Demonstration of Energy Efficiency in Russian Dairies

Final Report

August 2002

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Content

Dansk resumé

Med støtte fra DANCEE har Dansk Energi Analyes A/S og RDIEE, Russian-Danish Institute of Energy Efficiency, gennemført projektet "Demonstration of Energy Efficiency in Russian Dairies". Projektet omfatter energianalyse af et mejeri med efterfølgende gennemførelse af væsentlige besparelsesmuligheder. Projektet omfatter endvidere vidensspredning til den russiske mejerisektor. Projektet er en opfølgning på parternes tidligere projekt "Energy Efficiency in the Russian Dairy Sector".

Indledningsvis blev Tsaritsino mejeri i Moskva udvalgt til projektet, idet dette mejeri havde en stabil produktion og ledelsen var interesseret i at gennemføre energibesparelser. Mejeriet brugte i 1998 16,9 GWh el, 11 mio. m^3 naturgas og 1,1 mio. m^3 vand.

Der blev gennemført energisyn, som afdækkede betydelige muligheder for rentable besparelser. I alt pegedes på besparelser svarende til 23% af naturgasforbruget, 10% af elforbruget og 23% af vandforbruget. Energisynet blev senere fulgt op af supplerende undersøgelser af kedelcentralen, CIP-anlæg og juice pasteuriseringsudstyret. Disse undersøgelser pegede på behovet for at forbedre styringen af kedelfødevand samt udbedre damp- og kondensatsystemet, ligesom der var behov for at installere en dampmåler til automatisk styring af dampforbruget.

I perioden 1999-2001 er der gennemført besparelser med en investering på godt 750.000 kr. Den første del af disse besparelser er finansieret af Tsaritsino mejeri og omfatter dampventiler, kedeltemperaturstyringer, varmevekslere m.m. vedrørende kedlerne og damp- samt kondensatsystemet. Den anden del, finansieret af DANCEE, omfatter nye frekvensregulerede pumper i isvandssystemet, en frekvensreguleret kedelfødevandspumpe samt vandudladere og dampmåler m.m.

De forventede energibesparelser er blevet opnået. De er på 16% af naturgasforbruget, 7% af elforbruget og 15% af vandforbruget.

Som en væsentlig del af projektet er der gennemført en række informationsaktiviteter. De har omfattet en energikonference i 1999, en energidag i 2001, kursus i energiledelse, to brochurer, tre artikler i russiske fagtidsskrifter samt fire rapporter.

Projektet er med hensyn til indhold blevet gennemført efter den godkendte projektplan. Dog viste det sig for ambitiøst at ville indføre planlagt eller tilstandsbaseret vedligehold i mejeriet. Med hensyn til tid har projektet løbet omkring dobbelt så længe som de planlagte 21 måneder. Det skyldes bl.a. ændringer i mejeriets ejerforhold med deraf følgende genovervejelse af tidligere trufne beslutninger, og det skyldes, at der først efter flere måneders ihærdig indsats fra RDIEEE opnåedes den nødvendige fritagelse for told på det importerede energieffektiviseringsudstyr.

Projektet har en direkte indflydelse på forholdene i Rusland gennem de opnåede energi- og vandbesparelser, og mere indirekte gennem videnspredningen til andre industrivirksomheder. Projektet har endvidere med en RDIEE-indsats på 6 mandår medvirket kraftigt til kompetenceopbygning i dette institut.

Projektet har påvist, at der er store besparelsesmuligheder med god økonomi i russiske industrivirksomheder, og det har demonstreret, at det er forholdsvis enkelt at realisere de tekniske besparelser. Der er yderligere besparelsesmuligheder via energiledelse. Russerne viser stor interesse herfor, men det er nødvendigt at understøtte interessen gennem en betydlig informationsindsats med kurser m.m.

Part I.

Summary of project activities and experiences

1. Introduction

In 1997-98, Dansk Energi Analyse A/S (DEA) together with the Russian-Danish Institute for Energy Efficiency (RDIEE), carried out the project "Energy Efficiency in the Russian Dairy Sector".

The project included energy audits in 12 dairies. Through the audits, possibilities for significant energy savings with quite short payback time were identified.

The present project has been proposed as a follow-up on the previous project with the aim to demonstrate the possibilities for improving the energy efficiency in the dairy sector by implementing profitable energy saving possibilities in a typical dairy, that could serve as demonstration plant for other dairies. The project received support from DANCEE in December 1998 and was carried out in January 1999 to May 2002.

2. Project activities

2.1 The appointed dairy

The first activity in the project was to appoint a dairy, well suited for the project. Tsaritsino Dairy in Moscow was selected. It is constructed in 1975 with Alfa Laval as the main constructor, and was in 1999 the second largest dairy in Moscow.

The average dairy production was in 1998 300 t of milk products and 200 t juice. There were 1.100 employees. The energy consumption was 16,9 GWh of electricity and 11 mio. m^3 of natural gas. The consumption of water was 1,1 mio. m^3 this year. The expenses for energy were 10,8 mio. roubles, and 12,8 mio. roubles for water. The sum of 23,6 mio. roubles was 30% of the total expenses this year.

The dairy management was very interested in the project, as it fitted well into the business plans for development of products and production facilities. Also, they welcomed visitors to the facilities.

2.2 Energy audit

Just after the appointment of the dairy, an energy audit was carried through. The audit is reported in appendix 3 in the report from the inception phase (Demonstration of Energy Efficiency in Russian Dairies". Rapport fra den indledende fase. Dansk Energi Analyse. Juli 1999).

In the audit, an overall energy saving potential of 23% of the heat energy (gas), 10% of the electricity consumption and 23% of the water consumption was identified. The payback period for most of the savings was around 1 year. An overview of the specific proposals is given in table 1 in the implementation report in appendix 1.

The audit was followed up in the main phase with supplementary investigations of energy efficiency possibilities concerning the boilers with fans and pumps, concerning the CIP system (Clean In Place) and concerning heat recovery on the juice pasteurizers.

Those supplementary investigations are described in chapter 1.2, 1.3 and 1.4 in part II of this report.

2.3 Implementation of energy savings

Based on the energy audit and the priorities of the dairy, an implementation plan for energy saving measures was negotiated.

To ensure a reasonable co-financing from the dairy in this project and – at the same time – to avoid problems with two companies as co-purchasers of each item, it was decided to split the investment programme in two stages. The first stage was fully financed by the dairy and the second stage was financed totally by the project (except for installation costs, which were paid by the dairy).

The first stage included improvements in the steam supply system including the condensate system. The equipment purchased was steam control valves and a temperature regulator for better control of the steam boilers, two heat exchangers for heat supply, condensate release valves to improve the condensate return etc. Totally, the dairy itself invested 34.000 USD in the first stage.

The second stage included improvements in the ice water system and in the boiler room. The ice water system was supplied with three new 55 kW pumps with frequency converters. In the boiler room, a feeding pump was equipped with a 30 kW frequency converter, and the deaerator system and the feeding water system of three boilers were improved with new control equipment. Further, a steam meter was installed to facilitate monitoring and control of the steam production and steam consumption. In total, equipment for around 58.000 USD were purchased in the second stage.

The equipment for the second stage were purchased in spring 2001 and installed in autumn 2001 and winter 2001/2.

The energy savings resulting from the project stages is estimated to be 16% of the natural gas consumption, 7% of electricity and 15% of the water consumption. Based on the year 2001 consumption of 12 mio. m^3 of natural gas, 23 GWh of electricity and 1,2 mio. m^3 of water, the estimated savings are 1,9 mio. m^3 of natural gas, 1,6 GWh of electricity and 180.000 m^3 of water.

2.4 Information and awareness activities

The information and awareness activities have included an Energy Conference and an Energy Day, pamphlets, articles, reports and an energy management course.

In April 1999 during the inception phase, an Energy Conference was held in Moscow to inform about the demonstration project, its aims and foreseen impact on the Russian dairy sector. Furthermore the participants were informed about the previous projects concerning Russian dairies and project results. Participants from dairies, equipment suppliers and public institutions were invited to the conference. Approximately half of the 12 participants were from dairies and the other half were from equipment suppliers. Even though the number of participants was limited, the conference had many fruitful discussions, and some participants doubted that much could be done at the demonstration dairy considering the limited financing for implementation of new equipment.

In December 2001 a large scale Energy Day was held at Tsaritsino dairy to inform about project results, lessons learned and to demonstrate the implemented energy efficient technologies. Furthermore an introduction to energy auditing and Energy Management was given. The Energy Day was attended by 32 participants (see the program and a list of participants as annex 1). Most of the participants were from other dairies. Furthermore equipment suppliers and public institutions were present. There was an extensive interest for the project between the participants and many good questions, ideas and discussions were brought up. A compendium containing the project results had been elaborated and was handed out for the participants along with other kinds of information material. A week later one of the participants approached the project team in order to have a similar energy efficiency project performed at a dairy in the Belgorod region. The dairy is a part of the Ingeokom dairy group that have two dairies and other agriculture companies. The project team (paid by itself) had a meeting in Moscow with Ingeokom to investigate the possibilities to perform the project based on private financial sources, as possibilities for Danish financing were considered low. Contacts have been taken to the IØ Foundation (Denmark) and NEFCO (Finland) but unfortunately it has not yet been possible to establish the necessary financial foundation for the project.

The following two pamphlets has been elaborated in the project:

- a 31 page pamphlet summing up the results from the previous project with energy audits in 12 dairies. Printed and used at the Energy Conference, but also distributed widely. (1999 – in Russian).
- a 4 page pamphlet with a short description of the demonstration project (2002 – Russian and English version) (see annex 2).

Three articles have been written for Russian magazines:

- an article on energy consumption and energy saving measures in Russian dairies. Printed in Moloshia (Dairy Industry), nr. 12, 2000
- an article on energy savings and energy management in ASEM 2001, the magazine of Russian Energy Managers Association
- an article on the project results. Is expected to be published in Moloshia in 2002.

Four reports have been elaborated:

- Energy Audit Report, 1999 (Russian and English version)
- Implementation Report, January 2002 (Russian and English version)
- Rapport fra den indledende fase, juli 1999. (Inception phase report including the energy audit. In Danish/English)
- Final report, August 2002. (In English)

The energy management course was arranged in September 2000. The "Danish model" of energy management was introduced during two comprehensive days for 13 technical managers and energy managers from the dairy sector. They showed a significant interest in the subject.

3. Project experiences

3.1 Carrying through the project

Concerning the content of the project, it has been carried out according to the plans in the project proposal. This includes the energy audit, the implementation of energy saving measures and the dissemination activities. One exception is that we were not able to implement a plan for scheduled maintenance at the dairy – and thinking of the very big organisational and cultural impact from such a change, this also looks too optimistic today. An other, minor exception is that we only had one meeting in the Advisory Committee, as we did not found it necessary to consult the committee during the implementation stage.

Concerning the time schedule, the project has run for 3 years and 8 months (January 1999 – August 2002) in stead of the planned 1 year and 9 months. The deviation is mainly caused by changes in the ownership of Tsaritsino Dairy, which in 2000 became a part of the larger dairy company Wimm-Bill-Dann. Because of the involvement of the new management in the decision procedure, the project was delayed with around 6 months. Other delays were caused by the custom handling of the equipment, purchased in Western Europe, - it took quite long time to arrange the necessary documentation for exempt of duty – and by the interim pause between the inception phase and the main phase.

3.2 Influence on the host country

The most direct influence from the project is on the energy and water consumption of Tsaritsino Dairy. The savings from the two project stages will – based on the year 2001 consumptions – reduce the energy related emissions with around 5.500 t CO_2 and 4 t SO_x per year and the water consumption with 180.000 m^3 per year.

A further saving in energy and water consumption will be through the influence from the project on other industrial companies and specially dairies. It is not possible to quantify the influence from the rather comprehensive dissemination activities.

The project has also contributed to the survival of RDIEE. In the years of the project 1999-2001, the institute should turn around from granted activities to the free market. In this transfer period, the 6 man-years spend by the institute in the present project have been of great importance, both to the leaning process and the economic situation.

3.3 General experiences

The project and the previous project demonstrate that there is a big and profitable potential for energy and water savings in the Russian dairy sector. The potential may be realised through improvements of the equipment, as well as through changes in operation and monitoring of the dairies.

It is important to motivate the dairies for energy efficiency through demonstration projects and information activities, as the managers in general lacks information about the possibilities and are reluctant to the process of implementing the saving measures.

It takes longer time to carry out energy saving projects in Russian than in Denmark because of the longer decision procedure. “Software activities” like energy management and energy conscious maintenance are quite new and unfamiliar to the technical staff, and introduction of such activities requires a strong support from western consultants.

Part II.

Tsaritsino Dairy.
Implementation Report

1. Summary

This report contains the results of implementation of the demonstration project carried out by Russian Danish Institute of Energy Efficiency (RDIEE) and Dansk Energi Analyse (DEA) in the framework of project “Demonstration of energy efficiency in Russian Dairies”.
The project objective was to increase energy efficiency at the project dairy and demonstrate energy efficient technologies at the dairy. The project is based on results from an energy audit performed at the dairy and additional investigations of the most energy intensive systems and equipment.
In the energy audit the consumption of energy resources and water for technological and auxiliary equipment, space heating systems and water supply systems was estimated. Furthermore proposals for increased energy efficiency were elaborated. The energy saving proposals are shown in table 1.

Proposals	Heat saving [MWh/year]	Water & condensate saving [m^3/year]	Electricity saving [MWh/year]	Payback period [year]
Returning of condensate from space heating and ventilation systems	2.400	35.000	-	0,8
Installation of hot-wells for condensate in the system of condensate returning	1.100	6.500	-	1,6
Automatic regulation of space heating system	1.200	-	-	1,7
Replacement of electric motors of circulating pumps		-	30	-
Returning of condensate from pasteurisers into the boiler	140	1.400	-	-
Using of condensate from pasteurisers with mixing heat exchanger	350	4.500	-	0,5
Installation of hot-wells for condensate at the tube-type pasteurisers.	1.100	1.500	-	0,2
Returning of condensate from juice production	98	3.000	-	-
Elimination of leakages in chambers	-	-	150	1,7
Replacement of electric motors of pumps for ice water and salt water	-	-	200	0,8
Automatic operation of pumps for ice and salt water	-	-	800	2,8
Automatic operation of circulating pumps	-	-	240	1,5
Replacement of electricmotors of ventilation units	-	-	150	1,2
Automatic regulation of thermal protection	700	-	30	1,1
Reconstruction of ventilation systems	7.000		-	4,0
Utilization of heat from hot water	9.000	-	-	0,5
Application of tips for hoses	700	20.000	-	0,1
Total	23.788	62.540	1.600	

Table 1. Identified energy and water saving measures.

The overall energy saving potential identified in the energy audit was:

- heat energy (gas) – 23%
- electricity – 10%
- water – 23 %

The energy audit was supplemented by additional investigations of some of the most energy intensive systems. The investigations were e.g.:

- Devices for easy starting of motors and frequency converters.
- Small cooling tower (shops of juice and air compressors)
- Operation regimes of large cooling water pumps
- Heat recovery in CIP systems
- Energy efficiency of boiler flue gas fans
- Steam boiler efficiency
- Heat recovery in general at the dairy
- Water recovery

During discussions concerning project implementation it was decided to divide the project into two stages. A first stage where energy saving measures, which didn't require additional investigations and had short payback time. The dairy purchased equipment for implementation of first stage measures immediately. Subsequently a second stage of the project that required additional investigations and was listed in the project implementation plan.

From the identified energy and water saving measures some of the most prosperous were selected for discussion.

- Modernization of the system for regulating of steam pressure (10/6/3 bar). Investment ~ 21.000 $.
- Installation of hot-wells and regulation wells (for the system of condensate returning). Investment ~ 20.000 $.
- Installation of equipment for automatic regulation (for the system of condensate returning). Investment ~ 6.000 $.
- Equipping of hoses with tips. Investment ~ 2-3.000 $.
- Water meters for registration. Investment ~ 10-12.000 $.
- Frequency converters for feeding water pumps and hot water pumps (equipment for boiler room). Investment ~ 10-20.000 $.

The total investment was estimated to app. ~ 71-84.000 $.

The result of the implemented energy and water saving measures are estimated to be:

Fuel (gas)	– 16 %
Power	– 7 %
Water	– 15 %

The estimated financial saving is more than 2,6 million roubles (around 90000 USD) based on year 2001 energy and water prices. The total investment costs has been app. 92.000 USD, so the average payback period is 1 year.

In table 2 the energy and water key figures are indicated.

Energy resources	Units	1998	2000	2001	2002 (hypotheti-cal)
Electricity	kWh/ton	96,5	111,5	106,0	95,5
Gas	Nm^3/ton	63,0	58,1	55,7	50,5
Water	M^3/ton	9,3	8,5	8,1	7,3

Table 2 Energy key figures for 1998, 2000 and 2001.

The production increase between 1998 and 2000 years is 3%. Due to additional equipment and an unchanged energy efficiency for electrical equipment power consumption increased. The specific heat consumption however was reduced due to the energy saving measures of the first stage.

In 2001 the volume of production increased by 30% compared to 2000. The specific energy consumption was reduced by 4%.

For year 2002 the specific energy consumption per ton of the production is foreseen to be app. 95,5 kWh/ton (power), 50,5 Nm^3/t (gas) and 7,3 m^3/ton (water) because of implementation of all saving measures and because energy efficiency will increase further due to increased equipment loading.

2. Implemented energy and water saving measures

In table 3 equipment purchased by Tsaritsino dairy without any financial support from Denmark are listed. In table 4 equipment which were financed by Denmark (DANCEE) are listed.

	Equipment	Firm	Quantity	Cost per item	Place of installation
1	Temperature Controller CAMCOH 1/2231 DN65	Samson	1	5.052 DM	Boiler room, boiler for hot water
2	Heat exchanger APV H17 W3252	APV	2	$ 2.698	Heat station
3	Hot-well TD32F DN15	Spirax-Sarco	15	$ 207,2	Techolog.equipmen t
4	Filter BS4504 DN25	Spirax-Sarco	2	$ 177,0	Boiler room
5	Valve DCV1 DN25	Spirax-Sarco	2	$ 117,4	Boiler room
6	Hot-well FT43-4,5 TV DN25	Spirax-Sarco	2	$ 490	Boiler room
7	Controller SX70	Spirax-Sarco	1	$ 1.058	Boiler room, steam pipe
8	Control Valve KE73 DN100 EL5641P	Spirax-Sarco	2	$ 4.980,3	Boiler room, the main steam pipe
9	Control Valve KE73 DN100 PN5433 PP5	Spirax-Sarco	1	$ 3.915,6	Heat station, steam pipe 6 bar from boiler room
10	Filter Regulator MPC2	Spirax-Sarco	1	$ 100,7	Heat station, regu-lator of pressure
11	Pneumatic Controller PN623	Spirax-Sarco	1	$ 1.974,7	Heat station, regu-lator of pressure
12	Cast Iron Strainer DN200 PN16	Spirax-Sarco	1	$ 2.627,5	Boiler room.
13	Cast Iron Strainer DN150 PN16	Spirax-Sarco	1	$ 1.582,6	Pressure regulator for heat station
14	Pressure Transducer 43-41-242	Spirax-Sarco	1	$ 216,2	Boiler room.

Table 3 Equipment financed completely by Tsaritsino dairy.

Furthermore following measures were realised at the first stage of the project:

- The system of condensate returning was reconstructed
- The reconstruction of heat station for space heating of dairies building was made.
- The equipment for automatic regulation the water temperature in hot water supply system was installed
- The tips were installed on the hoses of manual CIP system.
- Three decentralised chambers for freezing and cooling of products were installed

	Equipment	Firm	Quantity	Total Cost	Place for installation
1	Pump NK-100-200, Q=300 m^3/h, N=55 kW	Grundfos	3	29.256 DM	Ammonia compressor room, "ice water"-system
2	Frequency converter EC01 5500/3, N=55 kW	Siemens	3	12.423 EUR	Ammonia compressor room, "ice water"-system
3	Pressure converter 7MF 1563-3BG00, P=6 bar	Siemens	3	368,1 EUR	Ammonia compressor room, "ice water"-system
4	Frequency converter EC01 3000/3, N=30 kW	Siemens	1	2.505 EUR	Boiler room, feeding pump
5	Level controller LC2200	Spirax-Sarco	3	$ 1.410	Boiler room, feeding system of 1,2,3-d boilers
6	Capacitance Probe LP20	Spirax-Sarco	3	$ 1.251	
7	Pre-amplifier PA20	Spirax-Sarco	3	$ 918	
8	Control valve DN50 KE43 (K_v=16) Electric Actuator EL5631 and potentiometer	Spirax-Sarco	1	$ 2.195	Boiler room, feeding pipes of 1,2,3-d boilers
9	Control valve DN50 KE43 (K_v=25) Electric Actuator EL5631 and potentiometer	Spirax-Sarco	2	$ 4.390	
10	Feed Water Check valve DN50 DCV2/B,	Spirax-Sarco	3	$ 432	Boiler room, feeding system of boilers
11	Strainer Fig.33 DN80 with ss 100-mesh screen	Spirax-Sarco	1	$ 237	Boiler room, deaerator system of boilers
12	Control valveDN50 KE73 with Electric Actuator EL5621 and potentiometer EL5961	Spirax-Sarco	1	$ 1.634	Boiler room, deaerator system
13	Controller SX65-T-AN,	Spirax-Sarco	1	$ 448	Boiler room, deaerator system
14	Temperature sensor EL2270, L=125mm	Spirax-Sarco	1	$ 117	
15	Stainless steel pocket for EL2270	Spirax-Sarco	1	$ 49	
16	Steam meter DN250 GILFLO "B"	Spirax-Sarco	1	$ 10.584	Boiler room, the main steam pipe
17	Isolation valve F50C	Spirax-Sarco	2	$ 90	
18	Pressure transmitter 0-25 bar (4-20 mA output) with'U' syphon and isolating valve	Spirax-Sarco	1	$ 484	
19	Differential Pressure Transmitter M610	Spirax-Sarco	1	$ 1.458	
20	Flow Coputer Wall Mounted M241G, 220V	Spirax-Sarco	1	$ 1.894	Boiler room

Table 4. Equipment financed by DANCEE.

The following systems and equipment were reconstructed at the second stage of the project:

- The ice water systems No.1, 2/4 and 3 were reconstructed. Grundfos pumps with frequency and pressure converters were installed in each system instead several pumps, which were operating in parallel

- The feeding system of boilers was reconstructed. The regulators of level water in the boiler's drums and frequency converter of the feeding pump motor were installed
- Equipment for automatic regulation of the steam input into deaerator was installed
- The steam meter was installed on the main steam pipe

In 1998 the cost of electricity was 0,4 ruble/kWh, the cost of gas was 0,3654 ruble/Nm^3 and the cost of water was 7,07 ruble/m^3. Furthermore the cost for usage of sewerage system was 6,75 ruble/m^3. In 2001 the cost of electricity was 0,74 ruble/kWh, the cost of gas was 0,496 ruble/Nm^3, city water costs 10,2 ruble/m^3 and sewerage system cost is 10 ruble/m^3.

Therefore the cost of the energy resources increased in the period from the energy audit in 1998 till 2000 by 85% for electricity, 36% for gas and 44% for water.

In 1998 Tsaritsino dairy consumed the following amount of primary energy carriers:

- Electricity – 16.858 MWh
- Gas – 11.079 thousand Nm3
- Water – 1.058 thousand m3

The structure of heat consumption is given in figure 1.

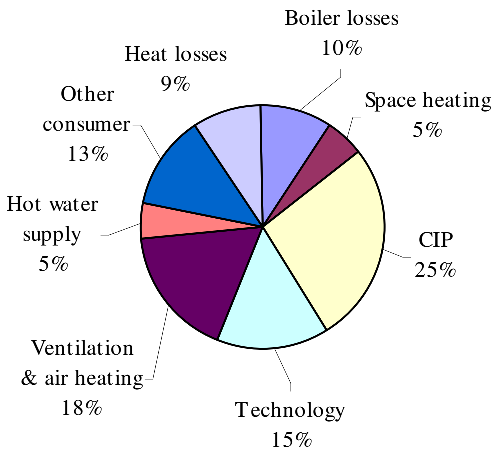

Figure 1 Structure of heat consumption in 1998

2.1 Heat savings

2.1.1 Reconstruction of the condensate system

The condensate system was restored at the factory during 1999. Before condensate was returned only from the heat exchangers for space heating in the laboratory and the hot water supply system located inside the boiler house. The condensate from heating system of production building, production lines and air heaters of heating system was discharged that resulted in losses both of heat and chemical treated water. At the present time the condensate of production building heating system is supplied in the hot well tank of boiler and is returned to boiler after passing the chemical treatment plant. The heat saving is estimated up to 3-4 %.

2.1.2 Installation of pressure actuator valves

At the first stage the dairy factory installed pressure regulators. Two regulators with parameters of 10/6 bar were installed at the main steam line, one regulator with parameters of 6/3 bar was installed at the pipeline of process steam in the room of heating station of production building. It allowed avoiding steam losses, which were estimated as 1-2% from the general heat output.

2.1.3 Installation of plate heat exchangers in the heating system of production building

Recently steam was used for heating the production buildings and the condensate was discharged to canalization. The heating distribution central was reconstructed in 1999 during the first stage of the project by means of dairy factory funds. The old shell-and-tube heat exchangers were substituted by two plate heat exchangers of company APV with power 0,7 MW each. One of them is operating; the second one is in reserve. The heat source is now condensate from steam supplied equipment that is cooled further before returning to the boiler house as boiler feed water. The heat saving is estimated up to 10% from the heat consumption by heating system or app. 1-2% of the total heat consumption.

Equipment	Firm	Quantity
Heat exchanger APV H17 W3252	APV	2

Table 5 Heat exchangers.

2.1.4 Automatic control of water temperature in the hot water supply system.

Automatic control of water temperature in the hot water supply system was carried out in the first stage of project. The equipment was installed by means of dairy factory funds.

Equipment	Firm	Quantity
Controller SX70	Spirax – Sarco	1
Control Valve KE73 DN100 EL5641P (10/6 bar)	Spirax – Sarco	2
Control Valve KE73 DN100 PN5433 PP5 (6/3 bar)	Spirax – Sarco	1
Filter Regulator MPC2	Spirax – Sarco	1
Pneumatic Controller PN623	Spirax – Sarco	1
Cast Iron Strainer DN200 PN16	Spirax – Sarco	1
Cast Iron Strainer DN150 PN16	Spirax – Sarco	1
Pressure Transducer 43-41-242	Spirax – Sarco	1

Table 6 Equipment for the hot water supply system.

The increase of hot water temperature by 1°C compared to normal increases the heat consumption by 2%. Thus, the automatic control of water temperature allows to save on the average up to 10% of heat consumed by the hot water supply system. The energy saving is app. 0,5% of the total heat consumption. A new system of hot water supply is currently being mounted at the dairy factory. It will use condensate for the production equipment instead of live steam. The heat consumption structure for year 2000 is shown by figure 2.

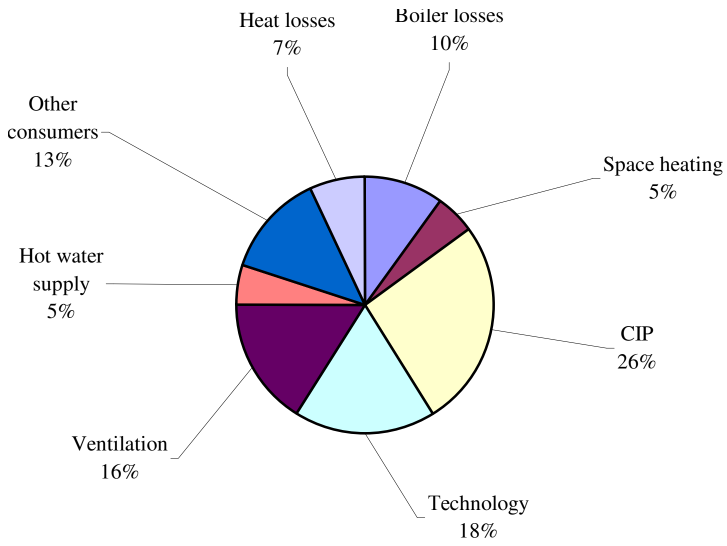

Figure 2 Structure of heat consumption in 2000.

Comparison of the two diagrams shows the changes in the energy consumption structure - heat consumption for production has increased and heat consumption for ventilation and heating and losses in pipelines have decreased.

2.2 Supplementary investigations

DEA and RDIEE carried out the additional examination of boilers and draught equipment as well as the system of washing the production equipment and the equipment for sterilization of juices for the deeper investigation of operation of the energy-consuming systems.

2.2.1 Energy efficiency of the boilers.

The boiler station is equipped with two boilers DKVR – 20/13 and one boiler DKVR – 10/13, their capacity is 20 and 10 ton/h correspondingly. These boilers have been in operation for more than 25 years. The investigation was carried out on 7th and 10th of December. On 7th of December boilers No.1 and 2 were in operation. On 10th of December boilers No. 2 and 3 were in operation. Total capacity of boilers is estimated to be 20 ton/h on the average. The boilers were loaded on 50%-60% on the average, the load variation was up to 4 ton/h.

The efficiency of boiler No. 1 and No. 2 has been measured by a flue gas analyzer. When a flue gas analyzer is used the losses with the flue gasses are calculated from the composition of the flue gasses. So the efficiencies below should be lowered by approx. 2-3% to cover heat losses from boiler blow down and heat losses from boiler casings. Boiler casing is partially broken, that increases losses. The results from the measurements are shown in the table 7.

	Unit	Boiler No. 1		Boiler No.2		Boiler No.3
		Measurement 1	Measurement 2	Measurement 1	Measurement 2	Measurement 1
$T_{flue\ gasses}$	[C]	101,6	97,5	103,3	112,5	138,8
CO_2	[%]	10,3	7,0	7,8	8,0	7,4
λ	[-]	1,16	1,72	1,51	1,5	1,63
CO	[ppm]	0,0	0,0	6,0	0,0	0,0
O_2	[%]	2,7	11,3	7,1	7,0	8,1
Efficiency	[%]	96,4	92,7	95,3	94,9	92,9

Table 7. Boiler efficiency.

As it can be seen the boiler efficiency varies a lot when it is taken into consideration that the measurements where done within 30 minutes all together. From the measurements it can clearly be seen that the cause of the variations in efficiency is due to variations in the gas/air ratio. The gas is supplied into a boiler automatically depending on boiler capacity. The gas/air ratio is manually controlled by valves in the gas and air supply pipes. There are automatic regulation systems of the gas/air ratio but these systems are not in operation because they are broken down. Furthermore some of the mounted measuring equipment at the boilers are broken down and should be repaired to increase the possibilities for the operators to operate efficiently.

The capacity of the combustion air fans is regulated manually from time to time. This increases the uncertainties for the gas/air ratio so a correct gas/air ratio is hard to obtain. The systems for automatic regulation of the gas/air ratio should function at all times and be adjusted so the gas/air ratio is lowered. It should be possible to increase the boiler efficiency by at least 2% by these measures corresponding to 81.000 rubles annually.

2.2.2 Combustion air and flue gas fans and feed water pump

The boilers No. 1 and 2 are equipped with combustion air fans with 22 kW motors and flue gas fans have 40 kW motors. Boiler No. 3 is equipped with combustion air fan with a 11 kW motor and the flue gas has a 30 kW motor.

It was intended to do total measurements of the combustion air fans but it was only possible to measure the static pressure after the fans. This was due to very turbulent air flow in the ducts after the fans. Furthermore there were no holes for measurements before the fans but the ducts before the fans are short so the pressure drop before the fans is limited. The static pressure after the combustion fan for boiler No. 1 was measured to be approx. 230 Pa and the similar static for the other fan was measured to be approx. 190 Pa. The dynamic pressure for the fans can be estimated to be approx. 120 Pa and 190 Pa so the total pressure will be approx. 350 Pa and 380 Pa. The power consumption of the two fans was measured to be approx. 6 kW each.

On the first day we measured the operation parameters of motors of combustion air and flue gas fans at boiler No.1. The results are presented in the table 8.

Phase	V	kW	Cosφ	I (A)	Remarks
Combustion air fan at boiler No. = 22 kW.					
A	240	2	-	38,4	
B		2	-	39,5	
C		2	-	38,3	
Total		6			High installed capacity
Flue gas fan at boiler No.1 No. = 40 kW.					
A	240	8	-	52,2	
B		8,2	-	52,7	
C		8,2	-	52,7	
Total		24,4			Large boiler capacity

Table 8 Fan measurements.

On the second day of investigation (10th of December) we measured the operation characteristics of motors of combustion air and flue gas fans at boiler No.2 and 3. The results are presented in table 9.

Phase	V	kW	Cosφ	I (A)	Remarks
Combustion air fan at boiler No.2 No = 22 kW.					
A	240	2,6	0,48	23,3	
B		2,3	0,48	22,2	
C		2,6	0,51	21,5	
Total		7,1			Large installed capacity
Flue gas fan No. 2. No. = 22 kW					
A	240	4,4	0,47	38,2	
B		4,4	0,47	40,5	
C		4	0,46	38,5	
Total		12,8			Large installed capacity
Combustion air fan at boiler No.3. No = 11 kW					
A	240	3	0,7	18,1	
B		3	0,72	18	
C		3	0,71	18	
Total		9			
Flue gas fan No. 3. No = 30 kW.					
	240	5,5	0,65	34,8	
		5,4	0,65	34,3	
		5,4	0,65	34	
Total		16,3			Large installed capacity

Table 9 Fan measurements.

The analyses of results presented in the table 8 and 9 shows that the efficiency of the two combustion air fans have been calculated to be approx. 40% (boiler No. 1) and 50% (boiler No. 2) respectively. The fan efficiencies are low which properly is due to a combination of low efficiency of the fans itself and oversized motors (22 kW). Fans with above mentioned capacities normally have maximal efficiencies of approx. 72% incl. motor. But fans are expensive so it will properly not be feasible to replace the fans will new efficient fans.

It is recommended to replace the fans motors by motors of lower capacity with frequency converters.

As it can be seen from the table 9 flue gas fan of boiler No.3 is more efficient. The more accurate assessment of fans efficiency is impossible to do because of the lack of graphical characteristics .

Main parameters of motor of the feeding pump were measured. The pump has a capacity of 38 m^3/h and a 30 kW motor. Measured data is shown in the table 10.

Phase	V	kW	Cosφ	I (A)	Remarks
Feed water pump - 30 kW.					
A	-	7,9	-	-	
B		8,8	-	-	
C		8,8	-	-	
Total		25,5			

Table 10 Boiler feed water pump measurements.

It was not possible to estimate the efficiency of pump because there were no characteristics of the pump. The steam production of boilers decreases during summer period and the regulation valves on boiler lines closes, so the efficiency of the pump decreases. It was therefore recommended to install frequency converters for pump regulation instead of the throttle valves.

The results of supplementary investigations were discussed with the chief of boiler station and chief engineer of the energy department. Additionally some sites and equipment were found out where repair and replacement by new installations is necessary, e.g:

1) Fans and blowers at boiler No. 1 and 2 require reconstruction that includes:
   a) replacement of electric motors by smaller motors. ThIS will increase the efficiency of electric drives by 5-10%
   b) repair guide vanes of combustion air and flue gas fans.
   c) installation of systems for regulation of gas/air ratio depending on the gas pressure in burners
   d) installation of systems for regulation of flue gas fan capacity depending on under-pressure in boilers
   e) instead of the recommendations stated in items b), c) and d) it is possible to install frequency regulated drives and automatic control systems on combustion air and flue gas fans.

2) Boiler feeding system needs repair and reconstruction
   a) replacement of control valves, including gauges and actuating devices on supply pipelines of each boiler
   b) installation of a frequency converter for the feeding water pump together with an automatic control system of pump capacity. In this case item b) is not considered, because the automatic system of frequency regulation includes set of control valves.

3) Steam pipeline system of boilers to reduce steam leakage's

4) Deaeration system
   a) replacement of control valve of steam supply into deaerator head
   b) repair of deaerator, including replacement of internal elements of deaerator, installation of new valve on water supply line after filters

5) New chemical water treatment plant

6) Installation of new control valves on supply pipelines of clean water and condensate

7) Purchase of equipment for lowering iron content in condensate returned to the boiler station

8) Space heating system
   a) installation of control valve on boiler steam supply line to adjust supply temperature in the domestic heating system automatically

9) Continuous purging
   a) installation of new separator for continuous purging

In accordance with the results of the investigations following decisions were made:

Installation of automatic boiler feed water control system
Installation of complete equipment for automatic control of the water level in a boiler drum. The equipment was financed and purchased by Tsaritsino dairy and DEA.

Equipment	Firm	Quantity
Level controller LC2200	Spirax-Sarco	3
Capacitance Probe LP20	Spirax-Sarco	3
Pre-amplifier PA20	Spirax-Sarco	3
Control valve DN50 KE43 (K_v=16) Electric Actuator EL5631 and potentiometer	Spirax-Sarco	1
Control valve DN50 KE43 (K_v=25) Electric Actuator EL5631 and potentiometer	Spirax-Sarco	2
Feed Water Check valve DN50 DCV2/B,	Spirax-Sarco	3
Frequency converter EC01 3000/3, N=30 kW	Siemens	1

Table 11 Equipment for automatic feed water control system.

The automatic control of boiler-feed piping system will give the considerable saving of funds due to increasing the reliability of boiler units operation.

Installation of a control system for steam supply to the deaerator
Deaeration was absent in the boiler feed piping system for the long period, because both deaerators required repair. One of them was used as the intermediate tank, where water came after chemical treatment. The condensate that was returned to the boiler house was also subject to the chemical treatment and the heat potential of condensate was not used. The temperature of feed water didn't exceed 40^{o}C. It was decided to reconstruct the deaeration system and to install a steam regulator to supply the deaerator. The pure condensate is now supplied directly to the deaerator which saves up to 10% of heat produced by the boilers.

The complete of equipment for steam supply regulation, which was co-financed by the dairy and DEA, is given in table 12.

Equipment	Firm	Quantity
Strainer Fig.33 DN80 with ss 100-mesh screen	Spirax-Sarco	1
Control valveDN50 KE73 with Electric Actuator EL5621	Spirax-Sarco	1

and potentiometer EL5961		
Controller SX65-T-AN,	Spirax-Sarco	1
Temperature sensor EL2270, L=125mm	Spirax-Sarco	1
Stainless steel pocket for EL2270	Spirax-Sarco	1

Table 12 Equipment for automatic steam supply to the deareator.

Automatic control of steam consumption inside the dairy factory
A continuous steam consumption meter of company "Spirax-Sarco" was installed at the main steam pipeline with diameter 300 mm at the second stage of project. It was co-financed between the dairy and DEA. Steam registrations is send to the boiler station surveillance computer. The installed equipment is necessary for control of heat supply system.

The complete of equipment for steam supply measuring which was purchased is given in table 13.

Equipment	Firm	Quantity
Steam meter DN250 GILFLO "B"	Spirax-Sarco	1
Isolation valve F50C	Spirax-Sarco	2
Pressure transmitter 0-25 bar (4-20 mA output) with'U' syphon and isolating valve	Spirax-Sarco	1
Differential Pressure Transmitter M610	Spirax-Sarco	1
Flow Computer Wall Mounted M241G, 220V	Spirax-Sarco	1

Table 13 Equipment for automatic feed water control system.

Estimation of heat energy saving is made on results of investigation of heat supply system operating regimes and is given in the table below.

Measures	Heat energy saving in 2000		
	MWh	%	ruble
Regulation of feeding system including frequency converter and level controllers	Increasing of boiler's operating reliability, saving of electricity.		
Regulation of steam input into deaerator	10.000	10	1.000.000
Installation of steam meter	Calculation of quality and quantity of produced steam.		

Table 14 Equipment for automatic feed water control system.
Restoration of the deaerator allows to use maximum heat potential of the returned condensate and will increase reliability of boiler operation and supporting their optimal efficiency. Automatic control of the boiler feed water system avoids load pulsation's subsequently ejection of boiler water in the steam line and to optimize the regimes of boilers operation and avoid emergency situations.

On the whole the fulfilled measures allow to increase the quality of heat supply and heat consumption systems maintenance and optimizes the boiler operation. The additional heat saving is estimated as 10-11%. Thus, the expected increase of heat supply and heat consumption system efficiency constitutes 16% within the frameworks of given project. It will result in a reduction of gas consumption by about 1.700 thous.m^3 corresponding to about 850 thous. ruble.

2.3 Heat utilization of CIP system modules

The CIP process at the dairy is carried out in 6 steps. First the production equipment, tubes etc. are rinsed with cold water, which is discharged to the sewage. Next lye solution is pumped through the equipment in a closed loop and collected in a tank for reuse. The equipment, tubes etc. are then rinsed with hot water. An acid solution is pumped through the system and collected in a tank for reuse followed by a rinse with hot water. Finally the equipment, tubes etc. are sterilized with 95°C water, which is discharged to the sewage. The CIP process is illustrated in the figure below.

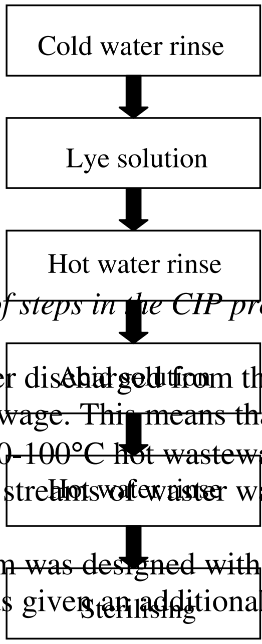

Figure 3 Illustration of steps in the CIP process.

All streams of wastewater discharged from the CIP system are mixed in a manifold before it is lead to the sewage. This means that the temperature of the wastewater varies between 30-60°C. The 90-100°C hot wastewater from the sterilizing process cannot be separated from the other streams of waster water with a lower temperature.

Originally the CIP system was designed with an extra tank for collecting water used for sterilizing. The water was given an additional heating and then reused. This tank was never implemented.

It is presumed that the total amount of mixed wastewater is equal to the amounts of water used for sterilizing; cold and hot rinse water during the CIP process. The amount of lye and acid solutions are not included in the heat recovery calculations.

Approximately 50 cycles of CIP is carried out per day. The average volume of equipment, tubes etc. cleaned by the central CIP system is 1,2 m^3 per system. The different steps in the CIP process demands various amounts of water. The hot water for rinsing is approximately 40°C. The average temperature of cold rinse water is approximately 8°C. The temperature and mass flow for the three types of water streams in the mixed wastewater is shown in the table below in table below.

Stream	Temperature [°C]	Mass flow per cycle [m^3]	Mass flow per day [m^3]
Cold water rinse	8	1×1,2	60
Hot water rinse	40	2×2,4	240
Water for sterilizing	95	1×1,2	60

Table 15 Temperature and mass flow for each type of water stream during the CIP process.

The total amount of mixed waste water is 360 m^3/day.The average temperature of the mixed waste water is calculated as a weighted average based on the mass flow of each stream to be $T_{average}$: 44°C.

2.3.1 Description of heat recovery system

During the visit at the dairy possible ways of heat recovery on the central CIP system was discussed between DEA, RDIEE and the technical staff from the dairy. It was decided to make a further investigation of a heat recovery system there the mixed waste water is collected in a open low level tank. From the tank the water could be pumped through a heat exchanger before it is lead to the drain. The tank is regulated with a overflow pipe. The heat recovery of the mixed waste water is used for production of preheated water. The system consists of a tank for preheated water. A thermal stratification of the water will occur in the tank resulting in a well defined top layer of hot water. Only minimal mixing between the hot and cold water in the tank will take place. The cold water from the bottom of the tank is circulated through the heat exchanger. Both pumps are controlled by the temperature in the tank to keep the temperature of the preheated water at 40°C. The pumps will start if the temperature in the tank is lower than e.g. 40°C and heat up the tank. Pump No.1 must be able to run without water in shorter periods.

The heat recovery system is shown below. All temperatures are estimated.

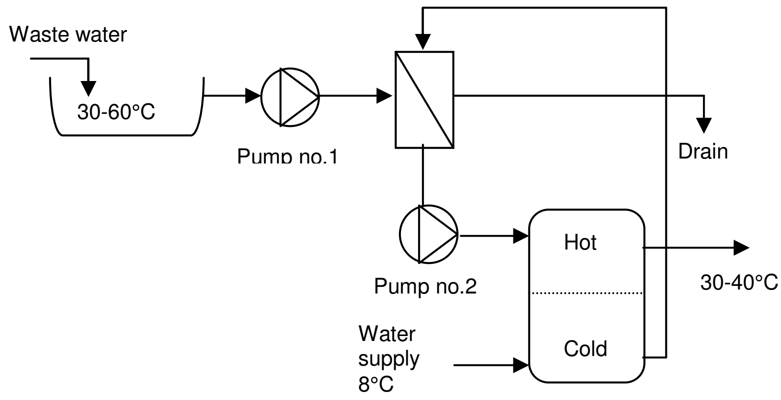

Figure 4 Illustration of the heat recovery system.

The preheated water could be lead to the CIP system instead of cold water, because in this way the existing CIP control system is not influenced. But the rinse water in the first step in the CIP process will then be ~40°C.

2.3.2 Calculation of amount of recovered heat

The amount of thermal energy in the mixed wastewater that can be recovered is depending of the efficiency of the heat recovery process. Typically a water/water heat exchanger will have an overall temperature difference of 5°C.

One proposal is to substitute the cold rinse water with preheated water and hereby carry out all rinsing with approximately 40°C water. The required amount of preheated water for rinsing and sterilizing will be 360 m^3/day, which is equal to the amount of mixed waste water.

Compared to the present CIP system the energy saved by using preheated water instead of cold water is equal to heating of 300 m^3/day from 8°C to 40°C. The amount of energy saved is approximately 40 GJ/day = 11 MWh/day ~800 rubles/day~300.000 rubles/year.

The pay back time for the investment in the heat recovery system will be less than 1 year.

2.4 Heat recovery on the juice pasteurizers

Three pasteurizer units are used for juice production and one unit is used for pasteurization of sugar syrup. All four pasteurizer units are multi-circuit units with re-circulation of the liquid. In the last stage of the process the juice in the pasteurizers is cooled by a cooling tower from approximately 50°C to 20°C.

The capacity of the pasteurizers for juice is 16 t/h and 8 t/h with 10% re-circulation. The 3 t/h unit has a capacity of 2,4 t/h with a re-circulation of 600 l/h. Temperature of the juice during the pasteurization process is 96-115°C depending of the type of juice. Temperature of the syrup during the pasteurization process is 85-90°C. The annual production of juice is 67.300 tonnes.

2.4.1 Efficiency of juice pasteurizers

According to the temperature of the juice during the pasteurizing process and the temperature of steam supply the efficiency of the three pasteurizers for juice are:

η= (87°C - 16°C)/(105°C - 16°C) × 100 % = 80%

This is a satisfying efficiency for the pasteurizers and further heat recovery is not needed.

2.4.2 Efficiency of sugar pasteurizer

According to the temperature of the sugar during the pasteurizing process and the temperature of steam supply the efficiency of the pasteurizer for sugar are:

η= (60°C - 35°C)/(90°C - 35°C) × 100 % = 45%

This is a low efficiency and the possibilities for further heat recovery should be investigated. One proposal is to increase the efficiency from 45% to 80% by increasing the heat exchanger area. To achieve an 80% efficiency the temperature of the re-circulated sugar most be raised from the present 60°C to 79°C.

3. Technical project decisions on electricity saving

The structure electricity consumption at dairy in 1998 is given in the figure 5.

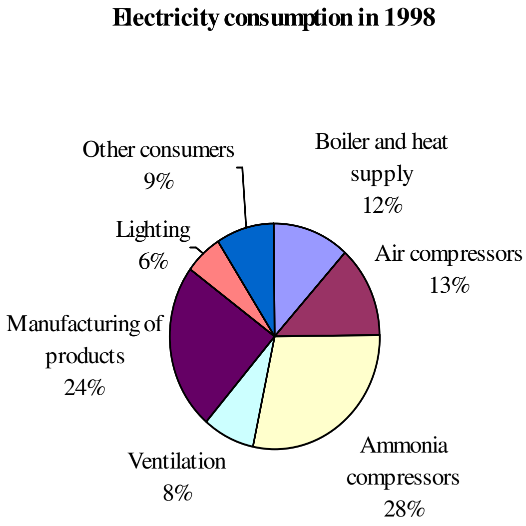

Figure 5 Structure electricity of consumption in 1998.

3.1 Electricity savings - first project stage

The ammonia compressor house with pumping cooling system is most energy consuming. It consumes almost one third of all electricity consumption of dairy factory. Ice water and brine are supplied to end users by 6 pumping systems.

Additional investigations of cooling systems were carried out at the second stage of demonstration project. The results of these investigations are presented below.

3.1.1 The pumps of cooling systems

All the changes were taken into account during supplementary investigation of pumps and compressor station. Some pumps have been replaced since the time of energy audit. Table with parameters of pumps and cooling systems is given below in the table 16.

Pump type	No.	**Capacity** m^3/h	Water pressure m	Installed capacity KW	**Pump capacity** kW
1 system - milk acceptance department, «iced water».					
4 K-12	2	90	32	17	10,8
4 K-12	1	90	32	30	10,8
KM 100-65-200	1	100	50	30	19
2 system – tanks cooling, «iced water».					
6 K-8	3	160	32	30	18,4
3 system – milk pasteurizing, «iced water».					
KM 80-50-200 (return)	1	50	50	15	11
KM 80-50-200 (return)	1	50	50	11	11
KM-100-65-200 (supply)	5	100	50	30	19
4 system – experimental building, «iced water».					
3K-6	2	45	32	30	10,5
5 system – cooling of large chamber, salted water					
KMM-125-100-160	3	160	30	30	No data
6 system – cooling of small chambers, salted water					
KM-80-65-160	2	50	32	7,5	No data
Return cooling system of compressor					
K 290/30	5	290	30	37	28,9
K 290/30A	2	250	24	22	21

Table 16 Equipment for automatic feed water control system.

Compressor parameters and cooling system for each of compressor are shown in the table 17.

	Compressor type, Working system	$P_{вс}/P_{н}$ [bar]	Cooling agent	Capacity [kW]	Cold production [kcal/h]
1	Screw type ammonia compressor				
	FMS 3/900, No.1 (1 sys.)	2,8/7,5	Ice water	132	344.800
	~ No.3 (1 sys.)	-	Ice water	160	344.800
	~ No.10 (3 sys.)	-	Ice water	160	344.800
	~ No.11 (3 sys.)	-	Ice water	160	344.800
	~ No.12 (3 sys.)	2,8/7,5	Ice water	132	344.800
	No.18 (2,4 sys.)	-	Ice water	132	344.800
2	Piston type ammonia compressor				
	АУУ-400, No.2 (1 sys.)	2,8/7,5	Ice water	160	400.000
	АУУ-400, No. 4 (1 sys.)	-	Ice water	160	400.000
	АУУ-400, No.7 (3 sys.)	2,8/7,5	Ice water	160	400.000
	АУУ-400, No.8 (3 sys.)	2,8/7,5	Ice water	160	400.000
	АУУ-400, No.9 (3 sys.)	-	Ice water	160	400.000
	АУ-200, No.5 (2,4 sys.)	2,8/7,5	Ice water	90	150.000
	АУ-200, No. 6 (5 sys.)	-	Salt water	90	150.000
	АУ-200, No.13 (2,4 sys.)	2,8/7,5	Ice water	90	150.000
	АУ-200, No.16 (5 sys.).	1,7/8,5	Salt water	75	200.000
	АВ-100, No.17. (6 sys.)	1,7/8,5	Salt water	55	100.000
3	Ammonia compressor units				
	21MKT280-7-13, No.14, 15	-	Salt water	132	280.000

Table 17 Equipment for automatic feed water control system.

Investigations of pump system operation were held twice: in the end of November and on December 7-8. Layouts of all systems were made. No. of pumps indicated on layouts correspond to the plant No.

In both cases the parameters of system operation were registered: temperature of inlet and outlet cooling agent (water, salted water and iced water), pressure indicated by manometers of pumps and operational parameters of pump motors (current, active power, cosφ). Data measured by PW during the second investigation is shown in the tables below.

3.1.2 Cooling tower system

This system is for cooling of condensers, compressor casing and oil system. The cooling tower system is equipped with seven pumps, -five pumps of type K290/30 (No.19, 20, 21, 23, 24) and two pumps of type K290/30A (pumps No. 18 and 22). As it can be seen the seven pumps are almost identically from type but as stated in the energy audit report K290/30 pumps have a capacity of 290 m^3/h / 3 bar and K290/30A pumps have a capacity of 250 m^3/h / 2,4 bar.

Parallel operation of pumps with different parameters of pressure is inadmissible. However the pumps were operating in parallel during the second investigation.

At the first inspection in November four pumps K290/30 were operating (No. 20, 21, 23 and 24). The power consumption of the four pumps were measured to be 22,6 kW, 17, 3 kW, 17, 6 kW and 18,3 kW respectively. When a diagram with pump characteristics is used it can be seen that all pumps were operating with minor or very low efficiency. This is because large pump capacity was used when the actual demand for cooling water was low. At the time of measuring one pump would have been enough.

The 8.th December the cooling tower system was inspected and measured again. This time pumps No. 20, 22 and 24 were in operation. Pumps No. 20 and 24 were operating with efficiencies of 70% and 78% respectively, which is high. But pump No. 22 had a very low (zero) efficiency because the pump was not able to produce enough pressure in order to contribute into the pump system so the pump was just "idling".

Parameters of motors operation are shown in table 18.

Phase	V	kW	Cosφ	I (A)	Remarks
Pump of circulating water No.20. No. = 37 kW.					
A	240	12,8	0,86	61,9	
B		12,9	0,81	63,3	
C		11,9	0,82	64,7	
Total		37,6			
Pump of circulating water No.22. No. = 22 kW.					
A	240	3,2	0,47	27,2	Low value of Cosφ
B		3,1	0,47	27,9	Load is below nominal
C		3,1	0,46	27	
Total		9,4			
Pump of circulating water No.24. No. = 37 kW					
A	240	10,5	0,8	55,7	
B		10,4	0,8	57,2	
C		10,8	0,8	54,8	
Total		31,7			

Table 18 Operation parameters for cooling tower pump motors.

Parameters of operating pumps are given in the table 19.

Pump type	No.	Capacity [m^3/h]	Water pressure [m]	Installed capacity [kW]	Consumed power [kW]
K 290/30	20	290	30	37	37,6
K 290/30A	22	250	24	22	9,4
K 290/30	24	290	30	37	31,7

Table 19 Operation parameters for cooling tower pumps.

From the two inspections can be concluded that there never should be more pumps operating than necessary. Pumps No. 18 and 22 can’t work in parallel with large pumps. They should be used when it is not necessary to operate any of the large pumps. Operators should be instructed about the operational modes of this system.

It is already suggested in the energy audit report to implement equipment for automatic regulation of the number of pumps put into operation. In this connection it is suggested that the pumps No. 18 and 22 only will be used as reserve for manual operation.

Parameters of cooling system are shown in the layout given in figure 6.

Cooling water system

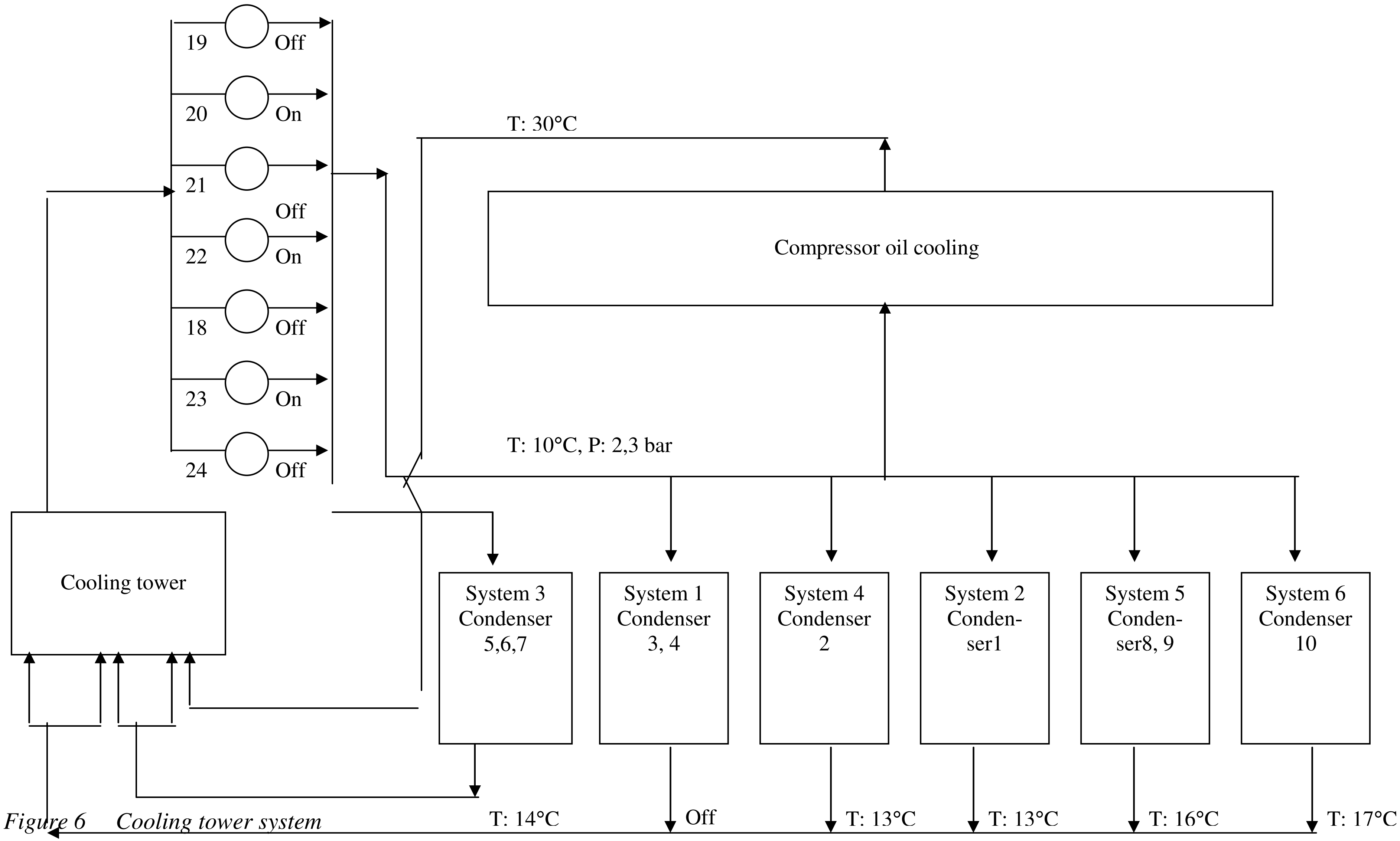

Figure 6 Cooling tower system

3.1.3 Salt water system

The salt water systems are used for cooling of large and small storage of experimental building. Pumps of these systems work all the time because the disconnection of these pumps leads to breakdown of both systems. During investigation pump No.43 was in operation in system No.5, pump No.60 was in operation in system No.6. Parameters of this system – temperature of cooling agent and pressure are shown in the schemes. Measured results of motors parameters are shown in table 20.

Phase	V	kW	Cosφ	I (A)	Remarks
Salt water pump No. 43, 30 kW					
A	239	6,6	0,8	34,5	
B		6,7	0,77	36,2	
C		6,4	0,78	35	
Total		19,7			
Salt water pump No. 60, 7,5 kW					
A	240	2,1	0,8	10,2	
B		2,4	0,86	9,6	
C		2,2	0,89	10,2	
Total		6,7			

Table 20 Operation parameters for salt water pump motors.

Parameters of pumps are shown in the table 21.

Pump type	No.	Capacity [m^3/h]	Water pressure [m]	Installed capacity [kW]	Consumed power [kW]
KMM125-100-160	43	160	30	30	19,6
KM 80-65-160	60	50	32	7,5	6,7

Table 21 Operation parameters for salt water pumps.

From the working conditions known from experience it is estimated that the efficiency of pump No. 43 is 60% and the efficiency of pump No. 60 is 65%. This efficiency is not good but acceptable. Nevertheless it is suggested to replace pump No. 43 with a more efficient pump for the actual working conditions. If a pump with an efficiency of e.g. 72% is used an annual energy saving of approx. 29.000 kWh can be obtained, corresponding to approx. 11.500 rubles.

Cooling system layouts are given in figure 7 and 8.

Salt water system 5 (cooling of large chamber)

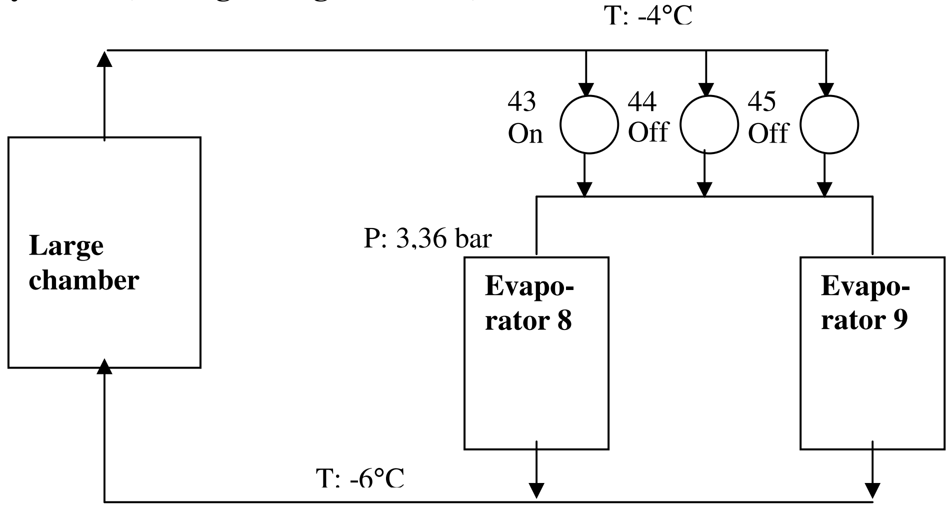

Figure 7. Cooling system for large chambers.

Salt water system 5 (cooling of small chambers)

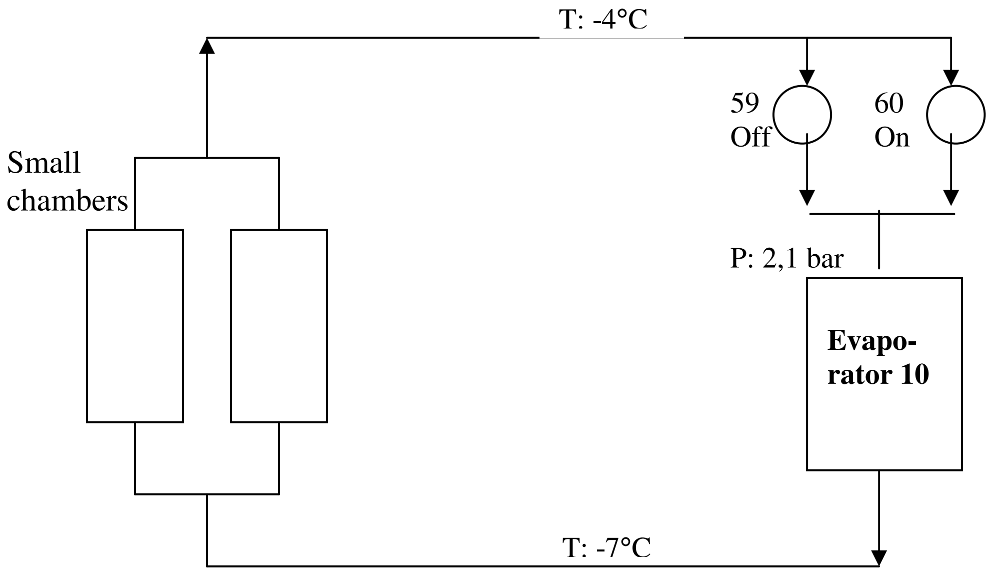

Figure 8. Cooling system for small chambers.

3.1.4 Ice water system No.1

The ice water system is used for cooling of equipment at milk acceptance department by means of iced water. The pump system is equipped with four pumps whereas three are of type 4K-12 and the last is of type KM100-65-200. At both inspections pumps No. 53 and 56 were in operation. The efficiency of the pumps have be calculated to be 78% and 72% respectively so these pumps are working under proper flow and pressure conditions.

Measured results of motor operation is given in table 22.

Phase	V	kW	Cosφ	I (A)	Remarks
Iced water pump No.53, 17 kW					
A	235	4,2	0,55	29,6	
B		4,5	0,59	29,8	
C		3,8	0,58	28,4	
Total		12,5			
Iced water pump No. 56, 30 kW.					
A	238	7,8	0,78	43,6	
B		8	0,77	41,8	
C		8,1	0,78	42,4	
Total		23,9			

Table 22. Operation parameters for ice water pump motors in system No. 1.

Parameters of pumps are given in table 23.

Pump type	No.	Capacity [m^3/h]	Water pressure [m]	Installed capacity [kW]	Consumed power [kW]
4K-12	53	90	32	17	12,5
KM 100-65-200	56	100	50	30	23,9

Table 23. Operation parameters for ice water pumps in system No. 1.

As it can be seen in table 23 these pumps have different pressure parameters that is not good if pumps operate in parallel.

During investigation the system worked in a mode close to optimal, but because of the daily load variation at the processing equipment in milk acceptance department, load variation occurs also in cooling system. It should be investigated whether it is possible to instruct the operators of production equipment to shut off the supply of ice water when the equipment is not in operation. In this way electric energy for pumps can be saved and unnecessary heating of circulating ice water is avoided. If the demand for ice water in this way becomes fluctuating a frequency regulated pump could be a solution.

It should be investigated whether it is possible to replace pump equipment with more efficient frequency regulated equipment.

Cooling system layout is given in figure 9.

Ice water system No. 1

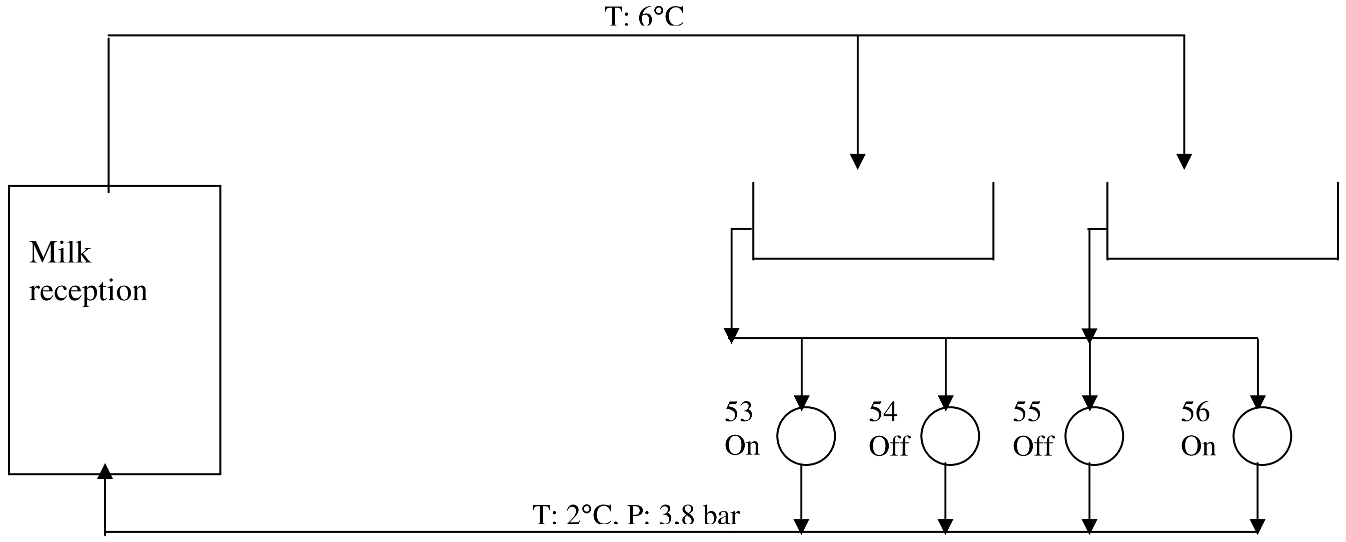

Figure 9. Ice water system No. 1.

During investigation additional processing equipment was put into operation. As the result, temperature regime of system was broken: temperature of return iced water increased up to 12°C, temperature of supplied water – up to 4,5 °C. One more compressor switched on automatically and temperature regime was restored.

3.1.5 Ice water systems No.2 and 4

Ice water system No.2 is used for iced water cooling of process tanks. The system is connected to system No.4, which is used in experimental building. System No. 2 and 4 can be regarded as one system. This system is equipped with five pumps in parallel. Three of pumps are of type 6K-8 and two pumps are of type 3K-6. Both at the inspection in November and in December two pumps were in operation. Pumps No. 47 and 61 were used during the first investigation, pumps No.46 and 61 were used during the second investigation. All pumps are of type 6K-8. Regimes of system operation were investigated: in the morning of 8.th December. The pressure was 3 bar and the temperature of iced water at the outlet of the tank was 2,5° C and-3,8° C at the inlet. An hour and half later temperature of cooling agent increased up to 3,5 and 8° C correspondingly. It means that the system has load variations. The results of investigations of motor operation are shown in table 24.

Phase	V	kW	Cosφ	I (A)	Remarks
Iced water pump No.46, 30 kW					
A	235	5,2	0,68	33,8	
B		5,2	0,66	33,5	
C		5,7	0,7	31,4	
Total		16,1			Large installed capacity
Iced water pump No.61, 30 kW					
A	238	5,9	0,75	34,5	
B		5,5	0,7	33,3	
C		5,6	0,74	32	
Total		17			Large installed capacity

Table 24. Operation parameters for ice water pump motors in system No. 2/4.

Parameters of pumps are shown in table 25.

Pump type	No.	Capacity [m^3/h]	Water pressure [m]	Installed capacity [kW]	Consumed power [kW]
6K-8	46	160	32	30	16,1
6K-8	61	160	32	30	17

Table 25. Operation parameters for ice water pumps in system No. 2/4.

The pump No. 46 delivered a flow of approx. 76 m^3/h at 3,9 bar which leads to an efficiency of 56%, and pump No. 61 had a flow of approx. 90 m^3/h at 3,8 bar with an efficiency of 62%. The efficiency of the pumps is low as efficiencies of 75-78% is normal for pumps of this size and the pump type has in fact a maximal efficiency of 76%. From the pump characteristics can be see that if one of the pumps is turned off the pump in operation will deliver the necessary flow at a pressure of 3,3 bar with an efficiency of 76%. So if a pressure of 3,3 is enough one pump should be turned off. If one of the pumps is turned off a 40% energy saving can be realized corresponding to approx. 115.000 kWh or 46.000 rubles annually.

Alternatively one of the pumps should be replaced with a new efficient pump which could be frequency regulated so it can meet the demand for ice water in an energy efficient way.

It should be stressed that installed capacity of motors is higher than it is necessary.
As in pump system No. 1 it should be considered whether it is a possibility to instruct the operators of production equipment to shut of the ice water supply when the equipment is not in use. This will give both an energy saving for circulation pumps and unnecessary heating of the circulating ice water is avoided.

Cooling system layout is given in figure 10.

Ice water cooling system 2/4

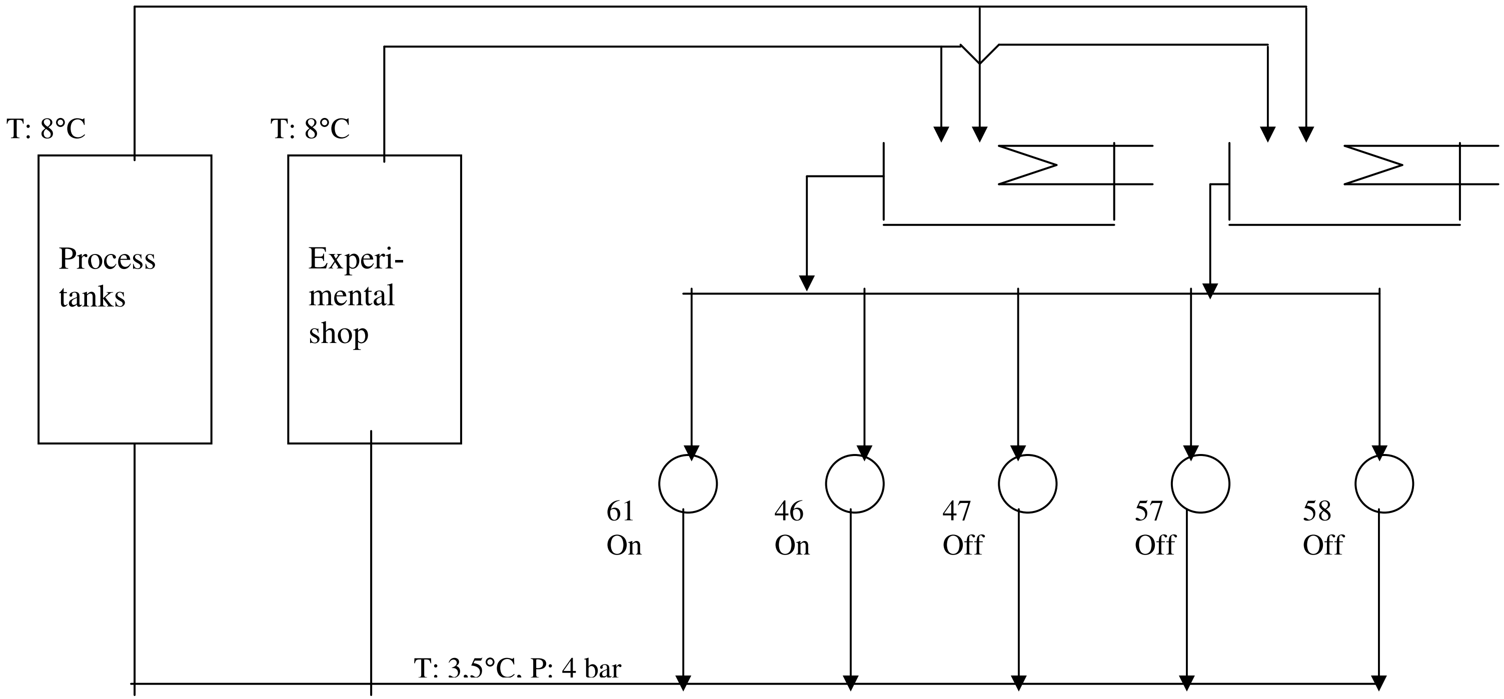

Figure 10. Ice water system No. 2/4.

3.1.6 Ice water system No. 3

Ice water system No. 3 supplies ice water to production equipment. It works with ammonia compressors No.10, 11, 12 (screw type), No. 7, 8 and 9 (piston type) and tanks with evaporators 5, 6 and 7. Ice water system No. 3 consists of five pumps whereas two pumps normally are working. At both inspections pumps No. 50 and 51 were in operation.

Device for measuring of consumed power of pump had bad batteries, so measured data was wrong. The measurement was made once again on 8.th December. Results of investigation are shown in table 26.

Phase	V	kW	Cosφ	I (A)	Remarks
Ice water pump No. 50, 30 kW.					
A	240	8	0,78	44,2	
B		8	0,77	44,7	
C		7,9	0,77	44,3	
Total		23,9			
Salt water pump No. 51, 30 kW.					
A	240	8,6	0,82	44,8	
B		8,5	0,78	45,6	
C		8,0	0,81	42,5	
Total		25,1			

Table 26. Operation parameters for ice water pump motors in system No. 3.

Parameters of pumps are shown in table 27.

Pump type	No.	Capacity [m^3/h]	Water pressure [m]	Installed capacity [kW]	Consumed power [kW]
KM100-65-200	50	100	50	30	23,9
KM100-65-200	51	100	50	30	25,1

Table 27. Operation parameters for ice water pumps in system No. 3.

The measurements of the power consumption of the pumps from November were obvious wrong so measurements were done again. From the measurements is has been calculated that pump No. 50 delivered a flow of approx. 123 m^3/h at a pressure of 4,5 bar with an efficiency of 72%. Pump No. 51 delivered a flow of approx. 128 m^3/h at a pressure of 4,3 bar with an efficiency of 72%. So the two pumps are in operation under optimal flow and pressure conditions.

To keep the cooling system in optimal mode, automatic system should be installed for regulation of number of operating pumps. It is possible to consider replacement of two pumps with one larger pump with frequency regulated motor. It will provide the optimal mode for the system in conditions of load variation of processing equipment.

It should be considered whether it is a possibility to instruct the operators of production equipment to shut of the ice water supply when the equipment is not in use. This will give both an energy saving for circulation pumps and unnecessary heating of the circulating ice water is avoided.

Parameters of cooling system are given in the layout in figure 11.

Ice water system No. 3

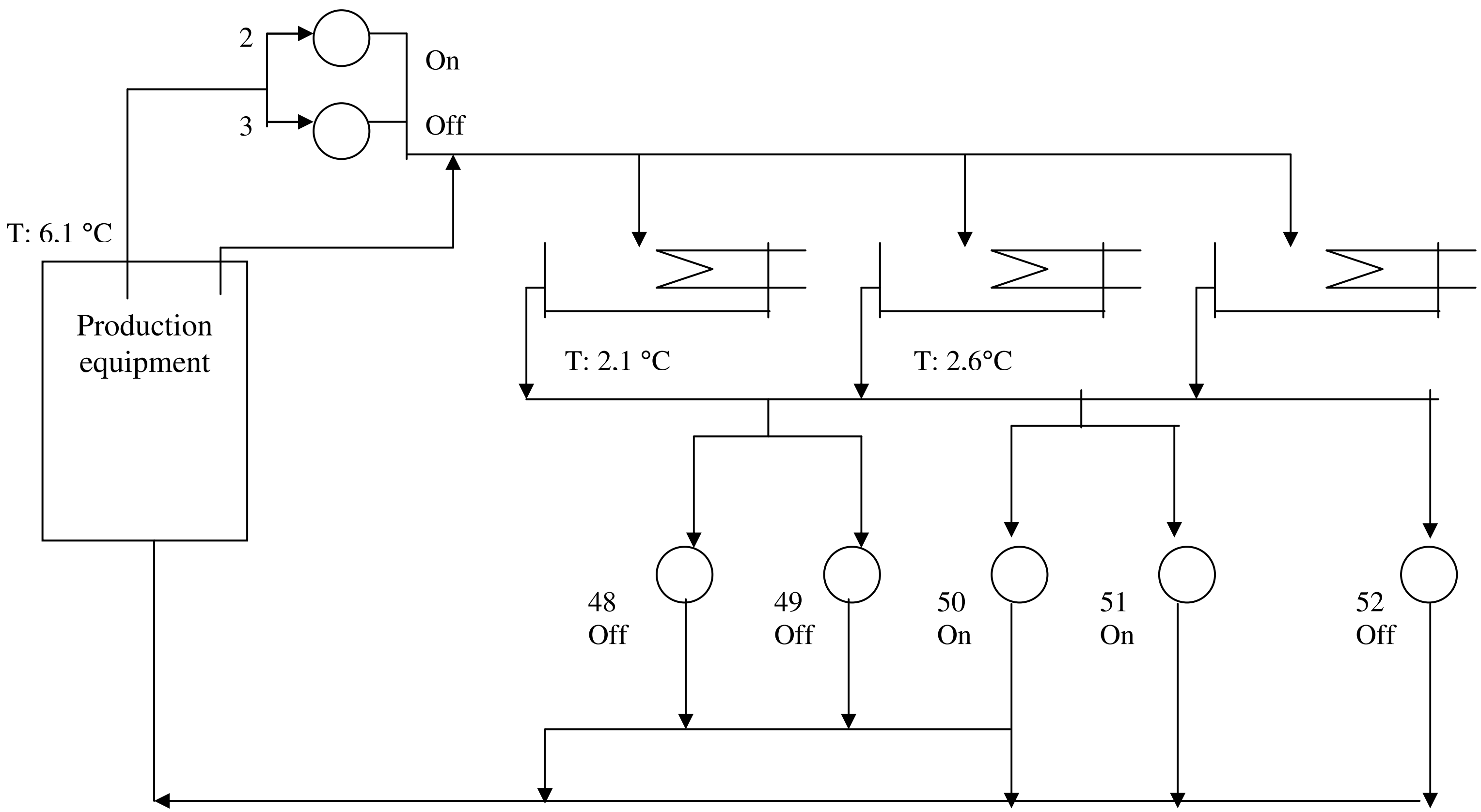

Figure 11. Ice water system No. 3.

Results of supplementary investigation were discussed with chief of compressor station and chief engineer of energy department. Additionally some systems and equipment was found out, where reconstruction and replacement is necessary.

Return water cooling system:

a) avoid the parallel operation of motors with different pressure parameters and give necessary instructions to operators.,

b) installation of equipment for automatic regulation of number of operating pumps.

It is suggested to replace two pumps with one pump of larger capacity and to equip this pump with frequency converter. This pump can supply cooling water for compressors most of the time. Frequency regulation will allow keeping the optimal regime of motor operation in wide range of load variation.

Salt water cooling system

a) installation of a efficient pump in system No. 5 instead of pump No. 43. This system is old and worn-out. The reconstruction is necessary.

Ice water system No. 1

a) avoid parallel operation of pumps with different pressure parameters and give necessary instructions to operators.

b) installation of equipment for automatic regulation of number of operating pumps.

c) due to the large variation of load during a day installation of an efficient frequency regulated pump and automatic control equipment can be considered.

Iced water system No. 2/4

a) motor for pump No. 61 should be replaced with a motor 22 kW.

b) installation of equipment for automatic regulation of number of operating pumps.

c) replacement of one of the pumps with new efficient frequency regulated pump to meet the demand in iced water in the most efficient way.

Iced water system No. 3

a) installation of equipment for automatic regulation of number of operating pumps.

b) due to the large variation of load during a day installation of an efficient frequency regulated pump and automatic control equipment can be considered. This measure will provide the optimal operation of the cooling system and it will makes the system independent from the operators.

From the results of additional investigations energy savings, investments and payback periods of equipment for reconstruction of cooling supply systems and feed pumps for the boiler station were calculated. The results are shown in the back of this report.

In the feasibility calculations pay back periods were determined for tariffs on energy carries, which have existed during additional investigations in 1999. In 2001 the tariff on electricity have increased in 1,8 times consequently pay back period for pumps with frequency converters have reduced from 3,3 to 2 years.

3.2 Electricity savings - second project stage

From the results of the additional investigations and calculation of payback periods it was decided to reconstruction all ice water systems, i.e. installation of pumps Grundfos NK-A-100-200 pumps with capacities of 300 m^3/h at a pressure of 4,9 bar. The pumps have motors of 55 kW, 2900 r/min with frequency converters controlled by the pressure in the systems. Such reconstruction allows changing the system of parallel operated pumps with singles pumps with frequency converters. The decreased pressure in the systems reduces leakage's of ice water and saves electricity.

The equipment for reconstruction of ice water system No. 1, 2/4 and 3 and boiler feed water pumps are given in table 32.

Equipment	Firm	Quantity
Pump NK-100-200, Q=300 m^3/h, N=55 kW	Grundfos	3
Frequency converter EC01 5500/3, N=55 kW	Siemens	3
Pressure converter 7MF 1563-3BG00, P=66 bar	Siemens	3
Frequency converter EC01 3000/3, N=30 kW	Siemens	1

Table 32. New ice water pumps.

The estimated data of saving of energy resources and financial means are given in the table 33.

System	Energy and water savings		
	Electricity [MWh]	Water [m^3]	Sum [ruble]
Ice water system No. 1	111	5.000	131.000
Ice water system No. 2/4	84	6.000	122.000
Ice water system No. 3	75	5.200	107.000
Boiler feed water pump	96	0	70.000
Total	366	16.200	430.000

Table 33. Energy and water savings from new ice water pumps and boiler feed water pump.

Total electricity saving is estimated to be app. 766 MWh if the salt water systems are shut down. It is about 15% from electricity consumption of cooling station and 4% from total electricity consumption of dairy. Real energy saving can be a few more due to reducing of water consumption (16-17%) and consequently the load of pumps (1 kWh per 1 m^3). Additional saving is estimated about 3%. Therefore the reduction in electricity consumption as a result of the demonstration project is estimated to be app. 7% that corresponds 1.000 thousand rubles.

Tsarizinski Dairy Moscow	Energy saving proposal No. 1	Date: 03.10.2000
<u>Energy saving proposal</u>: Installation of new frequency regulated pump equipment in iced water system No.1		Page: 1 of 3

<u>Present situation</u>: Ice water system No.1 is used for cooling of milk delivered to the dairy, and cooling of milk after processes of dry milk recovery and recombination (up to certain level of fat content in milk). Milk is cooled in two 2-section plate-type coolers. These coolers are turned on/off automatically depending on the milk supply. Operators-technologists should inform when processes of dry milk recovery or recombination are started. If they are late with this information, iced water is heated up to 20-30 ^oC. It breaks the operation of the whole system and it leads to the milk souring.

Four parallel pumps are operating in system No. 1. Capacity of these pumps is 100 m^3/h and 90 m^3/h. As a rule, two pumps are in operation, and two pumps are in reserve. Iced water pumps are turned on and off by operators. Information about turn-on/off of the processing equipment is not always delivered in due time. In this situation it is difficult to provide manually the optimal operation modes. During investigation in compressor station in November-December, most of the above-mentioned pumps were operating with low efficiency. Besides, it was found out that pump with different pressure characteristics were in parallel in system No.1.

During the last investigation of system No.1, main parameters were measured, i.e. pressure, temperature of incoming and outcoming ice water. Operation of processing equipment was observed.

At 10 a.m. two pumps No.53 and 56 were in operation, pressure in the system was 4 bar, temperature difference was 4^{o}C. Total capacity of pumps defined by the pump's characteristics was 180 m^3/h. All milk coolers were in operation at that time. There were no processes of dry milk recovery and recombination. At 14.00 one of the coolers was turned on. Operation mode was changed. Temperature difference reduced down to 2,5^{o}C, pressure in the system increased up to 4,3 bar. The same two pumps were in operation. As the analysis of pump operation showed, pump No. 56 with 5 bar pressure in nominal mode, was operating in network, its capacity was 125-130 m^3/h. Another pump which max pressure is 4 bar, was practically out of network but it was still in operation consuming power. Consumption reduced down to 130 m^3/h, there was too much water to keep the temperature difference at the level of 4-5^{o}C.

Tsarizinski Dairy Moscow	Energy saving proposal No. 1	Date: 03.10.2000
Energy saving proposal : Installation of new frequency regulated pump equipment in ice water system No.1		Page: 2 of 3

It was estimated that iced water consumption could be reduced down to 90 – 100 m^3/h. One pump is enough for this. The situation recurs daily during several hours.

Energy saving proposal: In system No.1 to install one pump NK-A-100-200 with the capacity of 300 m^3/h and pressure 4,9 bar instead of the pumps 4K-12. Pump NK-A-100-200 is supplied by company "Grundfos". Motor capacity is 55 kW, 2900 rotation/min. Frequency converter type ECO1 7500/3 is Siemens manufacture. It is recommended to install pressure converter (up to 6 bar), type 7MF 1563-3BG00 of Siemens manufacture.

It is recommended to install a pump with higher capacity. This recommendation is connected with new yogurt equipment that is planned. It is expected that the new line with pipe diameter 100 mm will be connected to the system.

The analysis of operation of iced water system No. 1 in 1999 was carried out for evaluation of new frequency regulated pump efficiency. Data from operational book, results of supplementary investigations and pump characteristics showed the main operational modes of the system; power consumption by pumps in 1999 was calculated, power consumption of frequency regulated pump was estimated. According to results of 1999, expected saving will make up to 111 MWh/year. Keeping pressure in iced water system on optimal level will reduce water leakage approximately 0,6 m^3/h. Besides the reliability of cooling and pump systems will be increased, optimal mode of technological processes will be provided. The systems will not depend on actions of operators.

3 modes of system operation were indicated:

1 - one pump works in mode close to nominal;

2 - two pumps work, part of processing equipment is turned off, the smaller pump works with very low efficiency;

3 - two pumps work in rather efficient modes, all processing equipment is in operation.

Estimation of power consumption for each of these modes is given in the table.
For estimation of energy ad water saving and pay back period we took figures of energy consumption and energy prices for 1999. Prices for equipment are taken from catalogues of equipment suppliers.

Tsarizinski Dairy Moscow	Energy saving proposal No. 1.	Date: 03.10.2000
Energy saving proposal (the last version): Installation of new frequency regulated pump equipment in iced water system No.1		Page: 3 of 3

The estimated yearly power consumption of present system is 278 MWh and the energy consumption in the future frequency regulated pump system is calculated to be 167 MWh.

Power saving: 278 MWh - 167 MWh = 111 MWh /year

Water saving; 0,6 m^3/h x 8760 h/year = 5.016 m^3/year

Economical effect: 111 MWh /year × 399 ruble/ MWh + 5.016 m^3/year x 13 ruble/m^3 = 109.600 ruble/year

Investment: total cost of equipment is 11.572 USD (incl. VAT) or 324.000 ruble if dollar rate is 28 ruble per 1 USD including:
- cost of pump of Grundfos NK-A-100-200 with motor is 6360 USD
- cost of frequency converters of Siemens EC01 5500/3 – 5050 USD
- cost of pressure converters of Siemens - 162 USD

Payback period: 32.000 ruble / 109.600 ruble/year = 2,9 year.

Notes: Pay back period with pump of Russian production is 2,1 years but the pump of Grundfos makes ensure greater reliability of operating system.

Tsarizinski Dairy Moscow	Energy saving proposal No. 2	Date: 1.03.2000
Energy saving proposal: Installation of frequency converter on feed water pump		Page: 1 of 2

Present situation: There is a feed water pump in boiler station. The type of the pump is TsSNG-38-176 which a capacity of 38 m^3/h at a pressure of 176 mWc. Installed motor capacity is 30 kW with 3.000 rev/min. At present the pump is operating for full load of the boiler station. The results of energy audit in 1999 showed that pump capacity changed from 25% to 75% of the nominal. Load was regulated by means of control valves installed at each of the boilers. During the investigation in December 1999 the measured power consumption of feed water pump was 25,5 kW while the boiler output was 17-21 t/h. During the energy audit consumed power reduced down to 23,5 kW while the mean load of the boiler was not more than 13 t/h. When the load is close to the nominal one the consumed power is 27-29 kW. As it can be seen from the yearly operation of boiler station load on the boilers is distributed depending on time.

Pump load %	Work. time %	Work.time hours
25	17	1488
30	8	720
35	17	1464
40	8	744
45	16	1416
55	8	720
65	17	1464
75	8	744
100	0	0
Total	100	8760

Water supplied into the economizer of boiler should be 100 °C. Feed water temperature is about 50 °C because the deaerator is almost out of operation.

Energy saving proposal: Installation of a frequency converter on the feed water pump with regulation of pump capacity according to pressure depending on changing load of boilers. It was suggested to install frequency converter VLT6042HVAC of Danfoss or cheaper frequency converter ECO1 3000/3 of Siemens. It is recommended to use pressure converter MBS33 for 25 bar of Danfoss manufacture or pressure converter 7NF 1563 – 3CD00 of Siemens, which is cheaper than the converter of Danfoss.

Tsarizinski Dairy Moscow	Energy saving proposal No. 2	Date: 1.03.2000
Energy saving proposal: Installation of a frequency converter on feed water pump		Page: 2 of 2

For estimation of energy saving and pay back period we took figures of energy consumption and energy prices for 1999. Prices for equipment are taken from catalogues of Danfoss and Siemens.

Cost of frequency converter VLT6042HVAC of Danfoss including VAT is 4.393 USD;
Cost of frequency converter ECO1 3000/3 of Siemens including VAT is 3.156 USD
Cost of pressure converter MBS33 including VAT is 496 USD
Cost of pressure converter 7NF 1563 – 3CD00 including VAT is 162 USD

Power consumption in present system and with application of frequency converters:

%	%	without FC	with FC	without FC	with FC
25	17	23,5	11	34968	16947
30	8	23,5	12	16920	8808
35	17	23,5	12	34404	18281
40	8	25,5	14	18972	10104
45	16	25,5	14	36108	19593
55	8	25,5	14	18360	9941
65	17	25,5	16	37332	23247
75	8	27	19	20088	14001
100	0	29	30	0	0
Total,MWh				217	121
Energy saving, MWh					96

Volume of saved heat energy is taken as 0,1% of yearly power production.

Heat energy saving: 102.500 MWh/year x 0,001 = 102 MWh/year.

Power saving: 217 MWh – 121 MWh = 96 MWh/year

Economical effect: 96 MWh/year x 399 ruble/MWh + 102 MWh/year × 71.7 ruble/MWh = 45.700 ruble/year

Investment: For purchasing of frequency converter and pressure converter of Siemens will be 3.318 USD or 93.000 ruble. Purchasing of frequency converter and pressure converter of Danfoss will be 4.889 $ or 137.000 ruble

Payback period for FC of Siemens: 93 000 ruble/45 700 ruble/year = 2 years
Payback period for FC of Danfoss: 137 000 ruble/45 700 ruble/year = 3 years

Tsarizinski Dairy Moscow	Energy saving proposal No. 3	Date: 03.10.2000
Energy saving proposal: Installation of new frequency regulated pump equipment in ice water systems No.2 and 4		Page: 1 of 3

Present situation: Iced water system No.2-4 is used for cooling of storage tanks for milk , two yogurt coolers and one kefir cooler (system No.2) and for cooling of experimental building (system No.4). The systems are combined and can be considered as one system. Yogurt coolers are turned on/off automatically depending on the product supply. Operators have remote control of iced water supply into tanks. As a rule, if there is no need, iced water is not supplied into tanks, but if the valve is broken, water is supplied into non-operating tanks. This reflects on operational parameters of system: pressure and temperature of iced water drop.

Five parallel pumps are installed in system No.2-4. Capacity of these pumps is 160 m^3/h and 45 m^3/h. As a rule, two/three pumps are in operation, other pumps are in reserve. Iced water pumps are turned on/off by operators. Information about turn-on/off of the processing equipment is not always delivered in due time. In this situation it is difficult to provide manually optimal operation modes. During investigation in compressor station in November-December, pumps were operating with low efficiency. Besides, it was found out that pumps with different pressure characteristics were in parallel in system No.2-4. Pump 6K-8 has max. pressure level 4 bar, pump 3K-6 has max. pressure level 6 bar. During the last investigation of system No.2-4, main parameters were measured, i.e. pressure, temperature of incoming and outcoming iced water. Operation of processing equipment was observed.
At 10 a.m. two pumps No.46 and 61 were in operation, pressure in the system was 3.2 bar, temperature difference was 4 ^oC. Total capacity of pumps defined by the pump's characteristics was 320 m^3/h. At that time 8 tanks, 1 kefir cooler and 2 yogurt coolers were in operation. At 14.00 5 tanks, 1 yogurt cooler and 1 kefir cooler were in operation, the rest of the equipment was turned off. Operation mode was changed. Temperature difference reduced down to 1 ^oC, pressure in the system increased up to 3.4 bar. The same two pumps were in operation. As the analysis of pumps operation showed, total capacity of pumps reduced down to 300 m^3/h. There was too much water to keep the temperature difference at the level of 4-5^oC.

Tsarizinski Dairy Moscow	Energy saving proposal No. 3	Date: 03.10.2000
Energy saving proposal: Installation of new frequency regulated pump equipment in ice water system No. 2 and 4		Page: 2 of 3

It was estimated that iced water consumption could be reduced down to 150 – 160 m^3/h. One pump is enough for this. The situation recurs daily during several hours.

Energy saving proposal: Installation of one pump NK-A-100-200 with the capacity of 300 m^3/h and pressure 4,9 bar instead of the pumps 3K-6. Pump NK-A-100-200 is supplied by company Grundfos. Motor capacity is 55 kW, 2900 rotation/min. Frequency converter type ECO1 7500/3 is Siemens manufacture. It is recommended to install pressure converter (up to 6 bar), type 7MF 1563-3BG00 of Siemens manufacture.

It is expected that the system load will be increased, as the new cooling line for juices with pipe diameter 65 mm will be connected to the system. It is expected that pump NK-A-100-200 can cover the increased load.

The analysis of operation of ice water system in 1999 was carried out for evaluation of new frequency regulated pump efficiency. Data from operational book, results of supplementary investigations and pump characteristics showed the main operational modes of the system; power consumption by pumps in 1999 was calculated, power consumption of frequency regulated pump was estimated. According to results of 1999, expected saving will make up to 84 MWh/year. Keeping pressure in iced water system on optimal level will reduce water leakage approximately 0,7 m^3/h. Besides the reliability of cooling and pump systems will be increased, optimal mode of technological processes will be provided. The systems will not depend on actions of operators.

6 modes of system operation were indicated:

1. one pump in operation
2. two pumps work in rather efficient modes, the most of processing equipment is in operation
3. two pumps work in mode close to nominal
4. two pumps work, the most of processing equipment is turned off, one pump would be enough for this mode
5. three pumps work, as a rule two pumps 6K-8 and one pump 3 K-6, most part of the processing equipment is in operation
6. three pumps work but part of the processing equipment is turned off

For estimation of energy ad water saving and pay back period we took figures of energy consumption and energy prices for 1999. Prices for equipment are taken from catalogues of equipment suppliers.

Tsarizinski Dairy Moscow	Energy saving proposal No. 3	Date: 03.10.2000
Energy saving proposal: Installation of new frequency regulated pump equipment in ice water systems No.2 and 4		Page: 3 of 3

Number of pumps in oper.	Capacity of pumps m^3/h	Presure in system bar	Capacity demand m^3/h	time of pump oper. hours	Consumed capacity kW		Power consumption MWh/year	
					without FC	with FC	without FC	with FC
1	180	3,2	120	736	22	19	16	11
2	380	2,8-3	350	1000	40	39	40	39
2	320	3,2	300	3000	36	35	108	105
2	300	3,4	150	2324	35	17	81	40
3	435	3	300	1140	53	36	60	41
3	380	3,2	200	560	48	22	27	12
	Total, MWh/year			8760			332	248
	Saving, MWh/year							84

The estimated yearly power consumption of present system is 332 MWh and the new system will have an energy consumption of 248 MWh.

Power saving: 332 MWh - 248 MWh = 84 MWh /year.

Water saving: 0,7 m^3/h x 8760 h/year = 6.132 m^3/year

Economical effect: 84 MWh /year × 399 ruble/ MWh + 6.132 m^3/year x 13 ruble/m^3 = 113.000 ruble/year

Investment: total cost of equipment is 11.572 USD (incl. VAT) or 324.000 ruble including:
- cost of pump of Grundfos NK-A-100-200 with motor is 6.360 USD
- cost of frequency converters of Siemens EC01 5.500/3 – 5.050 USD
- cost of pressure converters of Siemens - 162 USD

Payback period: 324.000 ruble / 113.000 ruble/year = 2,9 year

Notes: Pay back period with pump of Russian production is 2,1 years but the pump of Grundfos makes sure the greater reliability of operating system.

Tsarizinski Dairy Moscow	Energy saving proposal No. 4	Date: 03.10.2000
Energy saving proposal: Installation of new frequency regulated pump equipment in ice water system No.3.		Page: 1 of 3

Present situation: Ice water system No.3 is used for pasteurizers. Control of iced water supply in cooling sections of pasteurizers is carried out automatically. After the termination of pasteurizing process control valve stops the supply of ice water into the cooling section. Operator-technologist controls the whole process.

Five parallel pumps are installed in system No.3. Capacity is 100 m^3/h, pressure 5 bar. As a rule, not more than three pumps are in operation; other pumps are in reserve. Ice water pumps are turned on/off by operators. Information about turn-on/off of the processing equipment is not always delivered in due time. In this situation it is difficult to provide manually optimal operation modes. In comparison with systems No.1 and 2-4, system No. 3 has more stable operation. During the investigation in compressor station in November-December pumps were operating with efficiency close to the nominal one. Pump efficiency was estimated to be 72%. On 23 of February during the last investigation of system No.3, main parameters were measured, i.e. pressure, temperature of incoming and out-coming ice water. Operation of processing equipment was observed.

At 10 a.m. two pumps No. 50 and 51 were in operation. The pressure in the system was 5,8 bar and the temperature difference was 5^{o}C. Total capacity of pumps defined by the pumps characteristics was 180 m^3/h. At that time one milk pasteurizer (1808) and two kefir pasteurizers (3004 and 242) were in operation. At 14.00 a.m. one kefir pasteurizer (3004) was turned off and pasteurizers 1808 and 242 were still in operation. Operation mode was changed just a little. Temperature difference remained the same, pressure in the system increased on 0,1-0,2 bar. The same two pumps were in operation. As the analysis of pumps operation showed the total capacity of pumps reduced down to 150-160 m^3/h. Water flow was redistributed. It should be noted that the pressure gauges don't work properly. Their indications differ from measuring on 0.2-0.3 bar. Intake pipe works under pressure because ice water tanks are 3.5-4 m high above pump level.

Investigation of pump operation modes in system No. 3 shows that the system has periodically sharp pressure disturbance, as a whole this system works more stable than systems No.1 and 2.

Tsarizinski Dairy Moscow	Energy saving proposal No. 4	Date: 03.10.2000
Energy saving proposal: Installation of new frequency regulated pump equipment in ice water system No.3.		Page: 2 of 3

Energy saving proposal: in system No.3 to install one pump NK-A-100-200 with the capacity of 300 m^3/h and pressure 4,9 bar instead of the pumps 4K-12. Pump NK-A-100-200 is supplied by company «Grundfos». Motor capacity is 55 kW, 2900 rotation/min. Frequency converter type ECO1 7500/3 is Siemens manufacture. It is recommended to install pressure converter (up to 6 bar), type 7MF 1563-3BG00 of Siemens manufacture.

It is recommended to install the pump in connection with other equipment installing. It is expected that pump NK-A-100-200 can cover the increased load.

The analysis of operation of ice water system in 1999 was carried out for evaluation of new frequency regulated pump efficiency. Data from operational book, results of supplementary investigations and pump characteristics showed the main operational modes of the system; power consumption by pumps in 1999 was calculated, power consumption of frequency regulated pump was estimated. According to results of 1999 the expected saving will make up to 75 MWh/year. Keeping pressure in ice water system on optimal level will reduce water leakage approximately 0,6 m^3/h. Besides the reliability of cooling and pump systems will be increased, optimal mode of technological processes will be provided. The systems will not depend on actions of operators.

7 modes of system operation were indicated:

1. one pump is in operation with efficiency 72%
2. one pump is in operation with efficiency 72%
3. two pumps work in rather efficient modes, the most of processing equipment is in operation, pressure in the system is low, temperature difference is high
4. two pumps work in rather efficient mode
5. two pumps work, the most of processing equipment is turned off, pressure in the system increases, temperature difference decreases. One pump would be enough for this mode
6. three pumps work, most part of the processing equipment is in operation
7. three pumps work, part of the processing equipment is turned off

Estimation of power consumption for each of these modes is given in the table.

For estimation of energy ad water saving and pay back period we took figures of energy consumption and energy prices for 1999. Prices for equipment are taken from catalogues of equipment suppliers.

Tsarizinski Dairy Moscow	Energy saving proposal No. 4	Date: 03.10.2000
Energy saving proposal: Installation of new frequency regulated pump equipment in ice water system No.3.		Page: 3 of 3

Number of pumps in oper.	Capacity of pumps m^3/h	Presure in system bar	Capacity demand m^3/h	time of pump oper. hours	Consumed capacity kW		Power consumption MWh/year	
					without FC	with FC	without FC	with FC
1	120	4,6-4,8	120	660	23	25	15	16
1	100	5-5,2	100	930	21	21	20	19
2	200	5-5,2	200	1000	42	39	42	39
2	170	5,4	150	2000	35	31	70	62
2	120	5,6	80	4090	32	17	131	68
3	270	5,2-5,4	250	50	54	47	3	2
3	210	5,4-5,6	150	30	51	31	2	1
	Total MWh/year						282	207
	Saving MWh/year							75

The estimated yearly power consumption of present system is 282 MWh and the future energy consumption will be 207 MWh.

Power saving: 282 MWh - 207 MWh = 75 MWh/year.

Water saving: 0,6 m^3/h x 8.760 h/year = 5.256 m^3/year

Economical effect: 75 MWh /year × 399 ruble/ MWh + 5.256 m^3/year x 13 ruble/m^3 = 98.000 ruble/year

Investment: total cost of equipment is 11.572 USD (incl. VAT) or 324.000 ruble including:

cost of pump of Grundfos NK-A-100-200 with motor is 6.360 USD
cost of frequency converters of Siemens EC01 5500/3 – 5.050 USD
cost of pressure converters of Siemens - 162 USD

Payback period: 324000 ruble /98000 ruble/year = 3,3 year.

Notes: Pay back period with pump of Russian production is 2,3 years but the pump of Grundfos makes sure the greater reliability of operating system.

Annex 1. Programme for and list of participants at the Energy Day

The programme on results of energy saving project at Tsaritsino Dairy

It is intended on 6-th of December 2001

Time	Themes of reports	Speakers
09.00-09.15	**Presentation** ▪ Presentation of participants ▪ Seminar programme	J. Tananenko, Ts.dairy A. Derbishev
09.15-09.30	**Results of cooperation between DEA and Tsaritsino dairy for increasing of enterprise energy efficiency**	S. Draborg, DEA
09.30-11.00	**Aims and stages of energy saving demonstration project** ▪ Energy audit ▪ Additional investigations ▪ Choosing, purchase and mounting of equipment ▪ Energy Management as an energy saving tool	 L. Sheina, RDIEE S. Draborg, L. Sheina A. Derbishev, L. Sheina S. Draborg, DEA
11.00-11.20	**Short break**	
11.20-13.00	**Estimation of project energy efficiency** ▪ Automation of feeding and deaeration of boiler systems ▪ Control of steam consumption and regulation of steam presser ▪ Optimisation of hot water supply system ▪ Reconstruction of space heating system ▪ Reconstruction of cooling chamber	S. Draborg, DEA L. Sheina, RDIEE
13.00-13.30	**Results of "Demonstration Project" at possibilities for increasing energy efficiency**	A. Derbishev, Ts.dairy
13.30-14.30	**Lunch**	
14.30-16.00	**Inspection of systems and equipment were energy efficient equipment are installed**	
16.00-16.20	**Short break**	
16.20-17.00	**Energy saving processing equipment for dairies**	A. Burikin, WNIMI
17.00-18.00	**Discussion**	
18.00	**End of seminar**	

Список участников семинара 06/12/01.

1. Кузьмин Александр Иванович
2. Францевич Игорь Георгиевич
3. Францевич Ирина Анатольевна
4. Филимонов Павел Иванович
5. Балабан Владимир Георгиевич
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8. Стоумова Наталья Вениаминовна
9. Гусев Сергей Михайлович
10. Рябцев Николай Иванович
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12. Бурыкин Андрей Иванович
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14. Бондалетова Ирина Владимировна
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18. Байзиков Владимир Иванович
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20. Трубчанинов Александр Борисович
21. Рукавишников Вениамин Артемьевич
22. Сазонов Альберт Полиевктович
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29. Руденко Георгий Сергеевич
30. Малахова Ольга Викторовна
31. Астахова Ольга Николаевна
32. Васильева Наталья Сергеевна
33. Кабаков Владимир Исаакович
34. Шеина Людмила Сергеевна
35. Soren Draborg

Annex 2. Pamphlet about the project (English version)

Further information
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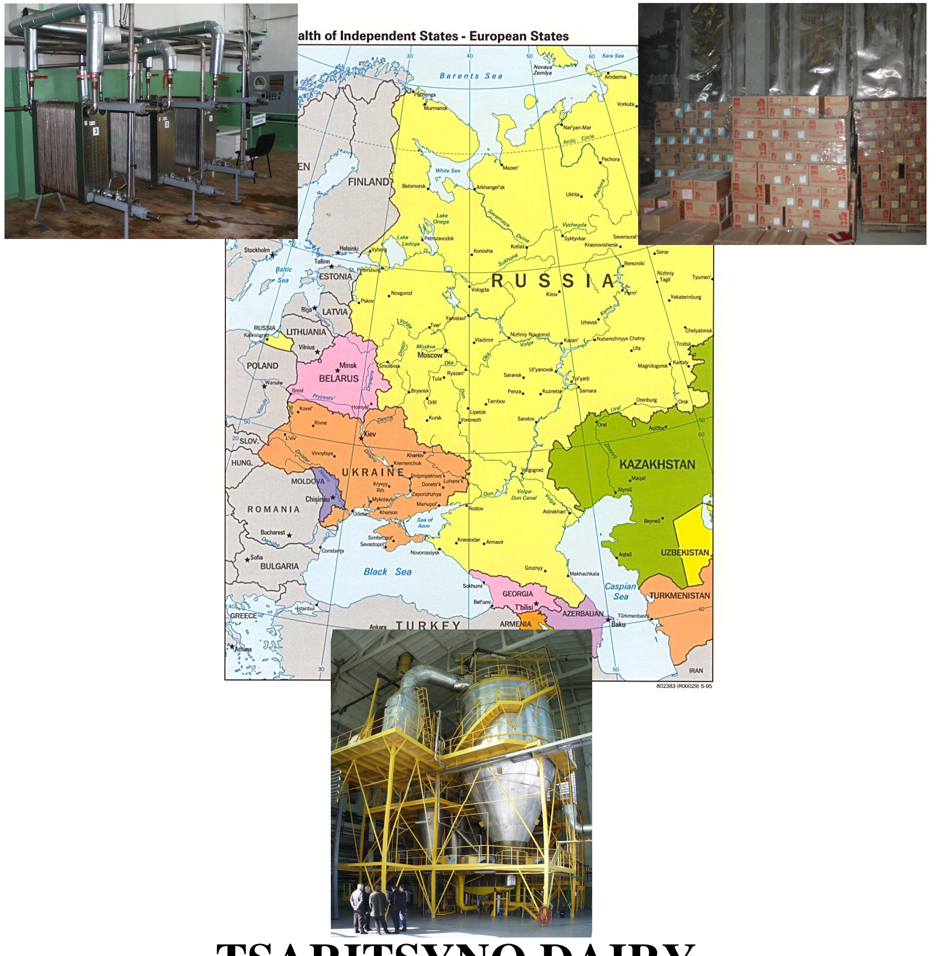
Energistyrelsen
MILJØ- OG ENERGIMINISTERIET

COMPANY
Wimm-Bill-Dann

DEMONSTRATION OF ENERGY EFFICIENCY IN RUSSIAN DAIRIES



TSARITSYNO DAIRY MOSCOW

The project idea
Previous projects in the Russian dairy sector has shown very large energy saving potentials in dairies. It has been found that heat and power consumption can be reduced by approx. 40% and approx. 25% respectively. Furthermore a considerable part of the energy savings can be realised with no or limited investments and are very feasible.
The energy costs in Russian dairies are very high compared to the total production costs. Energy costs normally accounts for 5% to 15% of the total production costs depending on the type of production. So energy efficiency is of large concern in the dairy sector.

Project objectives
The overall project objective was to demonstrate the possibilities in improving the energy efficiency by implementing identified profitable energy saving possibilities.

Furthermore the project should create awareness of the importance of energy efficiency in Russian industry in general.
A final objective have been to transfer know how about energy efficient technologies and energy management.

The dairy
Tsaritsyno dairy in Moscow was selected for the project. The dairy is a member of the Wimm-Bill-Dann group and is very progressive. Tsaritsyno dairy had already implemented some energy saving measures. The enterprise was constructed in 1975. The enterprise produces more than 16 different types of dairy products under more than 83 names. Furthermore fruit juices are produced. Both whole and dry milk is used in dairy production. Fruit juice concentrates of various fruit are used in production of juices.
The dairy has in general modern highly efficient equipment. Many production processes are fully automated.

Project activities
An energy audit was performed at the dairy to identify energy saving opportunities. The energy audit report contained all necessary information for development of an implementation plan for the identified saving possibilities.
A further output of the project has been an information campaign where seminars concerning the project were arranged.

Energy audit results

To start of the project an energy audit was performed. Energy audit efforts were directly to the main end energy. The energy audit revealed a number of energy saving options that were

listed and prioritised.
The energy saving potential at the dairy was app. 23% of the fuel consumption and 9% of the power consumption, which is less than average in Russian dairies.

Energy efficient technologies
Some of the identified energy saving options were implemented in a technical and financial co-operation between Zsaritsyno dairy and the Russian-Danish project team. Some of the implemented energy efficient

technologies are:
- Variable speed drives
- Steam traps
- Auto. deareator control
- Steam and water meters

The implemented measures resulted in an 12% fuel saving and an 4% power saving of dairy energy consumption. The implemented measures are all valid for dairies as for industry in general. The project has increased focus on energy efficiency at the dairy but also in a number of other dairies.