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**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 Meat Processing Subsector of the Ukraine's Agro-Industrial Sector

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**Kyiv 2012**

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# 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.

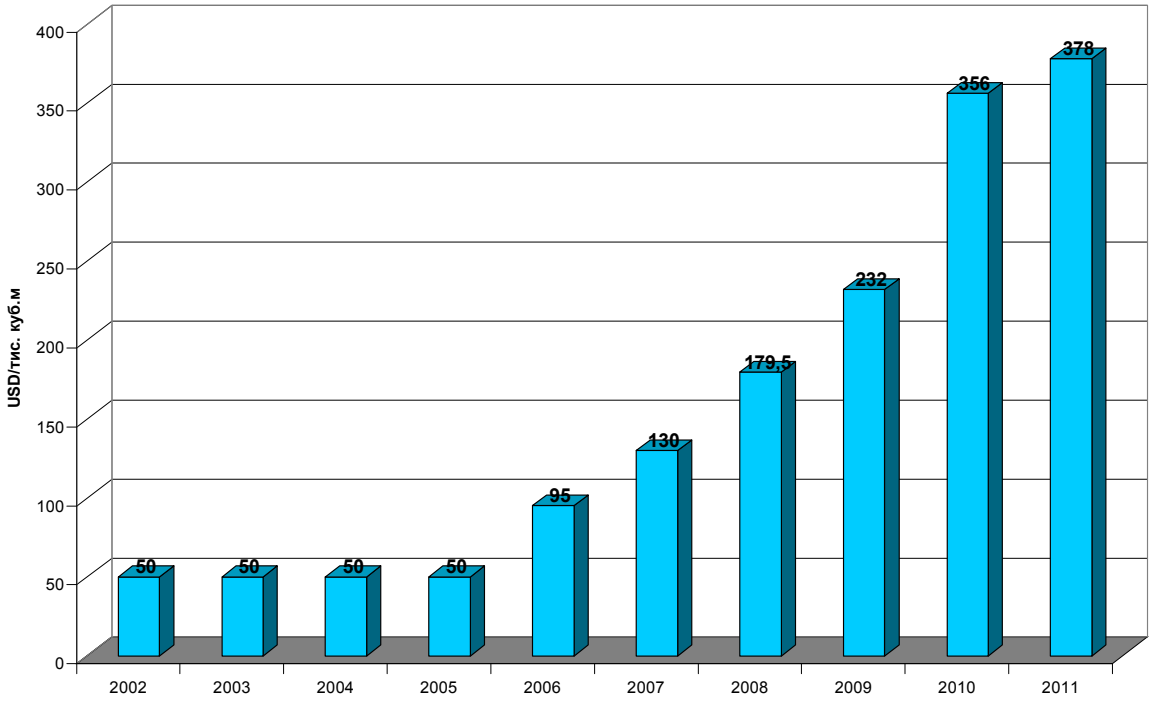


Diagram 1. Dynamics of natural gas price increase.

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. As concern 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.

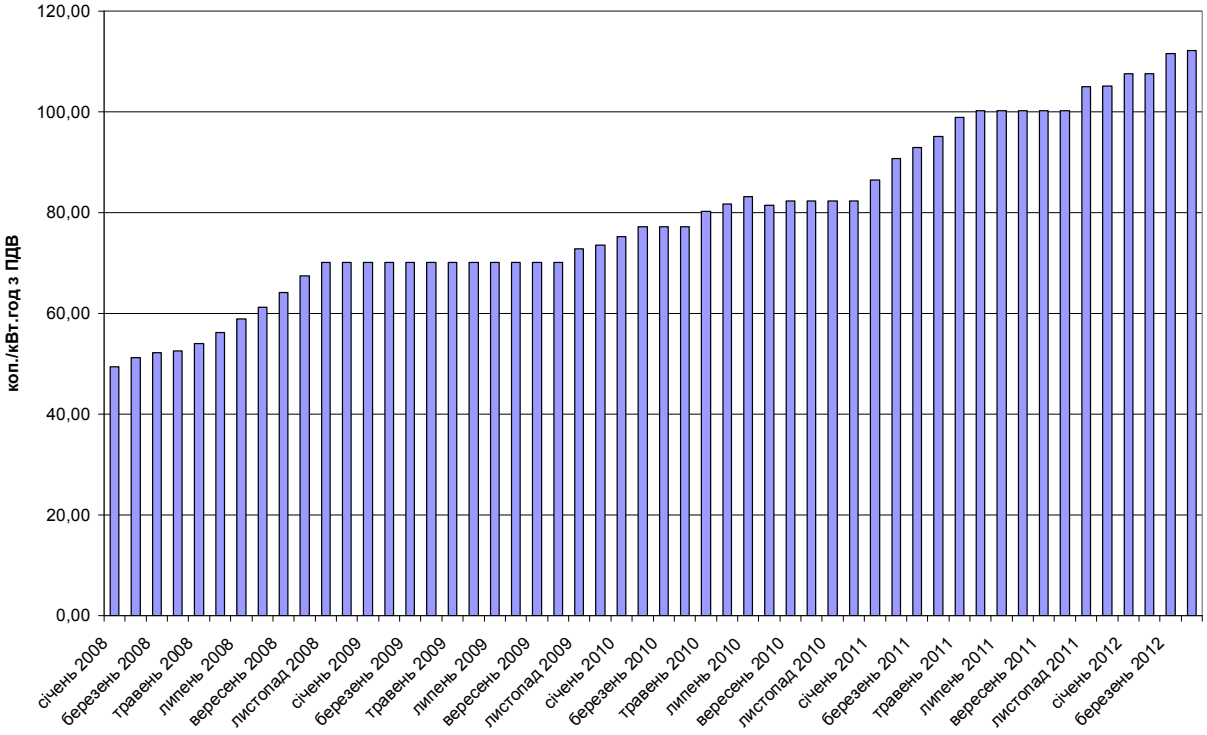


Diagram 2. Dynamics of electricity price increase

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, workshops 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

## Sausage Sector

Sausages are food products made of meat processed by mechanical, physical and chemical methods adding some other food products. Mechanical processing includes removing uneatable, not very nutritious parts of meat and meat mincing. Physical and chemical processing includes corning, ripening, roasting, boiling, smoking.

Sausage products are divided into cooked, smoked, liver, salceson and jellied minced meat. Smoked foods are also referred to the sausage group. Raw materials are: lean steak, pork, salted pork fat, more seldom mutton and poultry meat. In the regions where horse meat is an ordinary food product, sausages are made of horse meat. Meat by-products (liver, brain, heart, rumen, etc.) are used for liver sausages, saltison, jellies. Edible blood of slaughtered animals is used for production of blood sausages. To enrich minced meat intended for sausages with full-value proteins, edible blood plasma, unskimmed and skimmed milk, milk protein and eggs are added. To improve flavour of sausage products, sugar, spices (pepper, nutmeg, pistachio, garlic, etc.) are added. To preserve red colour of meat, a mild solution of sodium nitrite is added. To put sausage products into certain shape and protect them from hazardous external impacts, the casings are used: intestines and artificial (protein, cellulose, polymeric film) casings. Some products are shaped casing-free.

*Sausage Production Technology*

Sausage production starts with preparing raw materials. The meat thaws at the air temperature 20ºC and humidity 90%. Defrosting is deemed completed when a carcass temperature reaches 1ºC. Cooled and thawed meat is cleaned and flushed with water at the temperature 25-30ºC.

Once preparation is over, the meat is dressed, dissected (meat is disengaged from bones) and small bones, sinews, connective tissue, soft tendons, large vessels are removed. These processes are mostly manual. The next stage is corning. While corning, meat and salt are mixed in a mixer. Upon corning the meat is minced in a chopper and the minced meat is mixed after that. The temperature up to 12ºC is maintained during this process.

Once mincemeat is ready, supplements and water are added as per formula. After that, casings are filled with mincemeat (stuffing). Stuffing is performed with mechanical or hydraulic stuffing pumps. Then, sausages are subject to thermal treatment (sedimentation, boiling, frying, smoking). It is worth noting that sedimentation process takes place in the chambers at the temperature 2-4ºC that also demands electricity expenditure.

*Review of the Sausage Sector*

Top ten leaders on the Ukrainian sausage marketplace supply a half of the total meat and sausage products to the market. The manufacturers in the top group by output go one after another with a minimum lag. During several recent years Ukraine demonstrates the declining trend in production of meat and sausage products. For instance, during four months in 2010, Ukraine produced a total of 79.3 thous. tons of sausage products that is by 4.748 thous. tons less than in the same period in 2009.

The highest share in total consumption falls on boiled, smoked and semidry sausages on the meat product marketplace. One sector on the market of sausage products and meat delicacies demonstrated positive dynamics in 2010: during the first 4 months, domestic companies increased the output of boiled and smoked and semidry sausages by 3.4%.

The boiled sausage sector has experienced the lowest losses in its development dynamics (its share is about 52% in the total output of meat and sausage products). The meat product market depends on raw materials. Due to specifics of this type of products, sales of meat products are limited to the area where there production is based and adjacent areas: delivery of sausages and meat products to remote areas requires special vehicles. So, only large companies become manufacturers of the nationwide brands on the meat delicacy and sausage marketplace.

In 2011, top ten largest producers at the sausage market were a rather dense group. Each representative of the group failed to leave others behind by the output parameter. Ukrainian meat and sausage product marketplace has almost reached saturation. The bold competition dictates the range of products, their quality and regulates pricing policy. Product branding is still at the stage of development, so new brands are created spontaneously. Certain excess of sausage products in large retail chain outlets encourage manufacturers to produce branded high-quality products and seek new niches and create innovative products.

Stable product quality is an important condition underlying sales leadership: the ten key players provide for nearly 50% of the total output of sausage and delicious meat products. The five leaders by output on the domestic sausage marketplace are Globino Meat-Processing Ltd., Gorlovka Meat-Processing PJSC, Favourite Meat-Processing Ltd., Yuvileiny Meat-Processing Ltd., Yatran' Meat-Processing OJSC.

## Semi-Finished Meat Product Sector

Semi-finished meat products are the products that have been prepared for thermal treatment. Depending on their cooking method they are divided into natural, bread-crumbed, minced products and pelemene. Natural products by production method may be: large-cut, unit-packed and small-cut meat products.

### *Semi-Finished Meat Product Technology*

Consumer properties and range of semi-finished products much depend on raw material quality and compliance with technological operations. Meat of

various types and thermal status are used to produce semi-finished products. In general, preparation of raw materials is consistent with the sausage production technology. Upon preparation, raw materials are subject to mechanical grinding and other processes, based on a type of semi-finished product. The final stage is either ordinary freezing or freeze-quenching of a finished product. Freeze-quenching enables preserving product quality and extending its shelf life, so it becomes more and more common. Freeze-quenching is a sharp blow of cold when the temperature inside a semi-finished product is brought down to -18ºC. Therefore, refrigeration compressors consume large amount of electricity.

*Review of the Semi-Finished Meat Product Sector*

Speaking about semi-finished products it is worth mentioning that the Ukrainian marketplace of frozen products enlarged almost three times during the recent four years. The frozen product sector makes up 16-17% in the structure of the Ukraine's food market. However, as compared to the richest countries (for example, the USA), where the same segment accounts for 71-72%, the Ukraine's figure looks rather low. Some 47-50% of the frozen product consumer audience falls on Kyiv, with other large cities following behind. The demand for frozen products in towns and rural areas is far lower primarily due to the lack of storage conditions.

Semi-finished product market capacity annually grows by 30% and already makes up about 350 million dollars. At first sight, this figure looks high, however, it means that each adult Ukrainian buys these products only for 10 dollars a year.

The consumption of semi-finished meat products in European countries makes up 35-40 kg per person a year, while this indicator is far lower in Russia –8-9 kg, and it is as low as 7-8 kg in Ukraine.

A characteristic feature of the domestic semi-finished product market is that the leaders are domestic companies inter alia: "Hercules" CJSC (Donetsk-based); "Levada" (Odessa-based); "Ursulenko" private enterprise ("Osa" TM, Kherson-based); "Danika" subsidiary enterprise ("Sytyi Tato" TM, Kyiv-based); "Drygalo" private enterprise (Kyiv region, Bila Tserkva); "Ukrainian Frozen Foods" ("Pan Skovoroda" TM, Kryvyi Rig). The market players, besides them, are some 300 small manufacturers.

The semi-finished product market in Ukraine is very prospective. This situation can not but attracts attention of foreign companies (mostly, Russian-based companies). They examine not only prospects of importing finished products, but also opportunities to build own production bases inside the country. For instance, Russia-based "Alta" ("Morozko" TM) considers scenarios of constructing or buying a semi-finished product making factory in Kyiv region. The other Russian firm – "Molmiasoprodukt" – has established its representative office in the capital of Ukraine and supplies products under "Iceburg" TM through the same office.

Besides Ukrainian and foreign manufacturers, supermarkets and large retail outlets actively enter the marketplace as producers. They establish own culinary shops. According to the market operators, over 70% of semi-finished product

distribution currently falls on retailing. Therefore, culinary shop products can't be ignored by semi-finished product manufacturers.

Most large manufacturers operate in on-line mode, this means all produced goods from the production line are immediately dispatched and loaded into distributors' special vehicles equipped with freezers in order to avoid product thawing, in other words, damaging.

Specifics of the industry in terms of energy consumption:

1) **low productivity of the most enterprises** limits the possibility to reduce electricity consumption per unit of output;

2) **relatively high electricity intensity of the production** is related to freezing of semi-finished products, cooling of production premises and large number of small electric drives;

3**) no attention is focused on metering energy consumption and setting consumption rates** since small enterprises have no experts of relevant qualification. In the case of semi-finished product manufacturing by supermarkets, there is no metering of energy consumption by semi-finished goods production at all. This makes it impossible to analyze energy consumption in the industry at the adequate quality level.

## ANALYSIS FINDINGS

Since there are a lot of small enterprises in the industry, we have decided to apply regional benchmarking methodology. This approach provides us the opportunity to somewhat smooth the differences in the assortment among individual enterprises in the industry.

The data has been collected for the first six months of 2011 by two types of products:

- sausages and sausage products;
- semi-finished meat products.

The data on electricity consumption are presented below, since the meat-processing enterprises almost do not report the data on heat consumption. At the same time, we have removed the region-related data that materially (by several orders of magnitude) differ from the other data, possibly, because of too small outputs or erroneous statistics.

Table 1. Electricity consumption for production of sausage products

| Region | Region number on the diagram | Output, t | Consumed electricity, thous. kW×hour | Specific electricity consumption, kW×hour/t |
|---|---|---|---|---|
| Poltava region | 16 | 16,397.0 | 1,452.8 | 88.6 |
| Cherkasy region | 23 | 1,007.0 | 116.0 | 115.2 |
| Zhytomyr region | 6 | 4,276.0 | 759.0 | 177.5 |
| Kirovohrad region | 11 | 10,563.0 | 2,426.3 | 229.7 |
| Vinytsia region | 2 | 2,528.0 | 614.1 | 242.9 |
| Sumy region | 18 | 595.0 | 166.0 | 279.0 |
| Ivano-Frankivsk region | 9 | 815.0 | 265.0 | 325.2 |
| Kherson region | 21 | 38.0 | 14.0 | 368.4 |
| Chernivtsi region | 24 | 3,077.0 | 1,253.9 | 407.5 |
| Dnipropetrovsk region | 4 | 24,424.0 | 10,004.1 | 409.6 |
| Khmelnytsky region | 22 | 3,161.0 | 1,332.0 | 421.4 |
| Rivne region | 17 | 779.0 | 365.0 | 468.5 |
| Zaporizhia region | 8 | 4,597.0 | 2,213.9 | 481.6 |
| Kyiv region | 10 | 7,672.0 | 3,891.2 | 507.2 |
| Volyn region | 3 | 7,770.0 | 4,770.8 | 614.0 |
| Lviv region | 13 | 2,617.0 | 1,694.0 | 647.3 |
| Ternopil region | 19 | 526.0 | 349.0 | 663.5 |
| Donetsk region | 5 | 24,727.0 | 17,098.7 | 691.5 |
| Luhansk region | 12 | 8,716.0 | 6,143.0 | 704.8 |
| Zakarpatia region | 7 | 186.0 | 171.0 | 919.4 |
| Chernihiv region | 25 | 488.0 | 478.0 | 979.5 |
| Mykolaiv region | 14 | 940.0 | 970.0 | 1,031.9 |
| Kharkiv region | 20 | 9,349.0 | 12,920.3 | 1,382.0 |
| Odessa region | 15 | 3,170.0 | 4,540.1 | 1,432.2 |
| AR of Crimea | 1 | 1,064.0 | 1,809.0 | 1,700.2 |

Table 2. Electricity consumption for production of semi-finished meat products

| Region | Region number on the diagram | Output, t | Consumed electricity, thous. kW×hour | Specific electricity consumption, kW×hour/t |
|---|---|---|---|---|
| Volyn region | 3 | 951.0 | 41.0 | 43.1 |
| Vinytsia region | 2 | 6,997.0 | 370.8 | 53.0 |
| Ivano-Frankivsk region | 9 | 70.0 | 8.0 | 114.3 |
| Ternopil region | 19 | 1,052.0 | 123.0 | 116.9 |
| Dnipropetrovsk region | 4 | 27,181.0 | 3,362.3 | 123.7 |
| Cherkasy region | 23 | 7750 | 1,080.4 | 139.4 |
| Zhytomyr region | 6 | 667.0 | 104.0 | 155.9 |
| Kharkiv region | 20 | 408.0 | 64.0 | 156.9 |
| Luhansk region | 12 | 1,657.0 | 391.1 | 236.0 |
| Chernihiv region | 25 | 72.0 | 18.0 | 250.0 |
| Lviv region | 13 | 328.0 | 85.0 | 259.1 |
| Sumy region | 18 | 27.0 | 7.0 | 259.3 |
| Kirovohrad region | 11 | 1,243.0 | 331.0 | 266.3 |
| Kyiv region | 10 | 19,613.0 | 5,297.5 | 270.1 |
| Chernivtsi region | 24 | 382.0 | 111.0 | 290.6 |
| Donetsk region | 5 | 16,812.0 | 5,324.4 | 316.7 |
| Khmelnytsky region | 22 | 79.0 | 26.0 | 329.1 |
| Poltava region | 16 | 1,805.0 | 612.1 | 339.1 |
| Mykolaiv region | 14 | 271.0 | 105.0 | 387.5 |
| Odessa region | 15 | 28.0 | 46.0 | 1,642.9 |
| Zaporizhia region | 8 | 1,474.0 | 2,642.0 | 1,792.4 |

Benchmarking curves have been built applying the proved technique [2] (Diagrams 3-4).

The curves are used to identify enterprises' energy efficiency indicators.

***For the enterprises manufacturing sausages:***
**The most efficient region – 88.6 kW-hour/t**
**The least efficient region – 1,700.2 kW-hour/t**

**BAT = 88.6 kW-hour/t**
**BPT = 88.6 kW-hour/t**

***For the enterprises manufacturing semi-finished meat products:***
**The most efficient region – 43.1 kW-hour/t**
**The least efficient region – 1,792.4 kW-hour/t**

**BAT = 43.1 kW-hour/t**
**BPT = 43.1 kW-hour/t**

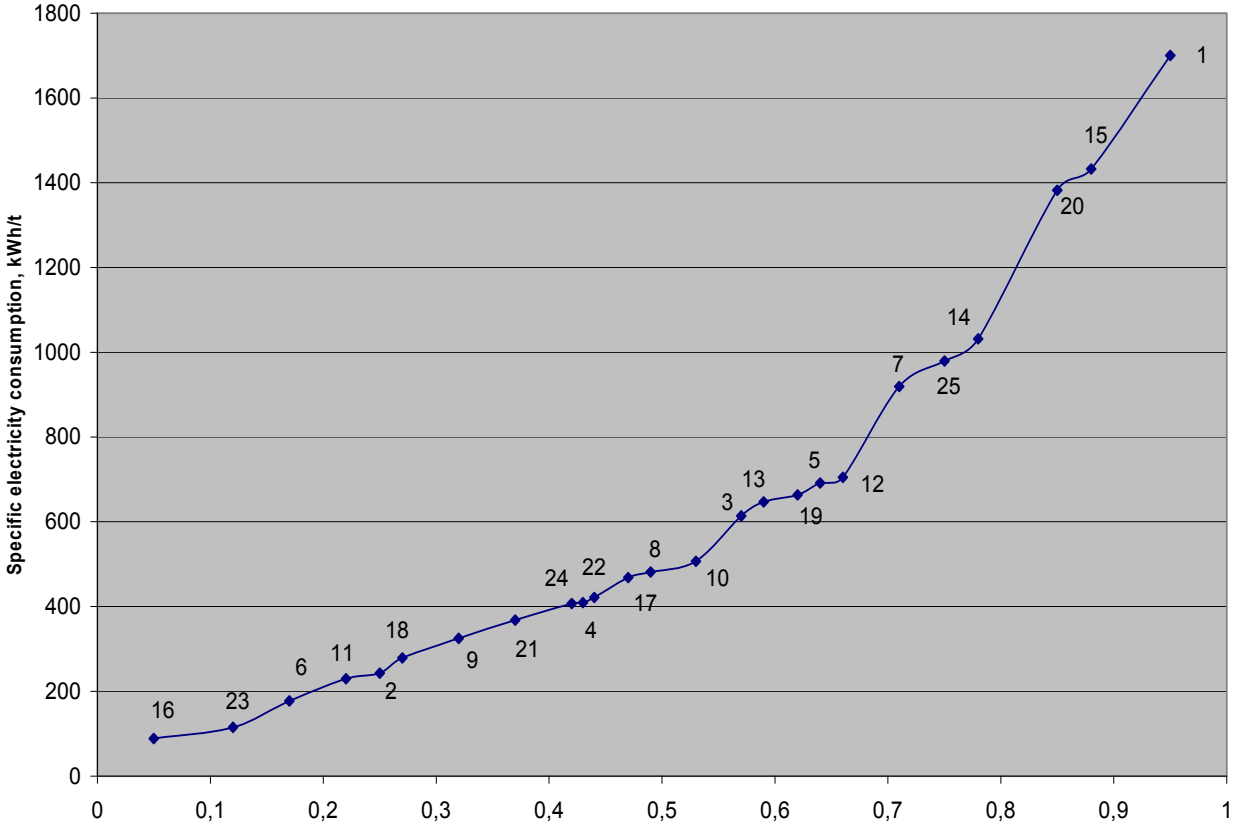


Diagram 3 - Benchmarking curve of specific electricity consumption by the sausage-manufacturing enterprises.

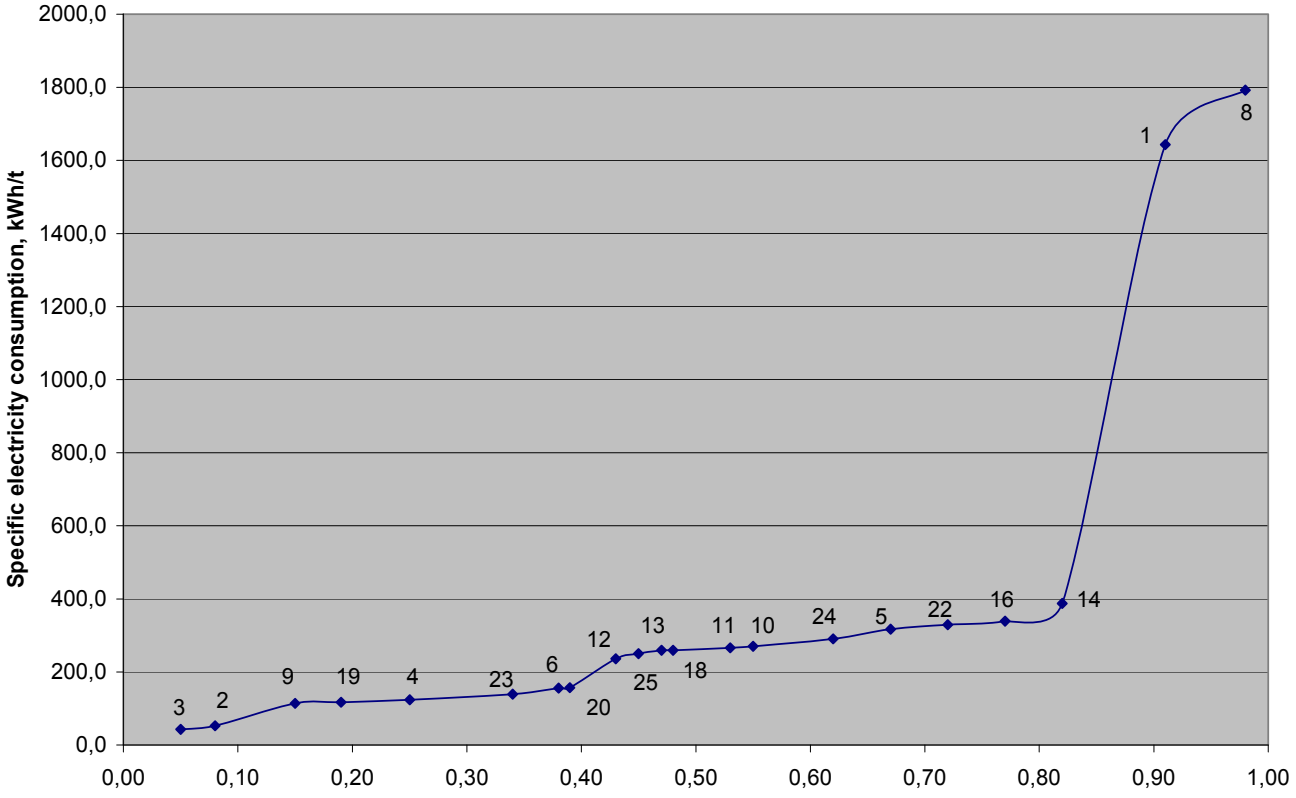


Diagram 4 - Benchmarking curve of specific electricity consumption by the enterprises manufacturing semi-finished meat products.

# CONCLUSIONS

1. Specific electricity consumption by the meat-processing enterprises varies in the range:
   - for the enterprises producing sausages from **88.6 kW·hour/t** to **1,700.2 kW·hour/t,** that is twenty times;
   - for the enterprises producing semi-finished meat products from **43.1 kW·hour/t** to **1,792.4 kW·hour/t,** that is forty times**;**

   The great difference is attributable to:
   - extremely differing assortment of products and raw materials;
   - processing and electricity generating equipment differing by age and efficiency;
   - differing qualification of enterprise production staff;
   - differing attention the factory owners pay to energy-saving;
   - possible under-metering of the output resulting in overstatement of unit electricity consumption.
2. Average specific electricity consumption by the sausage-producing enterprises is 543 kW·hour/t. 9 regions out of the selected regions are more efficient than the average level. The same indicators for the enterprises producing semi-finished meat products make up 226.7 and 8, respectively.

## SOURCES

1. State statistics reporting forms 11-MTP "Report on the Results of Fuel, Heat and Electricity Consumed" for 2011.

2. Global Industrial Energy Efficiency Benchmarking. An Energy Policy Tool.– Working Paper.– November 2010