HOW TO SITE SMALL POWER STATIONS

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1. General characteristics of small power stations

a) They have a small capacity, generally 1 to 20 MW, the capacity of the turbo-generators being below 10 MW.

b) They generate energy for large industrial plants or several small factories with the main purpose of *supplying heat* (industrial steam or heat energy) and the secondary purpose of providing electric energy.

c) They produce power and heat energy for smaller towns and housing estates.

d) Local power stations are connected with the national network, i. e. they produce electric energy for the use of the national network and take energy from it. The small power stations are located between the national

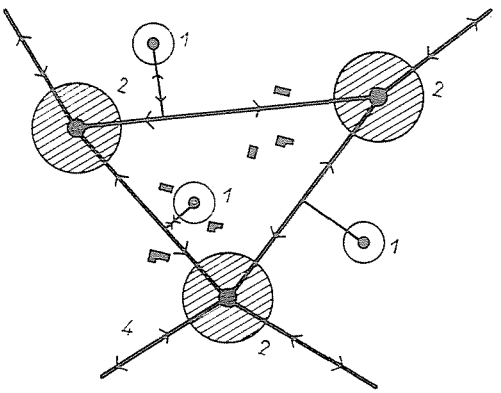

Fig. 1. The place of small power stations in the power system of the country: 1 — small power station; 2 — condensation power plant; 3 — housing estate; 4 — power transmission line

public power plants, they cooperate with them and satisfy the local demand on energy (industrial plants, factories, towns, housing estates) (Fig. 1).

e) As to heat supply, small power stations are self-supporting and isolated.

f) They generally use back-pressure turbines or condensing turbines with extraction.

g) They are usually located far from coal mines, directly adjacent to the consumers, so the fuel is transported to the stations. It is preferable to use oil or gas (local fuel).

h) Small power stations dispose of a reduced number of boilers and turbo-generators.

i) Their structure and architecture is less complicated than that of large public power plants.

2. The purpose of small power stations

Small power stations are known to be less economical than high-capacity power plants as concerns investment costs and specific heat consumption. Consequently it is important to establish power stations with a higher capacity and larger machine units and to restrict the building of small power stations. But, in spite of their relative uneconomicalness, they will be presumably necessary for 20 or 25 years more. Namely:

a) The electric energy and heat energy necessary for the new factories has to be supplied by local production or — if possible — taken from the national network. Since the dimensions of the power station depend mainly on the amount of available (or economically transportable) fuel, on the location of the consumers and their need of electric energy, the establishment of small industrial power stations may be justified.

b) The large power plants are, at present, in the northern and western regions of the country. They cannot satisfy, even in case of a co-operation network and a transmission-line system, the increased local demands of the entire country, especially those of the new industrial establishments in the South-East.

c) The large number of recently established factories necessitate to build and operate small industrial power stations.

d) The small power stations increase the safety against breakdown in the factories, and they can be adapted better to the rapidly changing requirements without causing a lag of production.

e) These power stations can be located in factories and plants in a way to facilitate the transmission of heat energy to the consumers.

f) Local fuel can be used very well.

g) There are factories requiring a special degree of heat for their technology; this can be supplied advantageously by small power stations (paper or sugar production etc.).

h) Instead of the outdated, inefficient boilers in one or several factories, it is more economical to use small power stations simultaneously producing heat and electric energy.

i) Concentrations of industrial plants can be served economically by small power stations.

j) Town and district heating by heat power stations is economically advantageous.

3. Siting small power stations in new or pre-existing industrial plants

The small power stations are characteristically heating stations and, therefore, closely connected with the plant, the factory or the town. The detailed lay-out plan determines not only the place of the power station and the factory buildings, but also the order of the building process, and the possibilities of extension both for the factory and the power station and it may settle the central position of the power station.

If the power station is to be built in the site of an existing plant, factory or town, its place is mostly determined by the given lay-out. It is advantageous for the small power station if the given lay-out offers different ways of placement. Then it is important to choose the one giving the best possibilities of exploitation both to the factory and the power station at a minimum of production costs of heat and electric energy.

4. Viewpoints of locating small power stations

The questions of locating grow in importance because it is becoming more and more difficult to achieve further advantages in the field of heat consumption by the means of technological and structural changes, and the cost of generated energy is increasingly dependent on the location conditions. Thus the choice of the site of a power station is a decisive factor in the costs of transporting fuel and water, or transmitting electricity and heat, as well as in building costs and general investment, i. e. the estimation of rentability. The following details are to be considered:

a) Size of the site and possibilities of extension. Area demands of small power stations are different, the specific demands, however, exceed those of large power plants of 200 to 1000 m^2/MW. For instance, one of our small power stations equipped with two boilers producing 15 t/hour and a turbo-generator of 2 MW is sited on 10 000 m^2 (Fig. 2). Here the area demand is increased by the large coal deposit. The tobacco-factory of Linz was built in the thirties on a site of 250 × 140 m (Fig. 3), of which 100 × 40 m were designated for the small power station, insufficient to coal storage and prejudicial to railway service. There is no possibility of extension, the factory buildings are soiled by the by-products of the power station. The only advantage of the lay-out is the central position of the station.

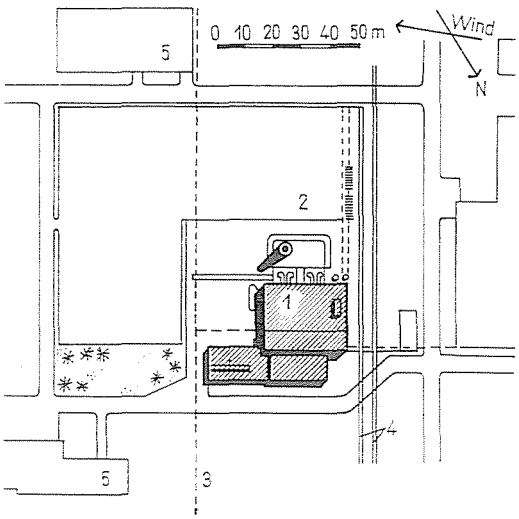

Fig. 2. Lay-out of a small industrial power station: 1 — power station; 2 — coal-storage; 3 — steamline; 4 — rail-track; 5 — existing factory buildings

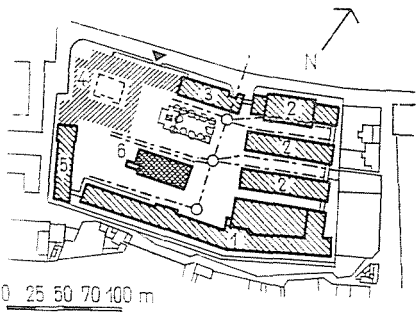

Fig. 3. Lay-out of a tobacco-factory: 1 — factory building; 2 — drying room; 3 — factory building; 4 — extension; 5 — service building; 6 — small power station

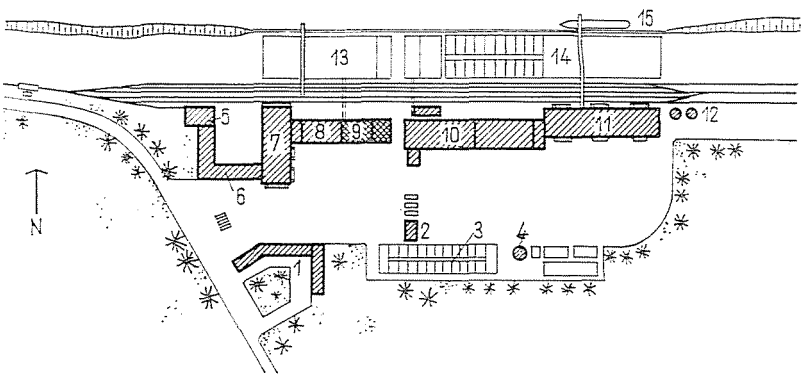

Fig. 4. Lay-out of a sugar-factory: 1 — entrance — garage — service building; 2 — delivery building; 3 — sugar-beet storehouse; 4 — cooling tower; 5 — engine-house; 6 — workshop; 7 — beetroot slice storehouse; 8 — drying room; 9 — power station; 10 — preparatory workshop; 11 — sugar storehouse; 12 — molasses storehouse; 13 — cinders deposit; 14 — beet storage; 15 — river

The space needed by the power station can be considerably reduced by compacting. The power station of the sugar-factory in Fig. 4 is closely connected with the factory unit consuming most of the heat, thus the steamline is considerably reduced and single, instead of several, units of certain buildings and workshops are needed.

In the textile factory Pausa AG. the power station is built together with the repair service (Fig. 5). Thus the service can carry out the repair work

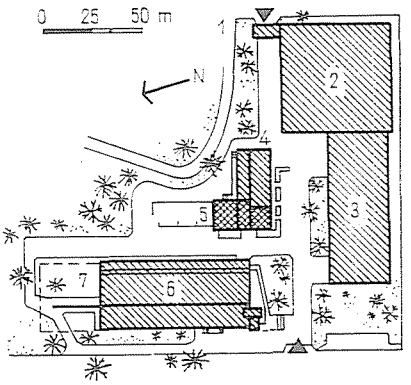

Fig. 5. Lay-out of the textile-factory Pausa A. G.: 1 — entrance; 2 — old weaving mill; 3 — printworks; 4 — repair workshop; 5 — small power station; 6 — new factory and administrative building; 7 — extension

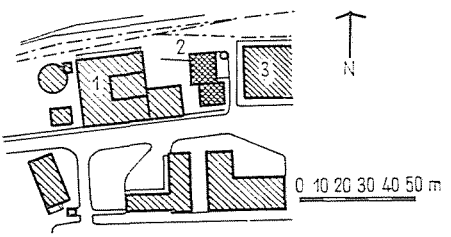

Fig. 6. Lay-out of a small power station (Alcohol-factory in Munich): 1 — instrument factory; 2 — power station; 3 — factory building

needed by the power station. A further advantage of this central position allowing to supply both the old factory and the new one is given by the establishment of one large building, which is architecturally preferable to a number of small, dispersed buildings. The boiler-house of the power station can be extended.

The alcohol factory in Munich disposed of little area to build an oil-fired small power station (Fig. 6). Because of the vicinity of the highly incendiary factory, the power station had to be made fire-proof by means of a multi-layer wall without openings and, on account of the explosion danger, with a flying

roof. The two-volume building has a simple plan and an attractive architectural appearance (Fig. 7).

The building area is determined as a function of fuel type and amount to be stored. It is usually necessary to reckon with a unidirectional extension of the power station.

b) Consumption distance, energy transmission problems. Small power stations produce industrial steam, heat and electric energy and transmit them to

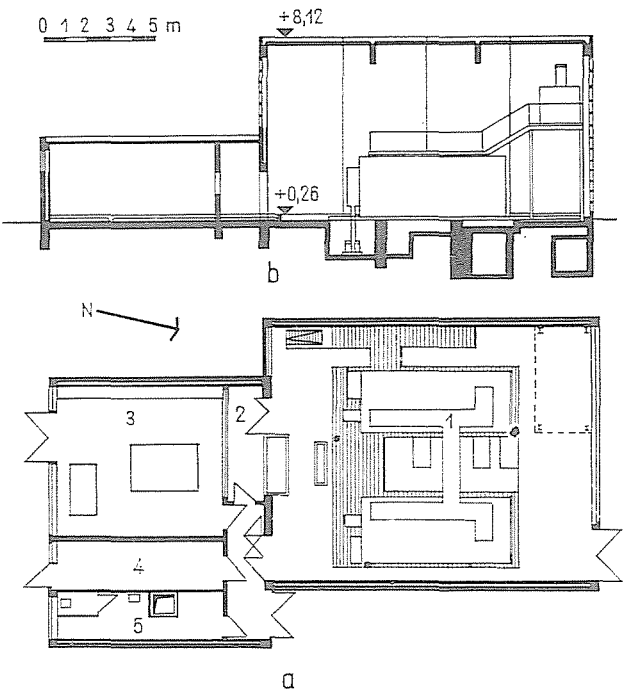

Fig. 7. Small power station (Alcohol-factory in Munich): *a* — plan; *b* — longitudinal section; 1 — boiler-room; 2 — heating room; 3 — machine-room; 4 — storehouse; 5 — lavatory

the consumers, acting in favour of a central position, near to the most important consumers. The lay-out of the sugar factory in Fig. 4 is generally satisfactory, considering the possibilities of road, railway and water transport, the inside technological system of the factory and, first of all, the central position of the power station. Steam lines are short because one of the factories consuming most of the steam is built together with the power station while the other factory is quite near to it. In this case the heat energy produced by the station is charged by a minimum of transport cost.

Since small power stations are not self-supporting in the production of electricity but receive and give electric energy to the co-operation network, it is advisable to establish them in the neighbourhood of a main transmission line,

to reduce the costs of connection. The prescriptions of tracing transmission lines of electricity (air cable or ground cable) must be taken into consideration.

c) Ways of access. When locating small power stations, the possibilities of road or railway access should be considered. These power stations need a considerable amount of transport, particularly the delivery of fuel, thus it is necessary to make use of the railway. If the factory itself does not need railway service, a special railway connection to the power station is hardly justified if not in case of a delivery of 6 to 10 waggons of fuel a day, in order to make transport economical. Gas-fired small power stations don't need any railway service. Besides of access by road and railway it is necessary to make use of

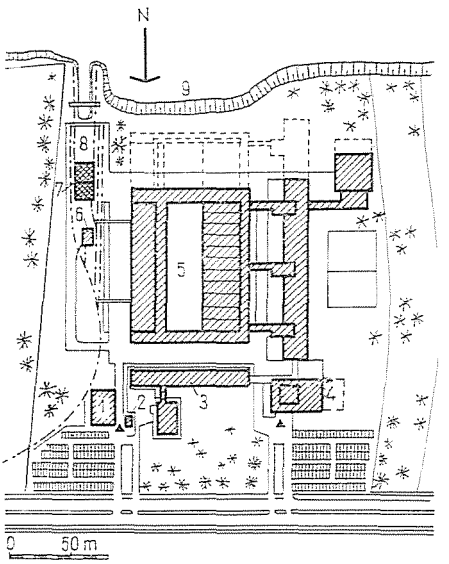

Fig. 8. Lay-out of a factory: 1 — storing bicycles; 2 — entrance; 3 — office — laboratory; 4 — dining hall — kitchen; 5 — factory building; 6 — oil tank; 7 — power station; 8 — coal storage; 9 — river

water transport if possible. Hungarian climate does not allow water transport in winter, then it has to be replaced by road or railway transport. When locating and designing the power station of the sugar-factory in Fig. 4, ways of access from different directions were considered and fully used. The choice of the site was favourable, allowing sufficient space and central location for the power station, adjacent to the factory, thus receiving the proper amount of feed-water and cooling-water and profiting of a good access by road, railway and water. The lay-out of the industrial plant presented in Fig. 8 is very advantageous from many respects, as it offers sufficient space for the factory buildings, their future extension and the establishment of an own power station. The massive block of the factory building is connected with the power station in the North-West of the site by good ways of access, which are used fully and

ingeniously. The power station is accessible from the entrance by a short road and it is circumambulable. The rails flank the power station thus allowing to unload the fuel on both sides. The railway service of the machine-room is solved too, and the possibilities of water transport are well exploited.

d) Fuel supply. Small power stations need a considerable amount of fuel to produce energy and since they have to work in the proximity of the consumers, the provision, transport and storage of fuel may be a very serious problem. If it is possible, small power stations are established together with the consumers in the neighbourhood of the provenance of gas or oil, and, first of all, close to the coal-mine, to allow Hungarian low-calory coals to be used economi-

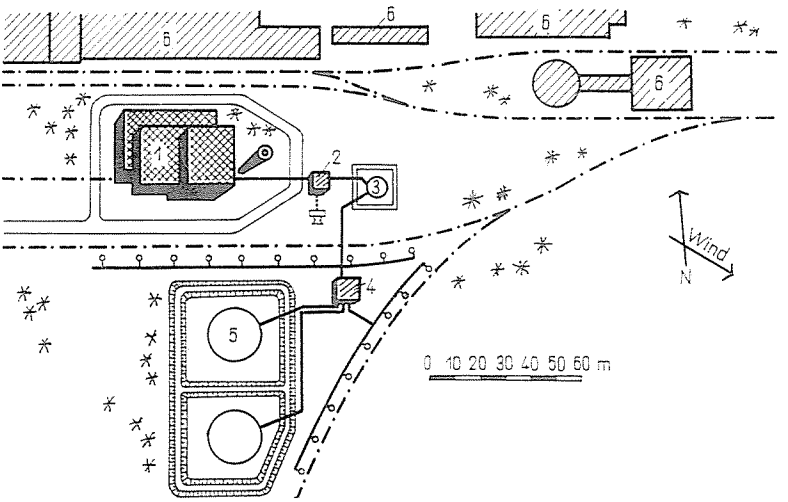

Fig. 9. Lay-out of an industrial power station (sugar-factory): 1 — power station; 2 — pump-house; 3 — crude oil storage; 4 — pump-house for drawing off oil; 5 — crude oil storage; 6 — factory buildings

cally. In conformity with the industry location policy, establishment of new factories and small power stations in the southern part of the country is justified by the local use of gas and oil explored there. Even fuels obtained as by-products from either the same factory or a nearby one must not be left without consideration. Present experience shows advantageous exploitation of power stations firing a mixture of fuels (e. g. coal-dust and oil or gas) in small amounts. To ensure safety and continuity of work, small power stations need a large amount of reserve fuel. In the lay-out seen in Fig. 2, 70 per cent of the available territory of 10 000 m^2 is reserved for storing coal. Storing oil or crude oil needs less space than storing coal, as it is enough to store oil for a month and space is needed not so much for storing as for drawing off oil and observing the minimum distance of 50 m to avoid fire hazard.

Fig. 9 presents the lay-out of a small power station at a sugar factory. It was built on an existing plant area with proper road and railway connection.

The power station is equipped with two 40 t/h capacity boilers and a 10 MW turbogenerator. The building has a simple plan and structure and supplies even the neighbouring canning factory with steam and power. The main volume built in two stages with the same span is surrounded by accessory and service premises of lower height (Fig. 10). The lay-out involved the problem of a large number (18) of spots to draw off the crude oil delivered by railway;

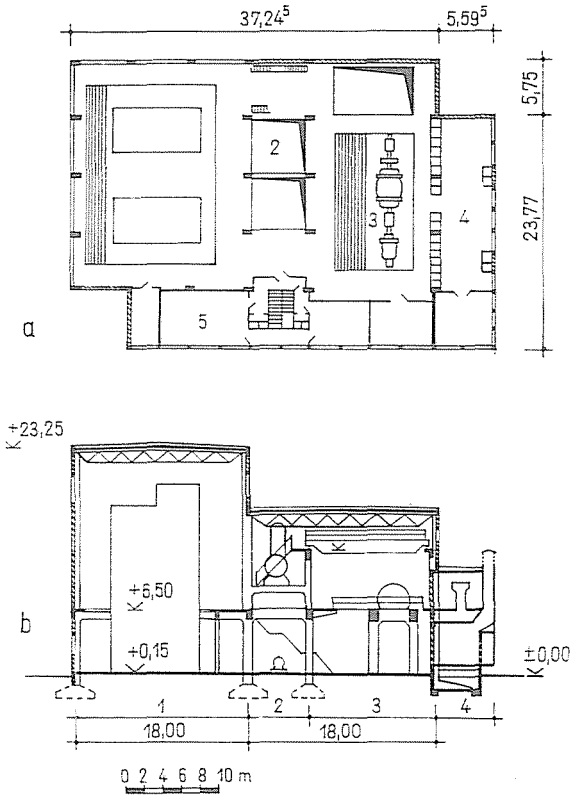

Fig. 10. Plan of a sugar-factory power station: *a* — plan on a level of 6,50 m; *b* — cross-section; 1 — boiler house; 2 — feeding house; 3 — machine-hall; 4 — switch cupboard, transformer; 5 — foreman's office, dressing-room (on the ground-floor: water-softener, store, accumulator)

this required considerable space and a great length of rails. The need of space of the entire lay-out is nearly 17 500 m², hence 1750 m²/MW.

On the site of the power station it is important to provide for the proper storage of a large amount of refuse (cinders, fly-ash) so as not to soil the neighbourhood, or for its immediate disposal. It is essential that the storage or disposal of refuse should not increase the production cost of energy. In case of power stations with oil or gas-firing this means little cost excess.

e) Water supply. The small power stations mainly for heat production are equipped either with condensing turbines with extraction, or more gener-

ally, with backpressure turbines. Thus, cooling-water is needed only for the first type, while all power stations require feed-water to be supplied, prepared, cleaned and softened. It is essential, at any rate, to minimize the costs of getting, preparing or cooling the water. For this reason the availability of water should be seriously considered. The sugar factory in Fig. 4 makes use of the river for both water transport, and the supply of water required by technological processes and by the power stations. If there is no river or lake, the necessary supply has to be taken from a well abounding in water or from an

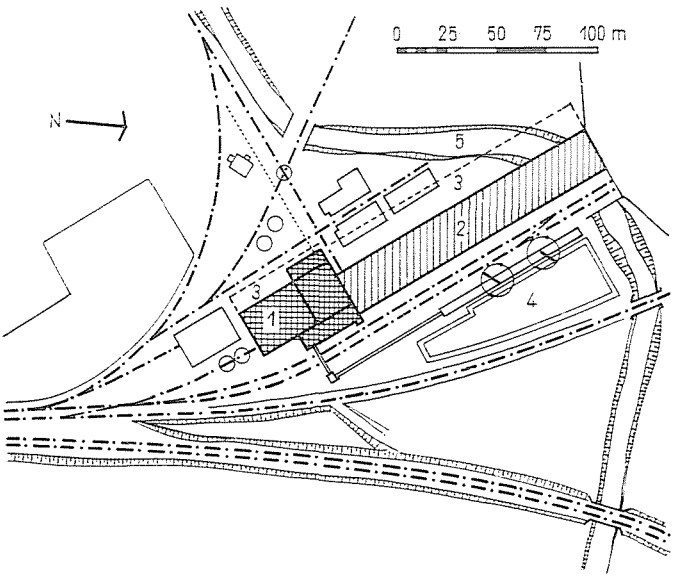

Fig. 11. Lay-out of power station at a paper factory (Dachau): 1 — power station; 2 — paper factory; 3 — extension; 4 — coal storage; 5 — creek

existing network of sufficient capacity. The risk of water stoppage has to be prevented by keeping sufficient reserves.

f) Future extension of the factory. Consideration of future plant extension is a factor in deciding the location of the power station. Correlations can best be considered, if the factory and its small power station are built simultaneously. Thereby the power station can be given a desirable central location, allowing for a later extension of the factory buildings. From this point of view the lay-out of the paper-mill at Dachau is a very good one: the factory building is closely connected with the small power station, thus providing sufficient space for the future extension of both the station and the factory (Fig. 11).

In a concentrated settlement of industrial plants, several factories are served by a common power station. In this case each factory is to be extended within its site, and so is, at least in one direction, the small power station, possibly located centrally between the factories. The concentrated industrial

area of a town in the Hungarian Plain (Fig. 12) has its steam and partly power supply from a central power station designed for oil or natural gas firing.

g) Aesthetical aspects. In addition to the above, certain architectural aspects closely connected to the location of small power stations must not be left without consideration. Integration of the mass of the power station with its high, accented chimney stack to the general view of the factory and adaptation to the aspect of the industrial plant or the factory building are of importance. The cardboard-factory built at Mayen consists of a few single buildings

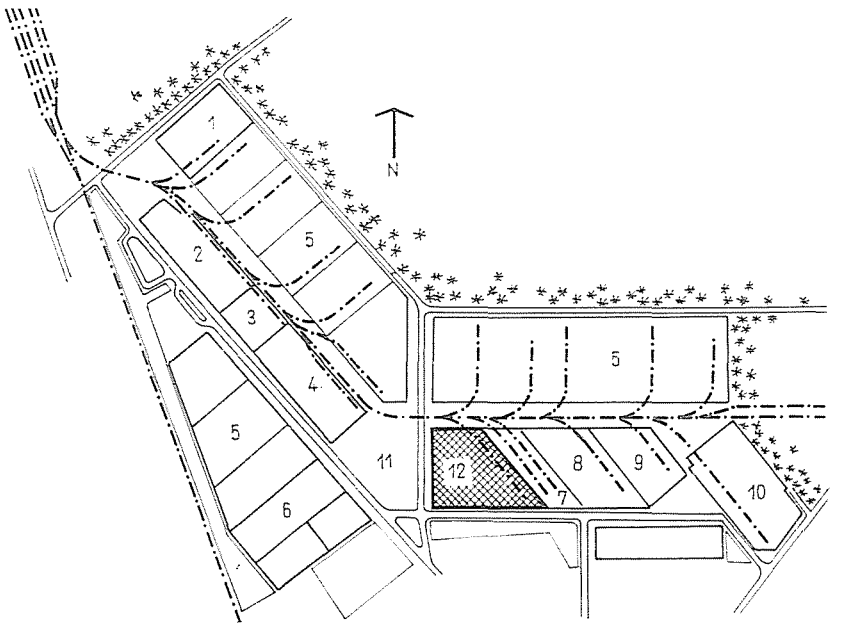

Fig. 12. Lay-out scheme for an industrial area: 1—10 industrial plants and reserve areas; 11 — public institutions; 12 — power station

accessible only by road (Fig. 13). The small power station with mixed firing, equipped with a 11 t/hour capacity steam boiler and a 1,2 MW capacity turbo-generator stands near the approach road. Its volume is of two stages; its central position near to the big consumer factory is favourable. The lay-out is equally remarkable from the aesthetical, architectural viewpoint. The long side of the power station seems to close the space formed by the machine-hall and the preparatory unit, so these buildings are united into a complex and offer a favourable sight from the entrance side. The high quality architecture, the considerable mass, the position and the rich colouring of the power station give an additional feature to the pleasant aspect of the whole plant. The design of the south-east elevation, the proportions of window and wall surfaces, the quality and colour of the materials offer an aesthetically pleasant sight (Fig. 14).

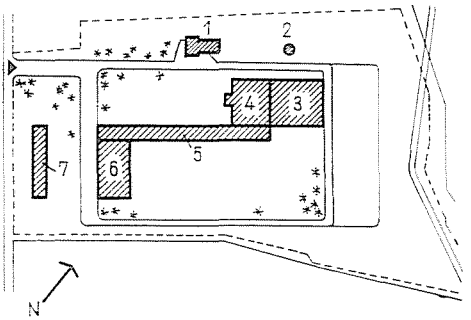

Fig. 13. Lay-out of cardboard factory (Mayen): 1 — power station; 2 — paper-sludge basin; 3 — storehouse; 4 — preparatory workshop; 5 — machine-hall; 6 — storehouse; 7 — office

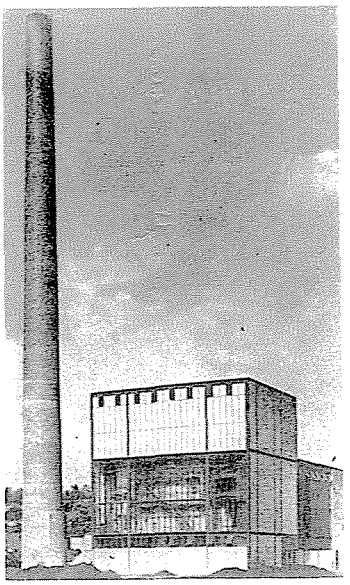

Fig. 14. The south-western elevation of the power station at the Mayen paper factory, with the boiler-house in foreground

A new pharmaceutical factory has been built on a nearly 20 ha site next to the university town of Michigan. Besides the road system, the five factory buildings are connected by a tunnel system too (Fig. 15). The lay-out is well spaced, each building is distinctly separated. According to this principle a separate steel framed power station with oil-firing has been established there, which supplies the factory with steam and electricity. It overpeers the other buildings with its glazed light metal curtain-wall, contributing to the pleasant appearance of the factory by the simplicity of its mass (Fig. 16).

h) *Particular questions of locating small power stations for housing estates and towns.* They underlie the same principles as industrial power stations, thus

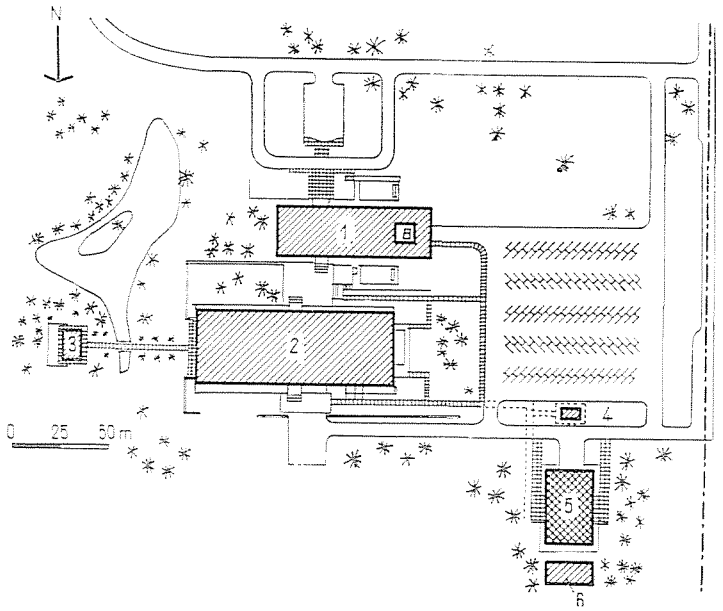

Fig. 15. Lay-out of the pharmaceutical factory Parke Davis and Co. (Michigan): 1 — office; 2 — laboratory; 3 — high-pressure laboratory; 4 — storehouse; 5 — power station; 6 — cooling house

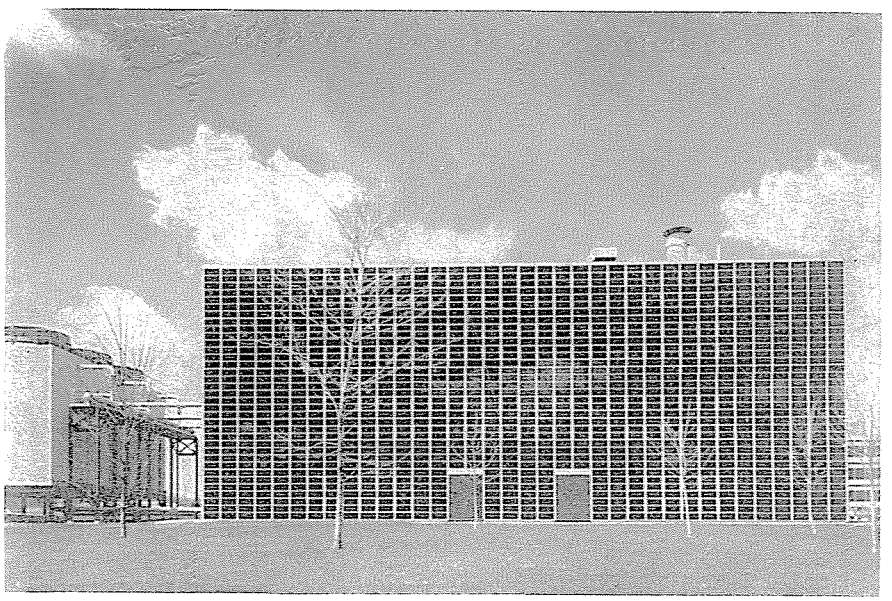

Fig. 16. Western elevation of the power station at the pharmaceutical factory Parke Davis and Co

the general aspects and requirements of location are the same, with differences inherent with the special features of their surroundings.

The power stations in towns or housing estates are established in the centre and supply heat energy (heating, hot water), producing at the same time power and transmitting it to the city sub-station or the co-operation network. It is important to plant a sufficiently large green belt between the power station and the residential area. The power station should be built in the direction of the dominating wind to blow the smoke and fly-ash in the direction opposite to the residential area. The separation of fly-ash and the cleaning of flue-gas requires a special care in housing areas. When locating heat power stations in towns or housing estates, great care should be taken not to disturb street traffic and that the road and railway access of the power station bypasses the town or housing estate.

The heat power stations in Hungary supply not only housing estates but also the industrial plants surrounding them, for this reason they are not built in the housing centre, but in the area separating the housing estate from the industrial zone. This is the principle of the establishment of the heat power station at Kőbánya, which is equipped with four 50 t/hour steam boilers with crude-oil firing and two 12.5 MW capacity turbo-generators.

There are other viewpoints besides expedience and economicalness, increasing the difficulties of locating and designing power stations in towns or housing estates. The location of power stations is subject to local conditions and particular circumstances decisive to the convenient choice of place and lay-out. It is essential to establish one large block rather than several small buildings. Besides of being more economical, this has the advantage to offer a general, integrated aspect, presenting co-ordinated scales and proportions, an accented element dominating the townscape.

Summary

Further small power plants are required in order to establish further industrial plants at the countryside to locally utilize recently explored oil and gas fuel and to operate district heating systems. Realized or planned lay-out schemes for small power stations on new or existing factory sites are governed by the following viewpoints: possibility of a future extension; the distance from consumers; the ways of access; supply of fuel and water; the future extension of the factory; aesthetical aspects; the special problems of establishing small power stations in towns and housing estates.

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