The heat engineering in the modern town, which fundamental factors are technology consumption and heating of the rooms, makes a serious problem with regard to power engineering, town-planning and environmental protection.

From technical solution of this problem the economical effects will depend and among them first of all economy of fuel and labour.

At present in Poland, in the greater part of cases the development or building of towns with intensive multi-families housing is carried on. Both the density of housing and its range and speed of realization are giving the economic bases for centralized development of supply system in heat energy. The choice of type of heat source will depend on local conditions and in greater part on magnitude and kind of industry.

In the power engineering balances of towns, important part takes heating of industries' and municipal rooms, which is about 40 to 50% of total energy demand. Still more distinct participation of rooms heating is in the power engineering balance in habitable district, considering the services and public utilities. With regard to 1 habitant and yearly consumption of energy, the structure of this balance presents itself as follows:

- heating and ventilating of the rooms - 4.7 MWh - 69%
- hot service water - 1.4 MWh - 19%
- preparation of meals - 0.25 MWh - 3.9%
- electrical power consumption - 0.85 MWh - 12.5%

\[ \text{total} \quad 7.20 \text{ MWh} \quad \text{100\%} \]

As it appears, heating of the rooms and preparation of hot service water takes together about 84% of the yearly energy demand in the habitable district.
In 1975 the participation of district heating systems in meeting heat demands amounted to about 55%. Remaining part of heat demand was covered by gas in preparation of hot service water and for rooms' heating by the individual heating devices fired by gas, furnace oil and accumulative electric arrangements.

The programme of Polish energy management development makes plans for improvement of populations' habitable conditions, taking into consideration the increased requirements of environment protection and decrease of energy consumption, mainly due to decreasing of losses connected with efficiency of production and transmission of energy and as well by improvement of buildings' heat insulation at standard temperature of habitable rooms heating 20°C.

In accordance with this programme, based on the national fuel and power balance, directions of energy systems development was defined, comprising as well district heating systems. As it appears from the above mentioned participation of district heating systems in meeting the demand of heat for rooms' heating and preparation of hot service water - the role of district heating in Polish power balance is very big.

According to present prognostic works, the national fuel ground in the near future shall be based mainly on the hard coal, restricted resources of brown coal and little of crude oil and natural gas.

In this situation, the centralized supply of heat to the municipal and industry agglomerations is the fundamental solution accomplishing both the requirements of environment protection and as well economic conditions and also gives the most economical consumption of fuel and energy economy at meeting its demands. Rationalization of fuel and energy economy - that is first of all - improvement of heat production efficiency, decreasing of transmission losses and economic utilization of heat carriers at the consumers.

The second important factor aiming at sensible management of heat energy is to decrease demand of heat. In the period of past 20 years the unitary demand of heat constantly increased.
The factor of unitary energy demand for 1 m³ for heating of the rooms in Poland increased from about 16 W in the years 1950 - 1955 to about 23 - 25 W in 1968. Further increase of comfort, height of buildings and their magnitude, increase of glazing surfaces are causing still bigger demand of energy up to 30 W.

The situation in industry building engineering does appear similarly, where rise of technological requirements increase the range of ventilation and air-conditioning of the rooms, what involve increasing of the unitary energy demand factor for 1 m³ from about 30 W in the years 1950 - 1955 to about 40 W in 1968. One does observe further increase of this factor to the number of 60 - 70 W.

Increase of energy demand for preparation of hot service water is resulting from the rise of comfort equipment in the rooms. The yearly factor of energy demand for 1 habitant increases to about 0,35 MWh in the years 1950 - 1955 and to about 0,95 MWh in 1968 and one should expect further rise up to 1,2 - 1,5 MWh.

Quite a separate problem, rather difficult to define, is the technological heat demand in industry. This demand does depend on technical progress, particularly in technological processes. Doubtless, the unitary factors of energy demand for production unit will decrease due to technological progress. Totally however, the increase of industrialization will involve the dynamic rise of energy demand.

From the analysis of the above mentioned factors of unitary heat demand does result, that it is necessary to restrict increase of these factors and to aim to diminish the demand of heat energy.

In the scheme of fuel and energy management's programme one does also considers large rationalization of heat energy consumption in industry, among others by application of less energy-consuming technological processes and by utilization of waste heat. The basic problem in the range of heating is to diminish of the unitary heat losses by improvement of buildings' partitions heat insulation. Research work carried
out at present will define the economic range of suitable materials, their energy-consumption and costs.

Development of district heating systems in Poland are strictly coordinated with development of towns and industry. Already in the phase of spatial plan's management elaboration up to 2000, carried out for each town, the centralized heat supply programme for the proper development of town is also considered. It is based on the complex analysis of town's heat energy supply and the choice of heat carries for meeting heat demand in the municipal and industry agglomerations are also based on technical and power engineering criterions and environment protection, considering economic management criterions as well.

The technical and power engineering criterions consist of the following elements:
- structure, magnitude and density of energy demand,
- use of fuels,
- development of technique in the heat power engineering.

Presently applied solutions in the scope of meeting the energy demand shall be further developed and up to 1990 improvement of covering these demands can be expected by:
- elimination of coal fired furnaces in individual multi-families housing and expanding the use of centralized system of heat supply from thermal power stations or large heating plants, meeting the demands in the range of room's heating, ventilation, hot service water preparation and technological purposes.
- in dispersed settlements replacing the individual coal fired furnaces used for room's heating by the coke fired furnaces or in justified cases by the oil furnaces or by electric accumulative heaters,
- wide introduction of accumulative hot service water heaters, where centralized heat supply system is not available.

It results from the analysis of economic factors, that the most profitable is heating from centralized heat supply system from thermal power station as a source of heat and then from the district heat plant.
The local heat sources fired by gas or furnace oil for the intensive multi-families settlement is not profitable. The choice of heat source for the centralized heat supply system does depend on magnitude of heat demand in particular system.

Research work of economic advisability was also carried out for introduction of electric accumulative room's heaters. It is justifiable only in less intensive one-family settlements of density below 100 habitants per 1 hectare.

Apart from the economic efficiency, one should remember of technical possibilities of the peak power covering. For instance, requirement of electric power for typical settlement of 4 to 5 thousands of habitants amounts to about 1,2 MW and considering room’s heating to about 7 MW.

Application of electric accumulative heating would need about 14,0 MW. This would cause the change of peak to night’s hours and would require other technical solutions. Consideration in the economic calculation all of these elements gives the negative result and restricts use this kind of heating in Polish climatic conditions. For that reason one can not expect in the nearest perspective introduction of electric heating.

The sources of heating in the district heating systems are: heating plants and thermal power stations. The condensing power stations supplying the heat to the district heating system may also be considered as such sources.

The thermal power stations can be divided for the 4 groups:

a/ the new professional thermal power stations built as a heat source for the need of municipal and industry building engineering,

b/ the thermal power stations adapted from the condensing ones for supplying the heat,

c/ condensing power stations in which besides the basic production of electric energy, heat energy is also produced,

d/ industry thermal power stations, which supply the heat
for the needs of nearby district after meeting the requirements of its establishment.

The district heating plants are constructed for the requirements of housing or industrial building. In many cases they are common source of heat for both consumers.

The choice of heat source in centralized heat supply systems for heating and hot service water depends on:
- maximum hourly demand of heat,
- density of heat consumption in the vital and municipal sector,
- magnitude of technological heat demand,
- localization of heat source with regard to the consumers.

The basic economic problem at the selection of heat sources for the towns and large industry regions is the problem of thermal power station's magnitude limit. The top limit of thermal power station's magnitude depends first of all on the radius of heat delivery to consumers.

The lately carried out considerations shows, that the lower limit of combined management's profitability at typical heating load amounts to 250 - 300 MW, what does respond to the yearly heat production of 500 - 600 GWh.

If the thermal power station is supplying heat for hot service water, this limit can be lowered to 200 MW.

Further lowering of this limit can apply only to the thermal power stations supplying the heat for technology for the whole year. The combined economy may also be profitable at small heat load for heating, if one is utilizing the existing condensing power stations, because it needs considerably less capital expenditure in comparison to the new thermal power station or industry power plant - in which utilization of reserves or development makes possible delivery of heat to municipal consumers at direct neighbourhood of industry establishment.

Development of district heating with thermal power stations as the source of heat finds its justification:
- economic: economy of fuel due to combined generation of heat and electric power,
- fuel: consumption of low-class assortment of coal,
- social: improvement of living conditions, elimination of hard work, decreasing of employment,
- environment protection: decreasing of air pollution.

At present, the largest thermal power station reached the power of about 1500 MW. It is anticipated that the largest thermal power station in Poland in the next few years will reach 2200 MW. This is the result of technological progress’ implementation and use of larger and larger power units. For instance, instead of presently used 30MW turbines, more district heating turbines of 50MW and 100 MW are introduced and as boilers for peak heat load - water boilers of 150/70°C parameters and of power 80 and 140 MW.

It is also anticipated that up to 1980 introduction of water boilers of 250 MW will take place. As well under consideration is application of district heating turbine of 200 MW.

The aim of using the larger and larger units does results from further range and bigger demand of heat by the municipal district heating systems. The economic assumptions caused, that application of thermal nuclear power stations will take place in about 1990.

The classic solution of electric energy production in nuclear stations are creating favourable conditions for introduction of combined production of electric and heat energy. These power stations will make in the future sources of heat for large municipal agglomerations. Passing then from classic production of energy out of coal to nuclear fuel will not cause the essential changes in heat delivery to municipal agglomerations by district heating systems.

In the range of energy conversion - changing to the nuclear thermal power stations with the peak part fired by low-sulphur furnace oil will enable to decrease environment pollution to the minimum. Application of these solutions will be possible in the large municipal agglomerations with heat demand of over 3000 MW.

In the further, directional development of district heating, one can expect elimination of peak boilers in thermal power stations and replacing them by the heat exchangers
fed from steam extraction of district heating turbines of higher parameters. In this way, the only fuel used in thermal power stations will be the nuclear fuel. It will be also possible to rise of the district heating network water’s temperature on the feeding side to about 170°C. The power of one unit will amount on the district heating side to 500 MW.

The new problem, which so far in Poland did not appear, is anticipated application of waste burning plants as the sources of heat. Rapid development of municipal agglomerations creates necessity to solve the problem of waste removal and neutralization. One of the most economic way is just to burn the waste and utilize heat energy for town’s use.

The waste burning plant can be both the component part of thermal power station and as well of district heating plant. In the Polish conditions one can expect, that burning plants as thermal power stations shall be used in largest municipal agglomerations. For the towns with population of about 500,000 inhabitants, burning plants should be anticipated as district heating ones. Introduction of waste burning plants is also the sanitary rationalization.

Development of district heating is justified not only with regard to national fuel possibilities. Its purposefulness is confirmed also by the results of economic analysis.

In the period of the past 15 years, due to changes of prices, the values of factors did also changed, but did not undergo changes in the essential manner the proportions between particular carriers and did not alter the point of view on the choice of energy carriers for the rooms heating.

The gradual change did occur in the limits of profitability of combined economy application.

The value of heat production’s effectiveness factor does depend on the kind and magnitude of heat sources and used fuel and are as follows:

- local boiler-houses fired by coke - 500 - 550 zł/MWh
- heating plants 10 - 30 MW - 310 - 360 "
- heating plants 50 MW - 290 - 320 "
- thermal power stations up to 250 MW - 220 - 260 "
- thermal power stations over 250 MW - 210 - 220 "

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The heat transmission's effectiveness factor depends on density of building and magnitude of district heating system. The value of this factor fluctuates from about 35 zł/MWh to about 120 zł/MWh.

As it appears from the above presented aspects of fuel and power engineering of environment protection and as well economic conditions, the dynamic development of district heating in Poland finds its full justification.

On dynamic development of district heating in Poland testifies the preliminary datas with regard to planned delivery of heat for heating and ventilation of rooms, preparation of hot service water and technological requirements in GWh/year.

<table>
<thead>
<tr>
<th></th>
<th>1975</th>
<th>1980</th>
<th>1990</th>
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<tbody>
<tr>
<td>- professional thermal</td>
<td>40.000</td>
<td>65.000</td>
<td>145.000</td>
</tr>
<tr>
<td>power stations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- thermal power stations</td>
<td>145.000</td>
<td>190.000</td>
<td>275.000</td>
</tr>
<tr>
<td>and industry heating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>plants</td>
<td>35.000</td>
<td>45.000</td>
<td>70.000</td>
</tr>
<tr>
<td>- municipal heating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>plants</td>
<td>220.000</td>
<td>300.000</td>
<td>490.000</td>
</tr>
<tr>
<td>total</td>
<td></td>
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As it appears from the above presented balance sheet, increment of heat supply in the years 1975 - 1990 in particular groups of heat sources is as follows:

- professional thermal power stations - 105.000 GWh
- thermal power stations and industry heating plants - 130.000 GWh
- municipal heating plants - 35.000 GWh

The participation of professional thermal power stations in meeting the town's and industry heat demands is rising from about 18% in 1975 up to 30% in 1990 and it should be represented by the increment of installed capacity in thermal power stations from about 14,000 MW in 1975 up to 27,000 MW in 1980 and 60,000 MW in 1990.

Such a great development of district heating does need proper organization. Organization of district heating in Poland is as follows:
- professional thermal power stations - state enterprises producing the heat and electric energy,

- industry thermal power stations and heat plants - state enterprises producing the heat and electric energy for its own use and selling it as well to the consumers,

- municipal heating plants - state enterprises subordinated to municipal authorities, producing heat for district heating systems.

Distribution of heat is carried out by the district heating enterprises subordinated to the municipal authorities. Their task is to deliver heat energy to the municipal and industry consumers. The heat energy is produced either by the professional or industry thermal power station or by their own.

The important energy aspect is to improve structure of energy carriers for meeting the heat demands. In assuming of the district heating’s programme’s development variant, as it is shown above, its participation in improving of this structure is quite clear and looks as follows:

The structure of meeting heat demands in towns for heating, ventilation and air-conditioning of the rooms in %

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>thermal power stations</td>
<td>16,8</td>
<td>23,1</td>
<td>28,2</td>
</tr>
<tr>
<td>district heating plants</td>
<td>16,1</td>
<td>20,2</td>
<td>27,0</td>
</tr>
<tr>
<td>local boiler-houses</td>
<td>12,0</td>
<td>13,5</td>
<td>14,0</td>
</tr>
<tr>
<td>individual furnaces</td>
<td>55,1</td>
<td>43,2</td>
<td>30,0</td>
</tr>
</tbody>
</table>

The structure of meeting heat demands in towns for preparation of hot service water in %

<table>
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</thead>
<tbody>
<tr>
<td>thermal power stations</td>
<td>13,5</td>
<td>18,5</td>
<td>22,8</td>
</tr>
<tr>
<td>district heating plants</td>
<td>3,9</td>
<td>4,0</td>
<td>5,0</td>
</tr>
</tbody>
</table>
coal fired furnaces | 41.6 | 29.4 | 13.2 |
gas fired furnaces | 39.0 | 44.1 | 51.0 |
electric furnaces | 2.0 | 4.0 | 8.0 |

As it appears from the above mentioned structure of meeting the heat demand, considerable development of centralized heat supply is anticipated to be delivered from thermal power stations and as well from heating plants - increase of more than double in comparison to 1975.

In 1990 about 55% of heat requirements for heating, ventilation and air-conditioning in towns shall be covered by the centralized systems fed from thermal power stations or heating plants. Prognosis for 2000 anticipates increment of district heating participation in about 70%. Parallelly will increase also covering of hot service water out of these systems, particularly where these systems will get the heat energy from thermal power stations. Clearly is decreasing participation of individual furnaces in rooms' heating and for preparation of hot service water.

Carried out the economic and energy analysis showed, that assumed programme of district heating development to 1990 will give important effects.

Development of district heating based only on professional thermal power stations in comparison to heat sources without combined heat production will permit to decrease consumption of fuel:
a/ on the end of 1976 - 80 period about 3.5 millions t/year of power engineerings' coal,
b/ on the end of 1976 - 85 period about 8 millions t/year of power engineering's coal,
c/ on the end of 1976 - 90 period about 13 millions t/year of power engineering's coal.

Dynamic development of district heating systems as introduced above, will require proper selection of heat sources and reliability of its work. The exploitation experience of heat sources showed, that essential influence on reliability of work will have production engineering's solutions and not magnitude of heat source.
Quantity of boilers, heat exchangers, pumps etc., should be selected in such a way, that falling out of work of one of the devices would cause decrease of peak power not more than 25%.

In the Polish district heating systems water was accepted as an energy heat carrying agent with variable temperatures, dependent on the outdoor temperature. At the calculated temperature i.e. for instance, for Warsaw - 20°C the temperature amounts to 150°C. The lowest temperature is 70°C. The temperature of returning water to the heat source amounts to about 73°C at the calculated temperature and the lowest about 45 - 50°C.

In case of district heating network's arrangements, one does also consider solutions aiming to increase reliability of heat supply. Securing of reserve is the basic element. So the proper heating scheme should be able to make it possible to have the reserve feeding of the system. Therefore the conclusion does arise, that each district heating system should have double feeding. Reserve feeding can be taken from one source of heat in the form of leading out few main lines instead of one or from few sources of heat.

Of course, the small district heating systems up to 120 MW don't have to comply with this condition, unless, that district heating network's configuration or its building by stages justifies to perform this condition.

The economic research work of district heating systems of various magnitudes proved, that centralization of heat production is justified. Even in small systems of about 50 MW, is more profitable feeding from one heating plant, then from few smaller ones - to say nothing of dispersed heat economy.

Of course, in large sources of heat, the introduction of combined economy confirms still more of its profitability.

Introduction of few smaller heat sources cooperating in district heating system is difficult for realization and in spite of appearances are more deceptive, to say nothing of economic effects of such a solution - introduction, for instance, in only one of the source - combined economy without the peak part, which would be localized in few smaller heat
sources fired by coal - is not justified from the production engineerin's point of view.

As it appears from the above presented considerations, particular significance has the network's system. One should distinguish here at least 3 elements:
- configuration of network's system,
- flow capacity of basic mains,
- methods of customers' attachment.

The configuration of network's system should consider:
- possibility of flexible development,
- stages,
- reserves.

Annular system is meeting these requirements in the best manner and in practice may be also used annular and radial system. Under the meaning of ring, one does not have to understand its geometric meaning, but to reserve one section of the system by the other. Such a system have also significance for development in stages. Reserve have not to perform reliability's condition for each case of the load. Full reserve for peak load is very costly and do not have to be performed.

Reserve of network's system is connected with flow-capacity of mains' system. The present exploitation experiences show, that flow-capacity should be restricted to diameter of 700 - 900 mm for the largest district heating systems.

Quite a big economic and power engineering effects have the sort of customer's attachments.

At present in Poland, the most current /about 80%/ is to joint customers directly by means of injectors /hydro - elevators/. However, as larger range of transmission is being done, more justified from exploitation reasons might be of value the group stations. These stations are making easy to control of hot water's supply, decreasing corrosion effects in hot water installations and facilitate using of variable hydraulic parameters connected with reserve in district heating system. They are meeting the requirements of work continuity and protect of heat supply proper parametras.
At differentiated delivery of heat - heating, ventilation of rooms, supply of hot service water - it necessary to have automatization of district heating system and application of quality and quantity control.

The new problem, which is to be solved is the heat transmission for the distance of 30 - 50 km connected with the nuclear power stations and as well with thermal power stations fired by brown coal, which deposits appear in Poland.

Existing of 25 year development of district heating in Poland proved high economic profitability and no doubt caused decrease of environment pollution. Further development of district heating systems is necessary for the new habitable building engineering and enlargement of industry.

Presented in the report power engineering aspects of district heating, are placing this system at the head of power engineering system enabling to meet the energy demands of modern towns.