DISTRICT HEATING

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Energy Conservation Through Utilization of Industrial Waste Heat

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Sweden is highly dependent on fossil fuel for its energy supply, and it has no fossil fuel deposits of its own. About 78% of the energy consumed in 1975 was imported. Due to the Country's difficult energy situation, it has been forced to develop an economical energy technology.

If we regard the energy-converting process from primary energy in oil or coal to heat or mechanical work, we find that this conversion often takes place at a high temperature level—for production of high-pressure and high-temperature steam, as industrial processes often need this high level. Furthermore, often only a smaller part of the energy remains in the product. The greatest part of the energy supplied to the industrial process is emitted to the environment in the form of hot water, hot air or hot gases.

In the pulp and paper industry, generally all energy leaves the plant in the form of low-rate heat. For the iron and steel industry, it is common that more than 50% of the supplied energy leaves the mill as hot air and/or hot gases. In the power industry, the energy loss is generally higher than 60% and here this part of the supplied energy is removed in the form of warm cooling water.

If, instead, we study the energy consumption for heating of dwellings, business and office buildings as well as hospitals and other public institutions, it will be found that even if the chemically bound energy in the fuel is released at a high temperature in a boiler, the heat energy will be used at a low temperature level. A central heating plant has, furthermore, a low efficiency. I would like to call this a "double-energy crime" as first, the energy is wasted in small plants with a low efficiency; and second, in spite of the fact that energy in the fuel is released at a high temperature level, we do not use this possibility for production of high-rate electrical energy.

Energy saving can be achieved by:

1. Combining Industrial Processes. In the pulp and paper industry, steam with a temperature of about 300 C (572 F) is needed (Fig. 1). By generating steam, with a high pressure and temperature, a turbine can be connected between the boiler and the heat consuming process, and thus produce more electrical energy at the same time. This is called "back-pressure power production."

   In the steel industry (Fig. 2) the chemically bound energy is released at a high temperature level, and the energy that is not bound in the product leaves the process as hot gases with a temperature of 600 to 800 C (1112 to 1472 F). In such a process it is possible to produce steam with the hot gases, either for condensing power production; or for back-pressure power production, if there is need for low-pressure steam in the plant.

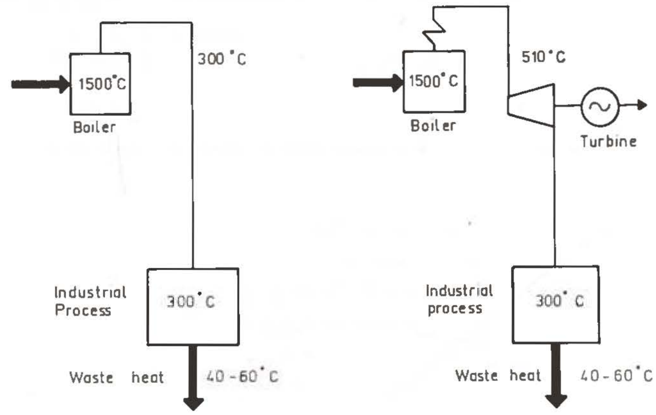

Fig. 1—Pulp and paper industry.

2. Combination Industrial Process—District Heating System. Another way to save energy is to combine an industrial process plant with a district heating system for heating of houses and other buildings. During the last few years, such energy combinations have been seriously considered in Sweden, and two such projects are described:
   a. One case is a sulphuric acid plant situated next to a population center in the south of Sweden. The burning of pyrites generates steam which is used first for heat consumption in the chemical plant. The steam, used at a low pressure, first passes a back-pressure turbine in which the heat drop is utilized for generation of electrical power. The back-pressure steam that is not used in the industry processes, goes to two heat exchangers where the heat energy is transferred to the district heating network of the City. The maximum supplied effect is 40 MW. The annual oil saving has been calculated to 15,000 m^3 which corresponds to a cost of about $1.3 million.
   b. The most interesting project that Energikonsult now deals with is the cooperation between Pitea town and Lovholmens Bruk. The town of Pitea has about 35,000 inhabitants, and the construction of a district heating network has just been started. The buildings to be connected to the district heating net have, actually, a maximum heat demand of 14 MW.

According to plans, the connection to the district heating net should be increased by about 6 MW/yr and reach 86 MW in 1987. Lovholmens Bruk, a pulp and paper mill with an annual production of 400,000 tons of kraft liner (Fig. 3), is situated outside of the town. The mill has a great excess of hot water: from a scrubber after the recovery boiler in the pulp mill; from the condenser after the last process in the liquor evaporation plant; and from unutilized heat as flash steam from the cooking plants.

The hot water from the condenser, after the last process in the liquor evaporation, has, however, too low a temperature to be used in a district heating system; however, by changing the process it is possible to raise the temperature level. Steam is extracted between the second and third processes, and the available heat is then 9.8 MW maximum. To achieve this, about 6 MW as primary steam must be supplied to the first process in the evaporation plant. Thus, the hot water production in the condenser, after the fifth process, will be decreased. This, however, is of no importance as the mill has an excess of hot water. In this way 9.8 - 6 = 3.8 MW waste heat can be supplied to the district heating system. It is thus possible, by supplying 6 MW primary energy, to get 9.8 MW heat energy. By using this method (adding a small amount of primary energy), the same results can be obtained in other plants.

If we look at a simplified diagram (Fig. 4) of a condensing power plant, we can see that to produce 200 MW electrical power, 468 MW must be added from the power station boiler. Of this heat amount, about 268 MW disappears with the condenser cooling water at a temperature of about 15 C (59 F); such a low temperature level that the energy cannot be used for heating purposes. When steam passes the turbine, the pressure and the temperature of the steam fall; and the heat energy is transformed to mechanical energy; and in the generator, to electrical energy. A part of the steam can be extracted at a place where the temperature is high enough to produce hot water for district heating purposes. If this extraction from the turbine corresponds to 204 MW, the steam flow and supplied heat to the turbine must be increased about 30 MW to maintain the electrical effect of the turbine. Of the heat flow delivered to the district heating net, only $\frac{30}{204}$ = 15% is primary heat. The cooling water losses will then decrease from 268 to 94 MW. What is then attained? By adding a small part of primary energy, a part of the cooling water losses at a low temperature level can be converted to primary energy at a sufficiently high temperature level to be used for heating purposes.

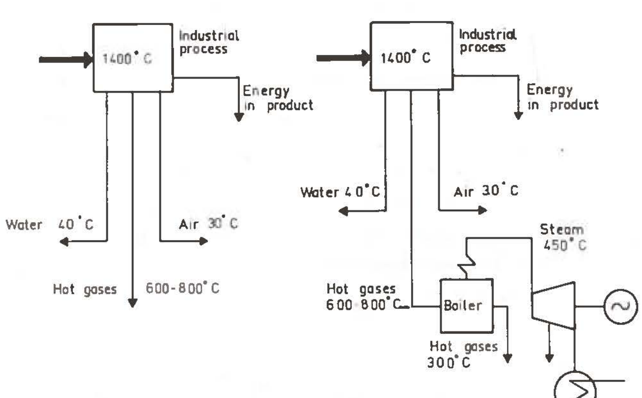

Fig. 2—Iron and steel industry.

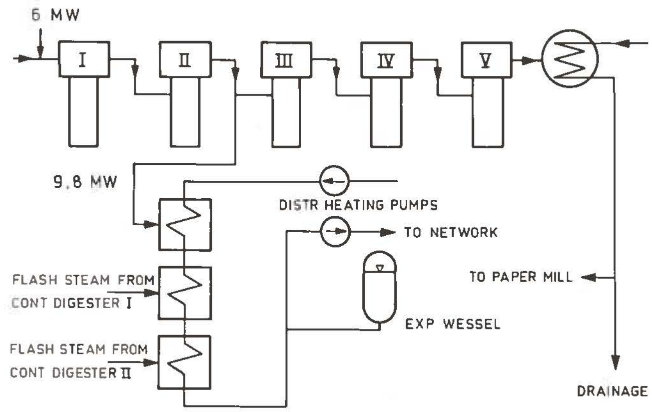

Fig. 3—Lovholmens Bruk pulp and paper mill.

In the above mentioned case, the energy which is supplied to the district heating system has what I call a valence of 0.85 (85% of it is mere waste heat). How high valence can be achieved by extracting heat for district heating purposes from a condensing turbine depends on the steam admission conditions, size and design of the turbine.

By making the waste heat at the power production usable and profitable to sell, a low energy cost and a cheap power production will be achieved. About 50 Swedish towns have district heating systems, and in 14 of these the heat production is combined with power production.

Energikonsult was commissioned by The National Swedish Industrial Board to perform a study about the possibility of using waste heat from industry to heat population centers by means of district heating systems. Because of their size, it is the pulp and paper mills, the iron and steel works, and the chemical industries which are the chief consumers of energy in the industrial sector in Sweden, and it is these industries that one would, therefore, expect to be the most important generators of waste heat. The number of companies in the investigation is 300, and their share of energy consumed by the whole Swedish industry is 73%.

According to the results of the waste heat study, in the autumn of 1975 the amount of waste heat available from industry for district heating purposes amounted to the equivalent of at least 160,000 m^3 of fuel oil a year. This quantity can be recovered by familiar techniques. With new technology, 185,000 m^3 of fuel oil a

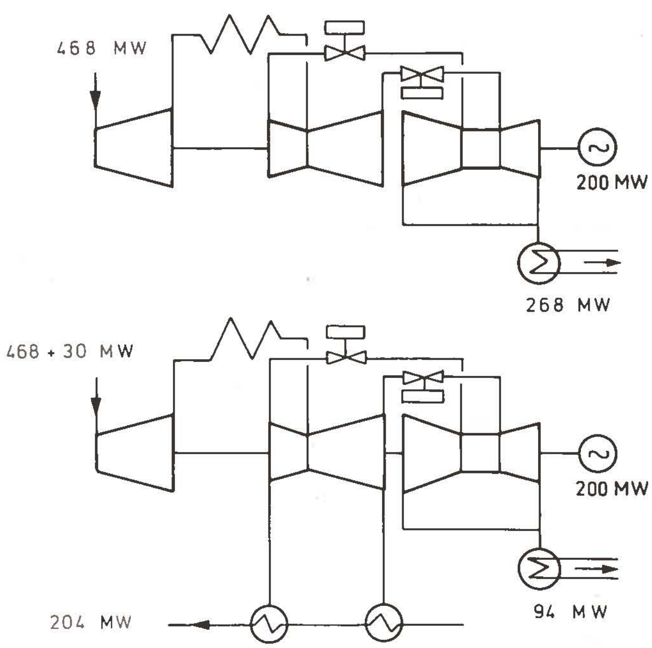

Fig. 4—Reheat condensing turbine (above). Reheat district heating-extraction condensing turbine (below).

year can be saved at the turn of the century. In addition to this potential source for district heating, secondary heat corresponding to somewhat more than 210,000 m³ of fuel oil a year might be used internally for heating the premises of the above mills and works.

The above figure of 185,000 m³ of fuel oil does not include the gain in efficiency obtained in relevant cases by changing from individual boilers to district heating; but if this is taken into account, the potential saving of energy would be increased by more than 55,000 m³ of fuel oil a year.

In addition, there are iron and steel works where the recoverable secondary heat cannot be utilized for district heating. Here we are concerned chiefly with combustible or very hot gases, and the reason that this secondary energy cannot be utilized is that there is no urban center in the vicinity, or that the amounts of waste heat are so great that they more than cover the town's heating needs. In these cases, however, the secondary energy is of such "high quality" that it can be used for the production of electric power. If the electric energy which can be obtained in this way should instead be produced from oil-fired condensing steam power plants, some 150,000 m³ of fuel oil a year would be needed.

To summarize, the investigation shows that if industrial waste heat is systematically utilized for heating purposes and for the generation of power, it should be possible to effect the following savings in fuel oil:

—Domestic space heating	185,000 m³/yr
—Power generation	150,000
—Heating of industrial premises	210,000
—Gain due to losses obtained by dispensing with individual boilers	55,000
Total	600,000 m³/yr

The value of this total annual saving of about 600,000 m³ of fuel oil is about $50 million.

The figure of 600,000 m³ is somewhat more than 10% of the total annual delivery of fuel oil to Swedish industry, and about 6% of the volume supplied for space heating in residential areas. Considered in relation to the annual consumption of oil products for the whole country, the potential savings amounts to about two per cent.

The investments in waste-heat plants in factories and in trunk conduits from the factories to the district heating network is calculated to be $2.75—$3 per saved m³ of fuel oil a year.

As a measure of profitability we have used what we call the gross rentability—that is, the percentage ratio of the net annual gain (saving in fuel less the running costs) to the investment. The gross rentability calculated in this way is, on the average, 30% with a variation of 15 to 75%.

We hope that the experiences in Sweden may be of use to others in today's energy situation. ✷

1978 MEMBERSHIP DUES

Company Classifications

Dues for all classes of company membership will remain at the 1977 level. Utility companies will be invoiced on the basis of their steam sales for the calendar year 1976 as reported to the IDHA Statistical Committee; but according to the calculation formula established in 1971.

At the September 22, 1977 Board of Directors Meeting, action was taken to set an annual dues rate for non-continental utility companies; that rate will be $50, which is the minimum charged continental utilities.

Allied and Affiliated dues will be $75; Associate, $40. Dues for these three company classes have not been increased since 1970.

Personal Classifications

Rates for all personal classifications will be the same as in 1977: $30 for Allied, Affiliated, Associate, and Individual. All company members must have at least one personal member who shall be designated the company's official representative in IDHA; but personal memberships are not limited to any specific number.

The special type of personal membership called "Individual" is just that—"Special." Eligibility for this classification is limited to those persons whose qualifications comply with the specific conditions designated in the IDHA Constitution; and applications for this class must be approved by the Executive Committee before they can be presented for approval to the Admissions Committee and the Board of Directors.

(This notice of the dues structure for the 1978 calendar year is in accordance with Article V Section 5 of the Constitution of the International District Heating Association.)