OCCASION

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

DISCLAIMER

This document has been produced without formal United Nations editing. The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. Designations such as "developed", "industrialized" and "developing" are intended for statistical convenience and do not necessarily express a judgment about the stage reached by a particular country or area in the development process. Mention of firm names or commercial products does not constitute an endorsement by UNIDO.

FAIR USE POLICY

Any part of this publication may be quoted and referenced for educational and research purposes without additional permission from UNIDO. However, those who make use of quoting and referencing this publication are requested to follow the Fair Use Policy of giving due credit to UNIDO.

CONTACT

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

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

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

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

REPORT

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

Drafted by: V. Chukhno

Kyiv 2012

This page internally left blank

CONTENTS

CONTENTS 3
SUMMARY 4
INTRODUCTION 5
POTENTIAL ROLE OF BENCHMARKING IN IMPROVING ENERGY EFFICIENCY OF AGRO-FOOD ENTERPRISES 7
BRIEF DESCRIPTION OF THE INDUSTRY AND ITS SPECIFIC FEATURES IN TERMS OF ENERGY SAVING 11
ANALYSIS FINDINGS 21
CONCLUSIONS 23
SOURCES 24

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.

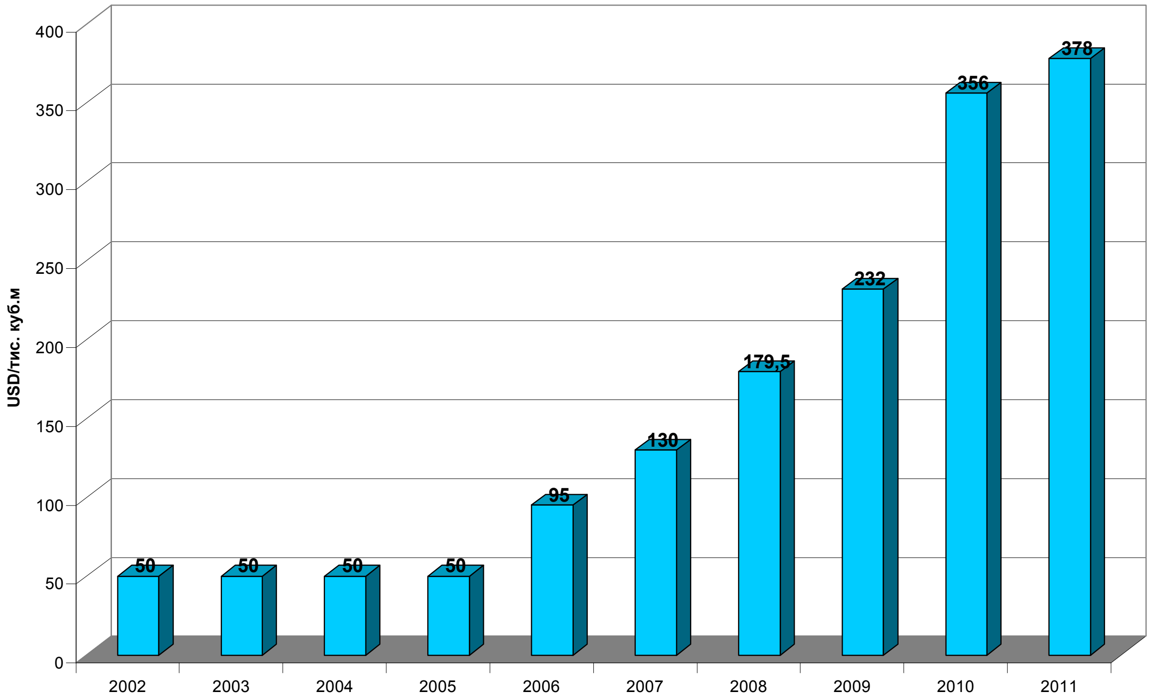

Diagram 1. Dynamics of natural gas price increase.

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.

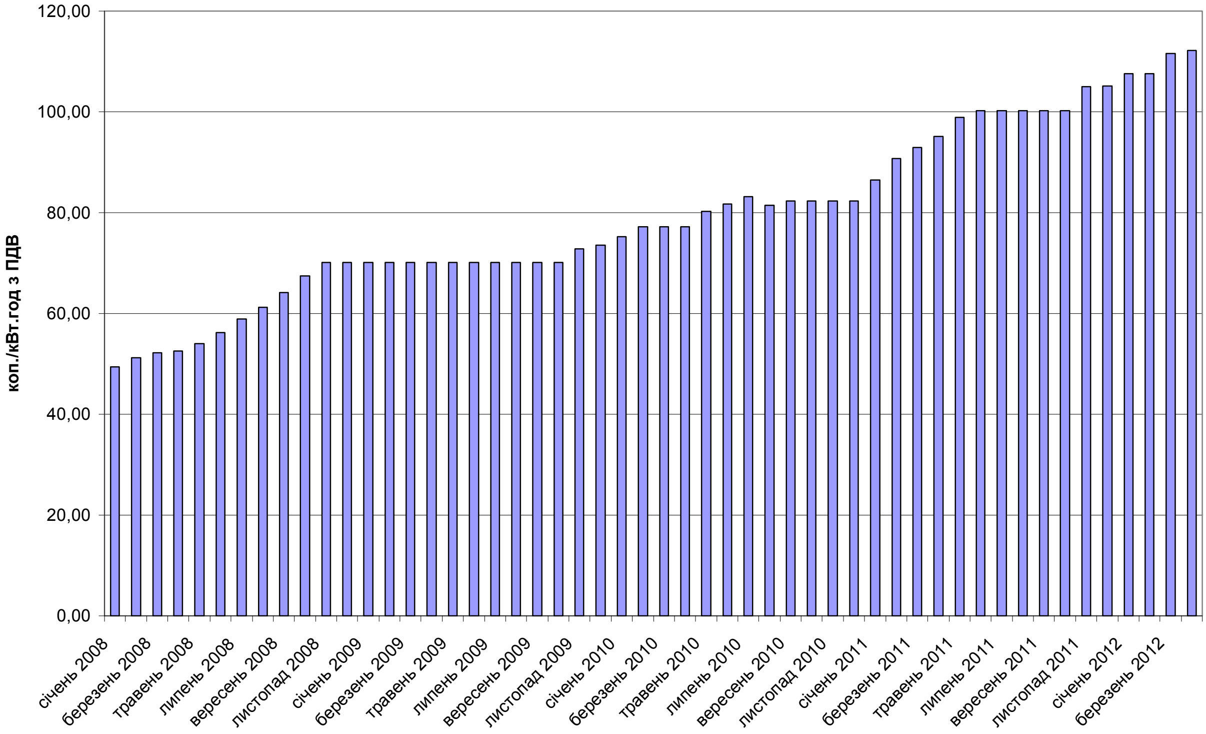

Diagram 2. Dynamics of electricity price increase

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:

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

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:

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

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

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

Confectionery industry in Ukraine is one of the most common in the food sector of Ukraine considering its powerful export potential, as well as production output and energy consumption. The industry manufactures 1.5 – 2.0 million tons of products annually. The range of products include: cocoa, chocolate and similar products with or without fillers, chocolate sweets, products of chocolate, confectionery products of sugar or its substitutes containing cocoa, white chocolate, panned sweets, coffee substitutes, extracts, essences and coffee concentrates, gingerbread and similar products, sweet cookies, waffles. This industry also includes the enterprises producing cakes and breakfast cereals.

Speaking about cocoa-containing products, it is worth noting that raw materials – cocoa beans – are imported. Output of semi-finished products for further use in production in Ukraine is rather limited. Only several largest manufacturers purchase them and produce cocoa liquor, crushed cocoa, cocoa butter.

According to statistics, confectionery product output in 2012 in Ukraine grew with a rather large share 30-40% of output intended for export. National confectionery industry is represented by the enterprises being components of the system of the State Department of Food of Ukraine: "Ukrkonditer" CJSC, "Ukrprodsoiuz", "Ukrhlib" and non-associated enterprises operating in the private sector. "Ukrkonditer" system covers 28 factories, food product manufacturing plants and catering enterprises. The aggregate capacity of 28 "Ukrkonditer" confectionery factories makes up ¾ of the total output of the Ukrainian confectionery industry

The confectionery industry output accounts for 3% of the national GDP. Ukraine's share on the world market (US $93 billion) reaches 1%.

Table 1

Breakdown by years of confectionery industry outputs

Year	2000	2004	2005	2006	2007	2008	2009	2010	2011
Output of confectionery products, thous. tons	668	930	1,000	1,080	1,100	980	935	971	1,065

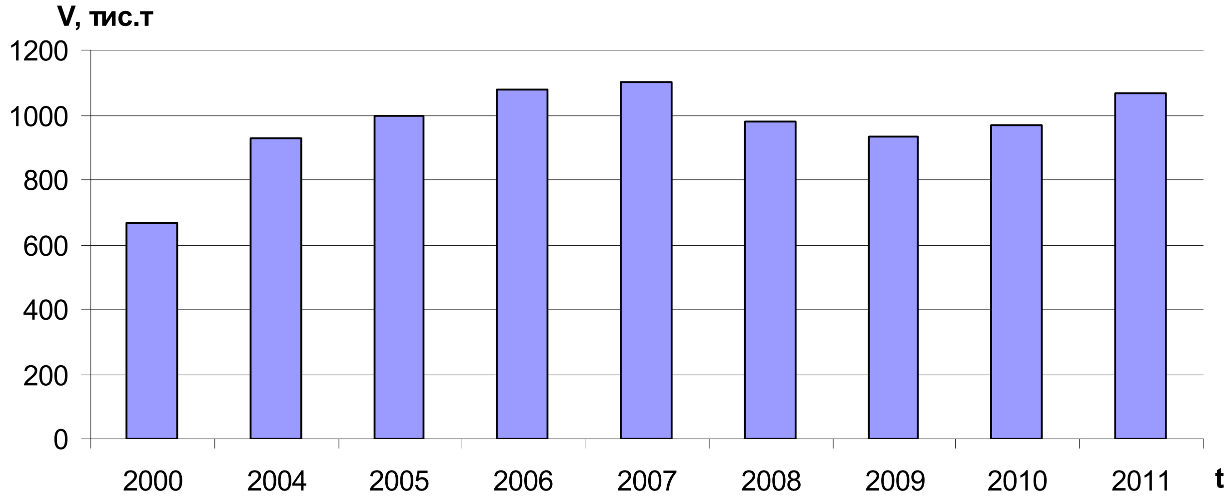

Diagram 3 – Output of confectionery products, thous. t

Relative decrease in outputs in 2008-2009 was due to the crisis and lower consumption of confectionery products as they are not essential items. The range of manufactured products covers almost all groups of confectionery products. Nearly 170 thousand people are employed in the confectionery industry. Production capacities in the industry are loaded approximately by 70%. Total industry production capacity makes up 1.5 million tons with about 45% (or 0.6 million t) falling onto sugar consumption. Forecast production capacity in 2012 may reach 2 million tons.

The total number of confectionery enterprises is nearly 800. Some 90% of the enterprises produce flour-based confectionery products with only 10% of the manufacturers producing sugar-based products (chocolate, caramel, sweets, dragee, etc.). Most enterprises produce mixed spectrum of products. Confectionery goods account for 0.1-20% in the output of bakery enterprises. Seven largest confectionery enterprises of Ukraine have market shares from 4% to 26% and manufacture 72% of the total output.

The confectionery marketplace conditionally may be divided into three major segments: sugar-based, flour-based and chocolate products. The smallest segment is sugar-based confectionery goods (caramel, dragee and sweets). The segment of flour-based goods (biscuits, waffles, cakes and crackers) accounts for 38.6% of the total output, with the share of chocolate goods segment accounting for 5.7%.

In recent years, most noticeable extension in the range of goods has demonstrated the following products: bar chocolate (on the account of aerated and high-quality thin chocolate); chocolate sweets (thanks to development of praline fillers); chocolate sticks (especially in waffle group); rolls, biscuits (including sponge-cookies), glazed biscuits and Twinkies.

At present, seasonal trends towards production increase and range extension are observed in each commodity group.

The largest confectionery manufacturers in Ukraine are Roshen, AVK PJSC, Svitoch Lviv-based confectionery factory, PJSC Craft Foods Ukraine, PJSC

“Kyiv-Conti” production association. The annual capacity of the domestic confectionery marketplace reaches nearly 1 million tons.

Generalized outline of main confectionery manufacturing technologies.

1. Caramel Production

Caramel is a type of product with high sugar content. Syrup and fruit and berry fillers are used in caramel production. Caramel goods are produced either without fillers (sugar candy) or with fillers. The latter is produced at the high-productive lines of domestic origin or imported. Caramels are manufactured in various shapes (oval, pill, etc.), colours, flavours, and with various fillers inside (fat, fruit, liquor, etc.). Small businesses are especially interested in producing sugar candies, as they do not require complicated equipment, but provide the opportunity to create unique products thanks to various shapes of finished products, application of differing aromatizers and colouring agents.

Caramels with fillers interlaying with caramel mass are produced in Ukraine both on aided lines that consist of isolated machines and on flow lines. This type of caramel has good taste qualities and is in great demand with the population. Various types of forming machines are used in industrial caramel production:

- chain linear-cutting (rectangular shape);
- rotational caramel-shaping (various shapes);
- chain caramel printing (oval, round shapes, etc.);
- enveloping aggregates where lollipops and caramels with dense fillers are both formed and twisted;
- pill-shaping machines;
- drop roller machines (shapes: boiled sweets in the form of various figures).

These types of goods are produced by casting in starch, starch-free casting in trays and pressing with extruder. The manufacturers use aided lines with average performance of 500 kg/hour to produce lollipops on sticks or caramels with chewing gum fillers of Chupa Chups type.

They are folded and packed on automatic lines.

Main energy consumption: saturated steam of low parameters (1-4 bar), condensate or hot water (mostly at the stage of filler preparation), electricity is consumed directly and indirectly in the form of cold or compressed air almost at all production stages.

2. Sweets Production

Mass production sorts of sweets with fondant and jellied centre are produced on flow mechanized lines.

The cast centres of retail assortment sweets like “Korova”, “Likerni” and “Fruktovi” are produced with casting machines and starch. The cast sweets centres are glazed with glazing machines.

Small production businesses often produce sweets of pigeon's milk and soufflé types. The following equipment is used for their production: spreading conveyor lines, refrigerant cabinets, cooking boilers, tempering, cutting and glazing machinery, mixers to apply chocolate and fat glaze.

Sweets paste (for production of praline centres of sweets) is produced with the following equipment: mixers, melangeurs and five-roll refiners.

Shaping of praline cupola-shaped sweets of "Zolota niva" type is performed on a flow-mechanized line.

The sweets of "Vershkova pomadka" type are produced on the line, where sweets are deposited on pallets and further manually packed up in boxes.

Wrapping and packing operations are performed on automatic and aided lines.

Sweets are packed in boxes either manually or on foreign-made mechanized equipment.

Main energy consumption: low parameter saturated vapour (1-4 bar), condensate or hot water (primarily, on the syrup boiling stage and for process temperature maintenance), electricity is consumed directly and indirectly in the form of cold or compressed air almost at all production stages.

3. Chocolate Production

Primary processing of cocoa beans is a complex process, where the following equipment is involved: sorting and hulling machinery, roasters, grinding and sorting machines, various plants for producing cocoa paste, presses for cocoa butter release, temperature assemblies, equipment for producing cocoa powder.

The following production of chocolate masses is performed on mechanized lines that consist of formula-based mixing stations, steel band conveyors, five-roll and two-roll mills, vertical and horizontal conching machines, tempering assemblies.

Chocolate bars of various weighs, aerated chocolate, assorted chocolates are produced on automatic lines. The shaping methods range from conventional (centres, fillers, bottoms) to novel (simultaneous centre and filler dosing) methods.

Productions of semi-finished products of cocoa beans, chocolate mass and chocolate bars are most energy intensive as concern fuel expenditure. Large volumes of high-temperature heat carriers are used at the cocoa bean roasting stage (saturated vapour at 9-10 bar or even superheated vapour). These operations at a large enterprise may account for 50-60% of heat consumption. It also includes maintenance of constant temperature in remote-mount chocolate collectors. Chocolate paste production is related with the use of large volumes of high-temperature cold (+5 – +20°C – in proportion to volumes) in the form of water for cooling of five-roll mills.

4. Toffee Production

Toffee production includes the following technological operations:

- formula mixing;
- mixture boiling out;

- cooling of toffee paste;
- toffee shaping and packing.

Main energy consumption: hot water at the stage of raw material processing and for maintenance of process temperature. Electricity is consumed directly and indirectly in the form of cold or compressed air.

5. Pastile-Marmalade-Marshmallow Production

Technological scheme of “Orange and Lemon Slices” marmalade, “Three-Layered” agar-based jellied marmalade, “Baltic” agar-based marmalade and “Pat” fruit marmalade includes the following operations:

- preparing fruit and berry pureed mixture with sugar and syrup;
- boiling this mixture out;
- preparing marmalade mass;
- shaping and jellying of marmalade mass;
- drying of marmalade;
- refrigerating;
- packing of finished products.

Domestic manufacturers produce a set of equipment for marmalade shaping. Small and medium enterprises apply pouring machines. If glazing machine is optionally installed in the processing flow line, chocolate dipped marmalade could be produced.

“Orange and Lemon Slices” marmalade is produced at aided lines.

Packaging in boxes or packaging in corrugated cardboard boxes of the goods sold by weight are mostly manual operations.

The equipment for marshmallow and pastille paste production includes a depositing (forming) machine.

Main energy consumers: hot water at the stage of raw materials preparation, maintenance of the processes temperatures, electricity is consumed directly and indirectly in the form of cold or compressed air.

6. Dragee Production

Dragees are small-sized oval-shaped sugar- or chocolate-coated confectionery products.

Operations:

- preparing powdered sugar;
- forming of centres;
- preparing syrup for wetting;
- drageeing;
- polishing;
- prepacking and packing.

The equipment for sugar sieving, crushing, forming of centres and preparing of syrup for wetting are main consumers of electricity.

Drageeing machines – boilers – are used in drageeing process.

Main electricity consumers: insignificant consumption of hot water at the stage of raw materials preparation, significant consumption of low-temperature cold in the form of air and Freon, electricity is consumed directly and indirectly in the form of cold or compressed air.

7. Halva Production

Halva is confectionery mass that falls to the group of oriental sweets and is prepared by mixing caramel and protein pastes. Depending on oil kernel type, halva may be made of sunflower, sesame, peanut, nut or may be combined.

The following flavouring agents could be added to halva paste as per formula: nuts, raisings, inflated cereals, vanillin, cocoa powder, etc. Halva is characterized by high calorific value – over 500 kcal per 100 g, it contains up to 35% of sugar, up to 35% of vegetable fat and 15-20% of protein. Consumption of relevant raw materials (primarily from external suppliers).

The entire halva production could be divided into two independent technological processes:

1) sorting, hulling and scouring of oilseeds with further processing them into tahini paste or sunflower protein paste;

2) preparing caramel mass beaten up with a froth former, further mixing with protein paste and sugar mass pulling. While preparing protein pastes, kernels may be separated from hulls by the dry separation method or by the method of dehulling in saline solution. Upon mixing, halva paste is packed up and cooled down.

Halva for retailing by weight is packed in cardboard boxes, as a rule, from 0.5 to 12.0 kg. Sunflower halva output in Ukraine is the highest as compared to other types of halva.

The process of making sunflower halva:

- cleaning to remove impurities;
- hulling;
- thermal treatment;
- refrigerating;
- grinding;
- tempering;
- preparing syrup;
- preparing sugar powder;
- cooking caramel paste;
- beating up caramel paste with soap root extract;
- mixing;
- forming;
- packing.

The initial stage (if available in the production process) is similar to the technological stages of cocoa beans treatment, the last stage is similar to toffee mass preparation, somewhat differing in terms of formulas.

8. Flour-based Confectionery Products

Flour-based confectionery products account for 55% of the total output of confectionery products.

Depending on raw materials, formula and production method, flour confectionery products are grouped as follows: biscuits, crackers, dry biscuits, butter biscuits, gingerbreads, waffles, pastry, cakes, raisin cakes, rolls, rum baba.

Sugar biscuits are formed in rotation machines.

The dough upon rolling is fed to a stamping machine. The stamping mechanism consists of matrices in the form of a cup with sharpened edges with the puncheon moving inside. The puncheon is engraved and contains pins to pierce dough pieces. Upon start, the stamping mechanism for some time runs together with the dough sheet in horizontal direction, then it lifts up and returns to the initial position and the cycle repeats again. While forming, the matrix cuts the dough pieces and the puncheon contacting with the dough sheet patterns the dough and the pins pierce the dough pieces. Piercing facilitates water evaporation from the dough piece and prevents fluffing on the surface of a baked product. Recently, short dough cookies are formed with the rotary forming method, which means cutting of the dough pieces from the rolled dough sheet by the rotating rotor with matrices fixed on the latter.

The formed pieces go to the baking stage. At this period, water removal processes take place. Under the impact of high temperature, heat and moisture in the dough pieces transfer. First, the dough is warmed and moisture is evaporated from the surface layers and a certain portion of moisture migrates from the surface layers to the central layers, then the time comes when the moisture migrates back from the internal to the external layers.

At the end of baking stage, the temperature of the surface layer reaches 180°C, and that of central layers is between 106°C and 108°C. Once the temperature reaches 50-70°C, proteins in the dough piece are denaturized, which process is accompanied with the discharge of water that was previously absorbed during swelling. Starch intensively absorbs water at these temperatures, swells and partially transforms into starch adhesive. Under the impact of temperature, chemical disintegrators decay and form gaseous products so the pieces expand. Vapour generation also facilitates dough leavening. The impact of high temperatures causes the whole range of chemical changes in the dough: a part of starch hydrolyzes with generation of soluble starch and dextrin, sugars decompose (caramelizing); besides that, sugars interact with nitrogen-containing substances forming the compounds characterized by a distinctive aroma and colour.

The mode of baking is preset for each type of dough based on dough specifics and optimum conditions for baking process. The baking period depends on moisture content in the dough, oven temperature and other factors and makes up 4-5 minutes for sugar cookies, short dough cookies and crackers, 3-10 minutes for butter biscuits, 7-15 minutes for hard biscuits.

Cookies are baked in ovens of various designs. The most commonplace are ovens with gas or electric heating and a baking plate in the form of feeding belt or chain conveyor.

The cookies at the oven outlet have high temperature (118-120°C), at which the products can't be removed from the baking plate without damaging their forms. That is why the products are first cooled down to the temperature 65-70°C, at which they gain hardness and could be removed from the plate, then they are cooled down to 30-35°C on cooling conveyors embodied in wooden or metallic boxes. The cooling period depends on air temperature and speed: at high temperatures the process continues and moisture losses increase; low temperatures result in cracking of product surfaces. The optimum mode is the air temperature 20-25°C and the air speed 3-4 m/sec. The cooled cookies get the packaging section.

Some sorts of cookies are decorated prior to packaging: they are glazed with chocolate glazing, interlaid with filler, dusted with refined almond, powdered sugar and sand sugar. As a result, appearance and flavour of the products are improved.

Cookies, hard bread and crackers are prepacked in packs, butter biscuits are prepacked in cardboard boxes. Special machines are applied for prepacking of cookies in packs and for depositing of the packs in boxes. Biscuits are prepacked in boxes manually.

Cookies, crackers and hard cookies should be stored in dry, ventilated, pest-free warehouses at the temperature under 18ºC and relative air moisture 70-75%.

Quality of finished products is regulated by relevant standards by organoleptic (taste, smell, colour, shape, etc.), physical and chemical (sugar, fat, moisture content, alkalinity, etc.) parameters.

Shares of thermal energy expenditure and electricity consumption broken down by the list of products manufactured by the individual enterprise are presented in picture 2 and picture 3, respectively, and in table 2.

Table 2

Model balance of electricity consumption at the enterprise

Products	Volume, t	q, Mcal/t	w, kW·hour/t	Q, Gcal	Q, %	W, kW·hour	W, %
1. Cocoa	3669	761,091	602,01	2792,44	22,1	2208775	12,9
2. Chocolate and similar products with/without filler	13609	230,348	617,252	3134,81	24,8	8400182	49,1
3. Chocolate sweets	1779	297,019	1100,916	528,397	4,2	1958530	11,5
4. Other chocolate products	224	204,637	1288,036	45,8387	0,4	288520	1,7
5. Confectionery products of sugar or its substitutes, containing cocoa	1073	579,771	1328,543	622,094	4,9	1425527	8,3
6. White chocolate	401	3252	809,669	1304,05	10,3	324677	1,9
7. Dragee	1492	202,399	670,265	301,979	2,4	1000035	5,9
8. Coffee substitutes, extracts, essences and concentrated coffee	3256	1198,51	456,007	3902,34	30,9	1484759	8,7

Total	25503			12631,9	100,0	17091005	100,0

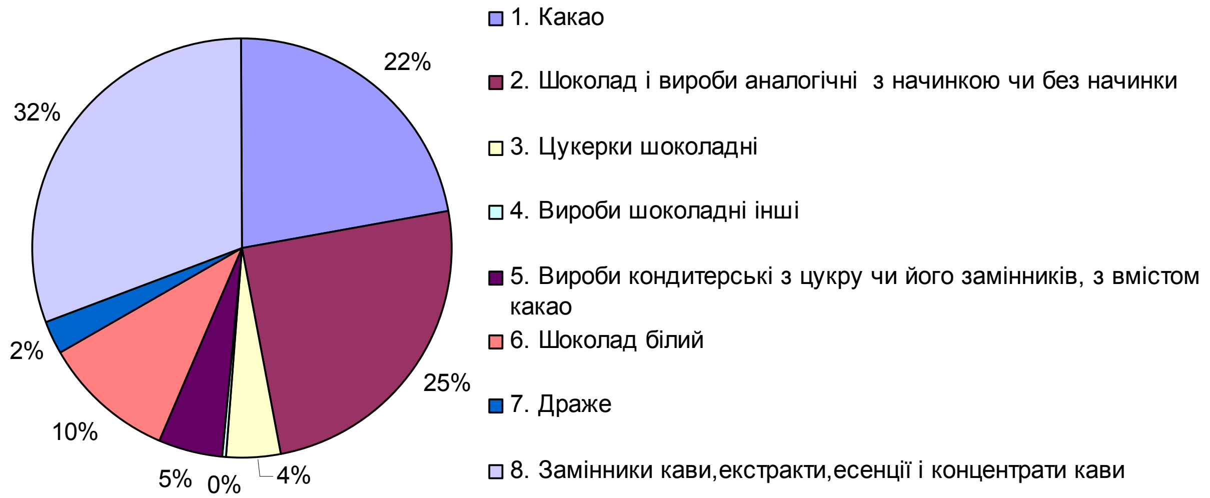

Diagram 4 – Breakdown of thermal energy consumption for the production

Diagram 5 - Breakdown of electricity consumption for the production

It is to be noted that the above enterprise does not produce cookies, but roasts cocoa beans.

Therefore, the major volume of thermal energy could be saved during the production of cocoa raw material and chocolate bars and prepacked products containing concentrated coffee, so the production itself should be the first subject to benchmarking.

The situation is almost the same in terms of electricity however the shares somewhat differ.

Specifics of the production in terms of energy consumption:

1) **insignificant seasonality of operations** – within a year product output increases prior to holidays, the increase accounts for 20-40% of the average output;

2) **high heat and electricity demand** that relatively low fluctuates during a day or season, insignificant fluctuations in summer and winter periods by heat and cold;

3) **various heat carriers** available in the factory's heat supply scheme as well as large volumes of low-temperature heat (30-60°C);

4) **bacteriological danger** within the area of raw cocoa beans warehousing (salmonella bacillus);

5) **large volumes of secondary energy sources** (spent vapour, condensates, hot gases with different parameters) that could be used;

6) **opportunity to use secondary resources** – husk upon roasting could be used as fuel.

ANALYSIS FINDINGS

The data on specific consumption of heat and electricity for production in 2011 have been collected from 4 enterprises. The data collection took place by the method of phone polling.

The analysis findings are presented in table 3

Table 3

Enterprise code *	Output in 2011, tons	Unit energy consumption	
		heat, kg oil equivalent/t	electricity, kW-hour/t
Confectionery-1	25503	68,794	611,938
Confectionery-2	27656	122,808	367,445
Confectionery-3	37740	79,812	163,114
Confectionery-4	2100	172,056	291,800

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

Benchmarking curves have been built on the basis of the obtained information using the proved technique [2] (Diagrams 6,7).

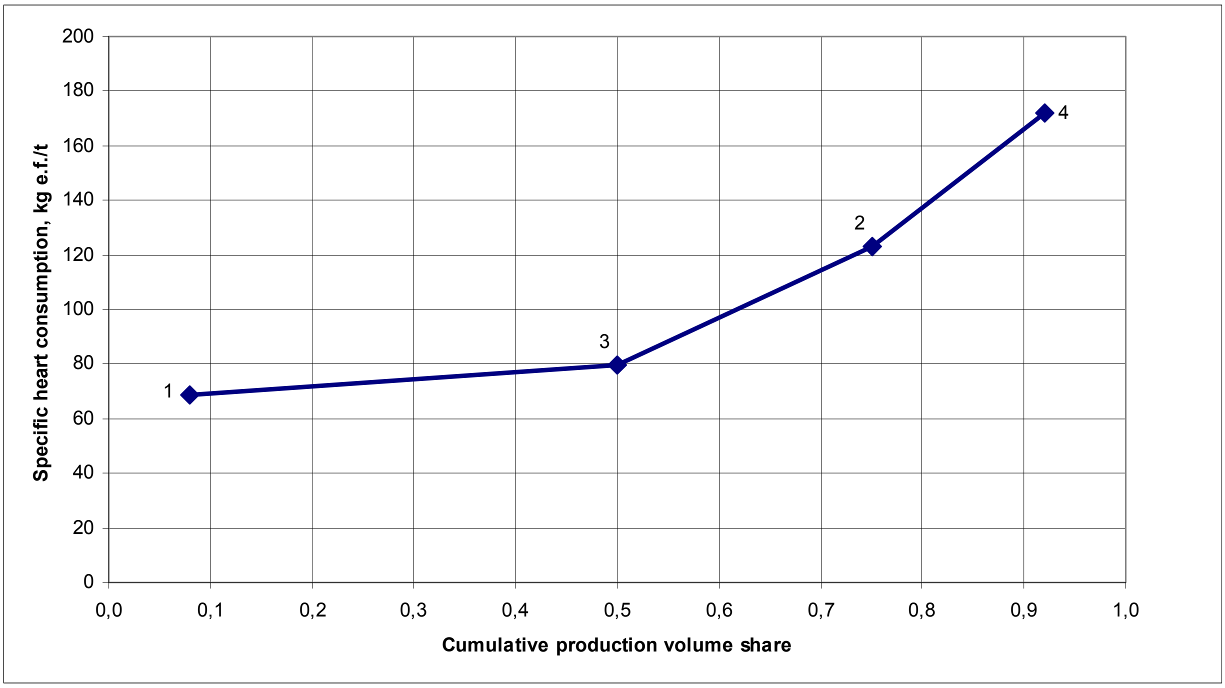

Diagram 6. Benchmarking curve of specific heat consumption in the form of oil equivalent by the confectioneries.

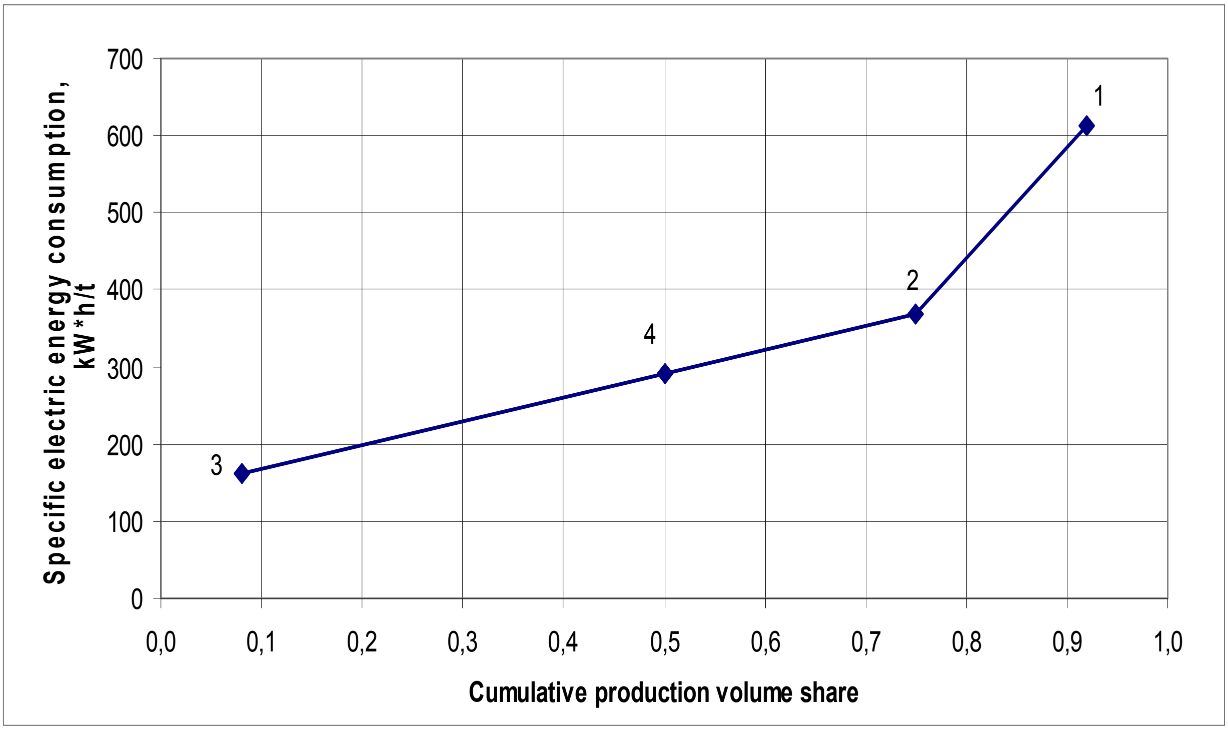

Diagram 7. Benchmarking curve of specific electricity consumption by the confectioneries.

The curves are used to identify enterprises' efficiencies.

By heat consumption:
The most efficient enterprise – 68.794 kg of oil equivalent/t
The least efficient enterprise – 172.056 kg of oil equivalent/t

BAT = 68.794 kg of oil equivalent/t
BPT = 68.794 kg of oil equivalent/t

By electricity consumption:
The most efficient enterprise – 163.114 kW-hour/t
The least efficient enterprise – 611.938 kW-hour/t

BAT = 163.114 kW-hour/t
BPT = 163.114 kW-hour/t

CONCLUSIONS

1. Specific energy consumption by confectionery enterprises varies in the range:
   - fuel: from 68.794 to 172.056 kg of oil equivalent/t;
   - electricity: from 163.114 kW-hour/t to 611.938 kW-hour/t.

   This difference is due to, firstly, different range of products manufactured by the enterprises and ingredients for them, secondly, the equipment differing by energy consumption levels.
2. The average specific heat consumption in the industry, according to statistic data, makes up 91.661 kg of oil equivalent per ton for confectionery. 2 enterprises out of the selected enterprises are more effective than the average level in the industry - 91.661 kg of oil equivalent per ton.
3. The average specific electricity consumption in the industry, according to statistic data, makes up 349.863 kW-hour/t for confectionery products. 2 enterprises out of the selected enterprises are more effective than the average level in the industry - 349.863 kW-hour/t.

SOURCES

1. Website of the Confectionery, Food-Concentrates and Starch-Syrup Industry Association of Ukraine - http://ukrkondprom.com.ua/statistika/

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