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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 Bakery Subsector of the Ukraine's Agro-Industrial Sector

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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.

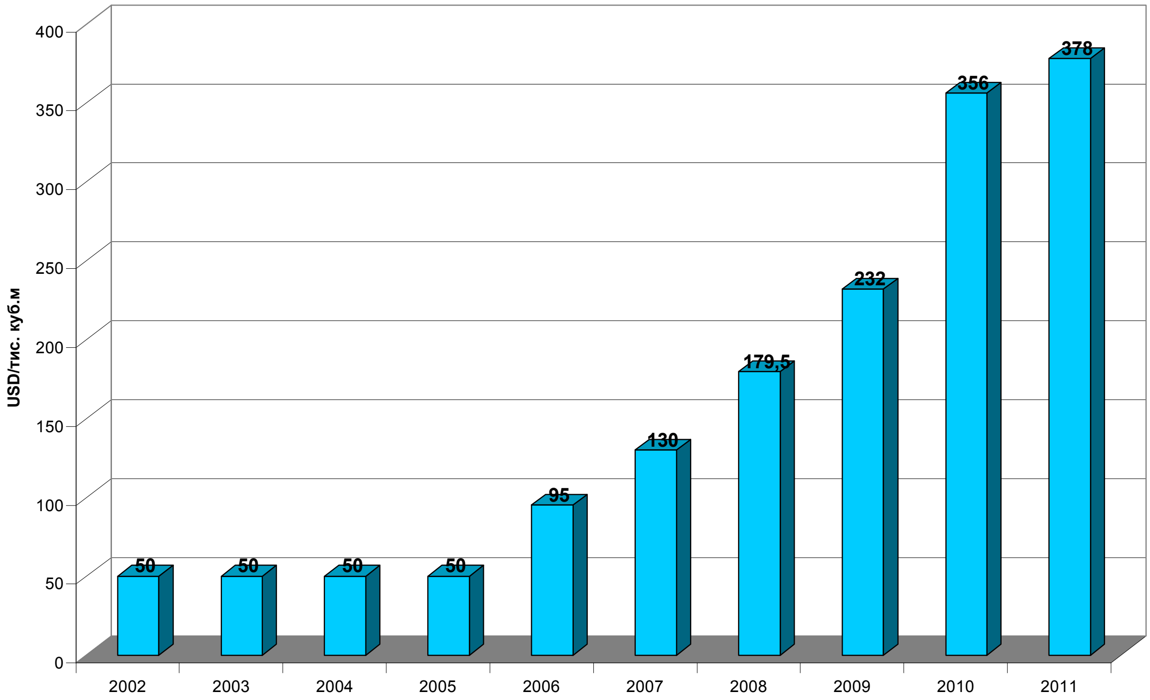

Diagram 1. Dynamics of natural gas price increase.

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.

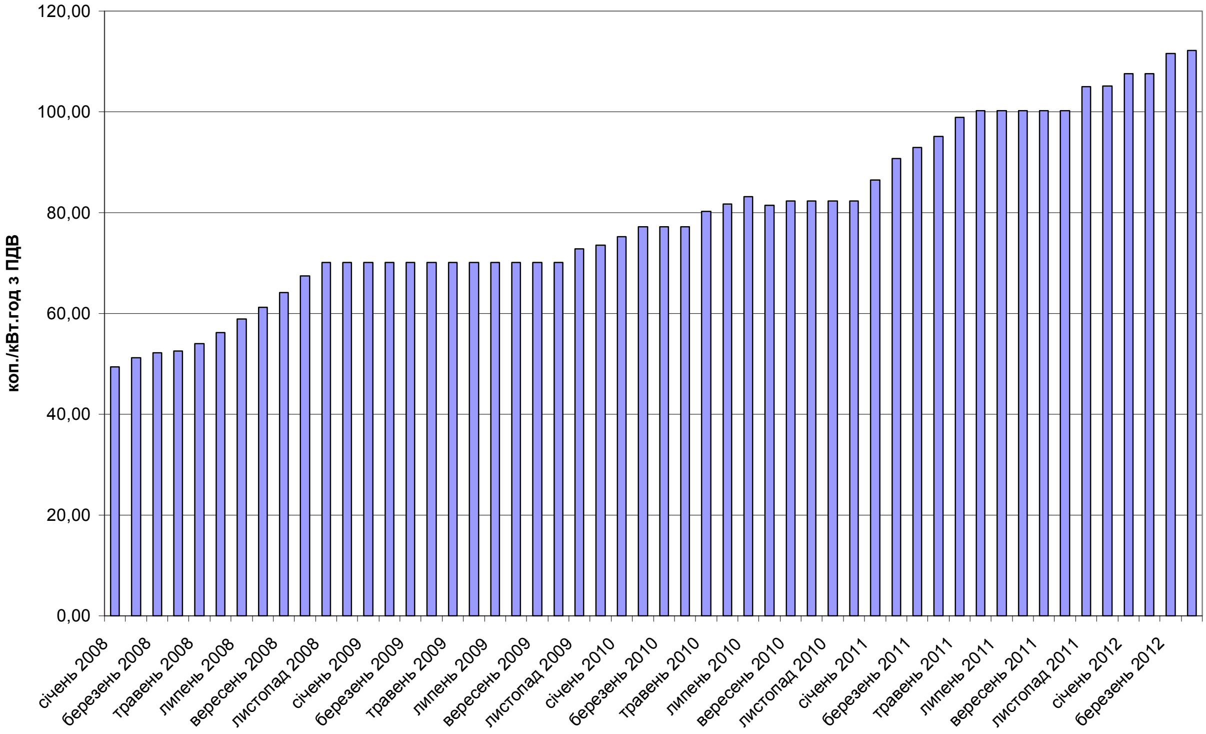

Diagram 2. Dynamics of electricity price increase

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:

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

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

Production of flour and bakery is one of the prevailing subsectors in the foods sector of Ukraine taking account of its powerful export potential and big production output and energy consumption. It manufactures 2.0 – 2.5 million tons of products. The industry manufactures the following products: various types of flour and products made of it, bakery items with fillings and semi-finished products at various readiness-to-use levels. Prices for the so called "social" sorts of bread are regulated by legislation therefore their profitability is limited to several per cents. As a result, production of intermediate products and confectionery assortment related to baked goods is available in different proportions at these enterprises. The share of the latter is insignificant making up 0.1 – 1.0% of total output, but it partially influences energy consumption indicators.

For the recent decade, specific share of industrial baked goods in the structure of bread and bakery consumption has been constantly decreasing in most regions of Ukraine. The volumes of homemade bakery of the same types have been increasing accordingly, despite of high labor-intensity of the process. The bakery enterprise activities have become low effective and many of them even became loss-making.

The major factors of impact on formation of bread and bakery consumer properties are type of raw materials and their quality and product manufacturing technologies.

The assortment of bread and bakery products being manufactured by Ukrainian enterprises covers over 1,000 names. It increases every year as a result of competitive struggle for consumers and leading to introduction of state-of-the-art technologies with the use of various flavors, fillers, etc. Some 50% of total bread produced in Ukraine fall on wheat sorts, the share of rye bread makes up about 30%. Rolls and buns account for about 16% of the marketplace. 4-5% of the market remains for other types of products (such as crisp bread, etc.). And due to launching new types of products, the demand for conventional bread sorts annually decreases approximately by 5%.

The largest bread and bakery manufacturers in Ukraine are 6-7 companies controlling almost half of the market, each of them concentrates the production capacities in a certain region. One of the largest companies is "Kyivkhlib" supported by the capital's public authorities with its share being 91% of Kyiv marketplace and 13.5% of the national marketplace. The capital's market is also filled by the products manufactured by "Khlibni Investytsii" companies (a holding company composed of the plants operating in many regional centers) as well as "Ukrzernoprom" CJSC (principal facilities are concentrated within the North-Eastern region). TiC holding company embraces the south of Ukraine, Concern Khlibprom PJSC operates in the Western regions (specific market shares of both companies are equal to about 6%). The rest of the companies (57% of the

Ukrainian market) are rather small and they focus on manufacturing products for individual towns or residential areas. The small companies are inter alia “Korovay” OJSC (some 3% of the national market), Agroservice 2000 Ltd. (2.9% of the market), etc.

The largest bread-making plants as a rule account for not more than 3% of the market that is due to the short product life, as a result manufacturers may sell bread and bakery products only in their regions – geographic expansion of the sales area leads to increased transportation costs and thus increases the product costs as well as reduces the product quality making it less competitive as compared to the local products. The following bread-making plants are worth noting: “Kyivkhlib” (bread-making plants No.10, 11 – Kyiv-based), “Odesky Korovay” (Odessa region), “Vinnytsiakhlib” Concern Khlibprom PJSC (Vinnytsia region), “Cherkasykhlib” (Cherkasy region), “Khlib” (Dnipropetrovsk region) and “Saltivsky” Bread-Making Plant (Kharkiv region), etc. 80% of the market falls on small bread-making plants.

Flour forms 50% in the structure of bread and bakery production costs, besides that, labor costs share is significant (30%), costs of the gas used for baking (10%) and other costs – oil, yeast, salt, gasoline, etc. In 2007, due to the growing production costs, the large number of bread-making plants started to raise prices for their goods. As a result, the government seeking to regulate the industry issued the Resolution dated 20 June 2007 that granted local executive authorities the powers to set profitability limits for production of I and II grade wheat flour, rye flour and certain sorts of social bread of it. Besides that, mandatory declaration of price changes by manufacturers was introduced (Resolution No.1222 dated 17 October 2007). Therefore, small manufacturers were forced to leave the market, while the large enterprises increased production outputs by 3-5%.

In 2008, the bread and bakery prices grew materially – in total by 27.6% during the year. Primarily, the rise resulted from the increased production costs as well as the increased energy prices. The national currency devaluation caused significantly increased expenditures and growing debts under foreign currency loans taken for purchase of imported equipment.

In 2009, those manufacturers raised the prices that did not change the prices in late 2008. The growth in bread and bakery prices in 2010 was less fast than in previous years. I quarter of 2010 saw the following average retail prices: wheat-and-rye bread – 3.42 UAH /kg (+6.9%), wheat bread – 3.49 UAH/kg (+9.0%), II quarter – 3.50 UAH /kg (+6.1%) and 3.56 UAH/kg (+7.9%), respectively.

According to the official statistics, the dynamics in bread and bakery output in Ukraine demonstrates a stable declining trend in bread output.

According to the latest data published by the State Statistics Committee of Ukraine, the bread-making enterprises of all patterns of ownership reporting to the statistics bodies produced 1,755 thous. tons of bread and bakery goods in 2009 that is 7.9% less than in 2008. During 4 months of 2010 they manufactured 538.6 thous. tons of bread and bakery. Production rates declined by 4.2%.

In the recent years, the state of bread and bakery industry is characterized with the declining output of bread and bakery related to the decreased demand, the demographic situation in the country and the increased output of bread by small bakeries, supermarkets and hypermarkets as well as households (these volumes are not included in the official statistic data). In 2009, according to the preliminary data, 1,755 thous. tons of bread and bakery were produced, that is 11.3% less than in previous year (diagram 1). During 7 months of 2010, the bread output was equal to 975 thous. tons (that is 3.7% less).

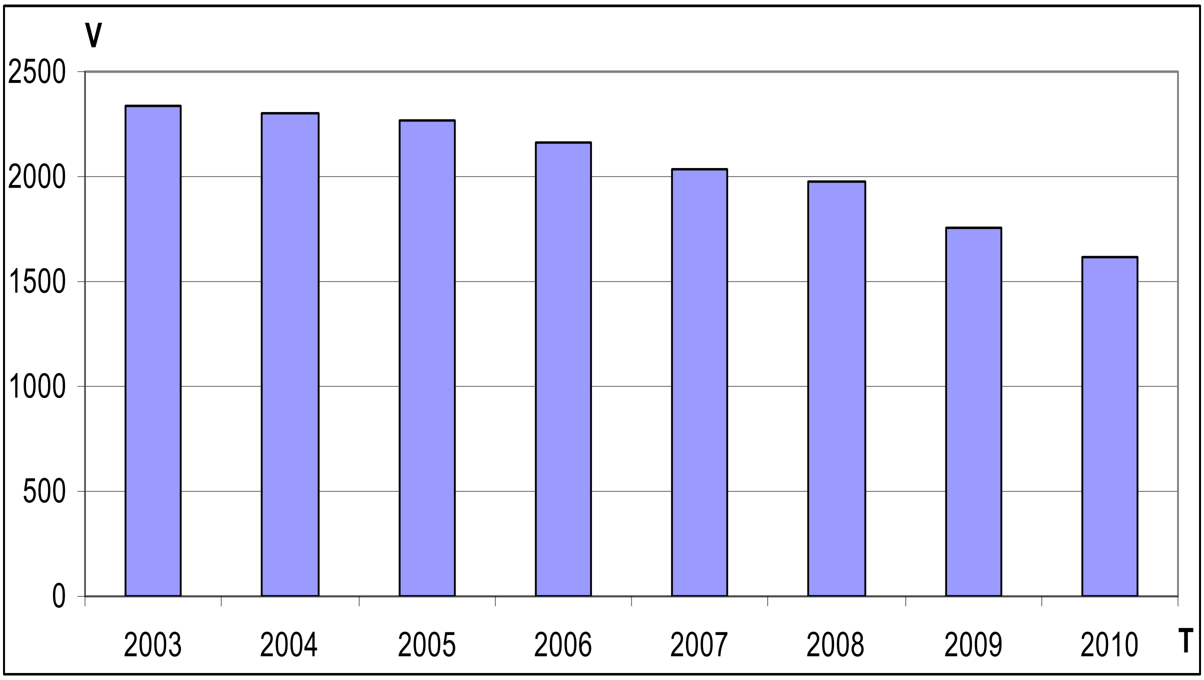

Diagram 3 – Dynamics of bread and bakery output in Ukraine, thous. tons

See below the summarized description of the main production technology stages.

Flour production

The flour-milling industry applies three main types of wheat milling: three-grade, two-grade and one -grade, however, proportion of grades may vary within each type of milling. The three-grade milling produce the flour of top, first and second grades; the two-grade milling may produce either top and second or first and second flour grades; the one-grade milling may produce, for instance, 72% of the first grade flour, or 85% of the second grade flour, or 96% of the darkest flour.

The flour grade is defined by the three parameters: color, fineness and content of wet gluten. Besides that, flour wetness, mineral particulate matter that could be removed with metal magnets.

Prior to turning into flour, the grain passes a 5-to-6-kilometer-long way at a mill. However, the whole grain is no longer exists as early as at the first stage of this way. A mill is divided into two main departments: preparatory and milling workshops.

Preparatory workshop

The mill's preparatory workshop cleans the grain from impurities and the grain experiences water and heat treatment.

The grain input to the preparatory workshop is weighed in automatic mode and then sent for cleaning.

One of the main grain-cleaning machines in the preparatory workshop is a separator where grain goes through screens and air flow.

Upon cleaning with separators and length separators, some fine stones, soil, fragments of glass, ore, pentatomid bugs remain in it. They are jointly named mineral impurities. As a rule, the cleaned grain contains not many impurities. For instance, 2-3 fine stones per kilo of grain. Despite relatively small content of mineral impurities, they dramatically worsen the quality of final products. Therefore, the grain input to milling workshop may not contain any mineral impurities.

First, grain at mills is cleaned from mineral impurities with high productivity, but, at the same time, 5% of normal grain is withdrawn along with impurities. Then this fraction is treated by the lower productivity machine where grain and mineral impurities are separated in full.

The grain free from mineral impurities comes for further processing and the fraction containing mineral impurities goes to the second cleaning stage. To this end, a rather small stone-separating machine is applied. Most stone-separating machines ensure productivity of 20 tons per hour and are configured in the form of cabinet-type separators. Structurally, a stone separator is a rectangular frame with a metal wired screen on it. Two solid bottom trays are installed under it: one - for outgoing clean grain, the other - for fine impurities.

This machine not only removes mineral impurities, but simultaneously cleans grain again from fine impurities falling through sieve’s apertures and discharged along the bottom. The sieve apertures are cleaned with rubber balls.

Grain surface is cleaned by two methods: first, the “dry” method, second, the “wet” method.

Milling workshop

The grain should turn into flour in the milling workshop. The main objective of grain milling is to smash grain and separate surface gluten. The short-term goal of flour industry, especially wheat milling industry, is to get as much as possible white or fine flour from given grain volume.

Grain is milled with a roller at mills.

Reduction to powder is the most energy-consuming process in the flour production. Each electric engine of the roller consumes up to 22 kW. Annual average electricity consumption for grain grinding makes up 16-18 billion kW-hour.

To produce top-sort flour, grain is milled not at once but gradually. First, less flour is got and more larger particles. Here, elasticity of wet coating is applied preventing their grinding into fine particles. Upon first milling, the outgoing mixture mostly contains (up to 90%) of large laminar capsule aggregates and endosperm, relatively small quantity of fine lumps (8.5% - 9.5%) and flour (0.5 – 1.5%).

The milling process is aimed at withdrawing as much as possible endosperm from milled products.

Flour flows of each sort go separately to test sieves for removing large particles that may occasionally get into flour.

The milling and flour formation scheme is exercised so that flour of all sorts is got from different grain areas and they differ by chemical composition and other parameters, respectively.

Flour vitaminizing

Besides the above flour quality indicators, its nutrition value is determined by its vitamin content. In contrast to protein and carbohydrates, humans need vitamins in rather small quantities. They improve metabolism and ensure normal development of human body. Concentrated vitamins contain vitamins and filler. The filler contains 4-5 kilos of flour with the preset amount of vitamins added. Upon thorough mixing, the mixture goes to a hopper and upon a special metering device, the flour containing vitamin mixture goes to a horizontal mixer.

We have passed step by step the entire way from grain to flour – the way that takes about a day for grain to complete.

Almost entire process of flour production is linked to electricity consumption either directly or indirectly in the form of air compressed at different pressures. Large enterprises may demonstrate some fuel consumption, but it is not of technological nature and is used on seasonal basis for premises heating.

Raw material acceptance and storage

The first production stage includes acceptance, transportation to warehouse premises and reservoirs and further storage of all types of raw materials.

Raw materials come to enterprises by batches.

Both main and auxiliary raw materials are delivered in containers and is subject to mandatory examination. Raw materials are weighed before acceptance. Where delivered in tank lorries or on trucks, mass of raw materials is checked by weighing tank lorries or trucks on motor-truck scales with and without raw materials in them. Where raw materials are accepted in containers (bags, boxes, barrels), they may be weighed by motor-truck scales or by platform scales. Raw materials acceptance with random mass check of individual packages is allowed where raw materials are delivered in standard packaging (bags, barrels, etc.) with nominal unit mass indicated on the packaging.

Storage and preparation of raw materials for production is in accordance with the requirements set for each type of raw materials.

Storage of first grade baker's wheat flour

Flour is delivered to a bakery and stored in bags or (in most cases) is manufactured in the flour milling workshop at the same enterprise. The reserves of flour of each grade should be sufficient to meet the enterprise's seven-day demand.

According to SanPiN 2.3.4.545-96, flour is stored separately from other raw materials. Flour storage premises should be dry, clean, equipped with heating and good ventilation; the floor should be dense, without slots, cemented or asphalted. The walls should be smooth, whitewashed or ceramic tiled. Flour is stored in compliance with GOST 26791-89. The temperature at floor of the warehouses should be maintained at above 8ºC.

Water storage

Water is fed to an enterprise from municipal drinking water supply pipelines. It is stored in special tanks where operative reserves of water are formed, while hot water is fed from enterprise's boiler house. Cold water reserve should be sufficient for uninterrupted enterprise operation for 8 hours, hot water reserve should be enough for 5 to 6 hours of operation.

Compressed yeast storage

Baker's compressed yeast enters an enterprise in the form of 500 g and 1,000 g bars packed in polymeric boxes. Yeast are stored on shelves or pellets at the temperature from 0 to +4ºC in a warehouse. The amount equal to one-shift or one-day demand may be stored within the workshop area.

Yeast warehouse should be dry, clean and ventilated.

Salt storage

Salt is delivered to an enterprise in paper bags consistent with GOST 2226-88, net weight of 50 kg. Salt is stored in separate premises at relative humidity up to 75%. Salt is poured from transportation bags into capped wooden boxes as salt eats away the bags if it is stored in them.

Granulated sugar storage

Granulated sugar comes to an enterprise in sugar-intended woven bags under GOST 8516-78E, or in woven bags with polyethylene or paper three-layer inserts, net weight - 50 kg. The bags should keep sugar clean and be free of any smell. They should prevent sugar spilling via cloth or seams.

Bags containing sugar are stored on pellets covered with clean tarpaulin, bagging or paper. A pile should be composed of the sugar of similar quality packed in the same type of packaging and of the same standard weight. Granulated packaged sugar should be stored at the temperature up to 40°C and relative humidity up to 70% at the surface of the lowest row of packaged sugar.

Sunflower oil storage

Refined sunflower oil is delivered to an enterprise in steel barrels consistent with GOST 13950-84, then it is pumped into vessels HE-44 and stored in bulk in closed dark premises at the temperature of 19°C.

Table margarine storage

Margarine is delivered to an enterprise in corrugated cardboard boxes under GOST 13511-84 or cardboard boxes under GOST 13515-80 covered with polymeric film. It is stored in refrigerating chambers at the temperature from -20°C to +15°C and continuous air circulation.

The detailed description of the conditions for acceptance and storage of raw materials demonstrate availability of electricity consumers related to unloading and warehouse microclimate maintenance. During the heating season, fuel is consumed to ensure necessary storage temperature.

<u>Raw materials preparation for production</u>

Treatment of flour for bread-making

Bagged flour is treated as follows: a flour bag, prior to emptying, is cleaned with a brush and cut along the seam, then a flour bag is loaded on a bag dumper.

Before entering production stage, the flour is sieved, cleaned with a metal magnet from impurities and weighed on automated scales. A sifter is used to sieve flour, its operating elements are wire screens.

To remove metal particles from the flour passing through the screen apertures, magnet traps are installed. They consist of the set of steel magnet arcs with a cross-section of 48×12 mm. Minimum capacity of the magnets of this cross-section is 8 kg, maximum capacity is 12 kg. Flour is weighed after screening as structural features of the scales may provide stable scales operation only for sifted flour.

To ensure the design productivity, an intermediate (over-scales) bunker is installed, where flour reserve should be equal al least to the set maximum dosage. An accumulating vessel for the measured dose is installed under the scales for the same purpose. This is the so-called under-scales bunker which capacity should be sufficient for ensuring failure-free operation of the scales and the feeding system that feeds flour to the production section. The scales metering device contains a gradient meter that meters and registers flour discharge.

Upon screening and weighing, the flour is fed to production bunkers to build an operating reserve. It is fed from bunkers to bulk material feeders installed next to dough-mixing machine. Flour is transported by mechanic transport with the use of elevators and screws.

Water treatment

The water is warmed to required temperature before use. The temperature is first estimated and then checked experimentally. The water temperature should be not higher than 45-50ºC.

Treatment of edible salt

Prior to feeding to production, the salt is diluted in a batch-operated salt dissolver, filtered and fed to a supply tank. The ready-made salt solution from a salt dissolver is pumped into a production dispensing vessel and supplied to a liquid component feeder.

Compressed yeast treatment

Compressed yeast are used in production in the form of suspended yeast. The suspension is prepared at 1:3 yeast-to-water ratio at the temperature 30-35ºC immediately before dough-making. A propeller mixer is applied to prepare the suspension. The yeast suspension passes through the screen.

Granulated sugar treatment

Sugar is supplied to a production section in a diluted, filtered form. The sugar solution is filtered through metal screens. Sugar solution dosage is set depending on its actual density.

The ready-made sugar solution is pumped into a production dispensing vessel and from the vessel to a liquid component feeder. If it is necessary to use solid sugar it is screened with a metal screen.

Sunflower oil treatment

Before supply to a production section, sunflower oil passes through the screen with up to 3 mm large apertures.

Margarine treatment

It is unpacked, visually examined, cleaned out and used as crumbs, in the unmelted form.

Dough-making section

Leavened dough and unleavened dough is made in portable bowls with a dough-kneading machine. To prepare leaven, water and yeast suspension doses are fed with a liquid component feeder into a bowl, then the machine is turned on and a desirable amount of flour is fed from a bulk component feeder during continuous agitation. Leaven is mixed during 8 to 10 minutes till homogenous mass is obtained. The mixed leaven is left in the bowl for fermentation during the period from 240 to 270 minutes.

To knead dough, the remained water, salt and sugar solutions and sunflower oil are added to the leaven in the bowl with a liquid component feeder and gradually the flour remainder is fed with a bulk component feeder. The dough is kneaded with a dough-kneading machine for 8 to 12 minutes depending on the flour grade. The knead dough is left in the bowls for fermentation for the period from 20 to 40 minutes. The finished dough then is sent for division.

Dough processing section

The dough processing includes the following technological operations: dividing of the dough into the pieces of preset weight, preliminary proof of dough pieces, rounding of dough pieces, panning of dough pieces, final proof of dough pieces.

The fermented dough is unloaded with a dumper into the dough divider's funnel, then the dough pieces of the desirable weight are fed into the preliminary rack proofer and after that into a dough rounding machine. Round dough pieces with the transfer conveyor are fed to the processing table where they are finally shaped and laid on plates. Prior to laying on plates, the dough pieces are oiled and sprinkled with pastry lumps (the operation is performed according to the technology). The lumps are prepared by adding sugar and flour into the margarine melted to the creamy condition, further the mixture is agitated till it becomes homogenous and rubbed through the screen. The plates with the dough pieces are put on load carriers in the rack proofer where the final proofing takes place for 40 to 70 minutes.

Baking section

The dough pieces on trays are moved from rack proofer load carriers into an oven, where they are baked at the temperature 210-230°C in the moistened baking chamber. The oven is a modular-framed all-metal oven with a baking chamber of dead-end type, there is a carrier chain with hearth chambers inside it.

Cooling section and dispatch

Upon exit from the oven, an item is dumped into a tray on a transfer conveyor feeding the products to the circulating table. Then, the products are piled into larger trays. While piled, rejection process is performed according to GOST 27844-88 by organoleptic parameters and weight. The items in the trays cool down for 30 - 50 minutes till the surface temperature reach 30-35°C, after that they are packed. The packed items on trays are sent to storage and dispatching and then to distribution network.

The cooling section and dispatch premises must be well-illuminated, clean and equipped with the combined extract and input ventilation. Record-keeping of the output products, as well as sorting and organoleptic evaluation are performed in the cooling section. The products of the wrong shape, dirty surface or wrong weight are rejected. The rejected items may be recycled into dried bread crumbs.

To prevent supply of stale bread to the distribution network "Specific Conditions of Bread and Bakery Supply" establish the period for bread storage at an enterprise and in retail chain. The bread storage time is calculated from the moment when bread exits an oven and till its delivery to a retail outlet. The period of bread stay at an enterprise may not exceed 24 hours, its shelf life in the distribution network is 72 hours.

As we can see, electricity is consumed at all the production stages. Heat consumption is related to the use of ovens, hot water for formula mixing tanks and for maintaining of the temperature modes.

Heat consumption in the form of warm water and warm air emissions provide the opportunity to use them and thus save energy. In the electricity saving aspect, the main potential includes the use of state-of-the-art ventilation and milling equipment as well as regulated drives at pumps, ventilators, conveyors.

Specifics of the production in terms of energy consumption:

1) **no seasonality of operations** – the plant operates all year round evenly with the productivity fluctuating from 5 to 15%;

2) **high heat and electricity demand** with relatively insignificant daily and seasonal fluctuations and insignificant fluctuations of heat loads in summer and winter seasons;

3) **various heat carriers** available in the heat supply scheme;

4) **product consumption declining trend** and lower production line loads, respectively, that is rather critical for baking;

5) **large quantity of reusable energy sources** (hot gases) that could be reused;

6) **combined product output** – both bread and bakery are manufactured with the continuously growing share of the latter.

ANALYSIS FINDINGS

The 2011 data on unit consumption of heat and electricity for production have been received from 14 enterprises. The data have been collected via telephone polling, questionnaires and from public sources of information.

The analysis findings are represented in table 1.

Table 1

Enterprise code*	Output in 2011, tons	Unit energy consumption	
		Heat, kg conventional fuel/t**	Electricity, kWt-hour/t
Bakery-1	25,180	108.071	72.014
Bakery-2	24,210	106.009	71.012
Bakery-3	3,570	120.878	121.237
Bakery-4	17,523	103.915	76.987
Bakery-5	43,805	104.950	65.992
Bakery-6	7,096	125.543	124.869
Bakery-7	14,149	142.494	213.734
Bakery-8	5,976	202.265	142.295
Bakery-9	3,081	175.756	252.707
Bakery-10	10,473	104.784	72.023
Bakery-11	2,771	177.747	59.025
Bakery-12	3,942	173.715	56.626
Bakery-13	24,250	80.933	46.774
Bakery-14	3,398	220.359	261.919

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

** oil equivalent of conventional fuel

Benchmarking curves have been built on the basis of the obtained information using the proved technique [2] (Diagrams 4, 5).

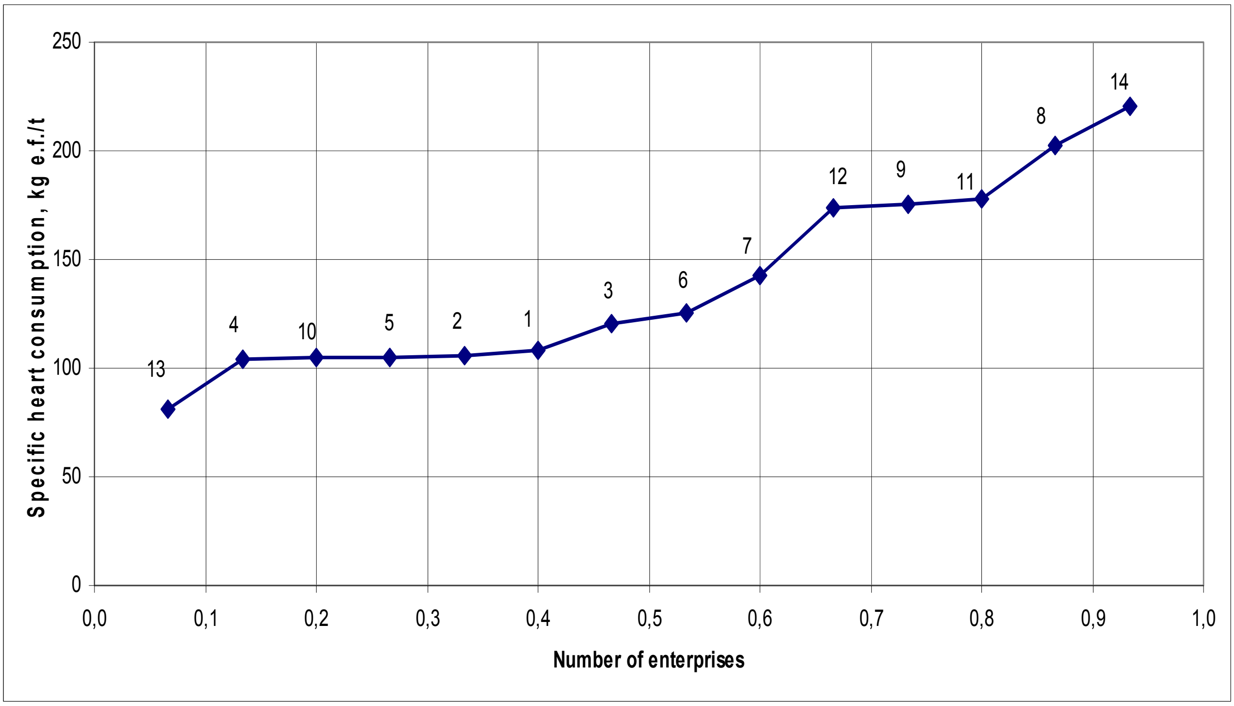

Diagram 4. Benchmarking curve of unit heat consumption in the form of conventional fuel by the manufacturers of bakery products.

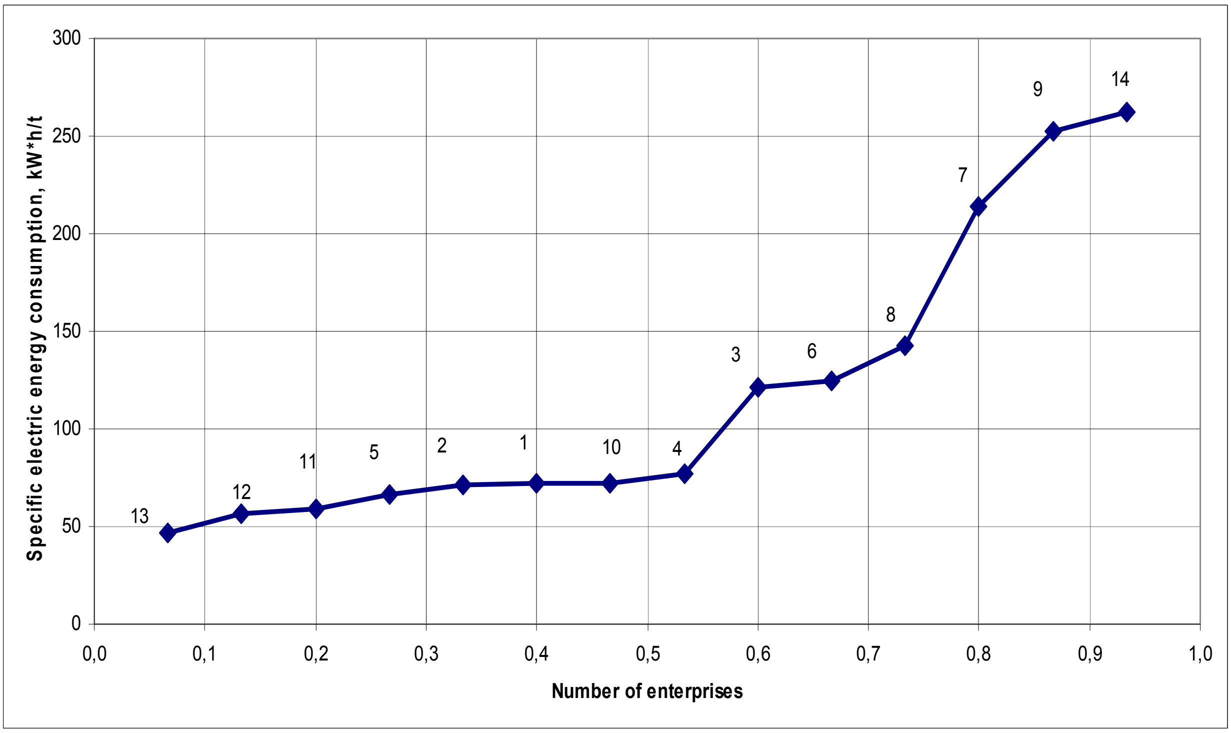

Diagram 5. Benchmarking curve of unit electricity consumption by the manufacturers of bakery products.

The curves are used to identify enterprises' efficiencies.

By heat consumption:
The most efficient enterprise **–** 80.933 kg of conventional fuel/t
The least efficient enterprise – 220.359 kg of conventional fuel/t

BAT = 80.933 kg of conventional fuel/t
BPT = 80.933 kg of conventional fuel/t

By electricity consumption:
The most efficient enterprise – 46.774 kWt-hour/t
The least efficient enterprise – 261.219 kWt-hour/t

BAT = 46.774 kWt-hour/t
BPT = 46.774 kWt-hour/t

CONCLUSIONS

1. Specific energy consumption by bakery enterprises varies in the range:
   - fuel: from 80.933 to 220.359 kg of conventional fuel/t;
   - electricity: from 46.774 kWt-hour/t to 261.219 kWt-hour/t.

   This difference is due to, firstly, different product structure manufactured by the enterprises, secondly, different volumes of product output, even where their structures are similar, thirdly, the equipment differing by energy consumption levels.
2. The average specific fuel consumption in the industry according to statistic data makes up 114.985 kg of conventional fuel per ton for flour and bakery. 6 enterprises out of the selected enterprises are more effective than the average level in the flour and bakery industry.
3. The average specific electricity consumption in the industry according to statistic data makes up 89.269 kWt-hour/t for flour and bakery products. 8 enterprises out of the selected enterprises are more effective than the average level in the flour and bakery industry.

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