>	<b>10</b>	<b>5</b>	<b>5</b>	<b>3</b>	<b>3</b>	<b>2</b>	<b>2</b>
<b>A</b>	<b>29 - 25</b>	<b>29 -19</b>	<b>3</b>	<b>10</b>	<b>2</b>	<b>5</b>	<b>1</b>	<b>3</b>	<b>1</b>	<b>2</b>
<b>A<sup>+</sup></b>	<b>&lt;25</b>	<b>&lt;19</b>	<b>12</b>	<b>10</b>	<b>6</b>	<b>5</b>	<b>4</b>	<b>3</b>	<b>3</b>	<b>2</b>



# way of definition of specific consumption of thermal energy on heating for settlement conditions

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**The Algorithm and accuracy of definition of heattechnical indicators of buildings    Magazine of Civil Engineering, No. 5, 2017**

**METHOD of DEFINITION of the SPECIFIC EXPENSE of THERMAL ENERGY ON HEATING AND VENTILATION of the OPERATED RESIDENTIAL BUILDINGS (the RB Patent No. 18898)**

**The application for the grant of a patent for the invention of the Republic of Belarus, # a20150303 dated June 3, 2015**

**Standards of the Republic of Belarus 2409-2015**

# The algorithm of measurement of the coefficient of the specific heat losses of the building

- The specific power of the heat source in heating of the building on the interval  $i$  is:

$$q_i = \Delta T_i \cdot f_1 - f_2$$

- $\Delta T_i = (T_{i\text{in.}} - T_{i\text{out.}})$ ,  $i=1...NN$ ,
- $f_1$  – coefficient of the specific heat losses of the building,  $\text{W}/(\text{m}^2 \text{K})$ ;
- $f_2$  – the specific power of internal heat emissions of the building,  $\text{W}/\text{m}^2$ ;
- **Assuming coefficient of specific heat losses of the building and the average power of the internal heat sources in the building constants, we can determine the coefficient of the specific heat losses by the following formula:**
- **determine coefficient of specific heat losses**
- **Standards of the Republic of Belarus 2409-2015**

Coefficient of the specific heat losses:

$$f_1 = \frac{\sum_{j=1}^J \sum_{i=1}^{NN-1} q_{ji} \cdot \Delta T_{ji}}{\sum_{j=1}^J \sum_{i=1}^{NN-1} \Delta T_{ji}^2} \quad q_{ji} = q_{ji} - q_j$$

$q_{ji}$  - the value of the average specific capacity of the source of heating on the measurement period  $i$  in the heating season  $j$ , W/m<sup>2</sup>;

$q_j$  - the value of the average specific capacity of the heating source of the buildings on the selected interval of measurements in the heating season  $j$ , W/m<sup>2</sup>;

$$\Delta T_{ji} = T_{jiout} - T_{jout}$$

Specific consumption of thermal energy for heating for the estimated conditions

$$Q_p = 0.024 \cdot (f_1 \Gamma \text{CO} \Pi_p - (f_{2p} + q_{sp} \cdot 3) \zeta \cdot N)$$

The definition of the class of buildings in use

- **Measuring the thermal energy consumption by the electricity meter for several time intervals**
- **Processing of the results of measurements for determining the coefficient of specific heat losses**
- **Calculation of the specific thermal energy consumption for the estimated conditions**

$$Q_p = 0.024 \cdot (f_1 \Gamma \text{CO} \Pi_p - (f_{2p} + q_{sp} \cdot 3) \zeta \cdot N)$$

# **External air temperature and specific power of the heating system of the building with the faulty automatic equipment (heating meter?)**

<b>Period</b>	<b>Specific capacity, W/m<sup>2</sup></b>	<b>External air temperature, °C</b>
<b>November 2013</b>	<b>28,47</b>	<b>4,60</b>
<b>December 2013</b>	<b>27,55</b>	<b>-0,60</b>
<b>January 2014</b>	<b>27,55</b>	<b>-7,70</b>
<b>February 2014</b>	<b>30,50</b>	<b>-1,30</b>
<b>March 2014</b>	<b>27,55</b>	<b>5,00</b>
<b>April 2014</b>	<b>9,56</b>	<b>4,40</b>

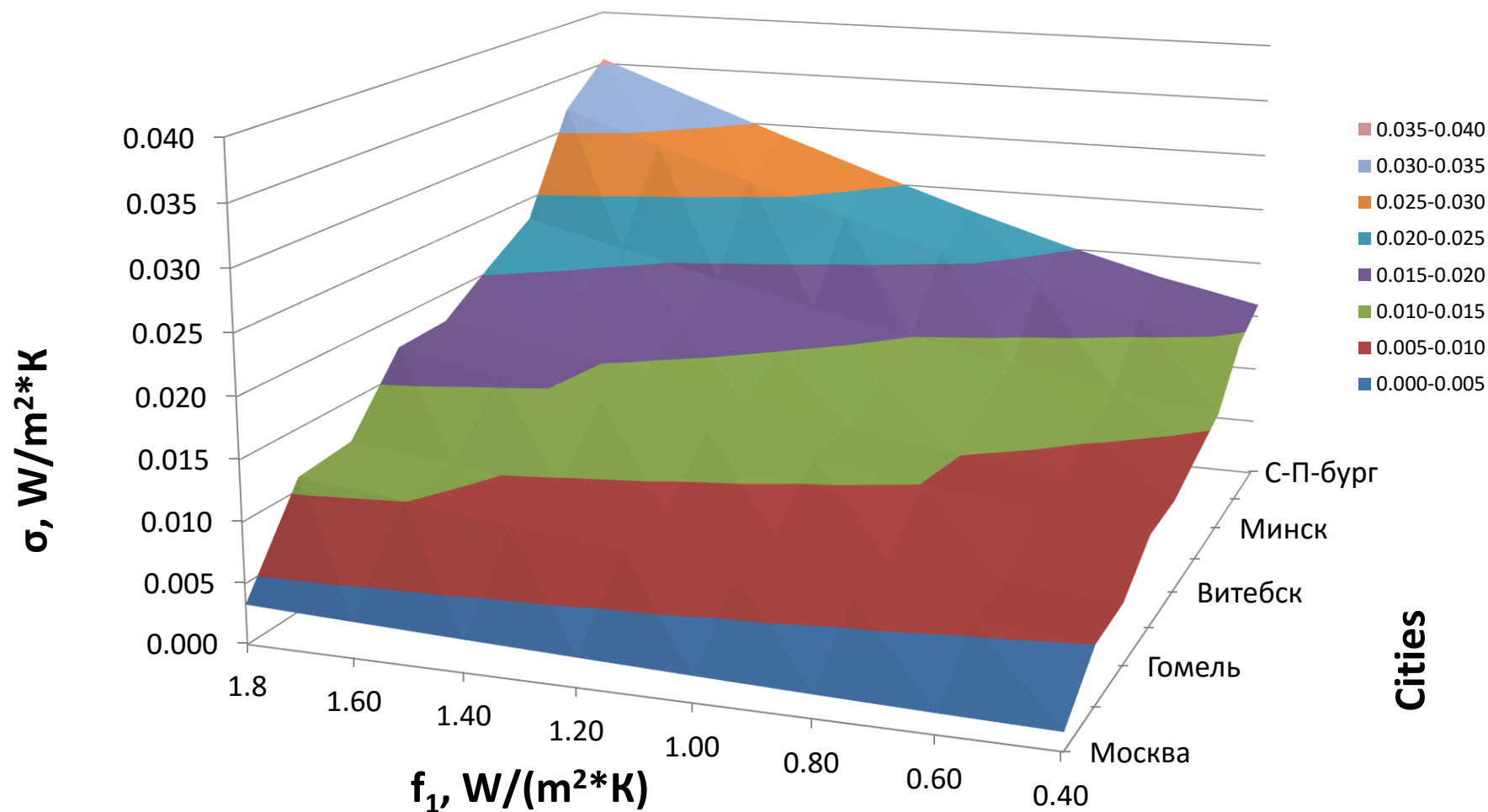
Adress				F <sub>1</sub> , W/(m <sup>2</sup> K)	Q <sub>k</sub> W <sub>th</sub> /m <sup>2</sup>	Confidence interval for Q <sub>cp</sub> kWh/m <sup>2</sup>
Minsk, Jakubovskogo, 25				<b>2,05</b>	<b>164</b>	<b>±11</b>
Minsk, Kharkovskaya, 86A				<b>1,81</b>	<b>143</b>	<b>±7</b>
Minsk, Pushkina, 29				<b>1,52</b>	<b>116</b>	<b>±9</b>
Gomel, Oskina, 14				<b>1,07</b>	<b>69</b>	<b>±7</b>
Gomel, Iliacha, 186a				<b>1,05</b>	<b>66</b>	<b>±7</b>
Minsk, Pimena Panchanko, 18				<b>1,17</b>	<b>85</b>	<b>±4</b>
Minsk, Pritytskogo, 51				<b>0,95</b>	<b>65</b>	<b>±7</b>
Minsk, Parnikovaya, 3/2				<b>1,2</b>	<b>88</b>	<b>±6</b>

# Potential accuracy of the coefficient of the specific heat losses measurement

$$\sigma_f = \frac{\sqrt{\left(\bar{q}^2 + 4 \cdot (f_1)^2 \cdot \bar{T}^2 + 4 \cdot \bar{q} \cdot \bar{T} \cdot f_1\right) \cdot \sigma_T^2 + \bar{T}^2 \cdot \sigma_q^2}}{\bar{T}^2}$$

$$\bar{T} = \sum_{i=1}^N T_i \qquad \overline{T^2} = \sum_{i=1}^N T_i^2 \bar{q} = \sum_{i=1}^N q_i$$

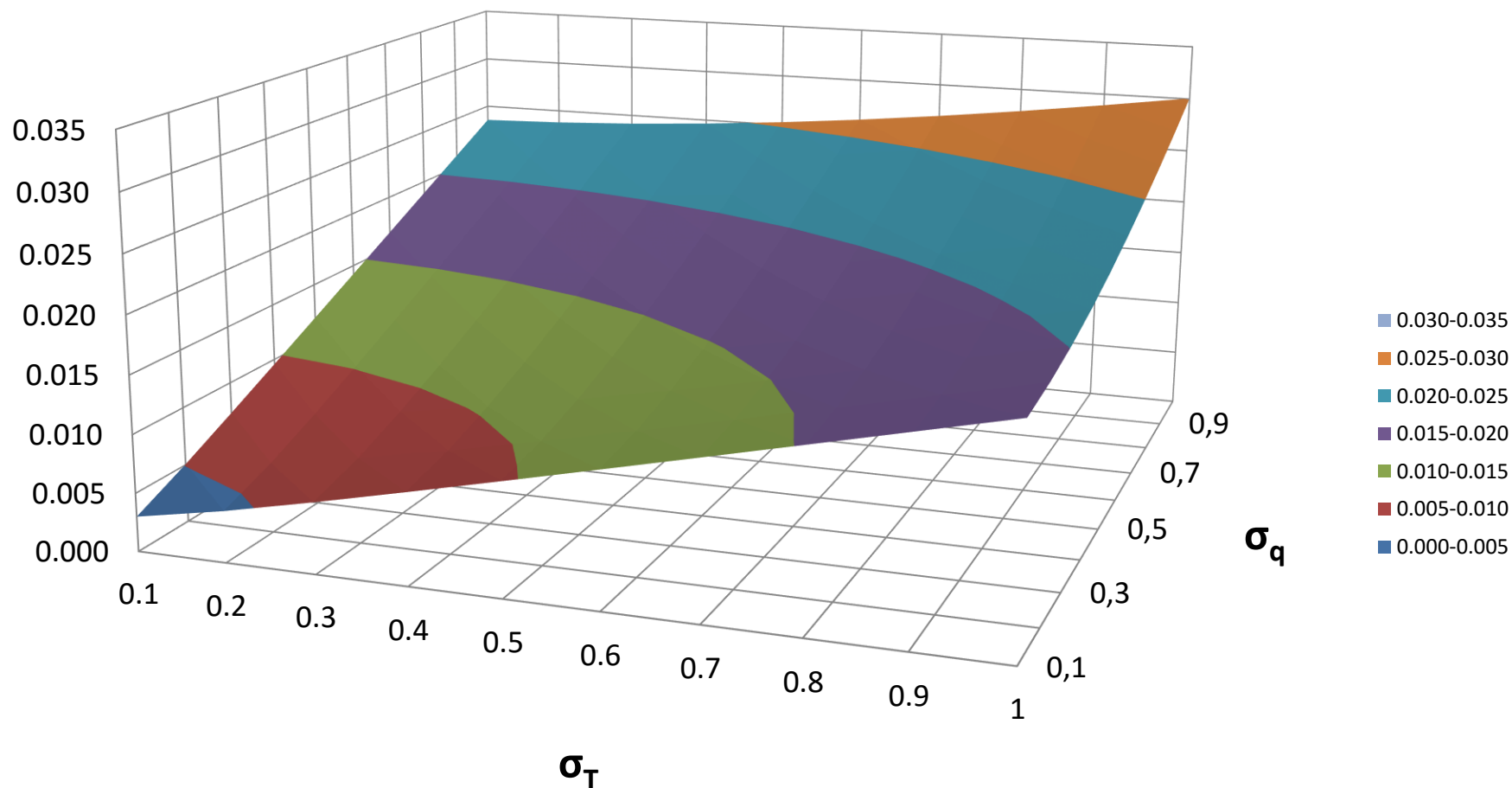
# The dependence of the potential accuracy from the measurement conditions





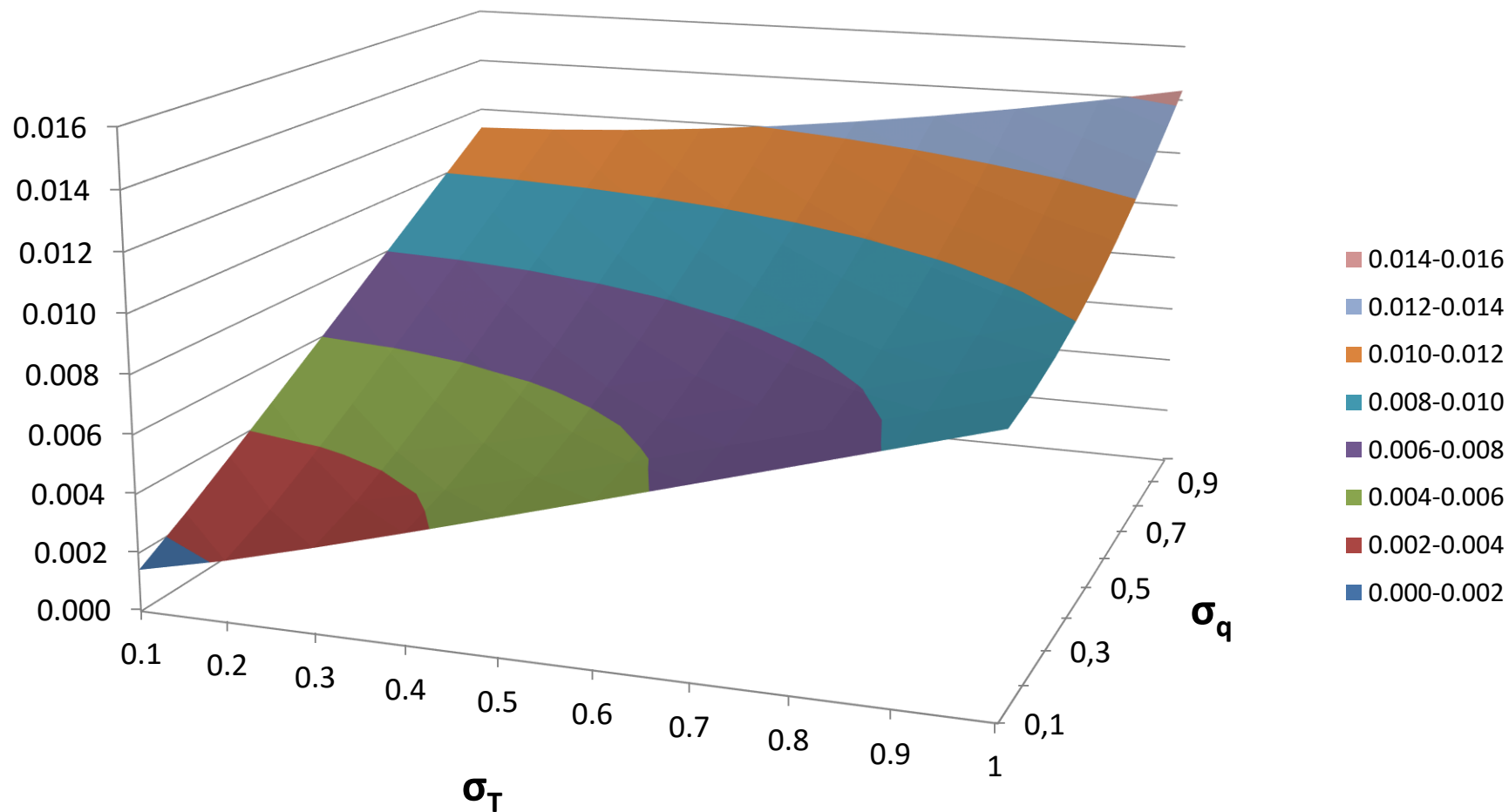
# The dependence of the potential accuracy from the accuracy of measurements for Minsk

Минск



# The dependence of the potential accuracy from the accuracy of measurements of parameters of Krasnoyarsk

Красноярск



# Potential accuracy of measurements

- For **Krasnoyarsk** the accuracy of measurements of  **$\sigma_{f1} = 0.01 \text{ W}/(\text{m}^2 \cdot \text{deg})$**  gives the accuracy of determination of specific thermal energy consumption for heating equal to

$$\sigma_q = 1,7 \text{ kWh}/(\text{m}^2 \text{ per year})$$

- For **Minsk** the accuracy of measurements of  **$\sigma_{f_1} = 0,01 \text{ Вт}/(\text{м}^2 \cdot \text{град})$**  gives the accuracy of determination of specific thermal energy consumption for heating equal to

$$\sigma_q = 0,9 \text{ kWh}/(\text{m}^2 \text{ per year})$$

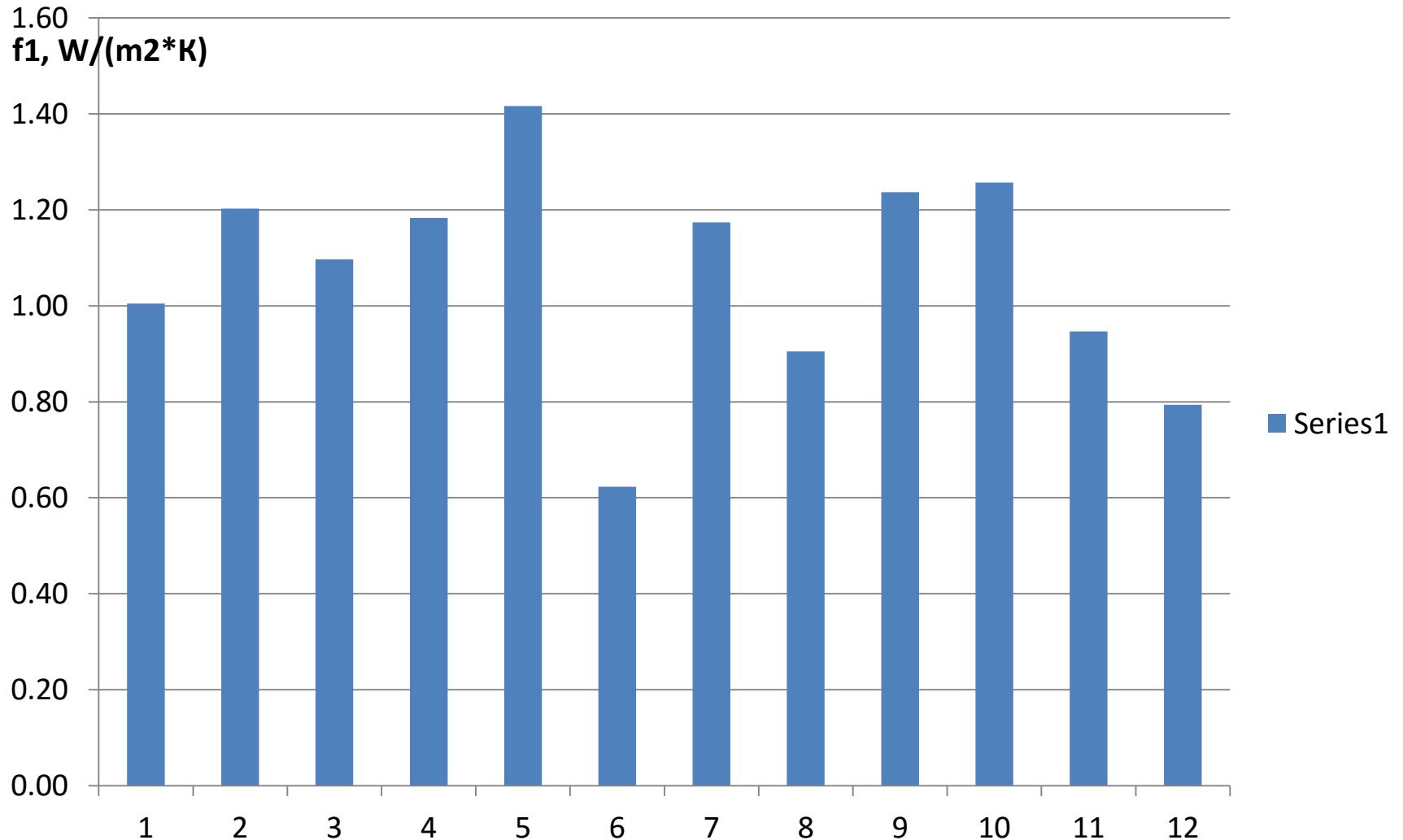
# Statistical characteristics of the estimation of the $f_1$ in automated accounting.

- 100(1- $\gamma$ )% confidence interval for the estimation of the  $f_1$  is in the following range:

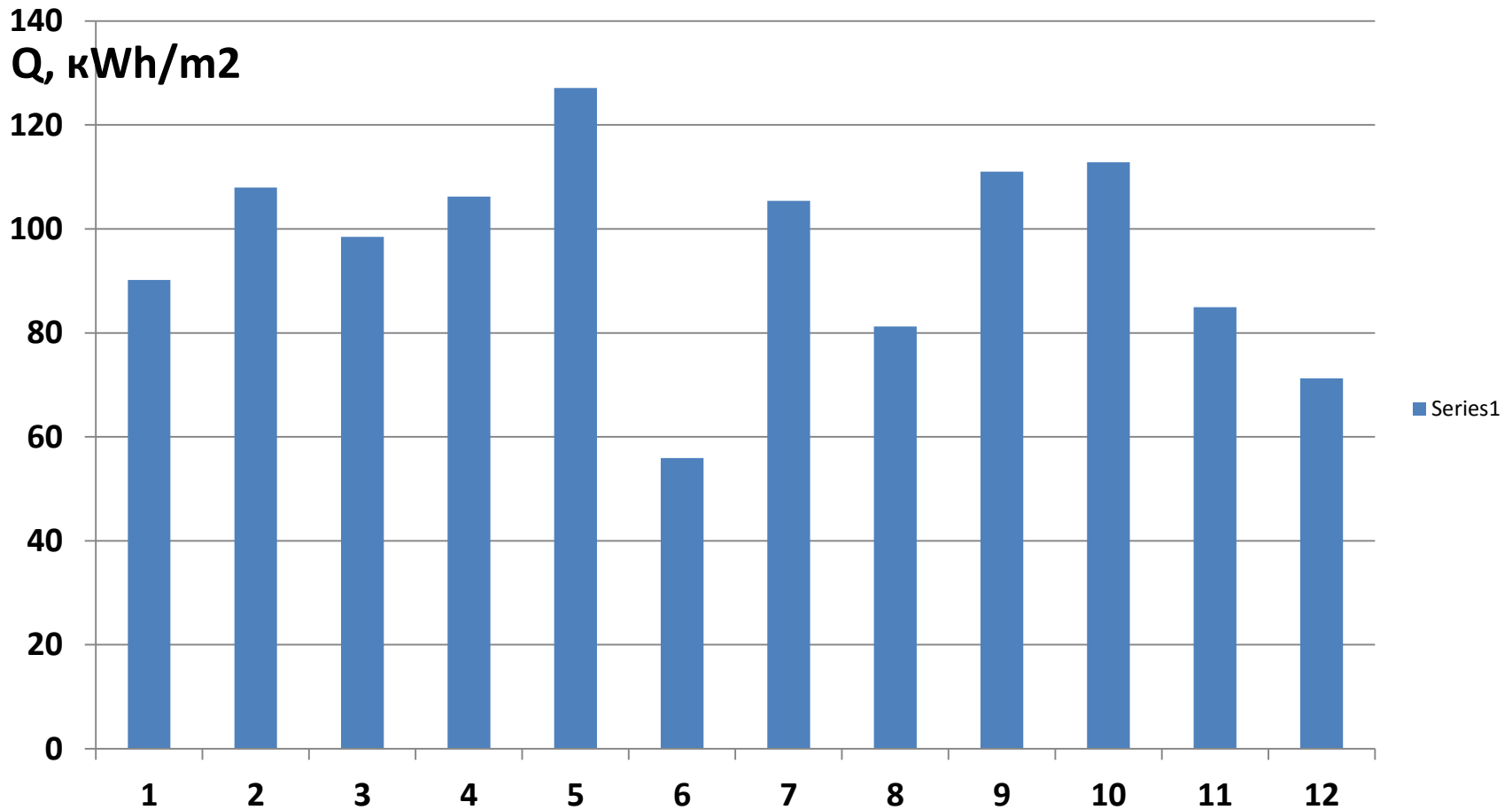
$$f_1 - \frac{t_{n-1;1-\gamma/2} \cdot S}{\sum_{i=1}^N T_i^2} \leq f_{10} \leq f_1 + \frac{t_{n-1;1-\gamma/2} \cdot S}{\sum_{i=1}^N T_i^2}$$

$$S^2 = \frac{1}{(N-1)} \sum_{i=1}^N (q_i - f_1 \cdot T_i)^2$$

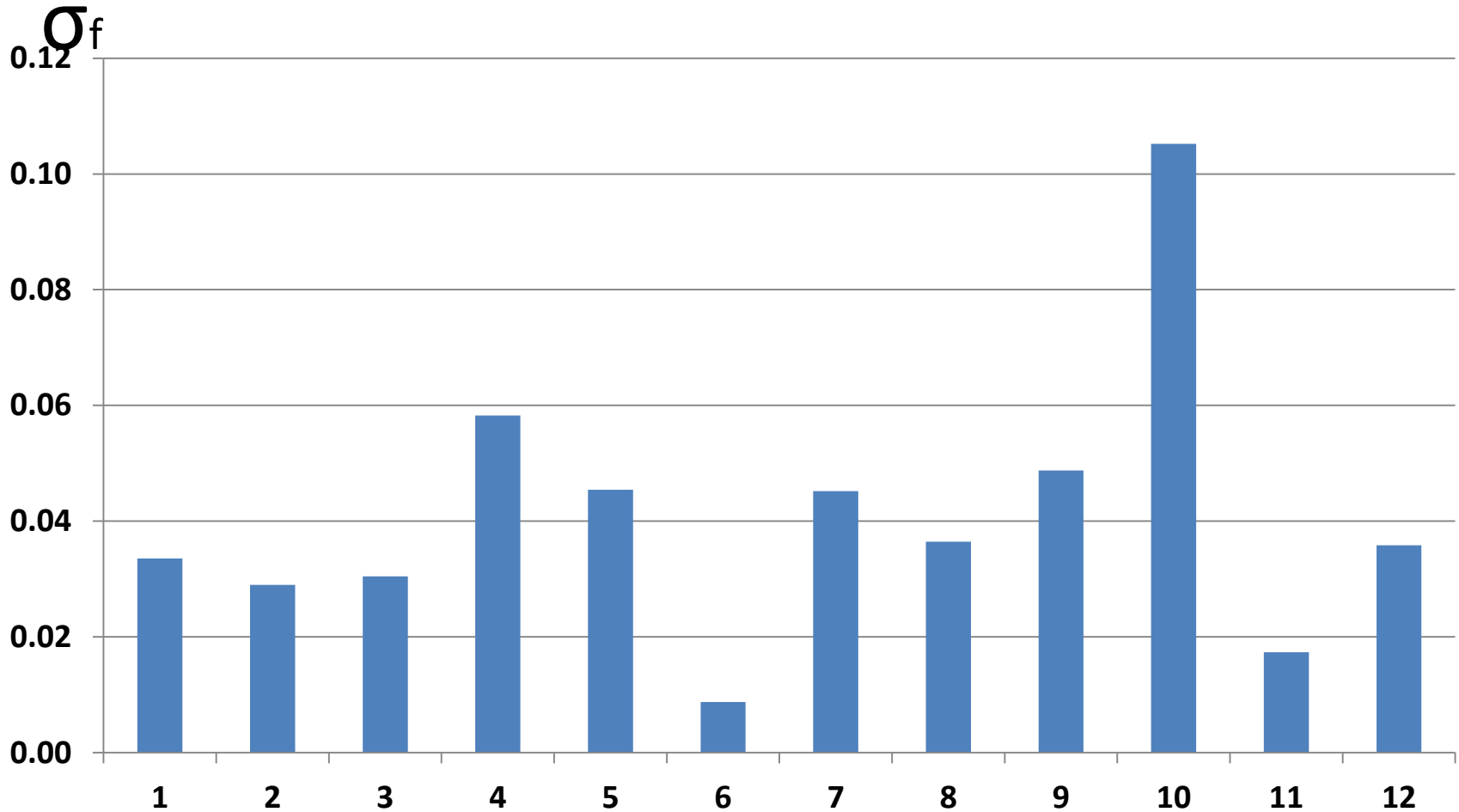
# Estimated values for $f_1$



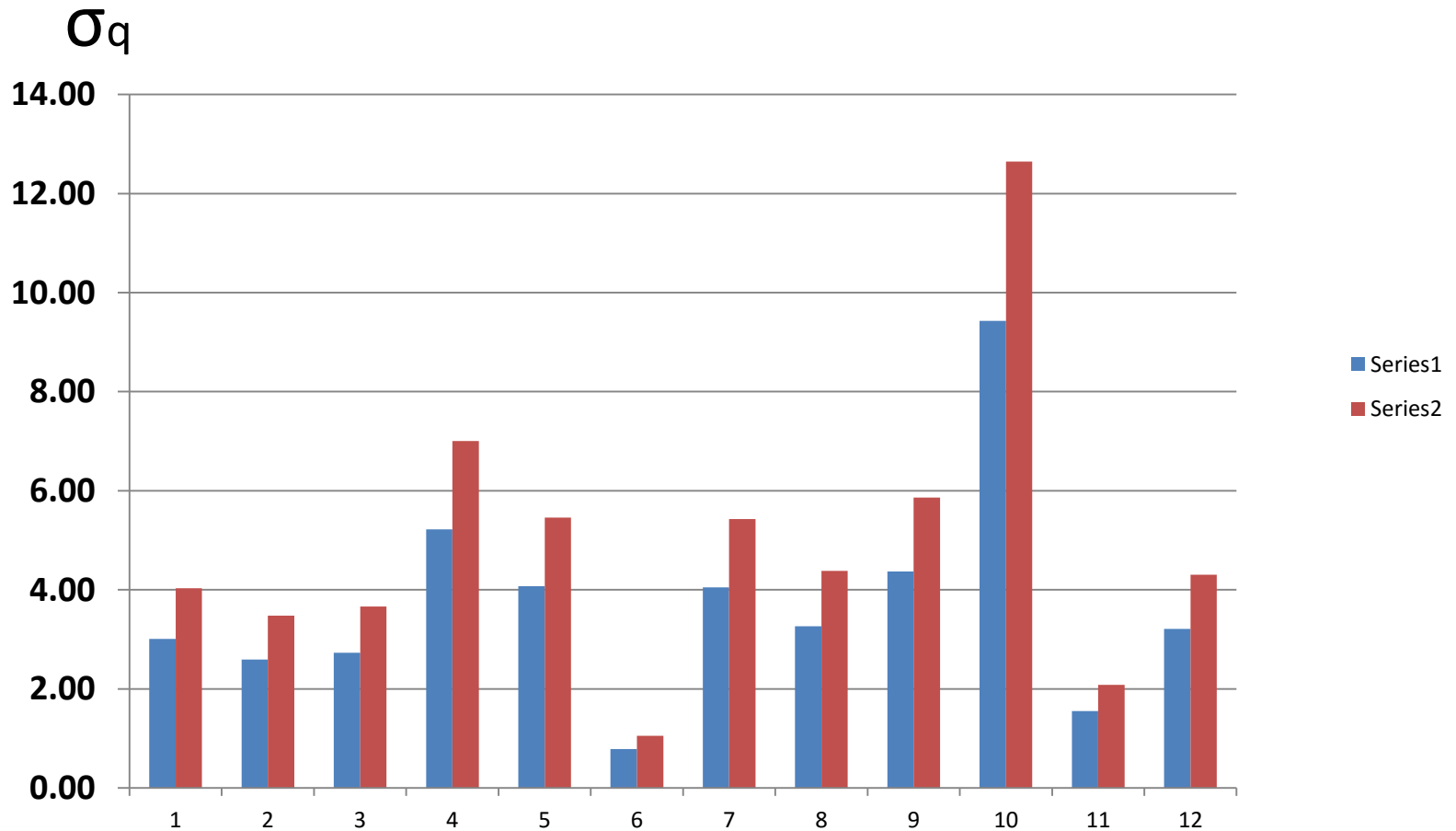
# Specific consumption of buildings for the estimated conditions Q



# The accuracy of $f_1$ measurements



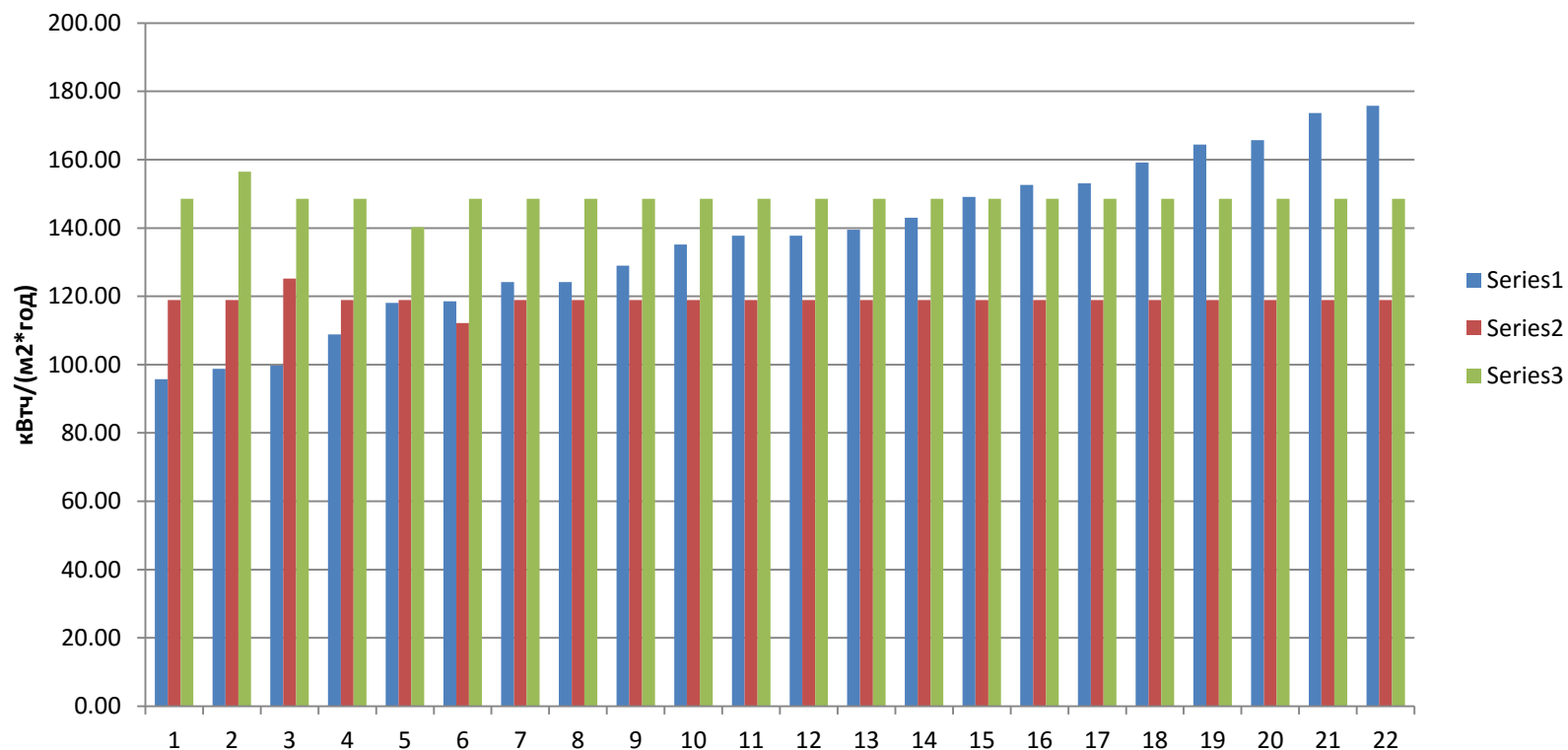
# Measurement error and confidence interval for the specific heat energy consumption for heating and ventilation for the estimated conditions





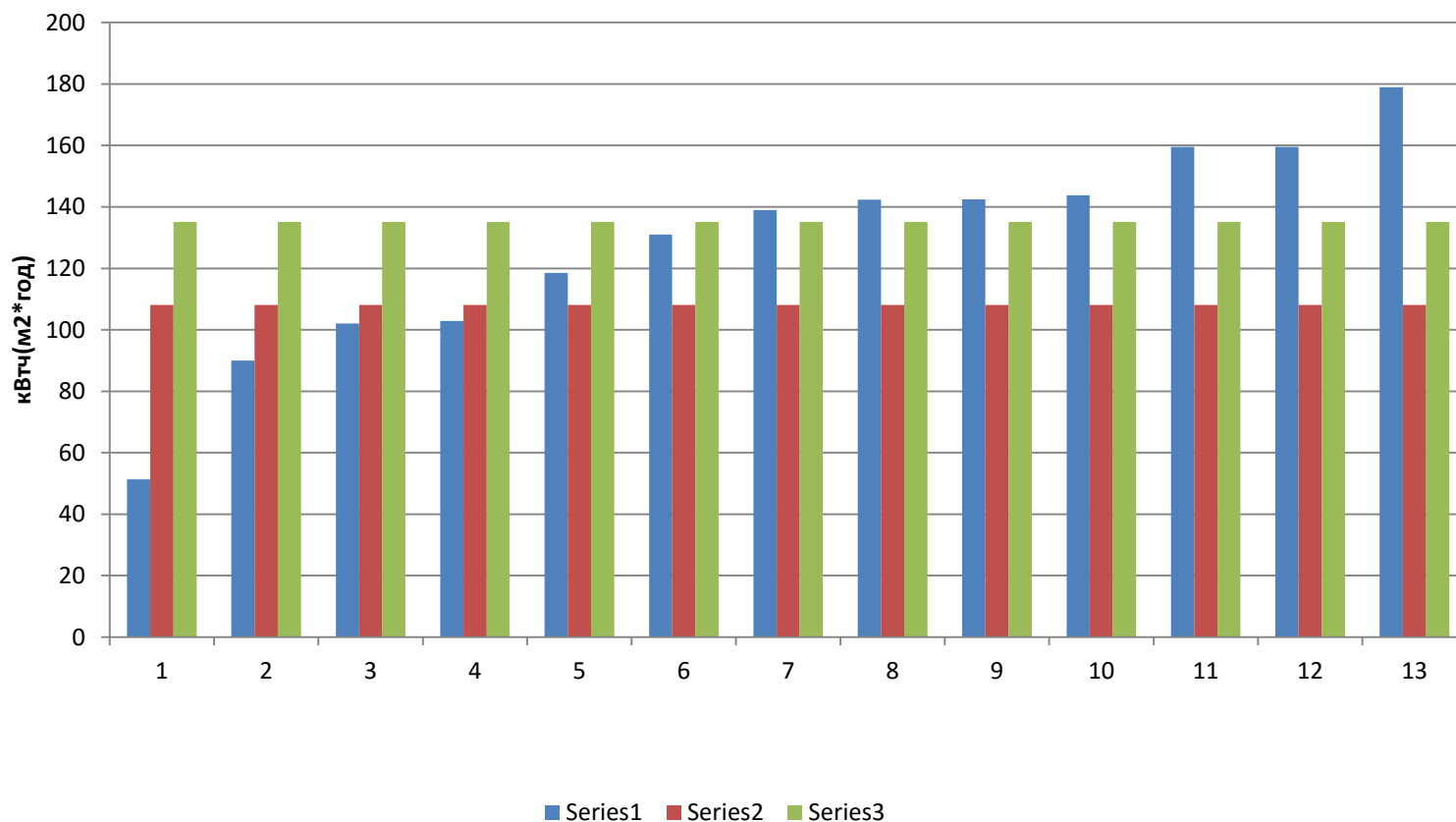
# Thermal energy consumption for heating of the average buildings and high-rise buildings (range 1) and the value for the energy efficiency classes (range 2) and G (range 3)

Specific energy consumption for heating of 6-9 levels buildings for the estimated conditions of Astana (1) for B (2) and C (3)



# Thermal energy consumption for heating in high-rise buildings (range 1) and the value for the energy efficiency classes (Range 2) and C (range 3)

Specific energy consumption for heating of high-rise buildings (range 1) and the classes of energy efficiency B (range 2) and C (range 3)



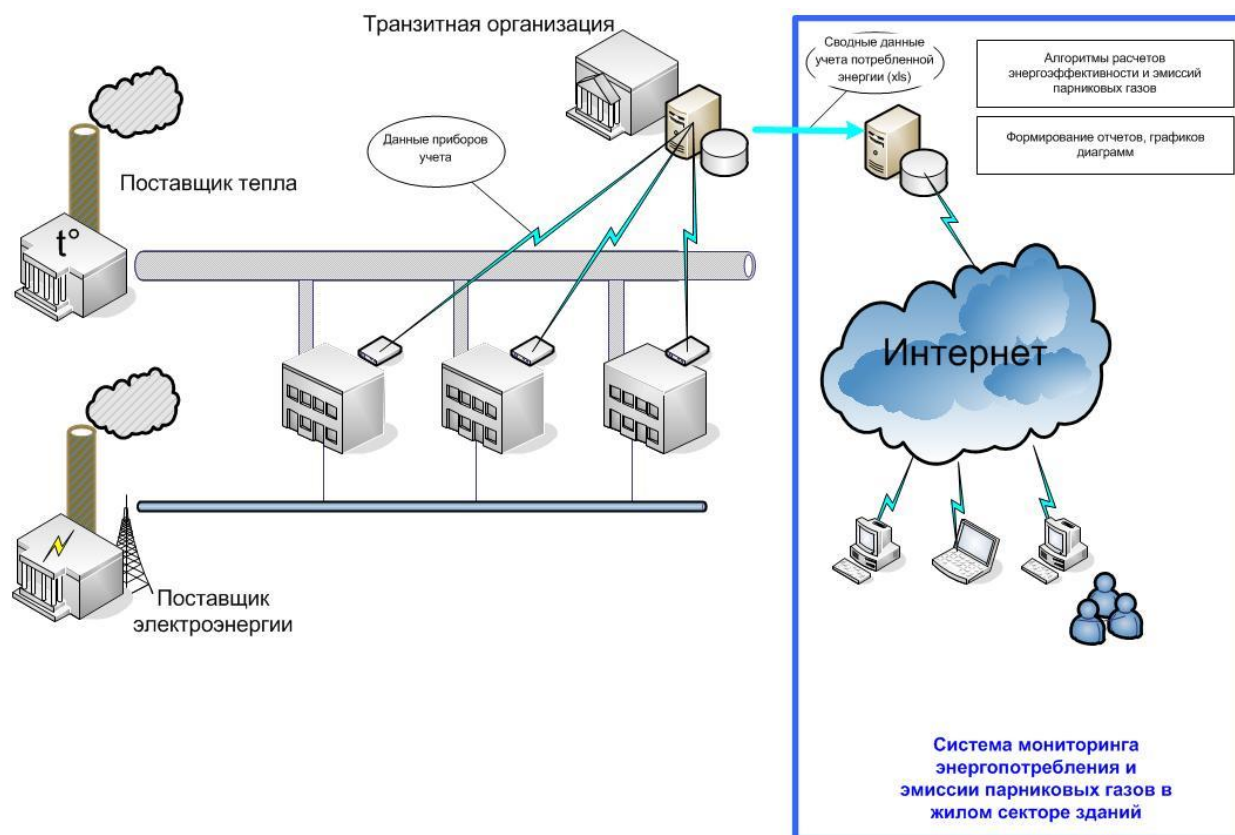
# BRIEF DESCRIPTION OF THE OPERATION OF THE SYSTEM



Empowered lives.  
Resilient nations.

The system is a WEB interface that provides the process of formation of summary information, comparative analysis and the estimated values for energy consumption, energy efficiency of residential buildings and greenhouse gas emissions.

The System provides the establishment of authority of the existing employees of the "User Enterprise" : "System Administrator" and "System User".



# THE MONITORING SCHEME



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Resilient nations.*



# ANNUAL ENERGY EFFICIENCY IN THE CONTEXT OF REGIONS (SUMMARY)



Empowered lives.  
Resilient nations.

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United Nations Development Programme in  
**Kazakhstan**

город Астана

Пользователь: UNDPKATINO

Мониторинг  
энергопотребления и  
эмиссии парниковых газов в  
жилом секторе

Настройки ▾ О проекте Мониторинг Администрирование Справочники Данные Инструкция

Главная > Мониторинг > Энергоэффективность > Энергопотребление > Парниковые газы

Энергоэффективность Отчет по районам Районы СН РК 2.04.04-2011  
Энергопотребление Отчет по кооперативам Районы СН РК 2.04.21-2004  
Парниковые газы Отчет по классам Сводные данные

Год Район Улица Этажность

2014 ▾ Все ▾ Все ▾ Фильтр

Годовая энергоэффективность в разрезе районов

Классы э/эффект Т/потреб Динамика т/потреб

Протокол Инструкция

Строка	Район	Улица	№ дома	Год постройки	Этажность	Площадь м²	Уд. теплопотреб. кВтч/м²·год	Класс э/эффект
								1 2
1	Сары-Арка	187-улица	14/1	2010	6	2116	176	D Г
2	Сары-Арка	187-улица	14/2	2010	6	2076	62	A+ А
3	Сары-Арка	187-улица	16	2010	9	2961	130	C- В
4	Сары-Арка	187-улица	16/4	2010	6	3622	123	C Б
5	Сары-Арка	187-улица	18/2	2011	5	2121	186	D Г
6	Сары-Арка	187-улица	18/3	2011	5	2115	228	E Д
7	Сары-Арка	188-улица	*10/1	2012	15	4369	152	D Г
8	Сары-Арка	188-улица	11	2010	10	3312	98	C+ Б
9	Сары-Арка	188-улица	11/1	2010	6	2135	109	C+ Б
10	Сары-Арка	188-улица	11/2	2010	6	2071	227	E Д
11	Сары-Арка	188-улица	11/3	2010	6	2070	199	E Д
12	Сары-Арка	188-улица	11/4	2010	6	2109	134	C- В
13	Сары-Арка	188-улица	13/4	2010	6	2108	141	C- В
14	Сары-Арка	188-улица	13/5	2010	6	2145	211	E Д
15	Сары-Арка	188-улица	14/3(22/2A	2010	6	4352	180	D Г
16	Сары-Арка	188-улица	14/4(24/2A	2010	6	4257	176	D Г
17	Алматы	3-й микрорайон	*12/1	2005	9	1896	176	D Д
18	Алматы	3-й микрорайон	1	1978	5	3252	209	E Д
19	Алматы	3-й микрорайон	12нов	1990	9	5732	173	D Г
20	Алматы	3-й микрорайон	2	1979	5	3241	196	D Г

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- **Thank you for your attention!**
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