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

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United Nations Industrial Development Organization

Dostr.
LIMITED

ID/WG.494/10(SPEC.)
30 August 1989

ORIGINAL: ENGLISH

Regional Workshop on Energy
Conservation in Industry

Cairo, Egypt, 1-5 October 1989

ENERGY CONSERVATION IN INDUSTRY
(CASE STUDY - SWEDEN)*

Prepared by

M. Lundstroem **
UNIDO Consultant

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** AF-ENERGIKONSULT, Malmoe, Sweden

V.89-58943

ENERGY CONSERVATION IN INDUSTRY

1. Introduction

Interest in energy conservation has increased due to the substantial increase in energy prices during the past 16 years. It is important for all countries to implement measures that can lead to a reduction in energy utilization and to ensure that domestic energy sources are utilized as much as possible. Due to the fact that energy conservation projects can lead to immediate reductions in a country's energy costs a program for national energy conservation is a very important part of a country's overall energy program.

The Swedish strategy concerning energy policy since the 1970s, has been to use different incentives to influence energy use in the industrial sector. The first goal has been to decrease specific energy usage and the second one to decrease oil consumption.

The incentives can be divided into two groups, firstly, incentives that influence the price of energy such as taxes and grants to increase the implementation of energy conservation measures, and changing from oil to other fuels. Secondly, so called administrative incentives such as information programmes, training, research and development programmes, and laws on how to regulate the use of resources when a new industrial plant is to be built.

This strategy, together with the fact that Swedish industry over the years has become more aware of the effect energy usage on the economy has resulted in the implementation of energy conservation measures in Sweden during the last ten years.

This experience has shown that an energy conservation program for industry will result in

- lower energy costs for industry
- reduced atmospheric pollution and better working environments
- the possibility of increasing industrial production at current energy utilization levels

2. Energy Conservation Work Schedule

Energy conservation means the more efficient exploitation of energy with the intention of maintaining present-day production levels while reducing energy utilization and energy costs. The goal, apart from cutting energy costs, can be the reduction of energy utilization in order to increase unexploited capacity at energy generation plants. In the case of rebuilding or new construction, e.g. at a factory where energy requirements are large, it is often more economic to invest in energy saving measures and thereby increase energy generation resources in the existing plant than to expand the existing plant, e.g. by the purchase of a new boiler.

Energy conservation at an industry means the implementation of measures which reduce energy utilization and energy costs while producing the same or a greater volume of products than at present.

A well performed energy conservation project for the industrial sector will result in a possibility for industry to produce an increased volume of products with the same or a lower total energy consumption than today.

The measures which contribute to a reduction in energy utilization are partly purely technical ones, such as e.g. the insulation of hot areas, the installation of heat exchangers to recover energy from waste heat flows and the changeover from the present process to a more energy efficient one, or from the present energy source or energy production technique to a cheaper one. They are also partly administrative and organizational measures e.g. the organization of company energy activities, drafting follow-up routines for energy utilization, and informing and training company personnel and company management in energy conservation technique.

However, even more important than the actual energy conservation measures is the way of performing an energy conservation project efficiently with the intention of reaching a practical result in the form of reduced energy utilization and energy costs at the plants involved.

The general outline of an energy conservation project is shown in following working schedule:

- Collecting information that is already available

- Project planning

- Energy audits, including energy measurements

- Energy balances

- Identification of measures to reduce the energy consumption

- Energy and cost calculations for all measures

- Priority list of measures - implementation plan

- Organization of energy saving activities

- Training of and information to factory personnel

- Preparation of a final report with conclusions, recommendations and terms of reference for the next stage.

The next stage includes

- Project execution including project design and implementation of measures

- Follow up of implemented measures

It must be noted that the required time periods for the different project stages, and thereby the costs for their execution, are completely dependent on the scope and complexity of the project.

The technical approach of an energy conservation program is presented below.

2.1 Energy Audits

What is meant by an energy audit is the systematic examination of an industrial plant or other energy using facility for practical ways in which dependence on energy could be decreased.

Briefly, an energy audit comprises:

- getting acquainted with the processes and energy systems at the factory

- gathering information regarding energy utilization, production etc, to base the energy balance on

- planning and execution of energy measurements

- gathering information regarding the energy systems development to serve as a base for the drawing up of energy saving measures.

One of the important results of an energy audit is the energy balance. Since the measurement results are intended to serve as the basis for the energy balance, the plannning and execution of these are very important parts of the energy audit.

What must be decided first when planning the measurements is which quantities must be measured in order to be able to produce the necessary energy balances with adequate accuracy. In some cases, it can be advantageous to produce a mass balance to check with the energy balance.

In practice, what shall be done (step by step) during the detailed energy audit is as follows:

1) Getting acquainted with the energy production plant, the distribution system, the process and the energy using equipment.

2) Collecting all current information at the plant in respect of energy statistics, process descriptions, drawings, already performed energy studies etc.

3) The identification of the energy flows for each separate process step and for the energy production plant including both the theoretical users and all types of losses.

4) The determination of the size of all the above (4) energy flows during 1 h, 1 shift or 1 day, depending on their continuity. This is done by measuring a number of steam, liquid and air flows, temperatures, electrical outputs, operating times, steam leakages, pressure, humidity etc.

5) The determination of the energy balance during 1 h, 1 shift or 1 day for each process step and for the energy production plant.

6) Collecting information from the factory in respect of production variations during one year (usually the entire previous year) and the total energy consumption during the same year.

7) The determination of an energy balance for one year, based on the energy balances during the shorter periods (1 h, 1 shift or 1 day) for each process step, the energy production plant and the yearly production variations.

Energy measuring instruments are needed for the energy audits. The following portable energy measuring instruments are often used together with stationary instruments such as oil flow meters, water flow meters and steam flow meters.

List of instruments in a portable measuring instrument set:

- Temperature meter with high temperature and surface probe

- Humidity meter

- Vane anemometer

- Tachometer

- Steam leakage detector

- Electrical meter for voltage, ampere and $\cos \varphi$

- CO_2-indicator, testing equipment for the combustion efficiency

2.2 Energy Balance

This means that, based upon all information gained during the energy audit and all measurement values taken, an accurate energy balance for a period of one year will be determined for the factory. The energy balance should show how energy is consumed at the factory, e.g. how much energy is consumed by each energy user and which waste heat sources exist. This energy balance should be presented in the form of a Sankey diagram. The Sankey diagram is the only energy balance presentation which, apart from showing incoming and outgoing energy flows, also shows how the energy is split up within the plant. In addition, the energy balance should also be presented in the form of a table. An example of a Sankey diagram is shown on the next page.

2.3 Identification and Evaluation of Measures

Based upon the energy balance, the measurement values taken and all other information gained during the energy audit, all types of measures that will lead to a reduction in energy utilization and company energy costs will be identified and evaluated. The measures can be of different types, e.g. simple straightforward energy saving measures, energy recovery measures, process changes and changeovers to alternative energy sources and energy production techniques.

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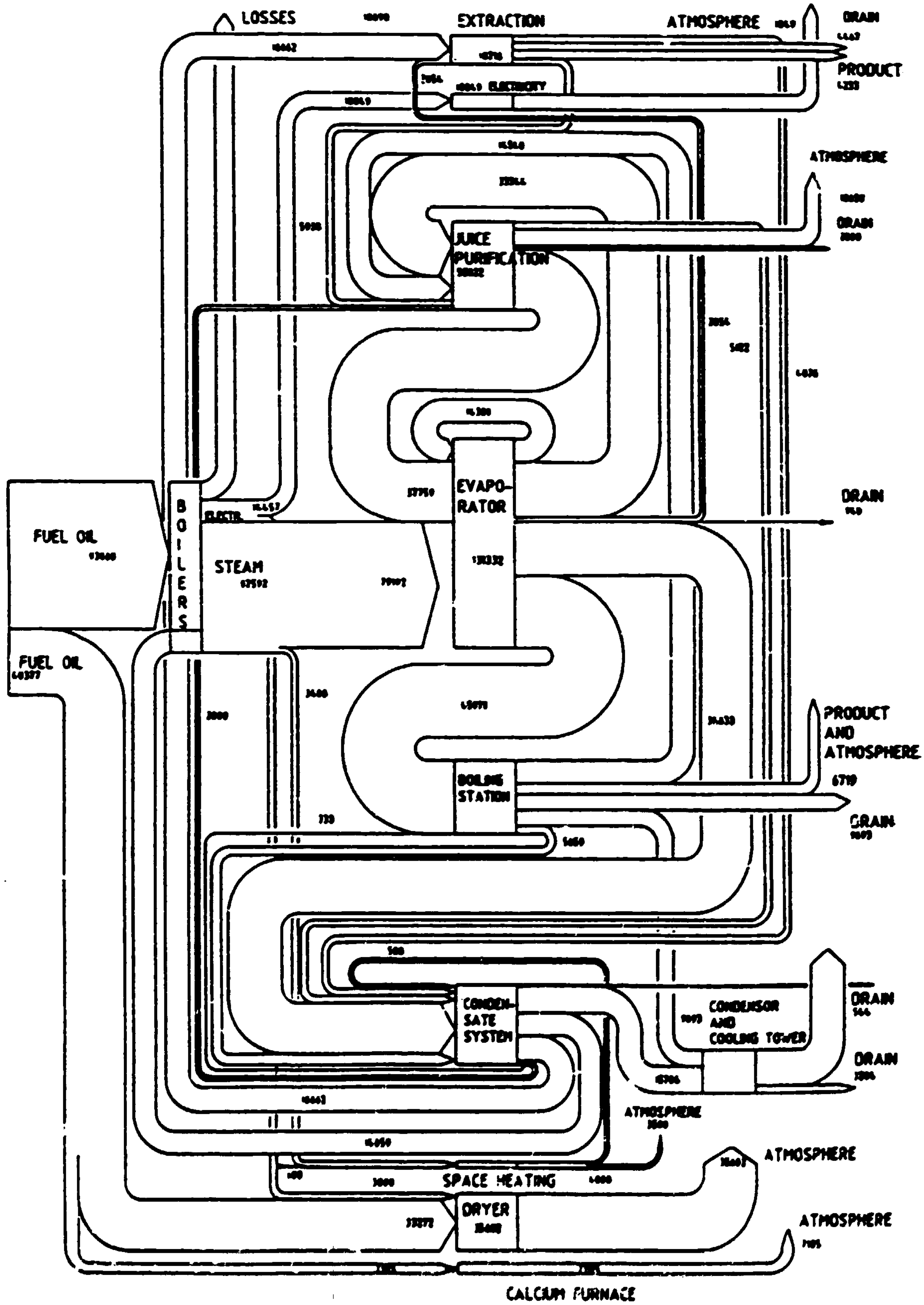


A list of general energy conservation measures that are often applicable is given below. It must be noted that these are just a few examples of all the different types of measures that exist.

- adjusting the burner to improve combustion efficiency
- installation of burner control equipment
- burner replacement
- tightening of boiler enclosure
- installation of economizer or air preheater
- installation of heat exchanger to utilize the energy content in the bottom blowing
- improved water treatment and water analysis for the boiler system
- increased condensate return
- repair of faulty steam traps
- insulation of steam and condensate lines
- sealing ot steam leaks
- reduction of flash steam
- cutting off peak loads by checking regulators and control equipment
- utilization of flash steam
- installation of a pressurized feed water tank
- installation of water flow or steam flow control equipment
- installation of temperature control equipment
- installation of heat exchangers to recover energy in waste heat flows
- tightening of compressed air systems
- utilization of waste heat from air compressors and refrigeration systems
- reduction of idle operation time losses

In addition to the energy conservation measures, the conversion to domestic or cheaper, alternative fuels is of great importance and this is also be studied.

All identified measures are described and the estimated energy savings, cost savings and requisite investment costs are presented for each of them. The measures are presented in the form of annual measure packages and the measures with the shortest pay-back period are given priority.

It is essential to clearly determine if each single measure or a combination of measures affecting each other will result in any negative situation when it comes to e.g. additonal maintenance costs, additional operation costs, production output, product quality etc.

It is also of great importance to indicate all eventual environmental improvements that will result from the identified energy conservation measures.

Some of the identified and evaluated measures can be immediately implemented by the factory, measures that do not need a detailed design or any further feasibility studies. By implementing these measures an immediate energy cost saving will be achieved.

However, a number of measures identified will need further investigation in the continuing feasibility study.

2.4 Feasibility studies

With the help of the feasibility study, the final decision should be made whether the technical, financial and economic prerequisites for the identified energy conservation measures exist and whether they shall be implemented or not. In the feasibility study, therefore, all of the elements that will influence the energy conservation measures should be defined and critically examined on the basis of alternative solutions. The result of these efforts is then a measure whose background conditions and aims have been clearly defined, e.g. the location selected, the appropriate technology and mechanical equipment, the scope of the investment etc.

The following is done during the system evaluation:

- preparation of system drawings

- detailed energy and power calculations

- determination of the proper level of the control systems

- preparation of working drawings

- preparation of schedules of parts

- calculation of energy cost savings and investment costs in the form of engineering design costs, equipment capital costs, installation costs, operation and maintenance costs.

- a calculation of the internal rate of return
- a sensitivity analysis, i.e. the influence of variations in energy prices, energy savings, investment costs etc. on the financial aspects of the measure.

2.5 Implementation Plan

In the implementation plan the optimum order of implementation for all the measures shall be presented. Preferably, this can be done in the form of annual measure packages.

A suitable number of years during which the implementation will take place is determined. This is usually a 2-5 year period. The measures to be implemented each year, the correct order of implementation also during each separate year, the energy cost savings, requisite investment costs, additional costs etc are presented in the annual measure packages.

All good house-keeping measures shall be implemented prior to energy recovery measures, process changes and changes in the energy production plant. This is because they generally, have very low pay-back periods and, even more important, that the good house-keeping measures will mean that the equipment needed for the other types of measures will be smaller and less expensive than would otherwise be the case.

Therefore, the correct solution is always, first of all, to reduce the waste of energy and, after that to invest in energy recovery measures, process changes and new energy production plants. In this way, more energy will be saved and the installation costs will be lower.

3. Company Organization

In accordance with the work schedule, the organization of a company's energy activities and the training of company personnel in such questions are all part of an energy conservation project. It has been shown to be imperative that one person is made responsible for company energy matters, if properly implemented measures and satisfactory results are to be achieved. Company management must realize the role played by this individual in the determination of company profits. The person responsible for energy might well have assistance from an energy saving committee, whose members should stimulate interest in energy questions in the various departments. The person in charge of energy matters, and indeed members of the energy saving committee, should have a practical technical background.

A careful and regular follow-up programme to ensure control of the company's energy position is necessary if achieved energy savings are to be maintained. This is equally applicable following straightforward measures to reduce energy wastefulness.

4. Case studies on the Experience of Energy Conservation in Swedish Industry

4.1 An integrated heating and cooling plant at a Swedish dairy

It is necessary to question the old, conventional solutions and systems when carrying out a preliminary study for a new industrial plant in order to create conditions for new ideas and possibilities for the introduction of new, modern techniques.

During the preliminary study for the new consumer milk dairy in Malmoe, owned by Scania Dairies (Skånemejerier), great efforts were made to ensure that future energy costs would be kept to as low a level as was practicably and economically possible. The dairy produces standard milk, low-fat milk, cream and Scandinavian sour milk products. The production capacity is 80 million kg milk/year or about 250,000 litres/day.

All processes were scrutinized carefully and all possible modes of operation examined thoroughly. This resulted in, inter alia, different required temperature levels being obtained for both the heating and cooling plants. It was decided at a relatively early stage in the project that the dairy should be built without a steam plant. The highest hot water temperature required at the dairy is 105°C, which is necessary for sterilization purposes and cream treatment. It was also decided that the cooling plant should consist of liquid refrigerating machines with a glycol/water mixture as the cooling agent. Scania Dairies (Skånemejerier) had a temperature requirement of + 2°C for the refrigeration of products and stores, which excluded the possibility of having a normal ice-water plant.

Another goal was to avoid using primary heat for the heat requirements of the building and to utilize recovered low temperature heat, as much as possible, as the heating medium.

The cooling plant comprises threee liquid refrigerating machines, screw compressors, which serve the milk treatment process, the air-conditioning system and a unit with two piston compressors which serves the cold store.

The heating plant consists mainly of two systems, one of which has an outgoing temperature of 70°C and the other an outgoing temperature of 100°C.

The 70°C system consists mainly of the two heat pumps which receive their heat from the condensers of the refrigerating machines, a 70 m^3 accumulator, a number of circulation pumps and two heat exchangers. Hot water is pumped from the bottom of the accumulator to the heat pumps when they have access to condenser heat. The temperature is raised to +70°C and the water is returned to the top of the accumulator. A pilot valve, to check that the flow through the heat pumps is such as to ensure that the temperature after the heat pumps is always 70°C, is controlled by means of a temperature gauge.

A radiator system is also supplied with heat from the accumulator. This system serves the offices, changing rooms, rest rooms, laboratory etc. The dimensioned outgoing temperature for this radiator system is 55°C. The possibility exists to transfer heat to the air-conditioning unit from the same 70°C system if the outside temperature should be extremely low or if the condenser heat for some reason should not be available.

The 100°C heating system also consists of two heat pumps which receive their heat from the 70°C accumulator, a 130 m^3 accumulator, a number of circulation pumps, a heat exchanger, two natural gas fired heating boilers and the heat exchangers for the milk treatment proces and the preparation of washing solutions.

The cooling agent for the heat pumps is R114. Hot water is pumped from the accumulator for 100°C water through the heat pumps where the temperature is raised from 80°C to 100°C and then back to the accumulator. Here too a temperature gauge controls a pilot valve so that the flow through the heat pumps is adjusted according to the hot water temperature on the evaporator side. The temperature must not be under 100°C.

The accumulators are designed to work on the different layers of temperature principle, which is why it is so important that the water pumped in at the top has as high a temperature as possible and the return temperature at the bottom is as low as possible.

The gas fired heating boilers are so dimensioned as to individually be able to meet the total heat demand, both for the proces and space heating.

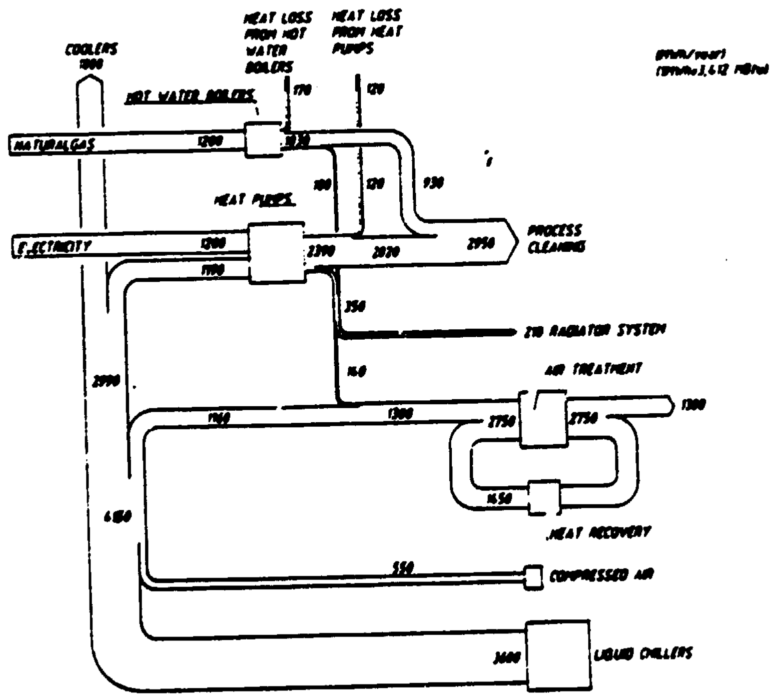
The accumulators also serve as expansion vessels for their respective heating systems. There is a nitrogen gas cushion at the top of each accumulator which makes sure that the pressure is constant.

Control and supervision of the equipment is carried out by means of a DDC-system (Digital Direct Control) with subcenters at nine different locations in the plant, e.g. in the energy center and in the fan room. A system having control functions and a number of optimization functions in the subcenters has been chosen in order to minimize disturbances in the system.

The energy balance for the dairy is shown in the following table and in a Sankey diagram in the table below:

			MWh/year
Primary energy:	Natural gas		1,200
	Electricity for heat pumps		1,200
		Total	2,400 MWh/year
Energy demand:	Process		2,950
	Radiator system		210
	Air treatment		2,750
	Heat losses		290
		Total	6,200 MWh/year
Recovered energy:			3,800 MWh/year

This means that the system solution for the dairy has made a 60% reduction in energy utilization possible.



LOW ENERGY DAIRY
SIMPLIFIED SANKEY DIAGRAM SHOWING THE ENERGY MAINFLOW

4.2 Energy Conservation Measures at a Swedish Slaughter house

Scan Väst in Skara is a slaughter house which also has sutting, curing and meat packing production.

The 1987 energy consumption was 1,396 m^3 oil and 18,400 MWh electricity and the water consumption was 346,000 m^3. The specific energy consumption in 1987 was 251 kWh(heat)/ton total production and 312 kWh (electricity)/ton total production.

These specific energy consumption can be compared with the values for 1981 which was 407 kWh (heat)/ton total production and 234 kWh (electricity)/ton total production.

The specific heat energy consumption has decreased with 38% and the specific electricity consumption has increased by 33%. The main reason for the decrease in the specific heat energy consumption is that a heat recovery plant from the cooling condensers with heat pumps has been installed. However, only 12% of the increased specific electricity consumption depends on the heat pumps. The rest is mainly because of an increased electricity usage by the process equipment.

Further measures have been designed to lower the plant energy costs. These are:

- heat recovery from different types of hot water users

- reducing the water pressure for cleaning purposes

- heat recovery from the ventilation plant

With these measures implemented the specific heat consumption will be 200 kWh/ton total production. This will mean that the heat energy consumption has been decreased by about 50% since 1981.

The following instruments were for this energy conservation project used:

- energy flow meters

- steam flow meters

- water flow meters

- electricity meters

Furthermore, an O_2-analyzer was used to optimize and calculate the boiler efficiency.

4.3 Cogeneration plant

Cogeneration means that both heat for industrial use and electricity are produced in the same plant with great efficiency. The most common cogeneration plant is the backpressure turbine application. For example, if a certain factory requires low pressure at 6 bar the steam could be generated in low presure boilers, but, with cogeneration, it is instead generated at higher pressures, e.g. 60 bar and at a temperature of 480°C. The steam passes through a turbine and is exhausted at the desired pressure, and generates electric power as a by-product.

These cogeneration plants are normally installed in paper mills, textile factories, sugar plants and petrochemical plants etc.

The advantages of an industrial cogeneration plant are the energy savings made and the fact that fewer power failures occur in the factory due to problems in the external power system. The energy savings can be shown by comparing the cogeneration plant with the traditional situation in a country. However, it is important to realize that the energy savings are made at the national level and that the factory can only directly reap the profits from its cogeneration plant if the energy price system is at the right level.

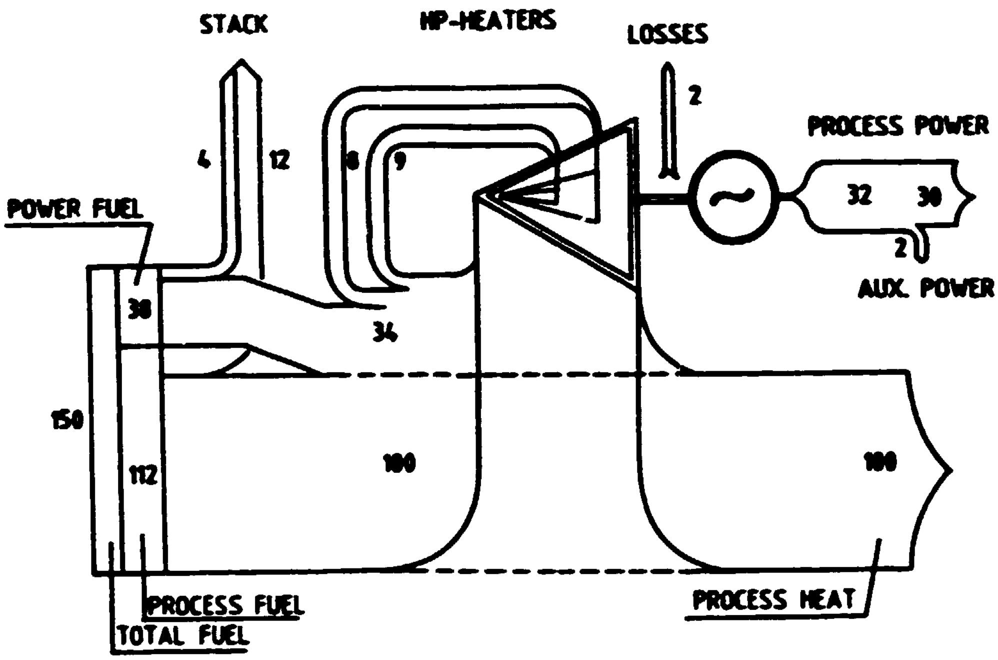
The total efficiency of a cogeneration plant is 85%. The total efficiency of the traditional system is 66% based on the 35% efficiency of the electrical production. This means that the energy savings when these two systems are compared is around 20%. An energy balance for a cogeneration plant and a large condensing plant is shown in the figures on the following page.

However, it is important to notice that the energy savings are made on the national level and the industry can only get the benefits from the cogeneration plant if the electricity price system is the correct one.

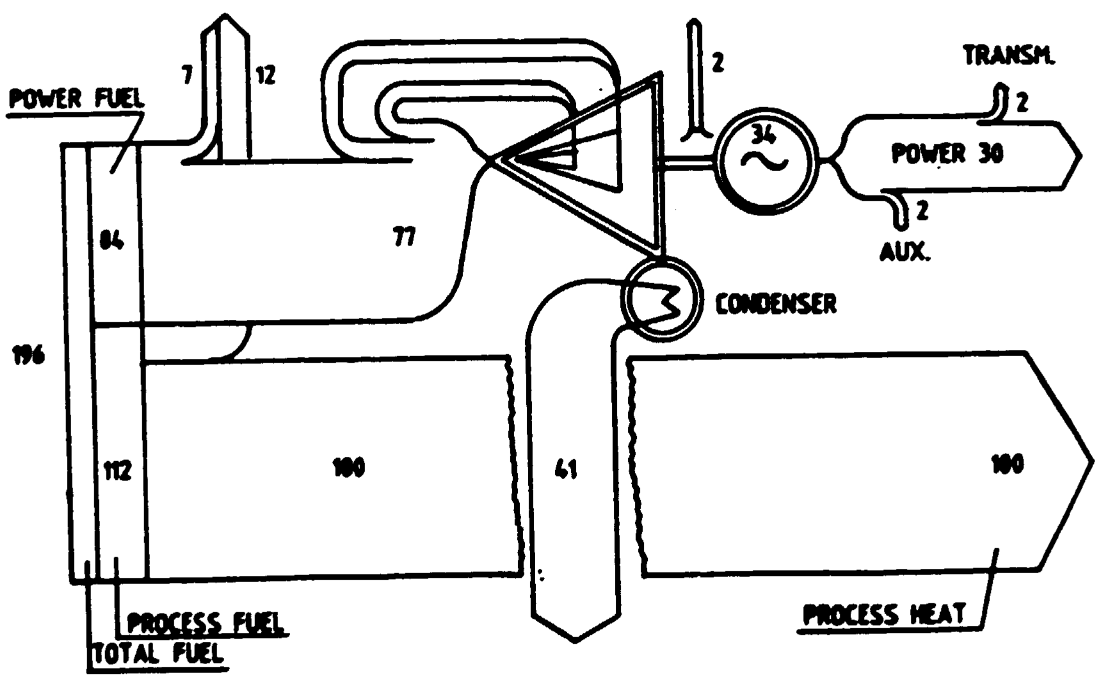
The problem of introducing cogeneration plants in factories is often that electricity prices are averaged or subsidized, which means that cogeneration plants are profitable for the country, but not for the factories which have them.

In Sweden these types of cogeneration plant are common in industry by tradition and because the Swedish marginal electricity price system makes cogeneration financially attractive to industry.

COGENERATION IN INDUSTRY



CONDENSING PLANT AND INDUSTRIAL PLANT



An example would be when a typical saw mill is going to change its boiler because of its age and availibility. The first alternative is to install a new wood fired steam boiler with 10 bar saturated steam and 10 ton/hour capacity. The cogeneration alternative is to install a steam boiler with 30 bar saturated steam at 425°C and 10 ton/hour capacity.

The investment cost of a new low pressure boiler is estimated to be US$1.350,000. The investment cost of a complete, 1 MW electrical output, cogeneration plant is US$2,250,000.

The pay-back time for the marginal investment cost of a cogeneration plant is 3.7 years at a wood price of US$23/ton (45% of the oil price) and an electricity price of US$43/MWh. The specific investment cost in this example is high, US$2,250/kW electrical output, because of the small unit. If the size of the cogeneration plant were increased to 5 MW electrical output or more, the specific investment cost would decrease and the profitability increase.

Another example of using a back pressure turbine in connection with a heat pump in order to utilize waste heat at a sugar refinery is presented below.

Arlöv Sugar Refinery is located in a suburb of the city of Malmö in the south of Sweden. The Refinery produces refined sugar for the Swedish market. It has a maximum capacity of 600 tons refined sugar per day and operates 4,500 h/year.

A decision has been made to expand the Malmö district heating network to the suburb of Burlöv. A pipeline will pass close to the Arlöv Sugar Refinery. Therefore, the idea of supply waste heat from the Refinery to the district heating network was proposed.

Large quantities of heat, in the form of low pressure steam, are available in the Sugar Refinery from the sugar refining process. The steam which is saturated at 65°C, has a mean condensing power of about 10 MW at maximum process capacity 600 ton sugar/-day. Today this steam is condensed and discharged into a nearby stream.

The waste heat will be utilized for internal heating in the Refinery and for district heating at a temperature level between 87°C and 120°C by means a steam turbine and a heat pump system.

The heat pump compressor is a two stage radial turbo compressor, which is driven directly by the turbine via a gearbox. The rotating speed of the compressor is 4,050 rpm. Due to process demands the evaporator is completely made of stainless steel.

The evaporator condenses water steam from the sugar process on the outside of the tubes and evaporates refrigerant on the inside of the tubes. There is a liquid separator drum in the system. From this liquid separator there are connections to the horizontal evaporator by separated downcome and rise tubes. An ejector is installed in the downcomer to improve the natural circulation in this system. The ejector is driven by flashing refrigerant from the condensor.

The steam turbine is an axial high speed turbine. It is connected to the generator by a gearbox. The rotating speed of the generator is 1,500 rpm. The generator is introduced into the system because the sugar refinery needs more electricity and because the control range of the total recovery system is improved with a generator. The generator in the process makes the turbine power independent of the compressor power demand. This means that the turbine control valve does not have to control the shaft speed of the compressor since the generator shaft and the compressor shaft are synchronised with the electrical net.

The steam to the turbine is produced by an existing coal fired boiler.

In the hot water system the heat pump condensor and the steam turbine condensor are in series. This means that the heat pump does not need to reach the final outlet temperature. This means a simple, cheap and highly efficient heat pump process. The outlet steam from the turbine is used to peak the hot water tempeature. This heat pump steam turbine process makes it possible to reach temperatures of up to 120°C.

When the heat pump steam turbine plant is running at design capacity it will recover 10.5 MW from the sugar process, and produce 16.9 MW hot water with a live steam heat demand of 6.4 MW. The process COP value is then 2.64. When the plant is generating 500 kW electrical power at full load the process COP value is 2.23 and the total hot water output is 18.9 MW.

5. Co-operation with Developing Countries

ÅF-Energikonsult AB has been working with industrial energy conservation worldwide for over 15 years and our experience in this field in Sweden goes back much further. The projects which we have carried out in developing countries have been financed by different development agencies e.g. the Swedish International Development Authority, the Swedish Agency for International Technical and Economic Cooperation, the World Bank, the Inter-American Development Bank, UNIDO and the UN.

They have shown that factory energy utilization can normally be reduced by 25 - 40% at the cost of a very reasonable investment, and that reductions of 10% energy utilization can be achieved by simple measures having pay-back times of well under a year.

The following case study of the Misr/Helwan Spinning & Weaving Company, Cairo, Egypt is presented as an example of know-how transfer in an energy conservation project.

5.1 Background

The energy conservation project for this plant was jointly financed by BITS, the Swedish Agency for International Technical and Economic Cooperation, and OEP, the Egyptian Organization for Energy Planning. Personnel from the latter participated in the work to facilitate technology transfer.

The Misr/Helwan Spinning & Weaving Company in Egypt is a comparatively large textile industry with an annual bleached fabric production of some 65 million metres. The raw material comprises both cotton and synthetic fibres. The company consists of two spinning mills, seven weaving mills, a finishing mill and a mill for ready-made clothes production.

The size of the plant necessitated setting limitations for the project. Since the biggest scope for energy savings in a textile plant is generally in the wet processing sections, it was therefore decided to concentrate the project on steam production in the boiler central and the utilization of heat in the finishing department.

5.2 Energy Audit and Energy Balance

There was a great shortage of measuring instruments at the plant and the existing ones were often malfunctioning. Therefore, the energy audit was performed with the aid of portable instruments, which were handed over to OEP following project completion. The energy audit was carried out in one week by a team of four experts from ÅF-Energikonsult, assisted by a number of engineers from the plant and from OEP.

An energy balance, based on the energy audit, was produced. This shows how the energy at the plant is produced, distributed, utilized and discharged, providing an excellent overview of the energy situation for the entire plant.

The first step in the process occurs at the boiler central, where three different oilfired steam boilers, annual consumption 26,400 m^3 heavy fuel oil at a cost of approx. US$4 million, produce high pressure superheated steam, 290 GWh/year. The steam pressure is reduced by means of a backpressure turbine and a reduction station. Low pressure steam is distributed mainly to the finishing department where it is used for heating purposes, direct heating and indirectly in heat exchangers, in different processes.

Substantial heat losses occur in the boiler central due to incorrect operational procedures in respect of load management. For example, steam is vented to the atmosphere during low loads in the production department in order to maintain a higher load on the two old base-load boilers. The fact that these rather inefficient boilers are operated as base-load boilers results in unnecessarily high flue gas losses. There are steam distribution losses due to the fact that reduction is not totally done through the turbine, but also by means of a pressure reduction valve. Further distribution losses are due to insufficient insulation and leakages.

Most of the low pressure steam produced is distributed to the finishing department, in excess of 200 GWh/year, and the biggest energy consumers are the two bleaching lines and different dyeing and washing machines. The steam is mainly used to heat water baths for dyeing and washing the fabrics. Temperature control of these baths is mostly by hand, which often results in maximum boiling and unnecessarily high energy consumption. Furthermore, water consumption is high, mainly because the water baths lack flow controllers. After being used in the processes the hot water is discharged directly to sewer.

Indirect heating allows the possibility of returning the hot condensate to the boiler central, thereby saving energy and valuable treated water. Despite the fact that the plant has a condensate recovery system, only 20% of the condensate that could be recovered is returned to the boiler central, the remainder goes to sewer.

Close cooperation with plant personnel is another vital factor in the determination of an energy balance. They can provide information on operation and production procedures, and other valuable data. After all, they are best informed on how the plant operates.

5.3 Energy Saving Measures and Pay-back Periods

On the basis of the energy balance and all other information obtained, a feasibility study of measures that would reduce energy costs was carried out. The energy savings potential turned out to be substantial. The following are some examples of the energy saving measures proposed:

1. Changing operational procedures at the boiler central to avoid venting steam during low production and to improve load management, ensuring that the most efficient boiler has the main load. This would result in saving some 1,500 m^3 fuel oil, then equivalent to US$230,000. Only minor investments were required in developing new operation procedures and training personnel.

2. Repairing faulty steam traps would save approx. US$180,000, with a pay-back period of only a few months.

3. The installation of water flow control to minimize the continuous discharge of hot water to sewer from some of the washing baths in the bleaching lines and from washers would reduce energy costs by US$ 340,000/year, with a pay-back period of just over a year.

4. The installation of heat exchangers to recover heat discharged to sewer, in order to preheat incoming water for eight different machin The total saving potential for these machines was appro . 31 GWh/year and the pay-back period varied from between six months to under four years, depending on the different condition of the machines.

In total, some 25 energy saving measures were proposed, including training programmes for the personnel, improvements to operation and maintenance procedures, and the installation of additional measuring instruments.

It was proposed that the measures be implemented in the form of annual measure packages over a three year period. The first annual measure package, mainly simple measures, would result in energy savings corresponding to US$410,000. The pay-back period was 1.1 years. The second package, somewhat more complicated measures, would result in energy savings corresponding to US$ 680,000, and have a total pay-back of 1.7 years. The last measure package would result in energy savings corresponding to US$500,000, and have a total pay-back period of under two years.

5.4 Summary

The total, the savings potential at the Misr/Helwan Spinning & Weaving Company is approx. 35% of heat energy costs, by only implementing measures with pay-back periods of less than one year. The implementation of more costly measures, with pay-back periods of up to three years, would mean a savings potential of 50% of heat energy costs.

A separate co-generation study shows that there is a good possibility of increasing internal electricity production, thereby reducing energy losses in pressure reduction.

Some of the simple low-cost measures have already been implemented with excellent results and discussions are ongoing on how to arrange financing for the more costly ones.

Another example of technical transfer between Sweden and developing countries is that ÅF-Energikonsult every year arrange training courses commissioned by the Swedish Agency for International Technical and Economic Cooperation (BITS) The training courses are in Industrial Energy Conservation and Energy Conservation in Sugar Plants. They are 4 week training courses for 24 participants. Half the course is theoretical and the other half consists of practical training in Swedish factories.

6. Conclusion

The similarity of results achieved by energy conservation project in Sweden and developing countries point clearly to the fact that energy savings potentials and the possibilities for environmental improvements are equally great for industries in all parts of the world.