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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 Canning 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.

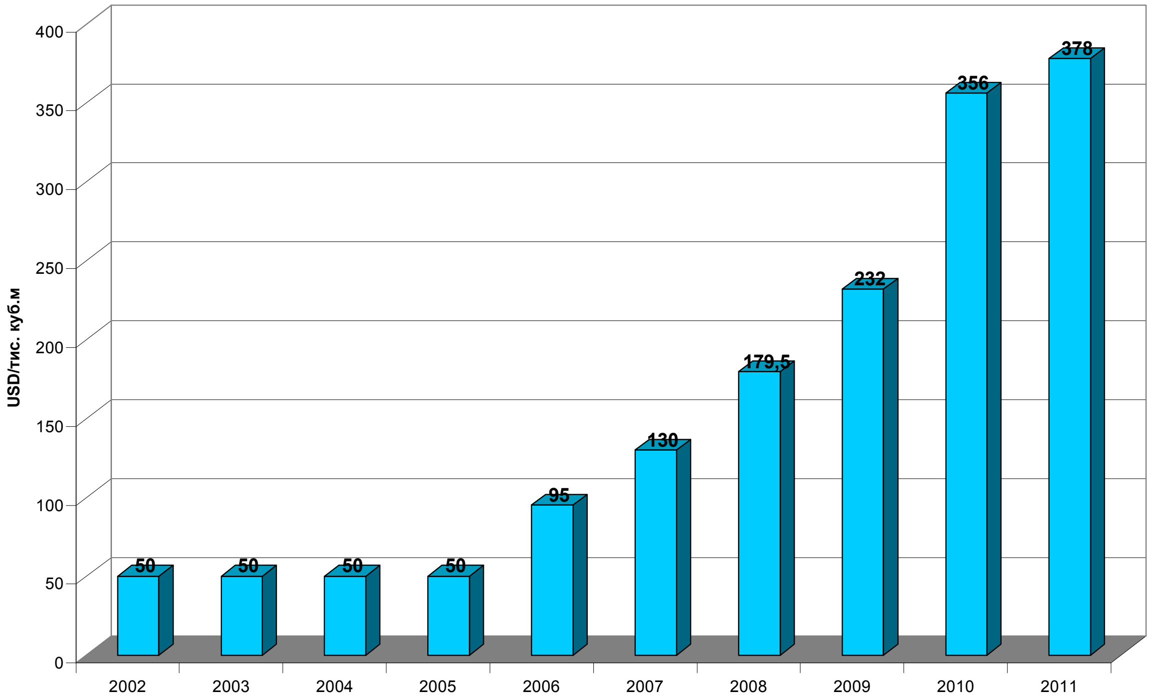


Diagram 1. Dynamics of natural gas price increase.

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. 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.

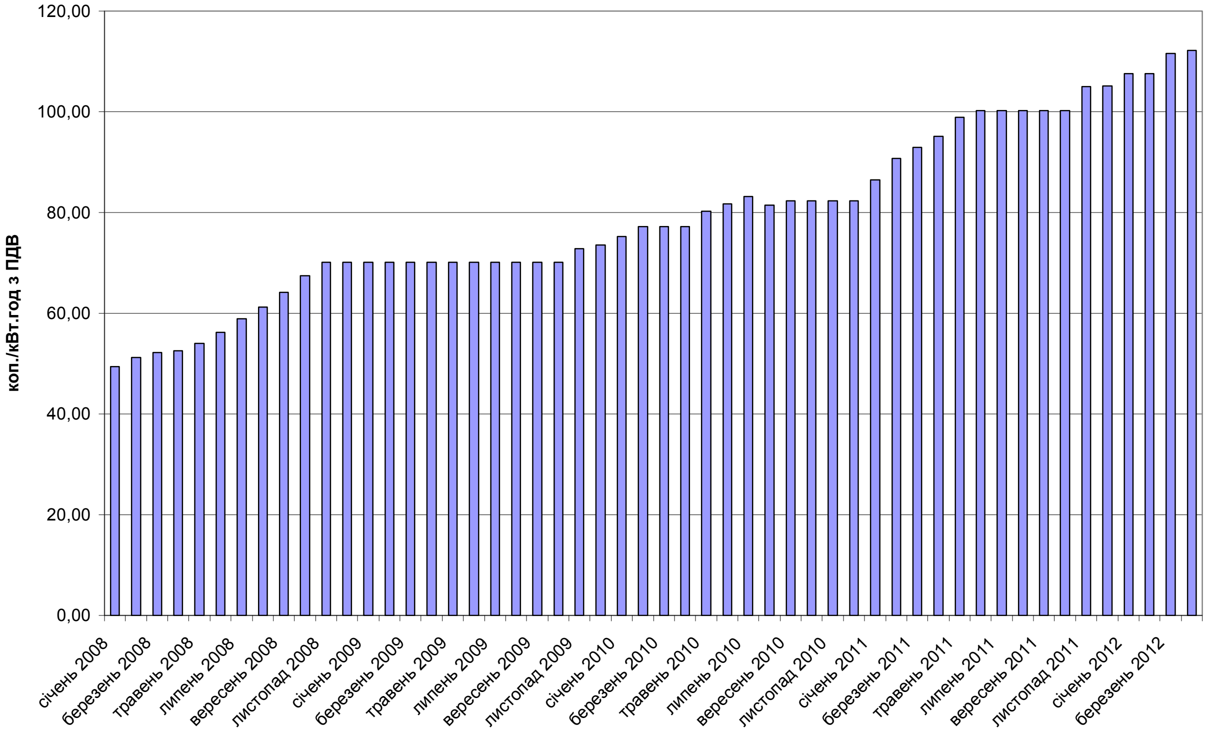


Diagram 2. Dynamics of electricity price increase

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:

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

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:

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

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

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

Thanks to favorable climatic conditions Ukraine is among top ten countries in the world by gross output of vegetables, gourds and melons. Therefore, the canning industry in Ukraine has great potential for development despite its highest energy intensity.

Distinctive feature of the canning industry is a wide range of manufactured products:

- **canned natural vegetables** - chopped, pureed or whole (not chopped) vegetables such as cabbage, green peas, corn, beans, beet, carrot and other root vegetables, dock, spinach, potatoes, etc.;
- **snack food** – ready-to-eat canned vegetables (sweet pepper, cucumbers, eggplants and tomatoes of all canning types including vegetable salads);
- **vegetable, fruit and berry juices** - tomato, carrot, beet, sauerkraut juices, etc. and fruit natural juices (with sugar and sugar-free) made of all types of large fruits and berries with pulp;
- **canned foods of tomato** - sauces, pureed tomatoes, tomato paste;
- **lunches and soup garnishes** – mixtures of the vegetable, bean foods, cereals, macaroni, meat, spices, fats, etc.;
- **canned fruit and berry** – compotes of fresh fruits and berries, melons and rhubarb in sugar syrup (desserts) as well as fruit and berry dressings, purees, pastes and sauces;
- **canned meat** - natural (roast) meat, boiled meat, fried meat, chicken fillet, chicken ragout, pressed meat, tourist lunch, jellied tongues; pastes; canned liver, kidneys, brains.
- **canned meat and vegetables –** meat and mashed potatoes, meat and porridge, etc.

Canned products are recorded in thousands of standard cans and millions of standard cans. Cubic capacity of a standard can is equal to 353 cm^3. Converting factors are set to convert cans of other cubic capacity into standard cans. Some products are recorded by weight. A standard can for tomato puree with 12% content of dry substances, fruit purees, natural juices, marinades as well as for fruit and berry confectionary products (jams, jellies) is equal to the product net weight equal to 400 g.

The output of canned fruit and vegetables in Ukraine demonstrates a stable growing trend upon a significant decrease in 2008. For instance, 2009 saw the output of about 3 billions of standard cans that is 17% more than in 2008. However, another trend is also observed: most canned products still have been imported to Ukraine.

As raw materials for the canning industry (fresh vegetables and fruit) spoil quickly and their volumes are large, canning factories are located close to fruit and vegetable producers – in villages and district centers. Nowadays, over 500 producers of canned fruit and vegetables operate in Ukraine. But the number of large manufacturers (VERES, CHUMAK, etc.) does not exceed a dozen. Most market operators are small low-profitable manufacturers operating low-efficient equipment that can't provide themselves in a stable manner with low-cost high-quality raw materials (both agricultural raw materials and cans, caps, etc.). This situation significantly limits the opportunities to use state-of-the-art high-capacity energy-efficient equipment and complicates the analysis.

Canned foods are valuable food products. They preserve flavor and aromatic substances almost in full, and in the event of adequate preparation, they well preserve vitamin C. Canned foods do not contain uneatable parts while added oil, sugar or tomato sauce increase their nutritive and caloric values. For example, caloric value of 100 g of green peas is 41 kcal or 172 kJ, that of borsch of fresh cabbage is 95 kcal or 397 kJ, that of aubergine paste is 154 kcal or 644 kJ.

Protein content in fruit and vegetables in average is nearly 1.5%, carbohydrate content is up to 90% (relatively dry substances). Fruit and vegetables contain also small amount of fats but they are rich in vitamin C, and contain smaller amounts of group B vitamins and vitamin A free and as carotene pigment, which may synthesize vitamin A in human body.

The season for production of canned fruit and vegetable in Ukraine lasts for 4-5 months. Between the seasons, the fruit and vegetable canning factories produce canned meat and canned meat with vegetables.

Production of frozen berries, green peas, corn, chopped fruits and vegetables, ready-to-eat mixtures for salads, etc. have spread in Ukraine recently. But this method entails high capital costs for purchase of a quick freezing unit and a freezer and high current electricity costs. Therefore, heat sterilization remains the main method of fruit and vegetable industrial canning.

Fruit and vegetable raw materials from suppliers are accepted at an enterprise, sorted out when spoiled and substandard fruits and vegetables are rejected. Raw materials are stored in refrigerators at canning factories and are gradually fed to production workshop during the production season.

Fruits and vegetables delivered to a production workshop are sorted by quality again, sized and washed. If appropriate, they are peeled or cut into pieces (vegetable marrows, peaches, etc.).

To improve penetration of salt, sugar and other substances into fruits or vegetables, their peels and cell membranes should be softened. To this end, fruits or vegetables are blanched (holding in hot water for a certain period). This especially concerns thick-skinned fruit (plums, vegetable marrow) – scalded (vapor treated).

Blanched vegetables (for borsch, dressing – vegetable mixture is selected as per formula) are packed into washed and vapor dried glass cans or tins and are poured with the sauce, which composition depends on a type of canned food:

- for natural canned vegetables, the sauce consists merely of water, salt, sugar and spices

- for marinades (marinated cucumbers, vegetable marrows, mushrooms, sweet pepper, etc.), vinegar is added as it is a preservative inhibiting microorganism development
- for fruit and berry compotes, the sugar syrup is added.

The filler is boiled in a steam-heated boiler for dissolution of components and sterilization and it is poured into the cans containing fruit. Vacuum-capping machine hermetically seals cans with caps (the caps are steam-sterilized separately) and the cans are fed for sterilization.

The cans are sterilized at the temperature 112-120°C in autoclaves filled with water under pressure. Autoclaves for sterilization of cans are equipped with steam blowers and water cooling coils. Cans in special metal baskets are submerged into autoclaves filled with water. Then, the autoclave is hermetically closed and high-pressure steam is bubbled into water. Being condensed, the steam warms the water in an autoclave and the cans containing the product. Condensed steam is mixed with autoclave water. The pressure and temperature in the autoclave and inside cans grow gradually and simultaneously. Sterilization time depends on the type of canned product and the can sizes. Once sterilization is finished, cooling water is fed to coils, and cans along with autoclave water are cooled down to 45-50°C (at the same time pressure in autoclave decreases to atmospheric pressure), after that autoclave lid is open, baskets containing cans are pulled out and cooled by air. Sterilized cans are placed for quarantine to check the quality of sterilization. If during the preset holding time (usually 10 days) no signs of microorganism vital activity are revealed, for instance: bloating (buckling), color change, mold damage, etc., the cans are transferred to storage or dispatched to a distribution network.

Canned snack food (vegetable pastes, sauces, etc.) are produced of pureed vegetables. Puree of vegetable marrows, eggplants, onions, carrots, etc. are rubbed through sieves; salt, sugar, spices are added and the mixture is boiled down in vacuum evaporators at the temperature from 65 to 75°C till the content of dry substances reaches 4% to 12%. Maintenance of vacuum during boiling provides the opportunity to reduce the water boiling temperature, thus more thermolabile nutritive substances, primarily vitamin C, may be preserved. The boiled down puree is filled in cans and sterilized.

In some cases, vegetables are fried in oil on steam or electric pans or deep-fat fried. This process enables removing excessive moisture from the products and saturating them with fats thus increasing their nutritive and caloric values.

Concentrated tomato products (tomato paste, etc.) – semi-finished products for culinary and sauce production are produced of pureed tomatoes in a similar way. Boiling down in vacuum evaporators leads to higher content of dry substances (30...40%). Salt, sugar, vinegar, spices, in some cases puree of other fruits (most often apple puree) are added to tomato sauces.

Vegetable juices are produced of tomato, carrot, beet and other vegetables. Vegetables are chopped, pulped into puree, juice is squashed and the parts suspended in the juice are crushed (homogenization). The juices packed in glass cans are sterilized in autoclaves or pasteurized in flow and furthered filled in multilayer paper, polymeric film and aluminum foil bags (Tetra Pak).

Fruit and berry juices are produced of fruit and berries with the use of presses. Upon pressing, the juices are **pasteurized** (warmed in heat exchangers during 20 seconds up to 85-90°C and fast cooled down to 30-35°C), centrifuged and filtered (if applicable).

To produce clarified juices, the squeezed and screened juice of grapes, apples, pears, cherries, currants, etc. is cooled down in heat exchangers to 3-5°C and fed to clarification apparatuses located in cooling premises. 1% gelatin and tannin solutions are added into clarification apparatuses. The juice is settled and the sediments are filtered away.

While making juices of cherry plums, cherries, sour cherries, other berries, manufacturers try to get as more coloring matter as possible out of the berries. To this end, berries are first frozen to –20°C and pressed upon thawing. In this case, juice color intensity grows by 10%, vitamins and biologically active substances are preserved as much as possible.

To store juices for a long period or to transport them, large volumes of juices are **concentrated** thus reducing their weight and volume and almost eliminating microflora development.

Most often juices are concentrated in multiple-effect evaporators under vacuum: water is evaporated from juice, the content of dry substance in it grows from 8-12 to 60-65%. Application of multiple-effect evaporators enables significant reduction in heating steam consumption for juice concentration. Prior to concentrating the juice, aromatic substances are distilled off and stored separately.

Juice evaporation even under vacuum demands warming to 65–70 °C resulting in significant juice changes, worsens its flavor, decreases nutritive value and decomposes vitamins. To avoid worsening of the concentrate quality, single-pass film evaporators are applied where the juice stays for a minimum period (up to 60 seconds).

Where juice is cryoconcentrated, the juice is gradually frozen down to freeze out. Once cryoscopic temperature is reached, ice crystals are isolated from the solution, they are other filtered out or separated by centrifuging. With the temperature decreasing, the solution concentration grows. This method provides the opportunity to get a solution where the dry substance content is 30–55%, and maximum amount of nutritive substances are preserved from the initial product.

Jams, confitures, marmalades etc. are made by boiling fruit puree down (sometimes adding whole fruits or chopped fruits) along with sugar till dry substance content reaches 65...70% in vacuum apparatuses. Vacuum enables decreasing the boiling temperature of the solution, thus thermal decomposition of nutritive substances contained in fruit is reduced and product nutritive value is preserved. Ready-to-eat product is filled in cans, capped and transferred to storage.

Biochemical canned products are produced with lactobacillus that are capable to ferment sugars contained in fruit and form lactic acid that inhibits development of other microorganisms and works as a preservative. At the end of canning process, the products contain 1...2% milk acid and 0.5...0.7% of ethyl alcohol. The process of producing such canned products bears different names depending on the type of raw materials: pickling (tomatoes, cucumbers, watermelons), souring (cabbage), wetting (apples, pears). The process most often takes place in barrels by adding salt that inhibits development of undesirable microflora. The temperature must be optimum for development of lactobacillus, but it must be unfavorable for development of other microorganisms. Significant advantage of these canned products is their better digestibility.

Canned meat and canned meat with vegetables are manufactured in winter and spring periods. This enables canning factories to prolong their production seasons. Vegetable and meat raw materials (meat, by-products) are prepared according to the formula, cut into pieces (if applicable, they are minced), put into cans and poured down with the filler containing water, salt, species. Cans are capped and sterilized just like canned fruits and vegetables.

Specifics of the industry in terms of energy consumption:

1) **seasonality of operations** – operation schedule of the enterprises is strictly linked to the period of harvesting fruits and vegetables;

2) **changes in the raw materials to process during the season and vast range of products** cause dramatic fluctuations in heat consumption during the season;

3) **low productivity of the most enterprises** limits the opportunities to use high-capacity heat generating equipment;

4) **large volumes of organic wastes**;

5) **periodic** operation of vacuum apparatuses and autoclaves – main consumers of heat; to avoid sharp fluctuations in steam consumption, autoclaves and vacuum apparatuses are installed in groups and an operation schedule is adjusted to ensure as even as possible steam consumption by the group;

6) **large volumes of secondary energy sources** (vapor, condensate, autoclave water) that are underused;

7**) products are metered**, and thus **energy rates** are often set in the industry not on the per ton basis but on the basis of thousand standard cans, this system complicates the energy consumption analysis.

ANALYSIS FINDINGS

Since there are many operators in the industry, a decision was made to apply regional benchmarking. This approach provides us also 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 regions of Ukraine for three types of products:

- canned meat and fish
- canned natural vegetables
- ready-to-eat products and canned fruit.

The data on heat and electricity consumption converted to tons are presented in annexes 1, 2. To build the curves, averaged specific energy consumption figures (see table 1, 2) have been calculated. At the same time, we have removed the regional data that materially (by several orders of magnitude) differ from the other data, possibly, because of too small outputs of products.

Table 1. Heat consumption

Region	Output, t	Consumed heat, Gcal	Specific heat consumption, Mcal/t
Donetsk region	613	66,020.1	107.7
AR of Crimea	4,271	465,966.1	109.1
Lviv region	998	121,990.9	122.2
Zhytomyr region	105	19,391.7	184.7
Zakarpatia region	517	121,999.5	236.0
Mykolayiv region	940	283,034	301.1
Dnipropetrovsk region	600	238,997.9	398.3
Khmelnytsky region	203	103,003.2	507.4
Rivne region	1,391	836,020.2	601.0
Vinytsia region	7,367	4,854,116	658.9
Ternopil region	670	478,989.5	714.9
Poltava region	64	52,002.8	812.5
Kherson region	4,606	3,851,094	836.1
Odessa region	10,502	9,028,827	859.7
Cherkasy region	8,871	8,532,823	961.9
Ivano-Frankivsk region	237	236,002.4	995.8
Chernivtsi region	618	631,000.3	1,021.0
Zaporizhia region	173	199,996.5	1,156.0
Kharkiv region	789	1,019,024	1,291.5
Kyiv region	557	834,003.1	1,497.3
Chernihiv region	130	211,998.2	1,630.8

Table 2. Electricity consumption

Region	Output, t	Consumed electricity, thous. kW·hour	Specific electricity consumption, kW·hour/t
Vinytsia region	7,367	277	37.6
Khmelnytsky region	223	17	76.2
Chernivtsi region	618	53	85.8
Zhytomyr region	148	14	94.6
Rivne region	1,391	146	105.0
Mykolayiv region	940	116	123.4
Kherson region	5,167	683	132.2
AR of Crimea	4,271	592	138.6
Dnipropetrovsk region	6,470	901	139.3
Odessa region	10,224	1479	144.7
Poltava region	266	39	146.6
Cherkasy region	8,871	1323	149.1
Ternopil region	670	101	150.7
Kharkiv region	797	124	155.6
Zakarpatia region	517	100	193.4
Chernihiv region	129	30	232.6
Ivano-Frankivsk region	643	194	301.7
Donetsk region	2,474	997	403.0
Lviv region	1,633	705	431.7
Kyiv region	557	270	484.7

Benchmarking curves of energy consumption have been built applying the proved technique [2] and are represented on diagrams 3, 4.

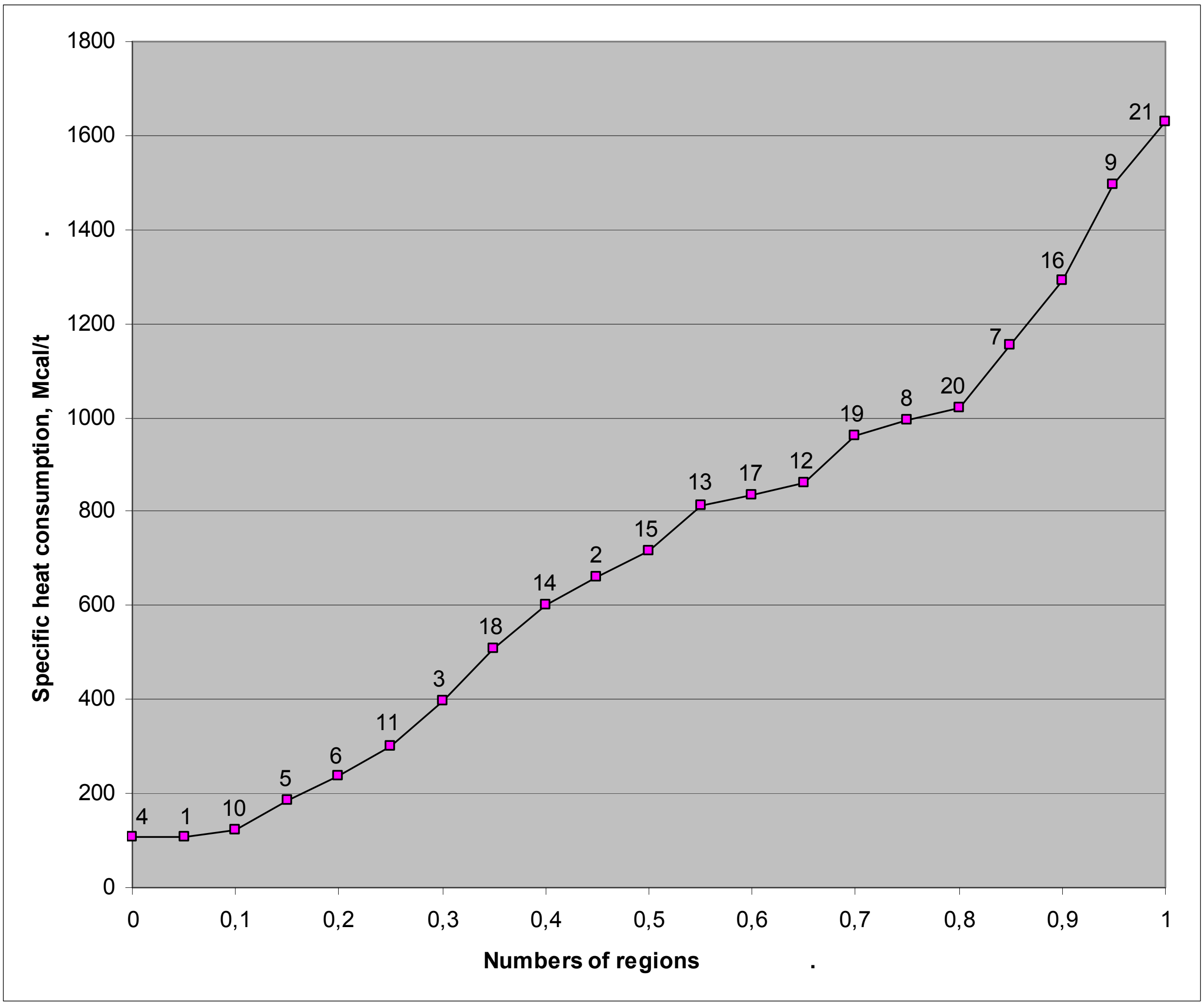
The curves are used to identify enterprises' energy efficiency indicators.

For thermal energy:
The most efficient enterprise – 107.7 Mcal/t
The most efficient enterprise – 1,630.8 Mcal/t

BAT = 107.7 Mcal/t
BPT = 122 Mcal/t

For electricity:
The most efficient enterprise – 37.6 kW·hour/t
The most efficient enterprise – 484.7 kW·hour/t

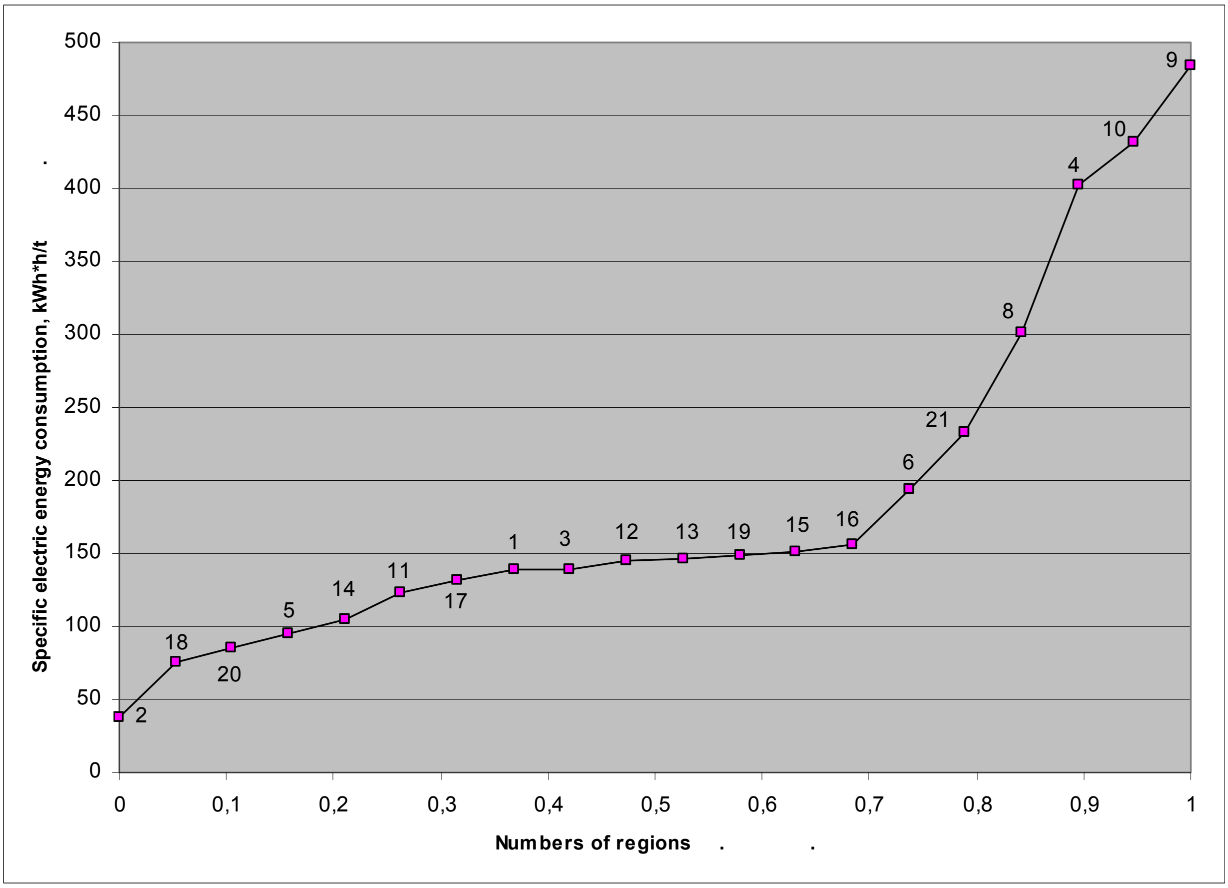
BAT = 37.6 kW·hour/t
BPT = 85 kW·hour/t



Codes of the regions:

1	AR of Crimea	12	Odessa region
2	Vinytsia region	13	Poltava region
3	Dnipropetrovsk region	14	Rivne region
4	Donetsk region	15	Ternopil region
5	Zhytomyr region	16	Kharkiv region
6	Zakarpatia region	17	Kherson region
7	Zaporizhia region	18	Khmelnytsky region
8	Ivano-Frankivsk region	19	Cherkasy region
9	Kyiv region	20	Chernivtsi region
10	Lviv region	21	Chernihiv region
11	Mykolayiv region		

Diagram 3 – Specific heat consumption for canned food production, Mcal/t



Codes of the regions:

1	AR of Crimea	12	Odessa region
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7	Zaporizhia region	18	Khmelnytsky region
8	Ivano-Frankivsk region	19	Cherkasy region
9	Kyiv region	20	Chernivtsi region
10	Lviv region	21	Chernihiv region
11	Mykolayiv region		

Diagram 4 – Specific electricity consumption for canned food production, thous. kW·hour/t

CONCLUSIONS

1. Specific energy consumption by the canning enterprises varies in the range:
   - for heat: from **107.7 Mcal/t** to **1,630.8 Mcal/t**
   - for electricity: from **37.6 kW·hour/t** to **484.7 kW·hour/t**

   This difference is attributable to:
   - too large range of products and raw materials;
   - different age and technological efficiency of processing and energy generating equipment;
   - different extents of secondary heat used (heat of hot condensates, vapors, etc.);
   - differing qualifications of the enterprise production staff;
   - differing degrees of factory top management's commitment to energy-saving.

   The average specific heat consumption indicator for the industry according to the statistics makes up for canned products **727.8 Mcal/t**. **11** regions out of all preselected regions are more efficient than the average level in the canning industry.
2. The average specific electricity consumption indicator for the industry according to the statistics makes up for canned products **152.9 kW·hour/t**. **13** regions out of the preselected regions are more efficient than the average level in the canning industry.

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1. Ministry of Agro-Industrial Policy of Ukraine // http://www.minagro.kiev.ua/user files/Image/ministry/Dep_xach_prom/image/novosti/.

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

ANNEXES

Annex 1. Data on heat consumption for canned food production by regions of Ukraine

Region	Canned meat and fish			Canned natural vegetables			Ready-to-eat products and canned fruit		
	Output, t	Consumed heat, Gcal	Specific heat consumption, Mcal/t	Output, t	Consumed heat, Gcal	Specific heat consumption, Mcal/t	Output, t	Consumed heat, Gcal	Specific heat consumption, Mcal/t
AR of Crimea	4,271	466	109.1						
Vinytsia region							7,367	4,854	658.9
Volyn region							76	1,675	22,039.5
Dnipropetrovsk region	571	232	406.3				29	7	241.4
Donetsk region	613	66	107.7						
Zhytomyr region				96	802.1	77	9	12	1,333.3
Zakarpatia region				476	116	243.7	41	6	146.3
Zaporizhia region	165	200	1,212.1	8					
Ivano-Frankivsk region				122	100	819.7	115	136	1,182.6
Kyiv region	129	310	2,403.1	310	244	787.1	118	280	2,372.9
Kirovohrad region									
Lviv region	423	86	203.3				575	36	62.6
Mykolaiv region				940	283	301.1			
Odessa region	747	1,049	1,404.3	5,261	4,632	880.4	4,494	3,348	745
Poltava region	47	32	680.9				17	20	1,176.5
Rivne region	28	35	1250	669	401	599.4	694	400	576.4
Ternopil region	5	3	600	497	357	718.3	168	119	708.3
Kharkiv region	132	128	969.7				657	891	1,356.2
Kherson region				3,776	3,430	908.4	830	421	507.2
Khmelnytsky region	73	45	616.4	130	58	446.2			
Cherkasy region	265	347	1,309.4	6,900	7,506	1,087.8	1,706	680	398.6
Chernivtsi region	332	362	1,090.4	17	26	1,529.4	269	243	903.3
Chernihiv region	39	85	2,179.5	38	63	1,657.9	53	64	1,207.5

Annex 2. Data on electricity consumption for canned food production by regions of Ukraine

Region	Canned meat and fish			Canned natural vegetables			Ready-to-eat products and canned fruit		
	Output, t	Consumed heat, Gcal	Specific heat consumption, Mcal/t	Output, t	Consumed heat, Gcal	Specific heat consumption, Mcal/t	Output, t	Consumed heat, Gcal	Specific heat consumption, Mcal/t
AR of Crimea	4,271	592	138.6						
Vinytsia region							7,367	277	37.6
Volyn region							76	960.5	73
Dnipropetrovsk region	571	77	134.9	5,337	660	123.7	562	164	291.8
Donetsk region	613	153	249.6	479	221	461.4	1,382	623	450.8
Zhytomyr region	45	7	156.6	95	5	52.6	8	2	250
Zakarpatia region				476	97	203.8	41	3	73.2
Zaporizhia region	165	372	2,254.5	8	1	125			
Ivano-Frankivsk region				122	38	311.5	521	156	299.4
Kyiv region	129	86	666.7	310	68	219.4	118	116	983.1
Kirovohrad region	2	3	1500						
Lviv region	423	40	94.6				1,210	665	549.6
Mykolaiv region				940	116	123.4			
Odessa region	747	407	544.8	4,983	667	133.9	4,494	405	90.1
Poltava region	47	17	361.7	189	18	95.2	30	4	133.3
Rivne region	28	2	71.4	669	93	139	694	51	73.5
Ternopil region	5	2	400	497	74	148.9	168	25	148.8
Kharkiv region	132	26	197				665	98	149.6
Kherson region	28	5	178.6	3,776	444	117.6	1,363	234	171.7
Khmelnytsky region	87	11	126.4	130	5	38.5	6	1	166.7
Cherkasy region	265	36	135.8	6,900	1,058	153.3	1,706	229	134.2
Chernivtsi region	332	43	129.5	17	1	58.8	269	9	33.5
Chernihiv region	38	22	564.1	38	6	157.9	53	2	37.7