OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

Improving Energy Efficiency and Promoting Renewable Energy in the Agro-Food and Other Small and Medium Enterprises (SMEs) in Ukraine
Project GF/UKR/11/004

REPORT

Energy Efficiency Benchmarking in the Dairy Products Subsector of the Ukraine's Agro-Industrial Sector

Drafted by: A. Chernyavsky

Kyiv 2012

This page internally left blank

CONTENTS

SUMMARY

This report is prepared in the scope of implementation of GEF/UNIDO Improving Energy Efficiency and Promoting Renewable Energy in the Agro-Food and Other Small and Medium Enterprises (SMEs) in Ukraine Project.

The main task of this analysis is to identify energy efficiency in the food industry, specifically, in the production of flour and bakery with the use of benchmarking. The approaches, methods and findings of this analysis will be further disseminated among all the stakeholders.

The report presents the findings of energy efficiency benchmarking in the flour and bakery productions via comparing their specific indicators of energy consumption per unit of output. These indicators are compared both among themselves and against those at the best enterprises of the relevant profile.

We hope that this report would popularize benchmarking and provide an impetus to its applications at food industry enterprises in Ukraine.

INTRODUCTION

The growing competition encourages domestic enterprises to seek new ways and methods to raise management efficiency, ensure stable competitiveness based on identifying and launching of innovations. The pressure of energy costs has become so high that threatens not only competitiveness of the enterprises but rather their existence.

One of these effective tools that provides an enterprise with the possibility to steadily build up productivity, improve performance, be energy efficient is benchmarking.

Benchmarking is the process of analysis and comparative assessment of the methods used in an organization to carry out its functions. This assessment may be conducted either inside an enterprise or organization (comparison of individual structural units or links) or by comparing an enterprise performance results with those of other enterprises. Based on the comparison findings, the enterprise may identify weaknesses in its production processes, find new effective ideas and select the best ways to improve based on the other companies' lessons learned.

Benchmarking stipulates ongoing analysis and assessment of the existing methods of production used at an enterprise through comparing it with the best internal and external practices with further launching of the most effective approaches.

Benchmarking is a very common practice in the world. The main idea underlying benchmarking emerged at the beginning of XX century. The most striking example was Henry Ford's visit to the slaughterhouse in Chicago. The carcasses hung on the hooks and the conveyor moved them from one worker to another with each worker doing his portion of processing. This manufacturing method inspired Mr.Ford and he launched it in the form of automobile conveyor.

The term "benchmarking" was introduced by Xerox in 1979 and within the fifteen years benchmarking spread all over the world at an incredible speed with its applications being available almost in all spheres of manufacturing and service provision. This analysis may be applied to any enterprise or organization operations, starting with performance of first aid stations and fire-fighting crews and ending with the strategic benchmarking at Coca-Cola, Sony, Kraft, etc. The enterprises establish benchmarking associations to perform unbiased analysis, where the main goal is its absolute confidentiality. So, enterprises may share the best practices while not disclosing their business secrets.

They are the following associations *inter alia*:

The Association for Benchmarking Health Care

ISO Benchmarking Association

Electric Utility Benchmarking Association

Knowledge Management Benchmarking Association

Technology Assessment Benchmarking Association and many others.

Unfortunately, the threat of hostile takeover induces enterprises to protect all their information related to energy consumption and product output, therefore benchmarking applications in Ukraine are very limited.

POTENTIAL ROLE OF BENCHMARKING IN IMPROVING ENERGY EFFICIENCY OF AGRO-FOOD ENTERPRISES

Energy efficiency of the industrial enterprises in Ukraine has been and remains low. This is a result of the long-run decline in production, and cheap fuel and energy upon the production revival. However, the situation with the energy prices has dramatically changed. In the latest five years, the cost of energy for Ukrainian enterprises has grown:

eight times - for natural gas;

twice – for electricity.

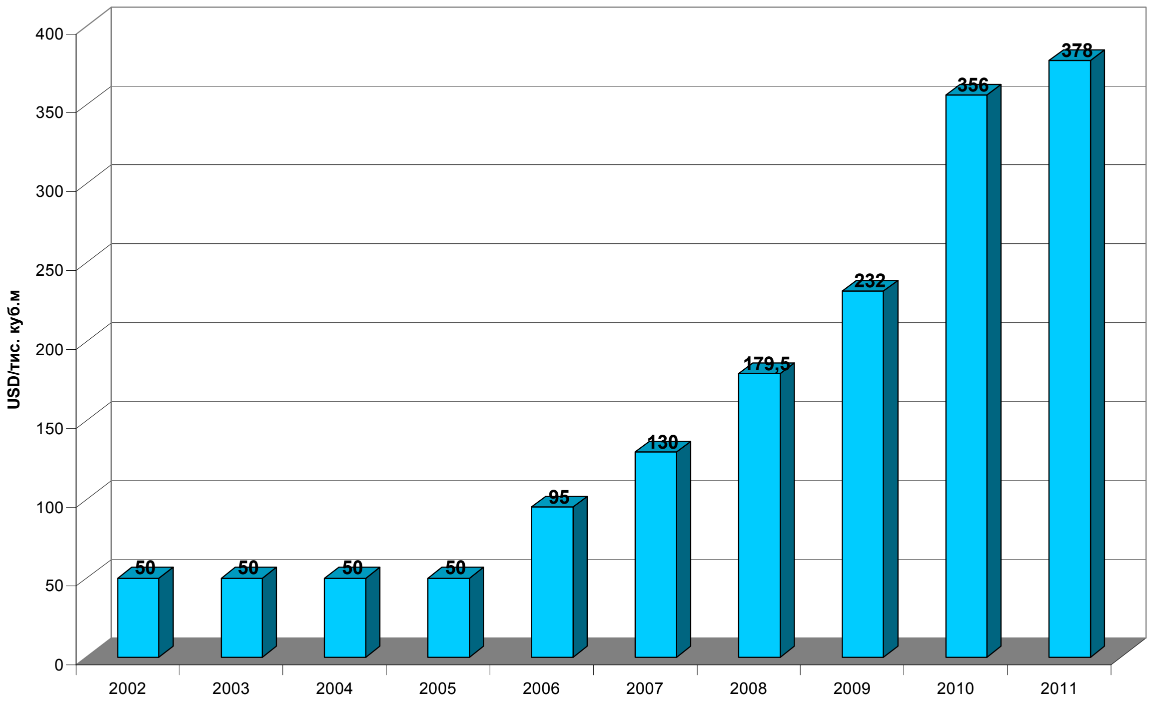

Diagram 1. Dynamics of natural gas price increase.

Every enterprise endeavors to save energy in various ways. However, the lack of experience in taking certain steps or misconception of the expected savings result in overspending of the finance, which are extremely scarce. This is the consequence of the lack of energy management systems and the lack of energy efficiency benchmarking.

Significant energy consumption values are inherent to the food production. This is attributable to the need of product thermal processing and sanitary rules, and cause an extensive use of thermal energy and natural gas, at the same time product preservation requires cold generation thus causing high electricity consumption.

And the enterprises' generating facilities are mostly obsolete. For instance, steam generation by 25-year-old boilers characterized by lower than 80% coefficient of efficiency is commonplace. Those boilers are manually controlled and the only measurement device is a steam pressure manometer and it is used to control the boiler accordingly. For cold generation, compressor refrigerating systems not always correspond to compressor performance capability, as the summer air temperatures have grown and the refrigerating systems are worn out. This causes overconsumption of electricity, as the compressors work in the inefficient mode.

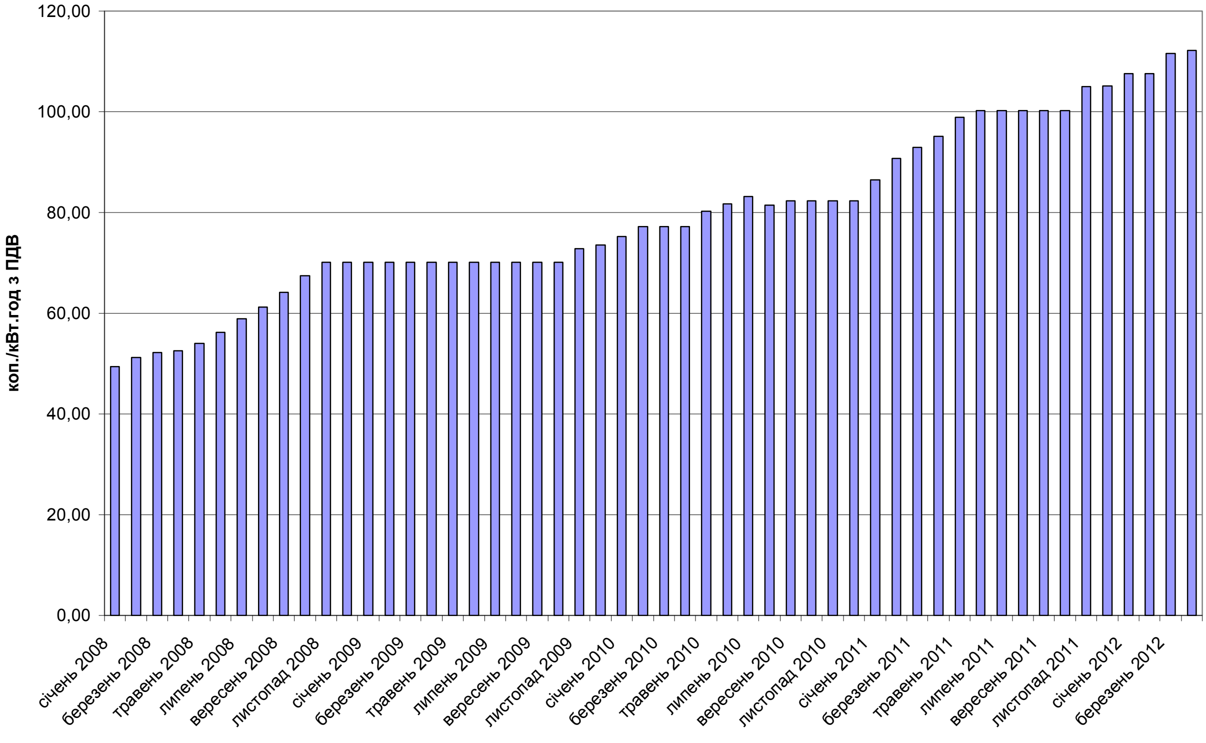

Diagram 2. Dynamics of electricity price increase

Energy efficiency benchmarking provides the opportunity to find out how effectively an enterprise uses energy resources as compared to its competitors and the best similar enterprises in the sector. It helps to identify the spots where energy is excessively consumed. For instance, what stage energy is wasted at: at generation, transportation or when consumed for product manufacturing?

However it is not essential to use only competitive or sectoral benchmarking. This method is flexible and provides the capability to compare enterprises from different sectors, although not in full, but by individual processes, departments or sectors. For example, the following issues may be analyzed:

- How much more energy do we consume for heating office premises than others? Why? What is the least cost solution to this problem?
- Why do we consume more fuel than other enterprises to generate steam? What is the best solution to reduce this indicator value?
- What potential percentage reduction in electricity bills may we achieve through application of the three-zonal tariff? Why do some enterprises manage to reach higher savings than others?
- What secondary sources of thermal energy do other enterprises use for hot water supply?

They are only several issues that benchmarking may help to address, however, an economic effect upon receipt of benchmarking findings and launch of the best practices offers an enterprise significant energy saving opportunities.

Energy Efficiency Benchmarking Methodology

Energy efficiency benchmarking is based on comparing of energy spending indicators in actual values per unit of output.

A model benchmarking curve reflects enterprise efficiency as a function of total product output at similar enterprises or as a function of total number of enterprises operating at this energy efficiency level or lower.

The most ineffective enterprises are portrayed in the left lower part of the curve with the most effective ones being represented in its upper right part. Benchmarking curve shapes will differ for various industries and regions. However, as a rule, several enterprises are most efficient while several enterprises are very inefficient. This situation is expressed in the form of steep region of the curve in the first and the last deciles, respectively. Between these two polar groups, the curve is usually depicted in the form of broad linear dependence between energy efficiency and cumulative output (number of enterprises). This relation could be used for approximate assessment of energy saving potential, which is defined as 50% of the difference between efficiency in the first and the last deciles.

The most efficient enterprise within the benchmark curve is taken to identify the Best Practicable Technology (BPT). Physical product output should be used, where possible, to identify an enterprise location by deciles. Where the data is lacking or unreliable, this approach may not be applied and deciles are formed on the basis of the number of enterprises.

Two other types of analysis could be applied to contribute to the enterprise-related data. They are based on average Specific Energy Consumption (SEC) per unit of output for the sector, region or country (I type) and Energy Efficiency Index (EEI) developed by Phylipsen et al. (2002) and Neelis et al. (2007) in the Netherlands (II type).

SEC analysis employs an average current SEC value at the national or regional level depending on data availability. Where no input data is available for this kind of analysis, statistics provide only the basis for evaluation of the energy efficiency. Statics enables analysis of the information on the use of energy resources at industry-specific (sector-specific) level including all production processes in a certain sector.

Country's EEI assessment j for sector x with production processes i is accomplished according to the following equation:

$$EEI_{j,x} = \frac{TFEU_{j,x}}{\sum_{i=1}^{n} P_{i,j} \times BPT_{i,x}} \quad (1)$$

where TFEU – actual use of energy in sector *x* according to the energy balance compiled by the International Energy Agency (IEA) (Petajoule (PJ) per year),

P – output of product *i* in country *j* (thousand tons (Mt) per year),

BPT – the best practicable technology for manufacturing product *i* (Gigajoule (GJ) per ton of products)

N – number of products to be pooled.

If the country's energy efficiency is the highest in the world, all processes for the sector (industry) would take BPT values. In this case, EEI of the country or region is equal to 1.

These approaches may be applied to identify energy efficiency potential for sector *x* in country or region *i* as follows:

$$Potential = 1 - \frac{International\ benchmark\left(BPT\ or\ SEC_{lowest,x}\right)}{SEC_{j,x}} \quad (2), \text{або}$$

$$Potential = 1 - \frac{EEI_{lowest,x}}{EEI_{j,x}} \quad (3)$$

Therefore, benchmarking provides the capability to evaluate energy efficiency of an individual enterprise as compared to other enterprises and economic sector as a whole, and to identify energy saving potential.

BRIEF DESCRIPTION OF THE INDUSTRY AND ITS SPECIFIC FEATURES IN TERMS OF ENERGY SAVING

Diary products rank high among the world food resources. Despite continuous reduction in milk output in recent years, Ukraine is still among the top ten largest milk and diary producers in the world. Milk and diary products segment accounts for one third of sales in the domestic food marketplace. This attracts large investors to the milk industry and motivates the battle for leading positions in the most prospective, in terms of sales, regions of the country.

The diary product market in Ukraine in 2011 supported the main trend in the diary product market development. Many Ukrainian manufacturers return to classic technologies of diary production increasing the output of natural products and optimizing their quality and packaging assortment.

Property restructuring, strengthening the influence of large companies, technical modernization of production, launching of new technologies – these are the main trends on the Ukrainian diary product marketplace today. Moreover, milk processing enterprises more often start producing innovative diary products containing various fillers and additives. Unpackaged milk more and more seldom appears in retail outlets.

Underdeveloped raw material market and its low quality has tuned into a permanent problem in the industry. According to analysts, the deficit of raw milk is due to reduction in the cow population and increased demand for milk in processing factories. Seasonality coefficient in milk production is very high in Ukraine that is attributable to the cattle farming technologies. The ratio is: 1 liter of milk produced in winter against 5 liters of summer milk yield. In Europe, this ratio is 1.0 : 1.5.

Profitability of diary production depends on the level of milk procurement prices. Since over 80% of milk is produced in households, the milk marketplace by its attributes is close to fair competition. However, producers are to sell their products to the milk processing factory in their close vicinity, which have milk lorries. So, producers are limited in buyer selection. Therefore, milk processing enterprises may dictate a purchase milk price during the period of seasonal milk yield increase, and this is of negative impact on profitability.

Diary production in Ukraine is characterized by high concentration. The major portion of fermented milk products is manufactured at the enterprises based in Kyiv and Kyiv region (17%), Dnipropetrovsk region (12%), Donetsk region (11%), Kharkiv region (10%), Lviv region (9%) and Poltava region (9%).

In 2011, the five leaders on the Ukraine's milk marketplace were as follows: "Danone-Dnipro" Ltd., "Galychyna" PJSC, "Molochny dim" Ltd., "Prydniprovsky combine" PJSC and "Wimm-Bill-Dann Ukraine" PJSC. Their total output accounted for 68%.

In general, a diary enterprise consists of the following production departments:

- whole milk department for production of pasteurized milk and a wide range of fermented milk products;
- sterilized milk department, which output is pasteurized and sterilized milk, cream;
- milk protein department, production of curd cheese, sweet creamed curds, processed cheeses;
- sour cream and butter production department;
- water treatment department
- warehouses for stores and finished products;
- air and cooling compressor units department;
- boiler house;
- administrative and amenities buildings, etc.

Heat supply at the enterprises mostly is provided from own industrial boiler houses equipped with steam boilers. In most cases, the boilers are equipped with automatic control systems and systems for adjustment of technological operation mode. Heat consumers include processing equipment, heating systems, inlet ventilation and household needs. See below a consolidated heat balance structure in table 1.

Table 1

Model heat balance of an enterprise

No.	Balance items	Share of heat supply, %
2	**Heat supply (total thermal energy generation):**	**100.00**
3	**Consumption (total):**	-
4	Heating and ventilation of production and warehouse buildings	**100.00**
5	Heating and ventilation of administrative and other buildings	11.99
6	Technology	4.66
7	Sanitary and hygienic needs	70.04
8	Losses in heat supply networks	2.09

The enterprise's needs in cold and compressed air are satisfied by its own compressor station.

Electricity is supplied to enterprises from the power grid through 10/0.4 kV step-down transformer substations. Electricity consumption recording levels differ among enterprises starting with the availability of commercial electricity consumption metering only and ending with modern high-tech enterprises where almost all electricity consumers are equipped with electricity meters. Major electricity consuming equipment is as follows:

- compressing and refrigerating units;
- supply-extract systems, conditioners;

– product preparation, sterilization, packaging units;
– freight elevators;
– electric engines of pumps;
– repair and maintenance equipment (welding apparatuses, turning and drilling machines, electric tools);
– boiler house equipment (ventilators, flue-gas fans, pumps);
– lighting of production premises and areas;
– laboratory equipment;
– computers.

See below a consolidated electricity balance structure in table 2.

Table 2

Model electricity balance of an enterprise

No.	**Balance items**	**Share of electricity supply, %**
1	**Supply (total consumed electricity):**	**100**
2	including:	
3	- for technological needs	62.0
4	- water supply	6.0
5	- compressed air production	7.5
6	- cold generation by refrigerating chambers	5.0
7	- heat generation and transportation	8.0
8	- ventilation and conditioning of production departments	8.0
9	- indoor lighting of production departments	1.0
10	- outdoor lighting	0.5
11	- losses in lines and transformers	1.0
12	- other consumers	1.0

ANALYSIS FINDINGS

For benchmarking, the factories and combines have been selected that have departments for production and processing of milk, fermented milk products, curd cheese, butter, cheese and sour cream.

The data on specific consumption of heat and electricity for production and processing of milk, fermented milk products, curd cheese, butter, cheese and sour cream in 2011 have been received from 32 enterprises.

The findings of analysis into specific consumption of heat and electricity for production and processing of milk, fermented milk products, acid curd cheese, butter, cheese and sour cream are represented in table 3.

Table 3

Findings of analysis into specific consumption of heat and electricity for production and processing of milk, fermented milk products, acid curd cheese, butter, cheese and sour cream

Enterprise code*	Product type	Unit of measurement	Production output in 2011	Specific energy consumption	
				heat, Mcal/unit	electricity, kW-hour/unit
Dairy-1	Milk	t	11,578.662	82.72	90.8
	Fermented milk products	t	15,094.855	370.09	145.54
	Curd cheese	t	197.173	1,170.34	135.39
Dairy-2	Milk	t	17,544.326	215.03	153.115
	Fermented milk products	t	21,717.751	254.87	193.808
	Sour cream	t	6,673.655	615.82	171.882
	Curd cheese	t	6,549.356	1,001.97	182.175
Dairy-3	Curd cheese	t	283	1,279.011	143.846
	Butter	t	3,025	2,467.074	524.378
	sour cream	t	7,967	289.651	65.437
Dairy-4	Молоко	t	4,386	118.452	22.524
	Butter	t	335.1	2,818.241	106.491
	Curd cheese	t	252.1	1,139.333	56.431
	fermented milk products	t	2,572.6	592.044	47.028
Dairy-5	cheese	t	5,468.9	1,672.732	705.735
	Butter	t	157.2	912.017	166.859
	Milk	t	478.3	490.753	111.175
	Sour cream	t	246	498.215	233.105
Dairy-6	Milk	t	19,418.1	91.08	92.54
	Butter	t	3,392.6	1,905.47	329.36
	Curd cheese	t	3,677.4	1,420.66	94.41
	fermented milk products	t	16,755.9	785.56	156.7
Dairy-7	Butter	t	822	1,535.3	201.9
	Curd cheese	t	2,888	2,273.2	204.6
	Milk	t	19,163	251.9	27.5
Dairy-8	Butter	t	834	3,497.85	1,013.35
	Milk	t	3,935	140.44	122.23

Dairy-9	Butter	t	132.1	3,333	290
	Curd cheese	t	515	4674	295
	Milk	t	10,293	210	44
Dairy-10	Butter	t	1,196	3,334.4	97.4
	Milk	t	258	351	50
Dairy-11	Butter	t	325	3,331.5	96
	Curd cheese	t	2,680	3,815	131
Dairy-12	Butter	t	312	2,250	118.6
	Curd cheese	t	2,188	299.8	170
	Milk	t	14,108	170	13.9
Dairy-13	Butter	t	1,767	1,031.2	119
	Curd cheese	t	246	1,951.2	162.6
Dairy-14	Butter	t	448	3,426.4	277
	Milk	t	20,665	518.7	61
	Fermented milk products	t	25,000	219.9	12.2
Dairy-15	Butter	t	62	2,250.2	274.1
Dairy-16	Butter	t	555	1,931.3	180.4
	Curd cheese	t	1,972	1,997.5	162.4
	Milk	t	18.5	864.9	54.7
Dairy-17	Butter	t	83	4,960	265
	Milk	t	6,438	126	57
	Curd cheese	t	36	5,295	290
Dairy-18	Milk	t	1,987.6	130	74.7
	Butter	t	803.3	2,400	425.3
	Sour cream	t	128.7	810	200.9
	Curd cheese	t	999.4	1,590	670.8
Dairy-19	Butter	t	449.2	2,210	175
	Curd cheese	t	1,874.8	2,350	160
	Milk	t	15,101.8	220	35
Dairy-20	Butter	t	6,000	342	73.5
	Milk	t	2,700	162.3	39.1
Dairy-21	Milk	t	20,050	324.7	124.4
	Butter	t	455	1,413.2	351.6
	Curd cheese	t	5,620	994.7	260
	Fermented milk products	t	28,605	337.7	247
Dairy-22	Butter	t	1,005	3460	818
	Milk	t	24,330	180.5	98.9
Dairy-23	Butter	t	595.7	437.2	937.4
	cheese	t	6,243.8	1442	1011
Dairy-24	Butter	t	223	2,678.1	310.4
	cheese	t	4000	1,475.5	258.2
	Curd cheese	t	747	937.7	256.1
Dairy-25	Butter	t	160	3,677.3	411.1
	cheese	t	906	3,485.3	404.1
Dairy-26	Butter	t	225	4,004	380
	cheese	t	1580	3,005	325.3
Dairy-27	Butter	t	160	2,493.7	341.6
	cheese	t	2,600	1,600.6	349.5
	Milk	t	3,000	133.3	33.6

Dairy-28	Milk	t	705	150	100
	Sour cream	t	60	250	300
	Butter	t	39	950	350
	cheese	t	41	1120	170
Dairy-29	Butter	t	240	1168	139
Dairy-30	Butter	t	493	2111	213.4
	Milk	t	25	66	41.2
	Curd cheese	t	15,812	297	35.2
Dairy-31	Butter	t	412	1,517.9	181.6
	cheese	t	377	1,821.2	152.8
	Milk	t	3,392	114.2	15.7
Dairy-32	Milk	t	5,700	91.4	102.4
	Butter	t	1,100	1,149.7	251.9
	cheese	t	9,914	1,048.7	204.6
	Sour cream	t	1,040	814.2	168.2

* names of enterprises are not disclosed in order to protect business information

Benchmarking curves have been built on the basis of the obtained information using the proved technique [12] (Diagrams 3-14).

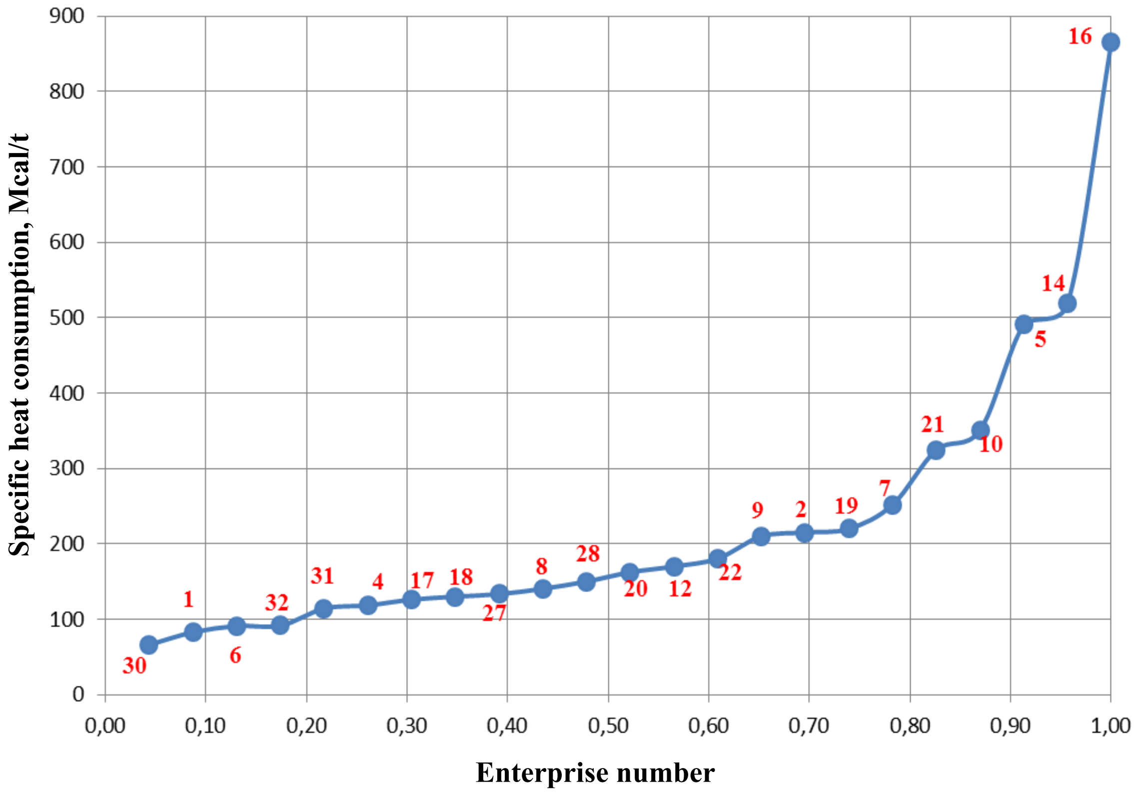

Diagram 3 - Benchmarking curve of specific heat consumption by the milk-producing and processing enterprises

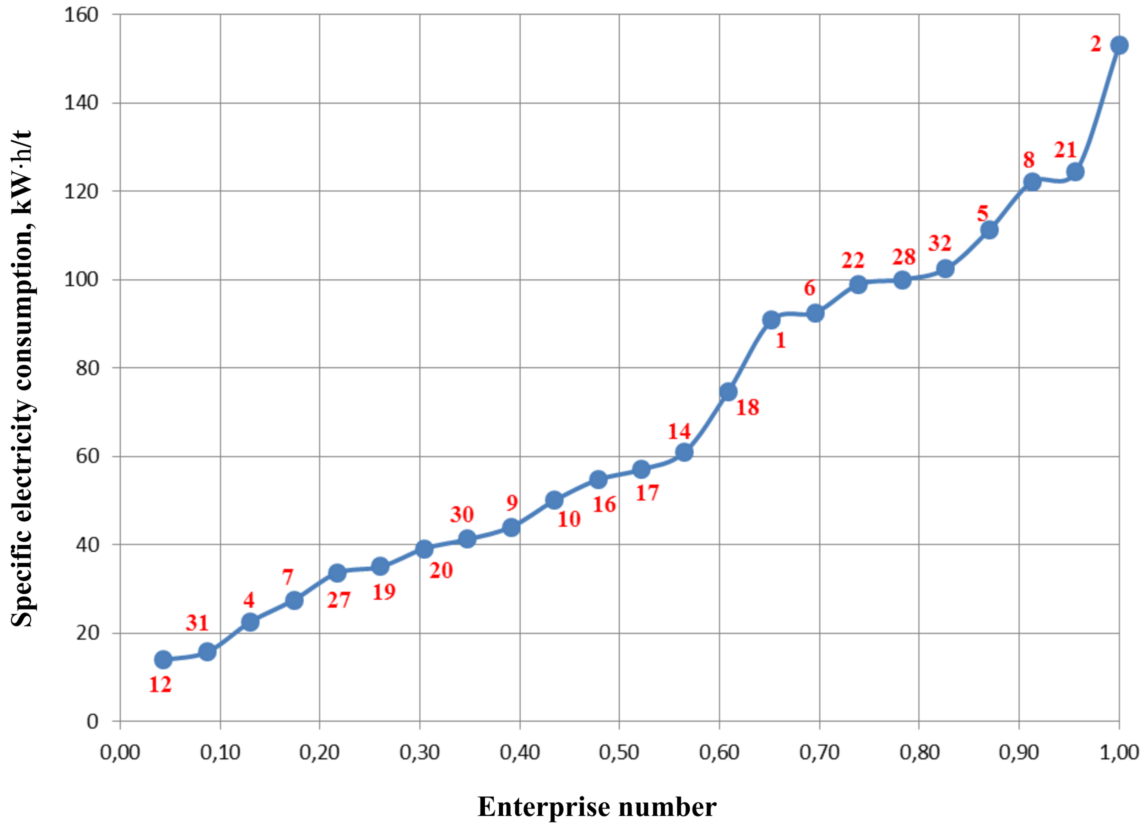

Diagram 4 - Benchmarking curve of specific electricity consumption by the milk-producing and processing enterprises

The curves (diagrams 3 and 4) are used to identify enterprises' efficiencies.

By heat consumption:
The most efficient enterprise – 66.0 Mcal/t
The least efficient enterprise – 864.9.0 Mcal/t

BAT = 66.0 Mcal/t
BPT = 66.0 Mcal/t

By electricity consumption:
The most efficient enterprise – 13.9 kW-hour/t
The least efficient enterprise – 153.15 kW-hour/t

BAT = 13.9 kW-hour/t
BPT = 13.9 kW-hour/t

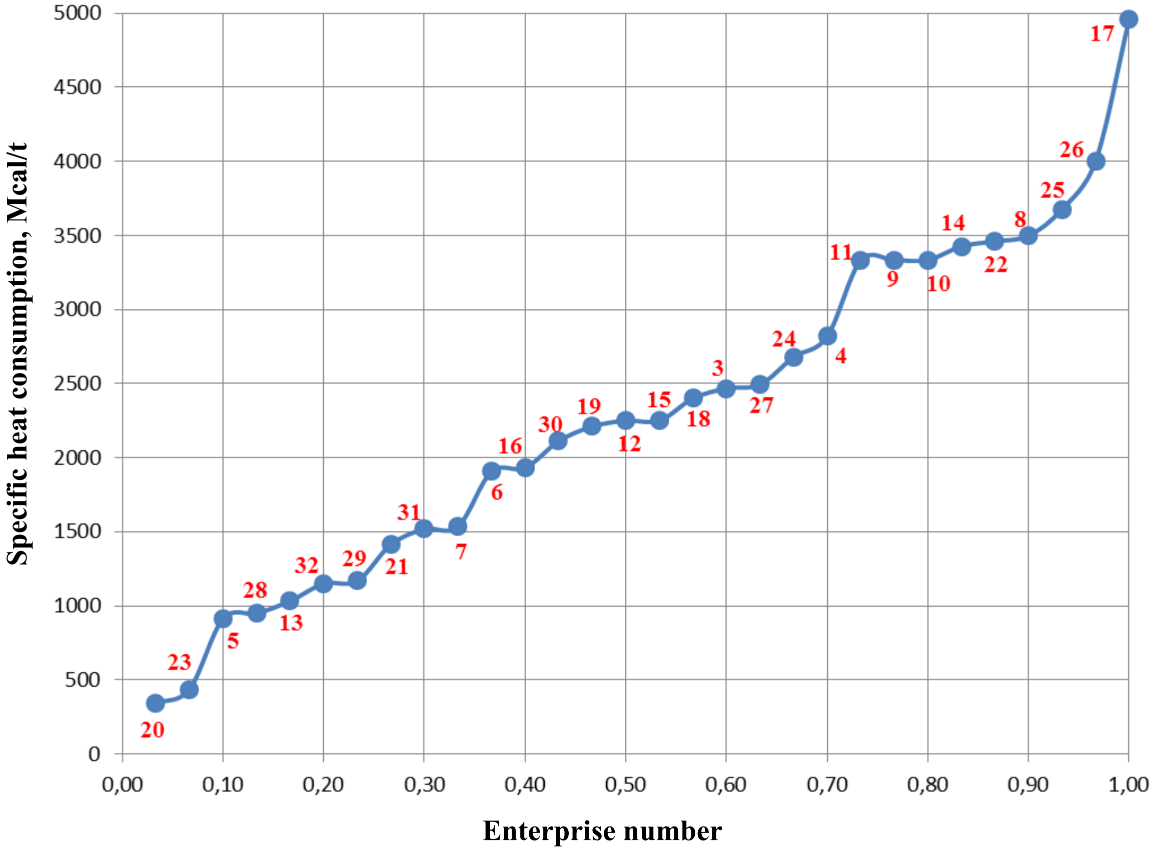

Diagram 5 - Benchmarking curve of specific heat consumption by the butter-producing enterprises

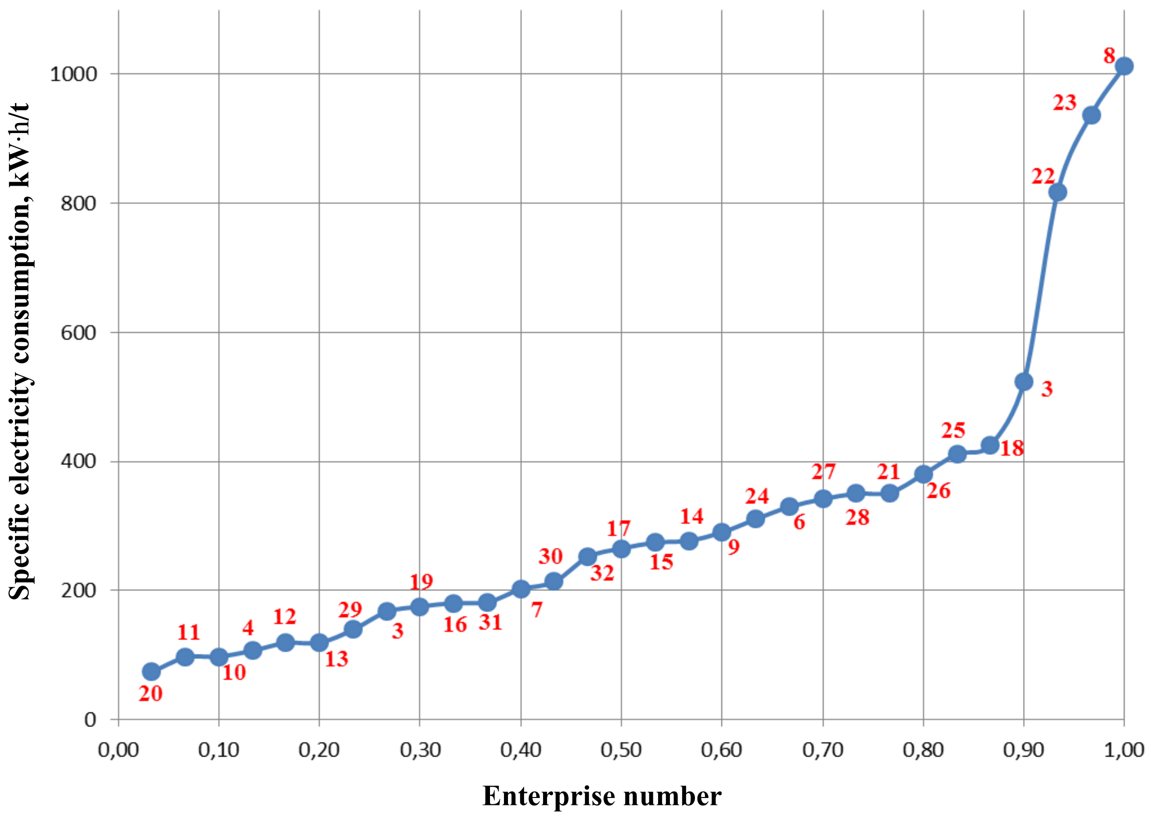

Diagram 6 - Benchmarking curve of specific electricity consumption by the butter-producing enterprises

The curves (diagrams 5 and 6) are used to identify enterprises' efficiencies.

By heat consumption:
The most efficient enterprise – 342.0 Mcal/t
The least efficient enterprise – 4,960.0 Mcal/t

BAT = 342.0 Mcal/t
BPT = 342.0 Mcal/t

By electricity consumption:
The most efficient enterprise – 73.5 kW-hour/t
The least efficient enterprise – 1,013.35 kW-hour/t

BAT = 73.5 kW-hour/t
BPT = 73.5 kW-hour/t

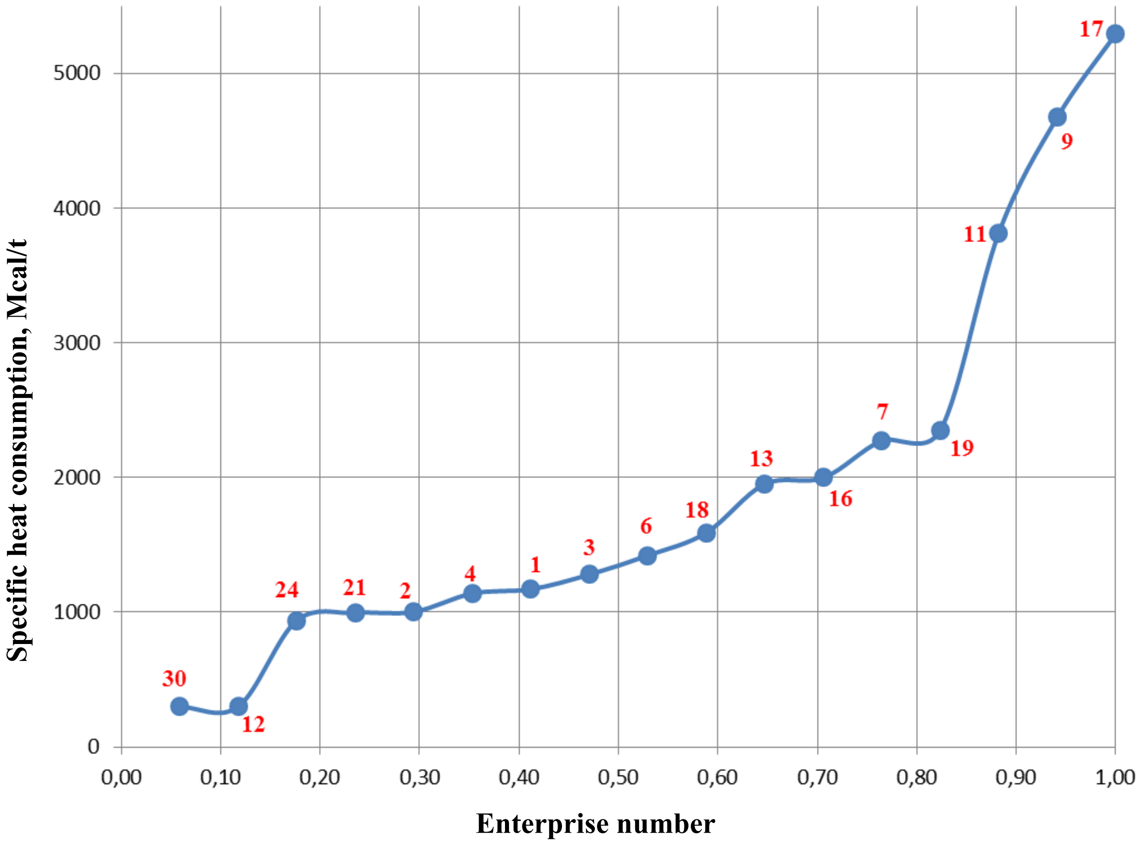

Diagram 7 - Benchmarking curve of specific heat consumption by the curd cheese-producing enterprises

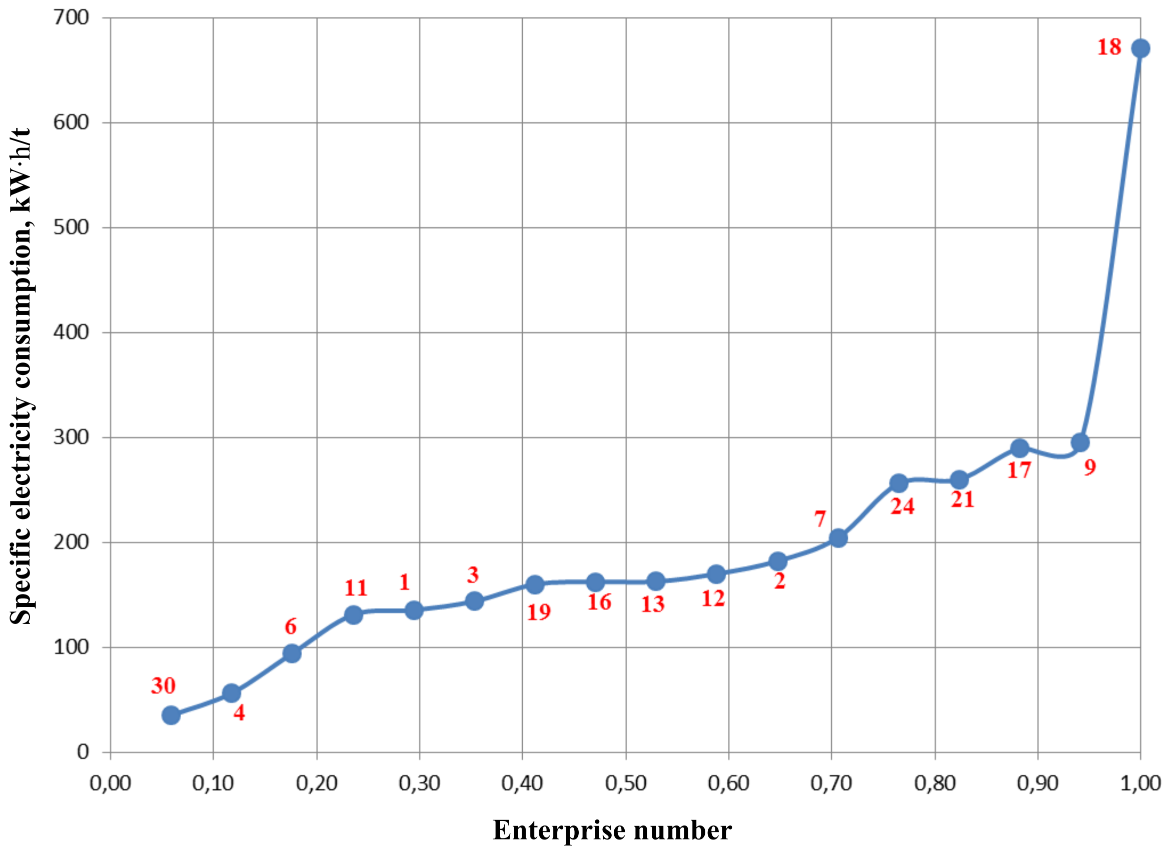

Diagram 8 - Benchmarking curve of specific electricity consumption by the curd cheese-producing enterprises

The curves (diagrams 7 and 8) are used to identify enterprises' efficiencies.

By heat consumption:
The most efficient enterprise – 297.0 Mcal/t
The least efficient enterprise – 5,295.0 Mcal/t

BAT = 297.0 Mcal/t
BPT = 297.0 Mcal/t

By electricity consumption:
The most efficient enterprise – 35.2 kW-hour/t
The least efficient enterprise – 670.8 kW-hour/t

BAT = 35.2 kW-hour/t
BPT = 35.2 kW-hour/t

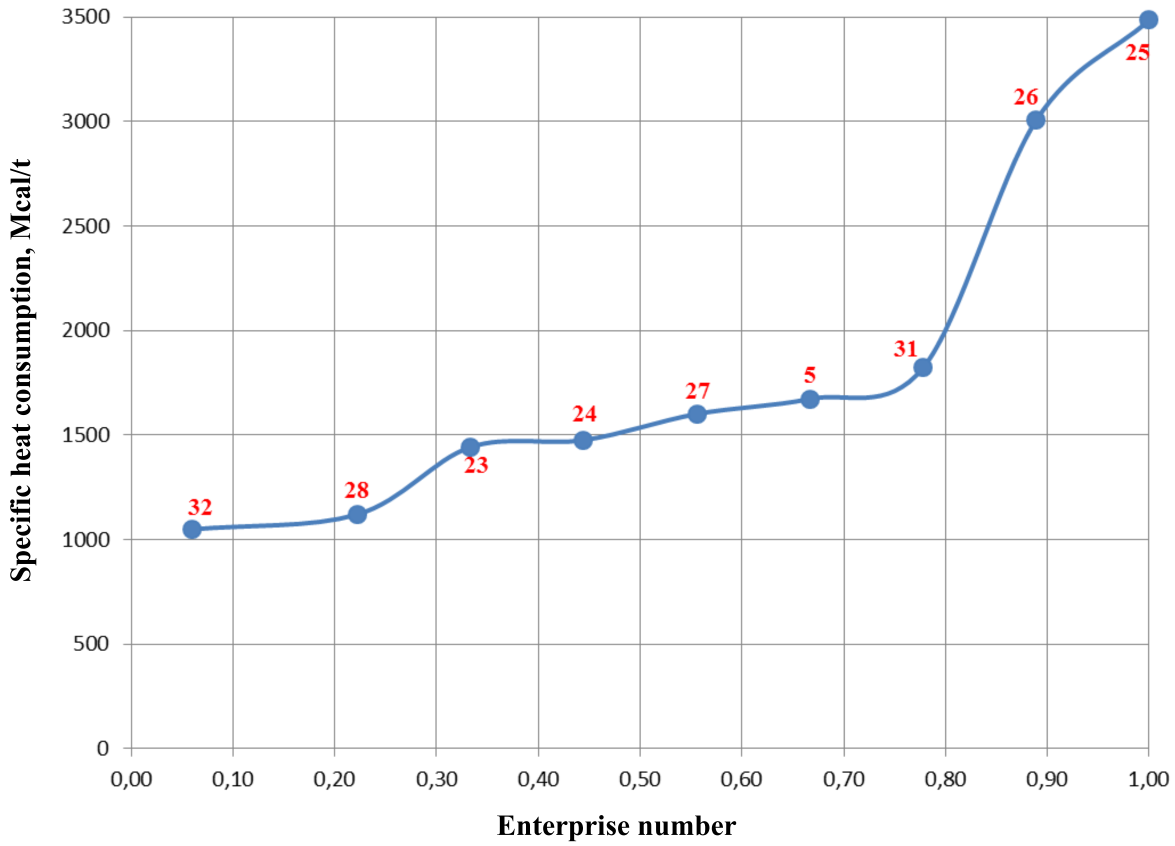

Diagram 9 - Benchmarking curve of specific heat consumption by the cheese-producing enterprises

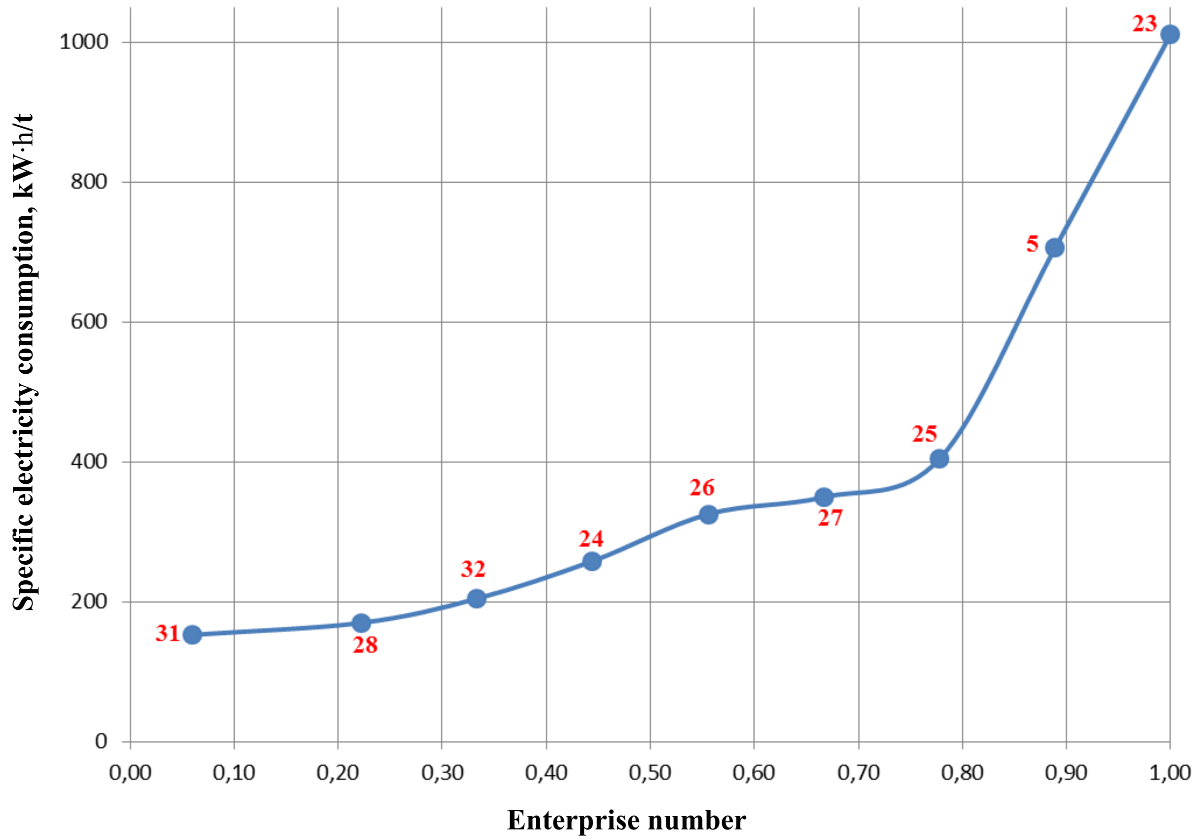

Diagram10 - Benchmarking curve of specific electricity consumption by the cheese-producing enterprises

The curves (diagrams 9 and 10) are used to identify enterprises' efficiencies.

By heat consumption:
The most efficient enterprise – 1,048.7 Mcal/t
The least efficient enterprise – 3,485.3 Mcal/t

BAT = 1,048.7 Mcal/t
BPT = 1,048.7 Mcal/t

By electricity consumption:
The most efficient enterprise – 152.8 kW-hour/t
The least efficient enterprise – 1,011 kW-hour/t

BAT = 152.8 kW-hour/t
BPT = 152.8 kW-hour/t

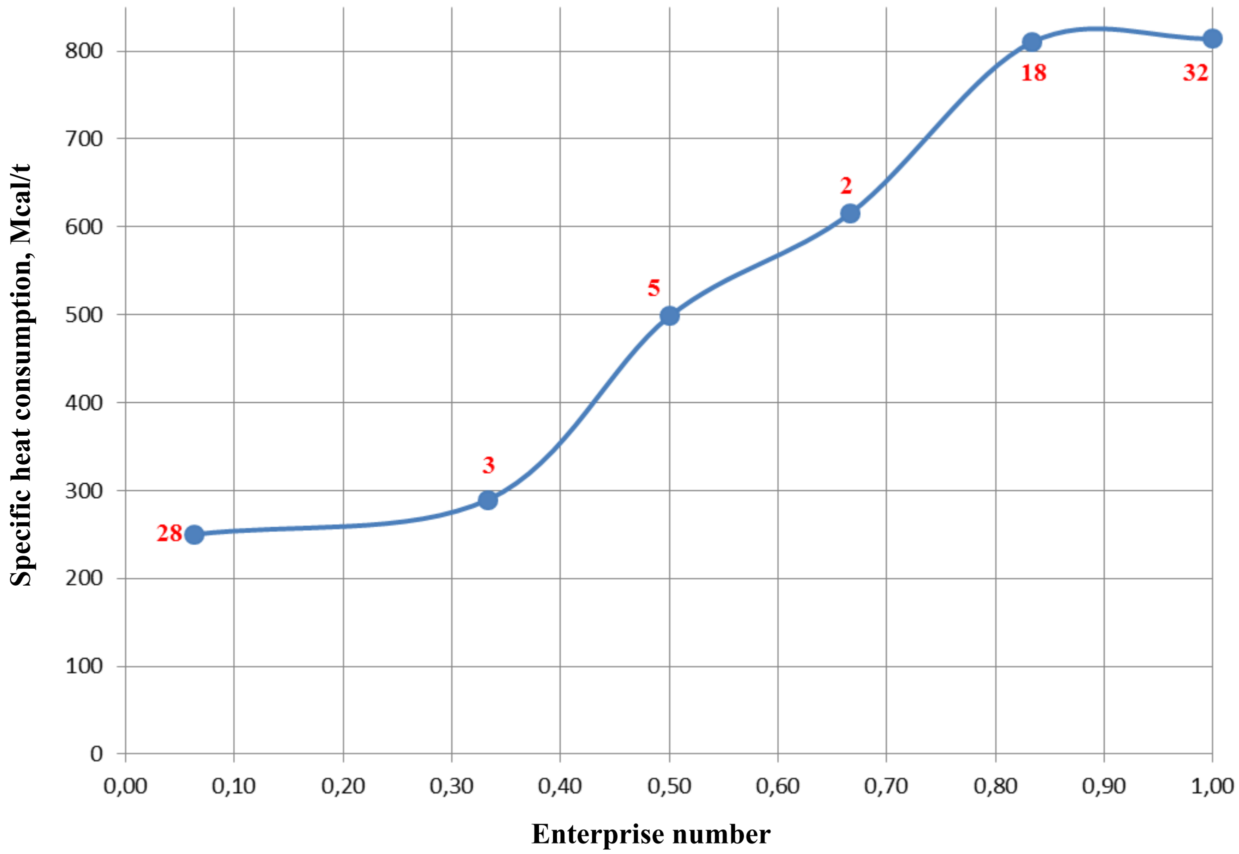

Diagram 11 - Benchmarking curve of specific heat consumption by the sour cream-producing enterprises

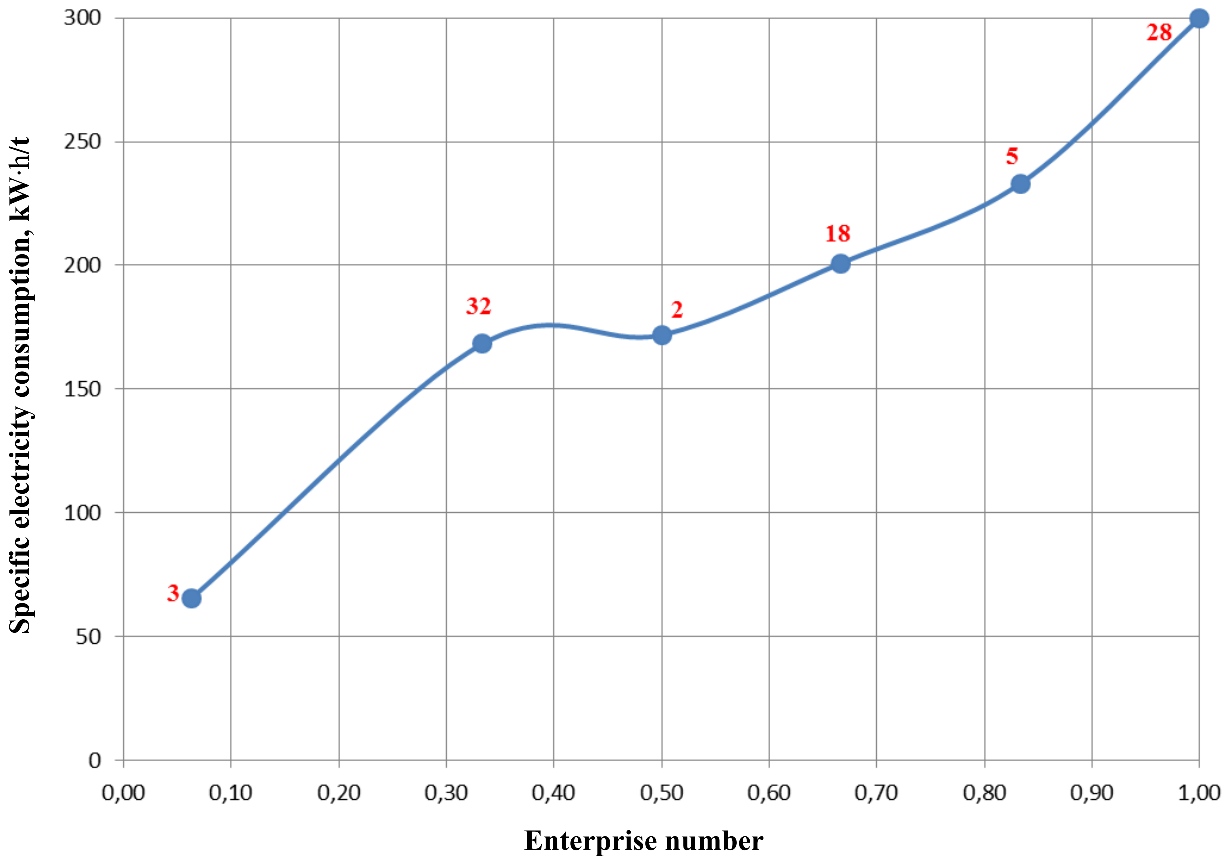

Diagram 12 - Benchmarking curve of specific electricity consumption by the sour cream-producing enterprises

The curves (diagrams 11 and 12) are used to identify enterprises' efficiencies.

By heat consumption:
The most efficient enterprise – 250.0 Mcal/t
The least efficient enterprise – 814.2 Mcal/t

BAT = 250.0 Mcal/t
BPT = 250.0 Mcal/t

By electricity consumption:
The most efficient enterprise – 65.437 kW-hour/t
The least efficient enterprise – 300.0 kW-hour/t

BAT = 65.437 kW-hour/t
BPT = 65.437 kW-hour/t

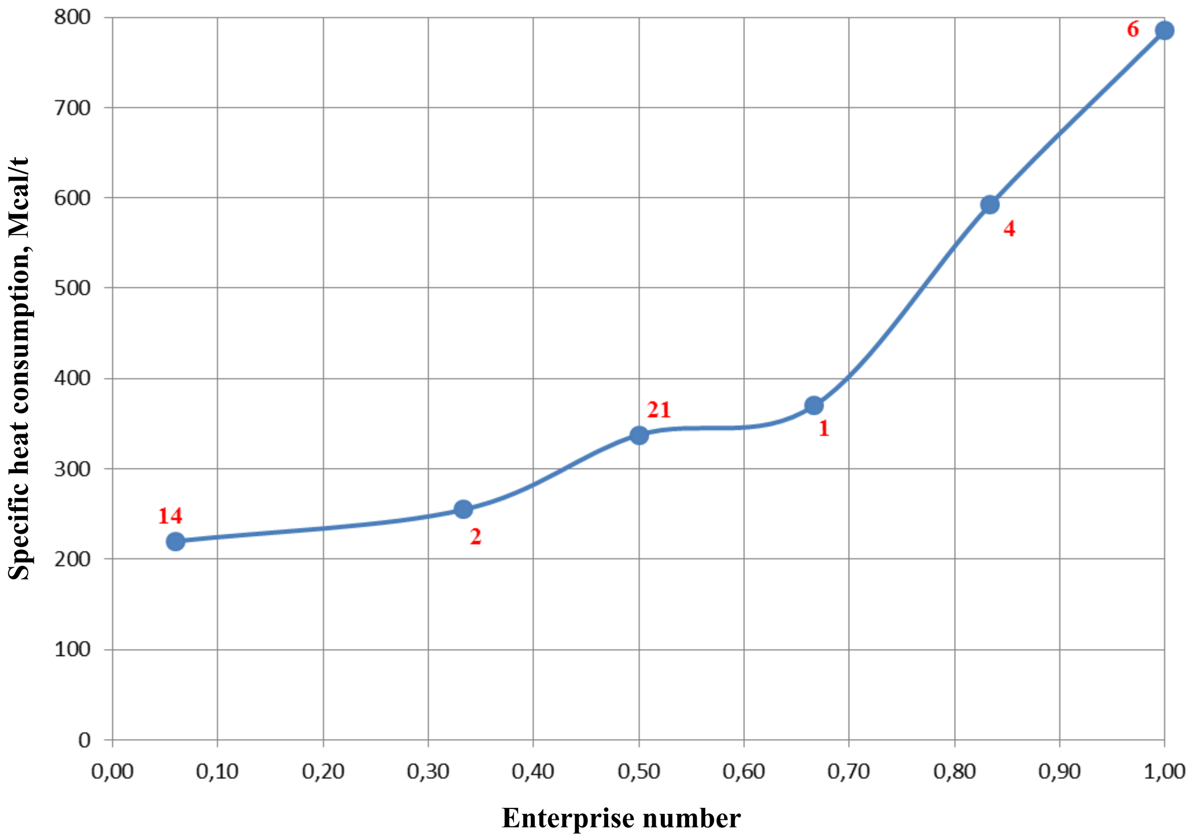

Diagram 13 - Benchmarking curve of specific heat consumption by the fermented milk products producing enterprises

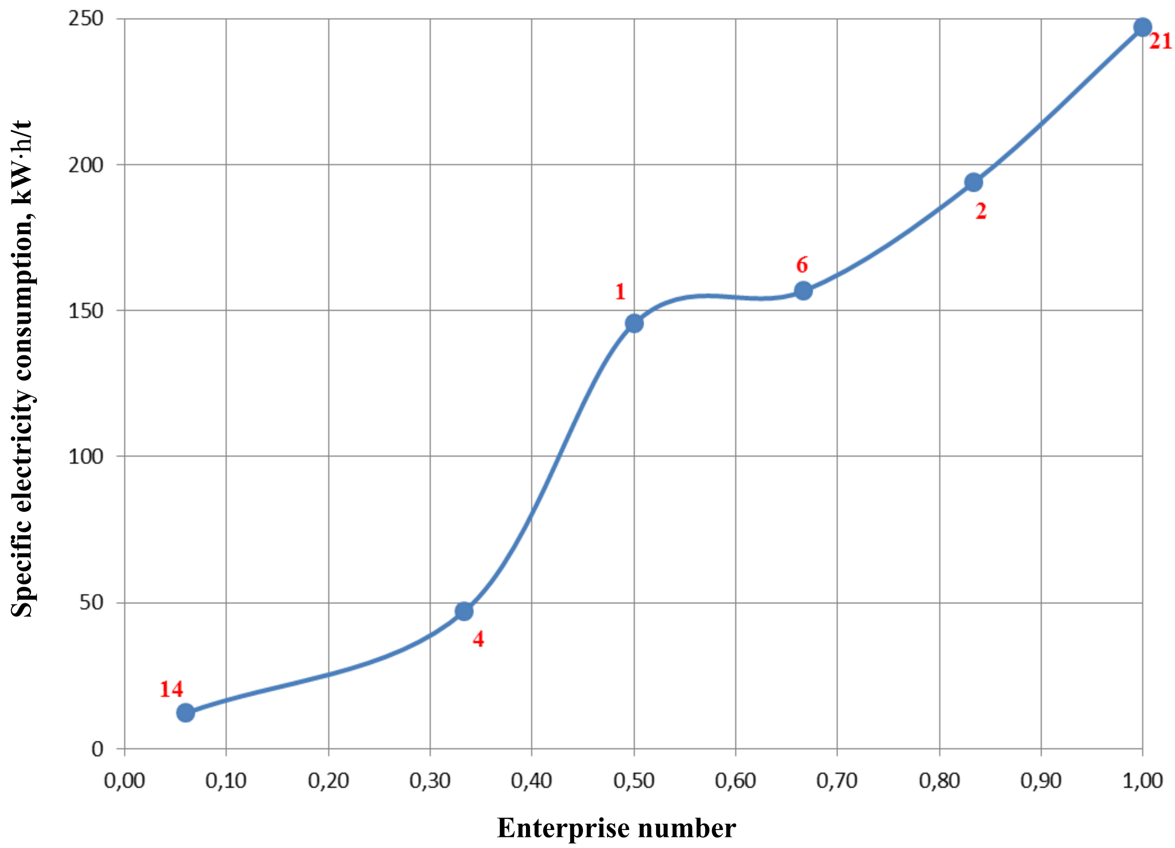

Diagram 14 - Benchmarking curve of specific electricity consumption by the fermented milk products producing enterprises

The curves (diagrams 13 and 14) are used to identify enterprises' efficiencies.

By heat consumption:
The most efficient enterprise – 219.9 Mcal/t
The least efficient enterprise – 785.56 Mcal/t

BAT = 219.9 Mcal/t
BPT = 219.9 Mcal/t

By electricity consumption:
The most efficient enterprise – 12.2 kW-hour/t
The least efficient enterprise – 247.0 kW-hour/t

BAT = 12.2 kW-hour/t
BPT = 12.2 kW-hour/t

CONCLUSIONS

1. Specific energy consumption by the enterprises that have departments for production and processing of milk, fermented milk products, curd cheese, butter, cheese and sour cream varies in the range:

   for milk:
   - by heat from 66.0 to 864.9 Mcal/t;
   - by electricity from 13.9 to 153.15 kW-h/t;

   for fermented milk products:
   - by heat from 219.9 to 785.56 Mcal/t;
   - by electricity from 12.2 to 247.0 kW-h/t;

   for curd cheese:
   - by heat from 297.0 to 5,295.0 Mcal/t;
   - by electricity from 35.2 to 670.8 kW-h/t.

   for butter:
   - by heat from 342.0 to 4,960.0 Mcal/t;
   - by electricity from 73.5 to 1,013.35 kW-h/t;

   for cheese:
   - by heat from 1,048.7 to 3,485.3 Mcal/t;
   - by electricity from 152.8 to 1,011.0 kW-h/t;

   for sour cream:
   - by heat from 250.0 to 814.2 Mcal/t;
   - by electricity from 65.437 to 300.0 kW-h/t.

   This difference is due to the following factors. The analysis of heat and electricity balances of the enterprises that have departments for production and processing of milk, fermented milk products, curd cheese, butter, cheese and sour cream demonstrates that over 25% of consumed electricity is spent for auxiliary and plant needs of the enterprises and this figure almost doesn't depend on product output volumes. Nearly 70% of heat is spent for sanitary-hygienic needs and this figure also almost doesn't depend on product output volumes. Besides that, as auxiliary department and plant needs of the enterprises include heating, ventilation and conditioning, we should remember that the energy expenditure for these components depend on the weather conditions at the enterprise location. It is worth noting that in most cases these enterprises produce not one group of products (for example, butter), but several groups of products simultaneously. So, the energy consumption for auxiliary department and plant needs of the enterprise is distributed among the groups of products in proportion to the amount of energy consumed by processing equipment for production of an individual group of products. So, the more energy-intensive the production technology is the higher share of energy consumption for the auxiliary department and plant needs of the enterprise fall onto the production of the individual group of products.

2. The average specific heat consumption in the industry, according to statistic data, makes up:
   for milk 255.1 Mcal/t;
   for butter 1,947.4 Mcal/t;
   for curd cheese 1,462.7 Mcal/t;
   for cheese 2,280.2 Mcal/t;
   for sour cream 546.3 Mcal/t;
   for fermented milk products 388.7 Mcal/t.
   For milk, 18 enterprises out of the selected enterprises are more effective than the average level in the industry for over 3.2 Mcal/t.
   For butter, 12 enterprises out of the selected enterprises are more effective than the average level in the industry for over 16.1 Mcal/t.
   For curd cheese, 9 enterprises out of the selected enterprises are more effective than the average level in the industry for over 42.04 Mcal/t.
   For cheese, 7 enterprises out of the selected enterprises are more effective than the average level in the industry for over 459.0 Mcal/t.
   For sour cream, 3 enterprises out of the selected enterprises are more effective than the average level in the industry for over 48.085 Mcal/t.
   For fermented milk products, 4 enterprises out of the selected enterprises are more effective than the average level in the industry for over 18.61 Mcal/t.
3. The average specific electricity consumption indicator in the industry, according to statistic data, makes up:
   for milk 81.0 kW-h/t;
   for butter 334.4 kW-h/t;
   for curd cheese 204.7 kW-h/t;
   for cheese 274.3 kW-h/t;
   for sour cream 193.5 kW-h/t;
   for fermented milk products 165.3 kW-h/t.
   For milk, 14 enterprises out of the selected enterprises are more effective than the average level in the industry for over 6.3 kW-h/t.
   For butter, 20 enterprises out of the selected enterprises are more effective than the average level in the industry for over 5.04 kW-h/t.
   For curd cheese, 12 enterprises out of the selected enterprises are more effective than the average level in the industry for over 0.1 kW-h/t.
   For cheese, 4 enterprises out of the selected enterprises are more effective than the average level in the industry for over 16.1 kW-h/t.
   For sour cream, 3 enterprises out of the selected enterprises are more effective than the average level in the industry for over 21.618 kW-h/t.
   For fermented milk products, 4 enterprises out of the selected enterprises are more effective than the average level in the industry for over 8.6 kW-h/t.

SOURCES

1. Global Industrial Energy Efficiency Benchmarking. An Energy Policy Tool.– Working Paper.– November 2010
2. State statistics reporting forms 11-MTP "Report on the Results of Fuel, Heat and Electricity Consumed " for 2011.