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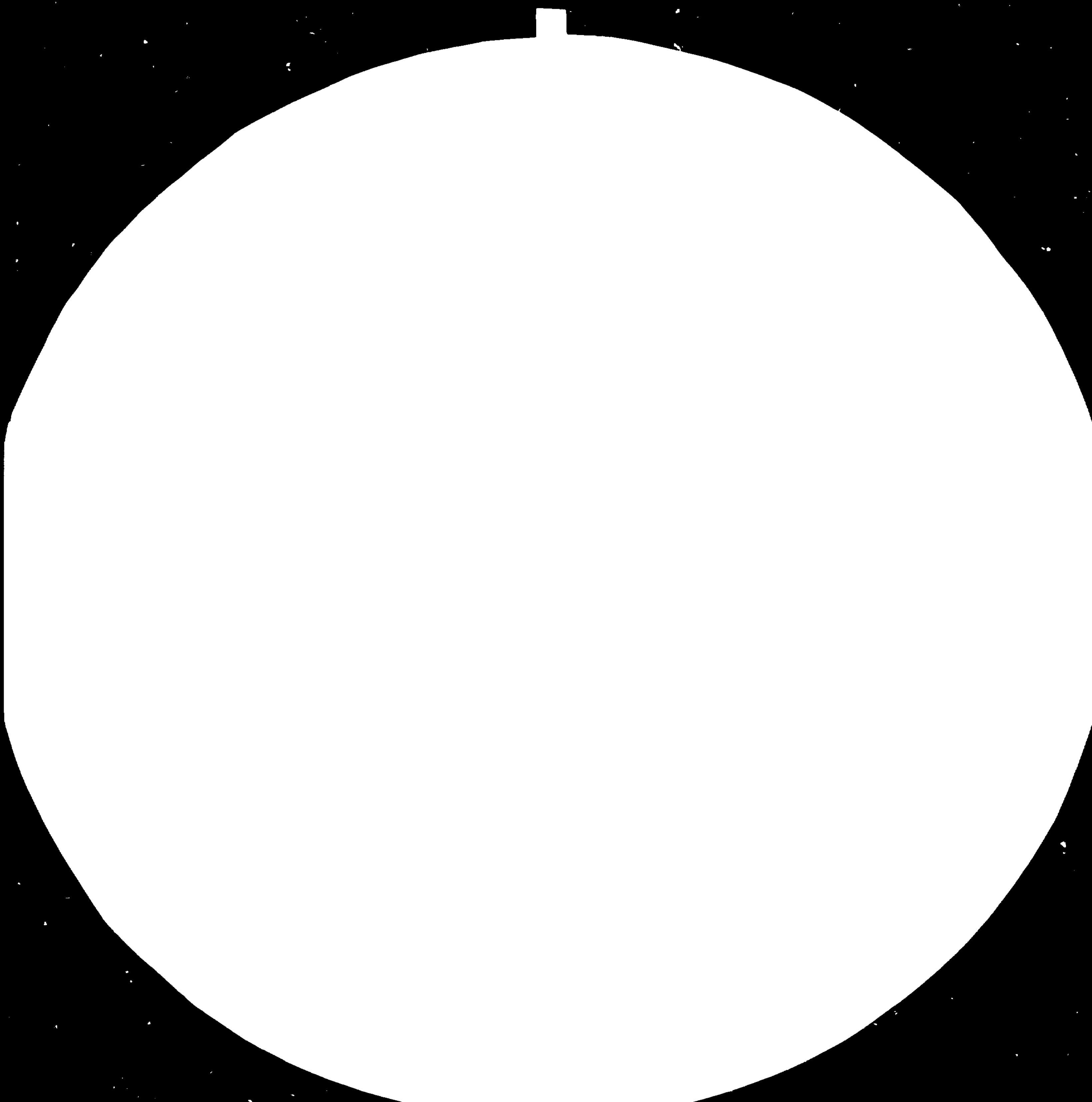

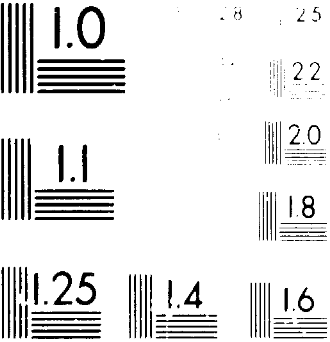
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A Case Study of Experience and Results in the GDR on Energy-Related Equipment and Technology and Possibilities of Co-operation

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For: United Nations Industrial Development Organization,
Vienna

Vienna, May 1984

Contents Pag

7. Annexes

1. Introduction

This case study has been elaborated in connection with the preparatory work for the Second Consultation on the Capital Goods Industry with Special Emphasis on Energy Related Equipment and Technology to be held in Stockholm 1985.

Working in the capacity as a UNIDO consultant, the author has prepared the study along the lines of the Terms of Reference attached to the respective concultancy contract.

The consultant expresses his appreciation and thanks to the GDR's institutions and firms concerned for their support and assistance in providing the consultant with information required, and to UNIDO's Negotiations Branch, especially to the Industrial Development Officer Mr. C. Gürkök, for their constructive co-operation.

Besides the experience and results represented, the study shows, inter alia, how a socialist society tackles successfully and in a well balanced matter problems of energy-related equipment, creating at the same time growing possibilities of international co-operation on the basis of equality and mutual benefit.

In this respect the GDR's approach, its experience and potential can particularly be used for promoting developing countries in adopting appropriate strategies and policies to cope with the process of industrialization.

2. General aspects of the GDR's national energy policy

2.1 Energy

The energy policy in the GDR has always been an integral part of the planned development of the GDR's national economy.
Taking into account, among others, that

- energy has to be considered a decisive prerequisite of the development in all spheres of life,
- each country's economic development and economic growth depend directly on an adequate supply of the different forms of energy required,
- the creation and expansion of a national energy basis is one of the most important elements for industrialization

the government has constantly given top priority to the strengthening of this particular sector. This finds its reflection in the directives for the GDR's national economic development, in the national plans and special programmes adopted.
Socialist relations of production, which also embrace nationally-owned power stations, electric power transmission and distribution plants, do not only enable but demand a long-term energy policy, whose guidelines are economic and socio-political needs.
This does not mean that the GDR, as other countries too, did or does not have any energy problems. They are mainly due to increasing production costs of domestic fuels and growing import prices but must also be seen in connection with higher costs for installing energy saving equipment in all branches of the economy.
In this respect the GDR reflects world trends.
Since its foundation 35 years ago the GDR has pursued a long-range policy in the energy sector to make the most economical use of its own resources. Apart from the broad support the GDR received, particular from the USSR, energy problems had and have to be resolved by relying on one's own strength.
Acknowledging this situation the GDR has always concentrated essential parts of its national income on safeguarding the energy and raw materials base as a fundamental requirement of the systematic and balanced development of the economy. For instance, the government's coal and energy programme adopted in 1957 provided for to channel half of all industrial investment into the development of coal mining and energy production. In the 1970s about two thirds of all industrial investments were made in the power and basic materials industry. 60 per cent of all industrial investments are devoted to this purpuse in the period 1981-85. Thus it was possible to guarantee a sufficient and stable power supply.

The "Economic Strategy of the Eighties"[1], a far-reaching programme adopted to achieve a high economic growth and rising efficiency on the basis of a rapidly advancing intensive development of production is, inter alia, directed in the energy sector o

- the comprehensive utilization of the domestic energy sources; this refers most particularly to lignite, 295 tonnes of which are to be produced in 1985 (lignite accounted for over 71 per cent of overall energy consumption in 1983),
- the long-term objective to meet the growing demand for the primary energy sector to an increasing extent by nuclear energy,
- the rational use of energy as an indirect means to enlarge energy resources and, the improvement of the efficiency of energy conservation in all areas of the economy,
- the reduction of the specific energy consumption in energy -intensive processes (metallurgy, chemical industry),
- the implementation of more efficient solutions of energy application in case of non-industrial consumers (e.g. railway electrification of 730-750 km between 1981 - 1985).

Administrative measures stimulating the rational use of energy and the reduction of energy consumption have been successfully supported the process of energy saving and intensification. The consumption of raw materials and fuel in industry has been reduced by 6 per cent in 1982 whereas the national income grew by 3 per cent. In 1983 the national income and the manufacturing output also increased by 4.4 and 4.1 per cent, respectively while unit consumption of key fuels, raw materials and feedstocks was reduced by 7 per cent. The more rational and sparing use of energy made it possible to ensure the growth in economic performance 1983 with approximately the same amount of primary energy as in 1982. Above all, the last two years have shown that it is possible to increase output and national income over a longer period and at the same time to reduce the consumption of fuels, raw materials and feedstocks in absolute terms. The 1984 National Economic Plan provides for the fulfilment of the new targets without increases in primary energy . The plan envisages a reduction in energy input by at least 4.2 per cent and changing the structure of primary energy further in favour of domestic sources of energy.

[1] 10th Congress of the Socialist Unity Party of Germany, Berlin, April 1981

Output of selected energy carriers is shown in table 1:

	1960	1970	1980	1982
Electrical energy in GWh	40,305	67,650	98,308	102,906
Lignite output in mill. tonnes	225.5	261.5	258.1	276.4
Lignite briquettes in mill. tonnes	56.0	57.1	49.7	50.0
Town gas in million cubic metres	3,045	4,269	6,203	6,348
Petrol in 1,000 tonnes	1,080	2,236	3,333	3,391
Diesel oil in 1,000 tonnes	1,289	3,619	6,119	6,142

Table 1 : Output of selected energy carriers
Source: Statistical Yearbook of the GDR 1983

Despite various changes in the GDR's primary energy balance, for instance the shift towards oil and natural gas in the 1960s and 1970s, solid fuels in the GDR have never lost their dominating role. On the contrary, along the lines of world trends in oil substitution the role of lignite as the GDR's major source of energy has grown during the last years, bearing in mind that lignite is also an important raw material used in chemical industry. The GDR is the world's largest lignite producer. Its economically recoverable lignite reserves amount to 3,000 millions of TCE, the proved reserves to 15,000 and the total resources to 30,000 respectively[2]. These are 0.3 per cent of world resources. Thus new mines can be opened and expanded even after the year 2000. It is estimated that open cast mines now in operation can be exploited until 2020 or 2030 and longer. Apart from the growing role of nuclear energy, this is of particular importance, since other sources like natural gas and hydro-power assume only modest proportions in the GDR's primary energy balance. Domestic supplies of crude oil and geothermal energy sources are negligible. Regarding the specific energy consumption per capita, the GDR's relative position to other countries can be taken from figure 1 (Annex 2).

In view of the results obtained in energy sector, the GDR's approach to solution of energy problems and its experience in this area can be regarded as an example several elements of which could be applicable not only to industrialized but also to developing countries.

[2] Energy supplies for developing countries (Study by the UNCTAD secretariat), United Nations, New York 1980

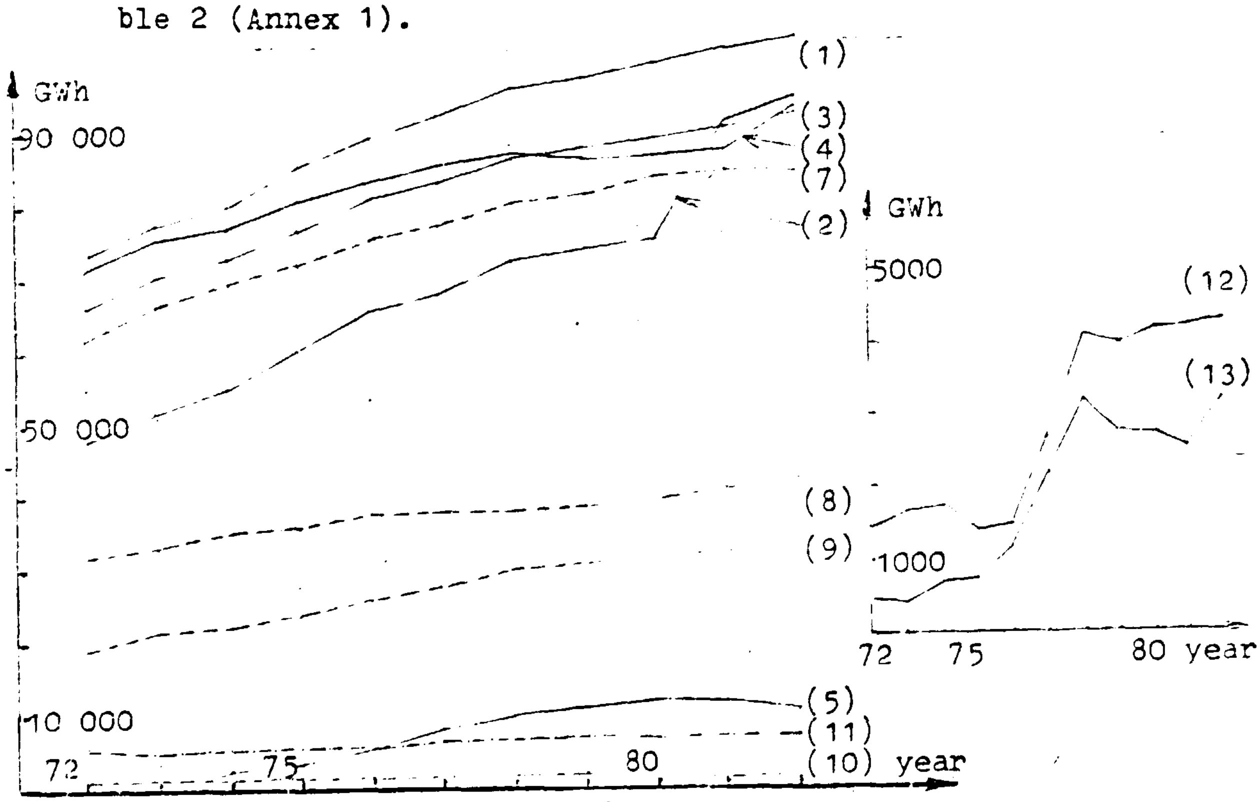
2.2 Electricity

2.2.1 Electric energy generation and consumption

The long-term demand for power equipment is determined by the rate of electricity consumption and, analysing international trends, the major power equipment producing countries are also the major consumers of electricity. Furthermore, since the process of power supply (generation, transmission, distribution) has to be realized through the power system, the development of the electric power system itself can be regarded as an indicator of the level and performance capabilities of the power equipment industry, provided that the countries concerned have taken care of their own material basis and techno-scientific capacities within the framework of the international division of labour.

In doing so the GDR has followed this line bearing in mind that the utilization of electricity is the key element for the efficient development of technical progress.

Figure 2 shows the trends of the GDR's electric energy generation and consumption from 1972 to 1982 on the basis of table 2 (Annex 1).



(1) generation total (gross)
(2) generation public total
(3) net production
(4) generation conv. thermal
(5) generation nuclear
(6) generation hydro
(7) consumption total
(8) consumption industry and constr.
(9) consumption households and other
(10) consumption transport
(11) transmission and distrib. losses
(12) imports (13) exports

Figure 2 : Electric energy generation and consumption (trends)

As can be seen from figure 2 and, in addition to that, from table 3 and table 4, the growth rates of electricity consumption and generation in the GDR and in other CMEA countries, too, decelerated reflecting on the one hand a general trend in the ECE-region[3] as a whole and on the other hand the effects of the GDR's and other government policies in practice. The GDR's exports and imports of electrical energy are nearly equal (see table 2/figure 2).

Table 3 :

Annual growth rates of the gross electricity consumption (%)

Source: 20 years CDO IPS, Prague 1983

Years	Bulgaria	Hungary	GDR	Poland	Romania	USSR-Southern Grid	Czechosl.	IPS
1961-1965	16,8	9,0	6,1	7,9	17,2	30,5	7,6	8,9
1966-1970	13,6	7,6	4,9	8,3	14,1	13,6	6,8	8,1
1971-1975	8,5	6,6	4,6	8,4	9,3	8,4	5,5	6,9
1976-1980	5,9	4,9	3,3	4,7	5,9		3,3	
1981	4,4	3,2	2,1	—5,5	3,0	1,1	1,5	0,6
1982	6,3	3,6	1,6	0,8	0,1	2,3	1,2	1,9
1963-1982	10,2	6,4	4,3	6,1	10,2		5,0	8,3

Table 4 :

Annual growth rates of electric energy generation (%)

Source: 20 years CDO IPS, Prague 1983

Years	Bulgaria	Hungary	GDR	Poland	Romania	USSR-Southern Grid	Czechosl.	IPS
1961-1965	17,0	8,1	8,8	8,4	17,6	38,4	6,9	8,9
1966-1970	13,7	5,5	4,8	8,1	15,3	21,1	5,7	8,3
1971-1975	5,4	7,2	4,6	8,5	8,9	3,8	5,6	6,5
1976-1980	6,5	3,1	3,2	4,6	4,6		4,2	
1981	6,2	1,7	1,9	—5,6	3,9	—1,5	1,1	—0,4
1982	9,7	1,6	2,2	2,3	—1,7	3,0	1,7	2,4
1963-1982	9,9	5,1	4,2	6,2	10,1		4,9	8,3

In 1982 the total consumption of electricity reached 84,247 GWh as compared with 61,440 GWh in 1972, i.e. an increase of 37 per cent. This corresponds to the increase in net production during that period. Over these ten years, electricity use per worker increased from 16,702 kWh in 1972 to 20,323 kWh[4] in 1982 concomitant with an increase in labour productivity (see table 5). As can be seen from the same table, the electricity efficiency per unit of national output has continuously increased.

[3] Energy Transition in the ECE-Region, United Nations, New York 1983 (E/ECE/1063)

[4] Statistical Yearbook of the GDR 1983

Table 5 : Specific energy consumption

Source: Statistical Yearbook 1983

Year	consumption per worker (kWh)	consumption per 1000 marks of gross industrial production (kWh)
1972	16,702	245
1973	17,472	235
1974	17,871	231
1975	18,532	225
1976	19,114	221
1977	19,197	213
1978	19,790	209
1979	19,586	197
1980	20,103	193
1981	20,133	186
1982	20,323	183

The average per capita consumption in the GDR reached 4,990 kWh in 1982 while the corresponding per capita generation amounted to 6,163 kWh in 1982. These figures exceed the average of the IPS member countries and can be classified, for instance, as lying between those of the FRG and Austria.
Table 6 shows the percentage proportions of industry end construction, transport, households and other consumers in the GDR's total electricity consumption:

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Industry and construction	51.2	50.5	50.1	50.2	49.9	49.5	47.6	47.6	47.2	47.7	49.8
Transport	2.2	2.0	1.9	2.1	2.1	2.2	2.1	2.2	2.2	1.8	2.0
Households and other consumers	31.4	32.9	33.1	33.4	34.7	35.7	37.9	37.9	37.9	37.7	36.5

Table 6 : Proportions of different sectors in the GDR's electric energy consumption (per cent)

Whereas the industry/construction's share as well as the transport's share by growing performances, expressing raising labour productivity, remained nearly stable at about 50 and 2 per cent, respectively, the electricity consumption in the field of households and other consumers grew from 31.4 per cent in 1972 to 36.5 per cent in 1983 thus reflecting a steady penetration of this particular sector with electricity changing the living conditions in favour of people concerned.

2.2.2 Main characteristics of the power system

Table 7 gives a breakdown of the GDR's electric energy generation by sources in power system. Additionally, table 8 (Annex 3) shows the main characteristics of the GDR's power system and a survey of the power grid is given in figure 3 (Annex 4).

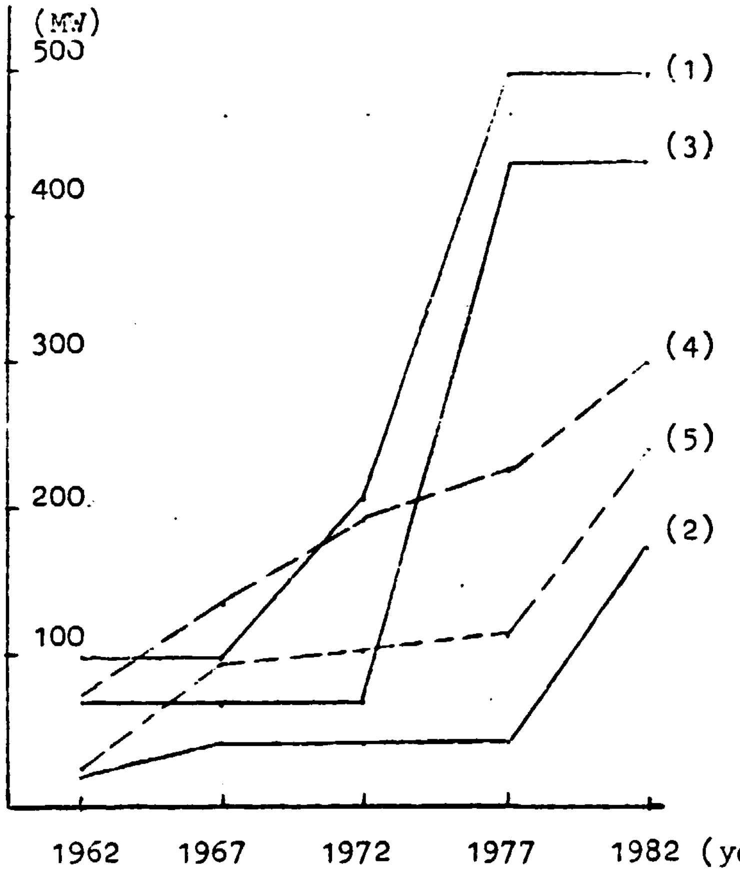
year	convent. thermal	nuclear	hydro	self-producer
1972	63.8	0.5	1.6	34.1
1973	64.9	0.5	1.6	33.1
1974	64.7	2.7	1.6	31.1
1975	66.2	3.2	1.4	29.2
1976	65.8	5.9	1.2	27.0
1977	66.4	5.7	1.2	26.6
1978	65.6	8.3	1.3	24.8
1979	64.6	10.1	1.3	24.0
1980	64.1	12.0	1.7	22.3
1981	77.1	11.8	1.7	9.5
1982	79.2	10.5	1.7	8.6

Table 7 : Breakdown of electric energy generation by sources in power system (%)

Main features of the power system can be characterized as follows:

(1) The GDR's power system which has significantly developed in size and power is a modern energy supply system reflecting long-standing design and construction experience, technical progress in the manufacture of energy-related equipment, and well adjusted to operational requirements as well as further expansion.

In 1982 the system comprised 56 power stations (hydro and thermal power plants) with diversified capacities of generation units transmission lines of 220 kV and above with a length of 9,976 km, 4,566 km lines of 330 kV and higher and 59 substations.
At the end of 1983 there were 7 substations of 380/220/110 kV, 4 of 380/110 kV and 28 of 220/110 kV with a step-up and step-down transformer capacity of 14,700 MVA, 1,750 MVA and 12,300 MVA respectively. The power system includes expanded medium- and low-voltage distribution networks with a broad scale of interconnection, involving all rural areas.
Merely from 1971 to 1977 new power generating capacities of 6,120 MW have been put into operation. In 1978 nearly 40 per cent of the total electricity was generated in plants and power stations put into operation after 1971.
By 1980 every second kilowatt-hour of electricity was generated at facilities put into operation during the 1970s.
Generation per installed capacity in GWh/MW varied during the period 1972-1982 between a minimum of 4.856 (1982) and a maximum of 5.378 in 1973, showing an overall decline.



With the development of the power system there has been a trend towards adopting larger equipment which reduces the cost per MW output.
In the field of power generation this can be seen from figure 4 reflecting the period of 1962-1982. The same figure shows how the average installed capacity of power stations has been increased during this period.

Figure 4 : Maximum unit capacities (———) and Average installed capacity of power stations (------)
(1) turbo-generator
(2) hydro-generator sets
(3) nuclear power reactors
(4) thermal power plants (incl. nuclear power)
(5) hydro power plants

The rate of utilization of the GDR's generating capacity amounts to more than 90 per cent. This is a leading position by international standards and reflects, among others, a strong planning of energy consumption, a stable supply, an efficient balancing of peak loads and a very well organized maintenance and break-down service.
The annual peak load has increased from 6,981 MW in 1962 to 16,690 MW in 1982.

(2) Lignite-fired power stations accounted for 81.5 per cent of electricity generated in 1982 (1981: 79.3; 1980: 78.1; 1975: 82.8). The use of oil in power stations is almost negligible (1982 only 0.7 per cent) and the remaining oil-fired stations are to be converted to lignite or gas within the next few years. Gas is becoming an increasingly important source of fuel in power stations and even more nuclear power. The growth of nuclear electricity from 0.5 per cent in 1972 to 10.5 per cent in 1982

was the most significant change in the structure of electricity generation. According to the current Five-Year plan the proportion of nuclear electricity is to rise to between 12 and 14 per cent by 1985. The foreseen increase in the installed nuclear capacities from 1986 to 1993 is shown in table 9:

commercial operation of new reactor units (year)	output (gross) per reactor unit (MW)
1986	440
1987	440
1989	440
1990	440
1991	970
1993	970

Table 9 : New nuclear capacities 1986-1993

Source: IAEA-Questionnaire Power Reactors in Member States, Basic Information

Table 9 indicates that the share of nuclear power output in total energy needs will grow considerably in the longer term.

(3) Regarding the GDR's hydroelectric resources pumped-storage hydropower plants play the decisive role in covering the variable part of the load line in the GDR's electric energy system since the running water potential is almost completely used by water stations. This explains why the share of hydroelectricity in the electric energy generation of the GDR is only a small one (1.2-1.7 per cent during the last 10 years- see table 7) while its share in the installed capacity (see table 2, Annex 1) has reached a considerably greater part (8.7 per cent in 1982).
The impact of the construction of pumped-storage plants on electricity generating systems is both positive (i.e. lower investment costs than base-load power stations) and negative (higher fuel costs of the power system as a whole etc.) and the economic value of influence depends on the features of the system itself (maximum-minimum load ratio, structure of the generating sources etc.).
As to the GDR's power system the necessary pumped-storage capacities result mainly from the specific composition of the system.

They are determined by operational requirements and for practical reasons and have to be utilized under optimum conditions for the system as a whole.
Moreover, pumped-storage power stations producing electrical energy during peak demand time and consuming electrical energy during low load time mean also an important capacity for emergency cases as they can be connected to the network from the dead state to full load within two minutes.

(4) The GDR's power system is part of the interconnected grids of CDO member countries. The creation of the Interconnected Power Systems is an important practical result of the multilateral co-operation among the CMEA member countries in the field of electric energy and has confirmed great advantages of parallel operation (higher security of power supply, better operating conditions, lower level of the required power reserves of individual power systems, beneficial effects due to superposition of load curves, better composition of generating plants, mutual assistance and power exchange). This enabled a more reliable and economical operation and facilitated the introduction of highly economical power equipment into the power systems.
The creation of the inter-system effect serves to curtail the commissioning of new generating capacities of the order of 300 MW for the GDR and 2000 MW for the CMEA-countries.

Altogether, the experience and results reached in the field of electrification indicate that electricity has important consequences for socio-economic development, living conditions as well as for technical and technological progress, for future economic growth and particularly for labour productivity.
Concerning the rational use of energy it should also be pointed out that in the long run there are still great many reserves to be mobilized. This includes the field of power generation, the reduction of transformation and transmission losses and other areas, as for instance the construction and transport sectors.
The share of electricity in final energy demand will further increase in future. In addition to that, electricity generation, transmission and distribution is capital-intensive. All this requires a particular long-sighted approach to the design and erection of electric power systems or its single components taking into account the local conditions and long-term targets to be achieved. Energy planning

has therefore to be at the centre of all management both from the economic and technical point of view, including technological and financial consequences as well as social implications. For example, the selection of the right voltage levels for transmission and distribution networks and the determination of suitable configurations of grid systems, a quite normal task in projects, could lead to negative effects, i.e. to many additional expenditures if such factors as economic growth, population growth, structural changes within the areas concerned, structure of electricity consumption, type of energy resources and capital goods available etc. were not taken into consideration. In other words, a well-devised concept should enable a gradual expansion from radiate grids to circular and interconnected meshed networks according to future requirements.
The same is true of the planning and construction of power plants requiring a wide range of expertise in civil, mechanical and electrical engineering, in power planning, in knowledge of equipment design and in project management.

In this respect the experience gathered by the GDR within the country and abroad, due to its international co-operation, stands for the high standard reached under socialist conditions in the field of power supply and the manufacture of energy related equipment.

3. Power equipment industry

The power equipment industry creates the conditions for the foundation and further reinforcement of the material and technological base in the field of power supply. Some results so far achieved have found their direct reflection under 2.1 and 2.2.

Additionally, the domestic production of energy related equipment, components and spares have strengthened the economic and technological development as well as export potentials of the GDR establishing growing possibilities for co-operation (see 3.2, 5.).

In terms of the percentage share of the value of industrial commodity production, the GDR's major industrial sectors in the field of manufacturing are (1982 figures from the Statistical Pocket Book 1983): mechanical engineering and vehicle construction, 20.8 per cent; chemical industry, 20.5 per cent; the foodstuffs industry, 14.1 per cent; energy and fuel industry, 9.9 per cent; light industry, 9.7 per cent; electrical engineering, electronics, instrument manufacture, 8.9 per cent; and metallurgy 7.9 per cent.

As far as the GDR's power equipment is concerned, i.e. related groups of SITC Divisions 71 and 77, it is mainly covered by the mechanical engineering and vehicle construction sector (power generating machinery, internal combustion engines etc.) and the electrical engineering, electronics and precision engineering sectors (electrical machinery, apparatus and appliances).

Both sectors occupy key positions within the structure of the GDR's industry. They achieved an above-average growth rate, in particular with respect to high-quality products. This can also be seen in figure 5 , showing the trends of the GDR's main manufacturing sectors in industrial production from 1972 to 1982, based on table 10 , Annex 5.

The electrical engineering and electronics branches have become the most important sector during the last years. This is of special importance because the development in that sector will facilitate growth in other industries.

In accordance with decisions adopted by the government, activities have been intensified to create and develop the capacity of producing microelectronics and robot technology. Utilizing such new sophisticated technologies in the electrical engineering and electronics sector itself, the GDR is able to introduce new generations of key products. This refers not only to electronic data processing, automation and control systems, precision instruments and a number of consumer goods but also to power related equipment in the field of generation, transmission and distribution of electricity.

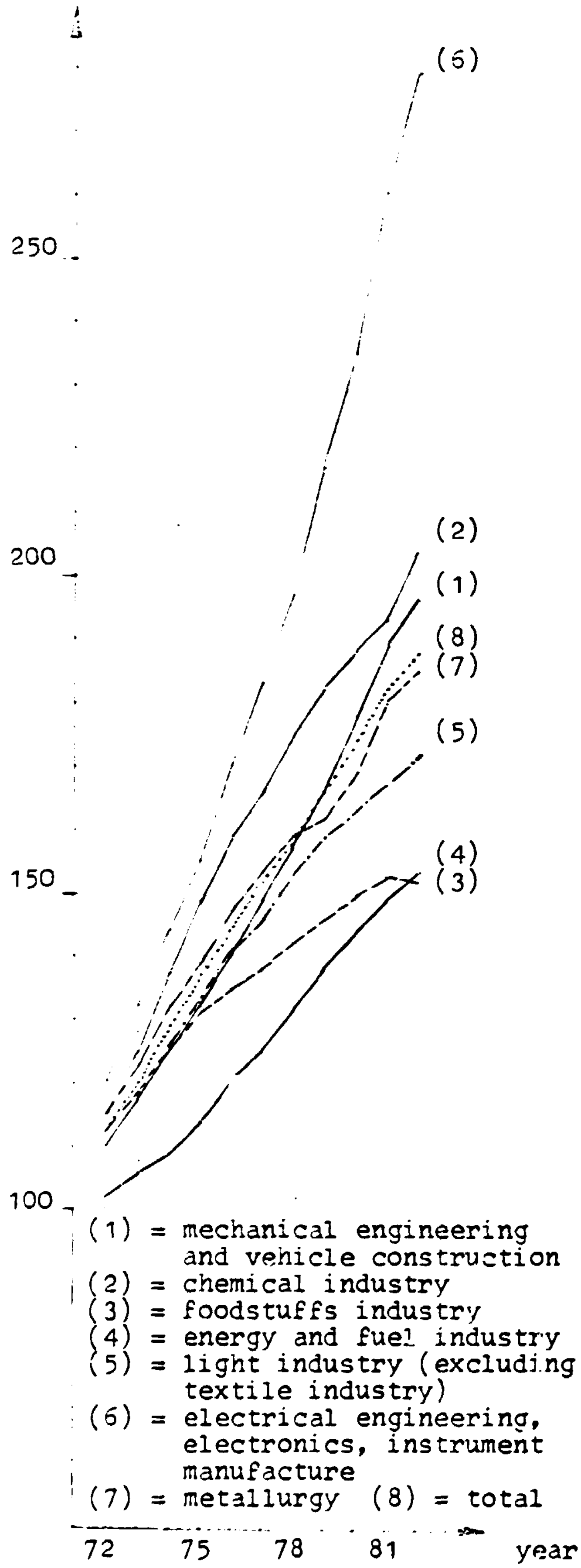


Figure 5 : Index of gross industrial production of the GDR's main manufacturing sectors, 1970 = 100

The manufacture of electric power equipment generally requires considerable investment and therefore adequate financing. Furthermore, the power-equipment sector is relatively research-intensive. This is one reason, that the mastering of science and technology in this particular field (see 3.3) has to be considered a prerequisite of top priority, too.

Taking into account that electric production technology and therefore the power equipment manufacturing technology itself has undergone important changes including all components of power supply, i.e. generation, transmission and distribution and in addition- the process instrumentation and control engineering equipment, the strengthening of technological capabilities through research and development in the power equipment industry is unavoidable.

Following this line , the GDR's power equipment industry has achieved results confirming the rightness of its approach.

Table 11 shows the output of selected products in electrical engineering, electronics and instrument manufacture in 1970, 1975, 1980, 1981 and 1982. The figures reflect the high production potential of the GDR in this particular field of industry.

Product	Unit	1970	1975	1980	1981	1982
Heavy-duty transformers	pieces	9 087	10 047	12 338	13 143	15 655
AC motors	MW	4 343	6 091	7 594	7 565	7 469
Electrical swich-gears and appliances	m marks	1206.8	2138.2	3218.8	3483.0	3686.7
Numerical controls	m marks	29.3	70.7	184.9	299.4	452.2
Relays (heavy and weak current)	m marks	192.5	257.7	321.8	342.0	349.6
Special technological equipment for the manufacture of electronic and electrical products	m marks	147.1	179.3	305.4	343.6	360.8
Cables and conductors	m marks	1703.6	2098.0	2540.0	2587.8	2217.2
Devices and appliances for monitoring and controlling	m marks	548.4	909.5	1333.7	1477.9	1589.2
Electronic components	m marks	430.0	1066.1	2306.7	2798.3	3314.4
Semiconductor elements	m marks	104.7	336.5	985.6	1268.3	1601.0
Integrated circuits	1 000 pieces	-	-	37 685	47 060	55 412

Source: Statistical Yearbook 1983

Table 11 : Output of selected products in electrical engineering, electronics and instrument manufacture- Monetary units at 1980 prices; m marks = million marks (Over the period 1972-1980 the annual average of the exchange rate US dollars/marks was 1/2.38; at present approx. 1/2.70)

Enterprises, workers and employees standing behind those peformances are included in the following table that is devoted to all major industrial sectors of the GDR mentioned above.

Industrial sector	Enterprises	Workers and employees (excluding apprentices) annual average	percentage
Mechanical engineering and vehicle construction	1,351	942,142	29.5
Electrical engineering, electronics, instrument manufacture	359	443,827	13.9
Light industry	933	491,825	15.4
Chemical industry	309	341,006	10.7
Foodstuffs industry	595	276,054	8.7
Energy and fuel industry	50	217,717	6.8
Metallurgy	43	137,443	4.3
Industry total	4,029	3,190,361	100

Table 12 : Enterprises, workers and employees by industrial sectors 1982

Source: Statistical Pocket Book 1983

The GDR exports of engineering products related to the SITC rev.2 code 71, 716, 77 and 771-773 concerning the years 1979-1981 are shown in table 13 (Annex 6).

3.1 Organization of production and the role of combines (Kombinate) in the GDR's economy

The GDR's industrial capacities in the power equipment industry are, like in other industrial sectors, too, nationally-owned and organized in combines (Kombinate) and "the people's own enterprises" (Volkseigene Betriebe, VEB).

In the GDR, combines as the basic units of economic management and operation in industry, construction, transport and communications have obtained their decisive importance for the economy since the end of the 1960s. Practice had shown that powerful economic units were the only rational way to organize advanced large-scale production. This especially refers also to the power economy and power equipment industry, because they require due to their specific nature a relatively high concentration of the production process.

Thus, on the road to an advanced socialist society combines have become the dominating organizational form in the GDR's economy. In 1982 there were 133 centrally managed combines in the sphere of the industrial ministries (1970: 35; 1975: 45; 1980: 130). By that time the foundation of combines in all industrial ministries was completed.

At present combines produce all industrial commodities and all manufactured finished goods for private consumption produced in industry. Furthermore, nearly all industrial exports are produced by combines (99 per cent) and 98 per cent of all workers and employees in the sphere of the industrial ministries are employed in combines.

A combine in industry consists of a number of organically linked and legally independent enterprises which have been merged in one organization, usually horizontally but also vertically, and report directly to the respective industrial ministry (see figure 6).

Organically linked and legally independent enterprises means that

- they are organized according to the production profile and structure as required by their economic responsibility and
- the individual plants remain legal entities, responsible for their own planning, management and clearing system, and retain their original name.

The general formation of combines in all industrial branches including the power equipment industry proved to be the most important step in perfecting management and planning, especially in view of the orientation towards a mainly intensive type of development of national economy in the 80s.

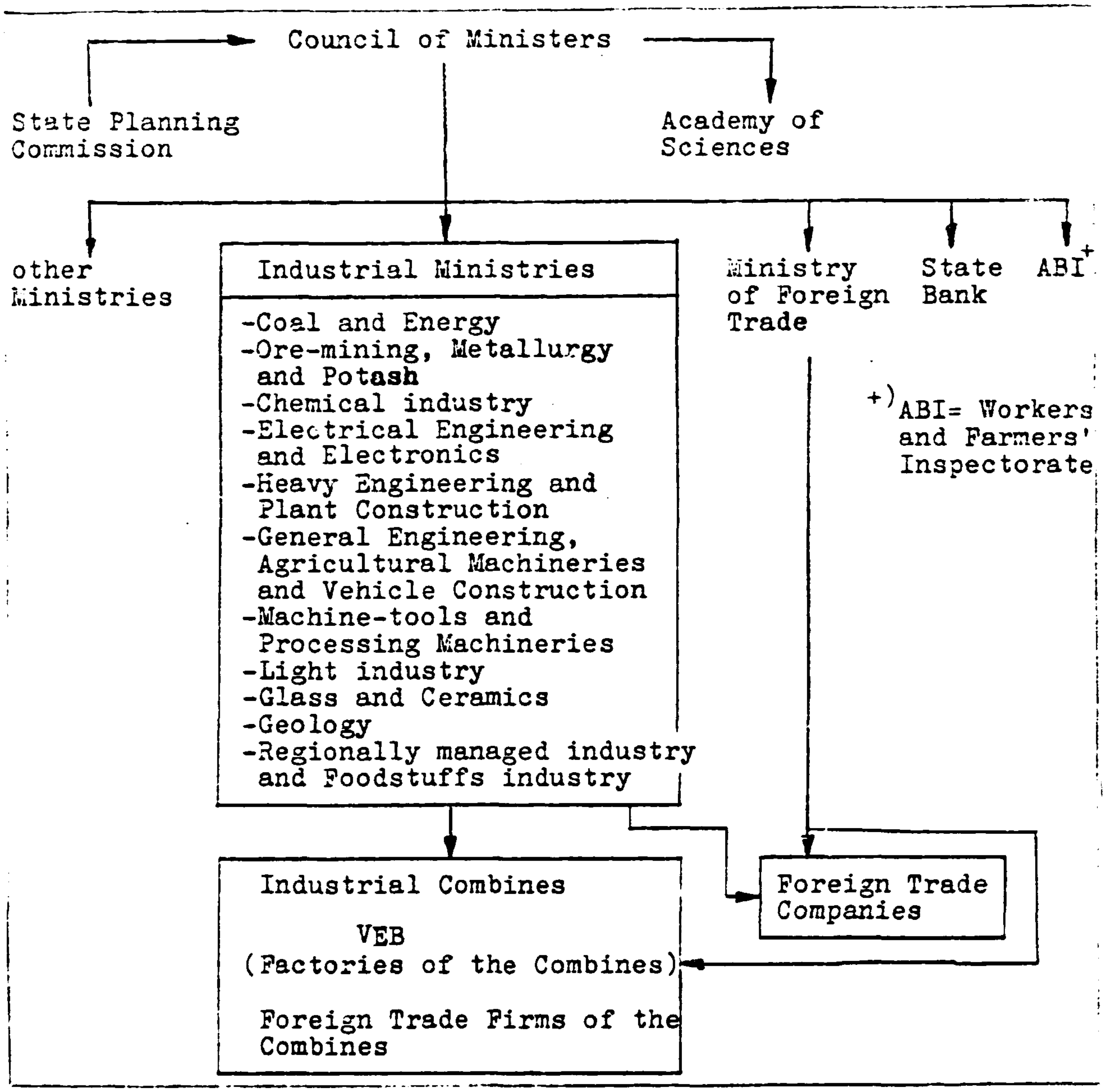


Figure 6 :Management Structure of National Economy in the GDR, (simplified)

The combines occupy a key position in the production process. They make it possible to organize the economic relations comprehensively in the very place where the process of reproduction takes place. Characterizing combines as the GDR's fundamental economic units with a relatively closed reproduction cycle reflecting objectively the economic concentration process on a socialist basis the following features should be underlined, too:

(1) Combines are large and efficient economic units operating on a precise cost-benefit analysis. They have every opportunity of raising levels of productivity, efficiency and quality and are in a position to make better use of advantages of co-operation and specialization.

(2) Combines reflect the necessary integration of science with production. They concentrate the material and technological capacities and almost the entire research and development potential of industry in the respective sectors. They are linked by contracts to universities, colleges and research institutes and their activities are aimed at applicating the latest findings of science and technology in industry.

(3) Combines fulfil foreign trade functions. Since 1981 foreign trade companies have been put under the direct control of combines or industrial ministries.

The organization of production on the basis of combines makes it possible to ensure the centralized management of the entire production process from research and development stage to the manufacturing phase and sales inside of the country and abroad.
At the same time it goes hand in hand with a large degree of responsibility on the part of individual enterprises.
As can be seen from figure 7 combines are also the mainstay of the GDR's power equipment industry which are able to respond in a flexible way to the requirements of the economy, consumer demand and export markets.
In connection with exports on which a great part of their capacities are concentrated and the fulfilment of their foreign trade functions, the following guiding principles, reflecting the social nature of socialist firms in international co-operation, should be mentioned:

(1) The work of economic organizations in socialist countries, including those of the power equipment industry, follows in line with the basic principles of co-operation, such as
- respect for national souvereignty,
- non-interference in internal and international affairs,
- equality and mutual benefit.

(2) Socialist firms operate in accordance with national development plans and within the framework of trade agreements between states and strictly observe local laws.

The GDR's Power Equipment Industry

Ministry of Heavy Engineering and Plant Construction

Kombinat Kraftwerksanlagenbau
6 factories

- normal-load power plants
- heat power stations
- industrial power plants
- gas turbines plants
- pumped-storage plants

Ministry of Electrical Engineering and Electronics

Kombinat Elektroenergieanlagenbau
10 factories

- complete electric power transmission plants
- complete electrotechnical plants
- repair shops for transformers and motors
- complete high-voltage test departments and laboratories

Kombinat Automatisierungsanlagenbau
12 factories

- complete automation plants
- signal, communication and power plants
- machinery controls and drives
- power electronics
- emergency current generating sets

Kombinat Kabelwerk Oberspree
13 factories

- power cables
- power lines
- telecommunication cables
- telecommunication lines
- winding wires
- power cable accessories
- telecommunication accessories

Kombinat Elektromaschinenbau
15 factories

- AC machines
- DC machines
- engine driven generating sets
- machines of the smallest category
- special machines and appliances

Kombinat Keramische Werke Hermsdorf
20 factories

- insulating solids and insulators
- electroinstallation materials
- low-voltage switchgear
- electronic components

Figure 7 :
Organizational structure of the GDR's power equipment industry

(3) Companies and foreign trade organizations of socialist countries base their activities not on establishing networks of subsidiaries and affiliates, but on contracts with local partners.

Thus, international co-operation of economic organizations of the GDR with developing countries contributes to the strengthening of the developing countries' economic and technological independence, to an increase of employment in those countries and to the promotion of their national economies as a whole. This underlines the quite different character of socialist firms with respect to activities of TNCs.

3.2 Profile and production programme of the GDR's power equipment industry

3.2.1 Power station installations and equipment

The VEB Kombinat Kraftwerksanlagenbau (KAB), (see figure 8) is the general contractor and general supplier of power station installations and power station equipment, especially in the field of energy machine building. Main products are shown in table 14 (Annex 7).
The combine with its 42,000 employees has more than 30 years of experience in the field of planning, production, mounting, testing and commissioning of complete power plants at home and abroad. The 6 enterprises attached to the combine are specialized for the manufacture of main equipment for power plants. They supply all the turbo-generator sets, steam generators, water-treatment equipment and piping systems as an integral part.
The VEB Kombinat Kraftwerksanlagenbau plans and designs complete power plants and plant systems. It offers to its partners and potential customers complex systems for all requirements of electrical energy and heat generation. The combine is able to realize both the construction of new power plants and the development and reconstruction of already existing energy-generating plants.
The close co-operation within the scope of socialist economic integration as well as the collaboration in research between the member countries of the CMEA enables the combine in the GDR to errect

- normal-load power plants on the basis of raw lignite as fuel with a block performance of up to 500 MW and steam generators with a capacity of up to 815 t/h;
- industrial power plants with block performances up to 125 MW;
- heat power stations with block performances up to 60 MW;
- heat stations with an output of the single boilers of up to 320 t/h.

Furthermore, KAB offers also complete heat power stations and industrial power plants of smaller capacities. For that purpose the following equipment can be used:

- steam generators with a capacity of 10, 25, 40, 64 t/h for solid, liquid and gaseous fuels;
- turbines 1 ... 16 MW.

This potential forms the basis for offering technological variants in power plant construction which are convincing as regards economic aspects.

VEB Kombinat Kraftwerksanlagenbau

Main contractor and main project planning for complete systems and equipment, adapted to individual demands

GDR- 1017 Berlin
Hans-Beimler-Straße 91-94
Telephone: 4 38 50 Telex: 011 2501

VEB Dampferzeugerbau Berlin

Planning, production and assembly of steam-generating sets for all kinds of fuel

GDR- 1086 Berlin
Behrensstraße 21
Telephone: 2 20 26 11 Telex: 11 48 22

VEB Bergmann-Borsig/Görlitzer Maschinenbau

Planning, production and assembly of power generating stations with steam turbine

GDR- 1110 Berlin
Kurze Straße 5-7
Telephone: 4 80 08 21 Telex: 11 23 95

VEB Rohrleitungen und Isolierungen

- Planning, manufacture and main assembly of industrial and power plant piping systems
- Distant heating and long-distant gas pipelines
- Production and delivery of single equipment

GDR- 7021 Leipzig
Hohmannstraße 1
Telephone: 5 61 60 Telex: 051 625

VEB Wasseraufbereitungsanlagen Markleeberg

Planning, production and delivery of water-treatment and filtering stations for drinking water and water for industrial use

GDR- 7112 Leipzig-Markkleeberg
Koburger Straße 45
Telephone: 3 95 20 Telex: 051 401

VEB Strömungsmaschinen Pirna

Production of gas turbine sets for emergency power systems as well as hydrodynamic elements for power transmission

GDR- 8300 Pirna
Sonnenstein
Telephone: 820 Telex: 028 322

Exporter:

Technocommerz G.m.b.H.

GDR- 1080 Berlin
Johannes-Dieckmann-Straße 11-13
Telephone: 22 40 Telex: 011 4861

Figure 8 : The combine Kraftwerksanlagenbau, enterprises and exporter

Due to the GDR's importance as lignite mining country the combine has special experience in the field of constructing power plants on the basis of raw lignite as fuel. Projects such as the largest lignite-fired power plant in Europe, namely the B o x b e r power plant with a power of 3,520 MW, attracted international attention. The thermal power station T h i e r b a c h, which was erected in close co-operation with the USSR, Hungary and Poland (see figure 9) can be regarded as another example.

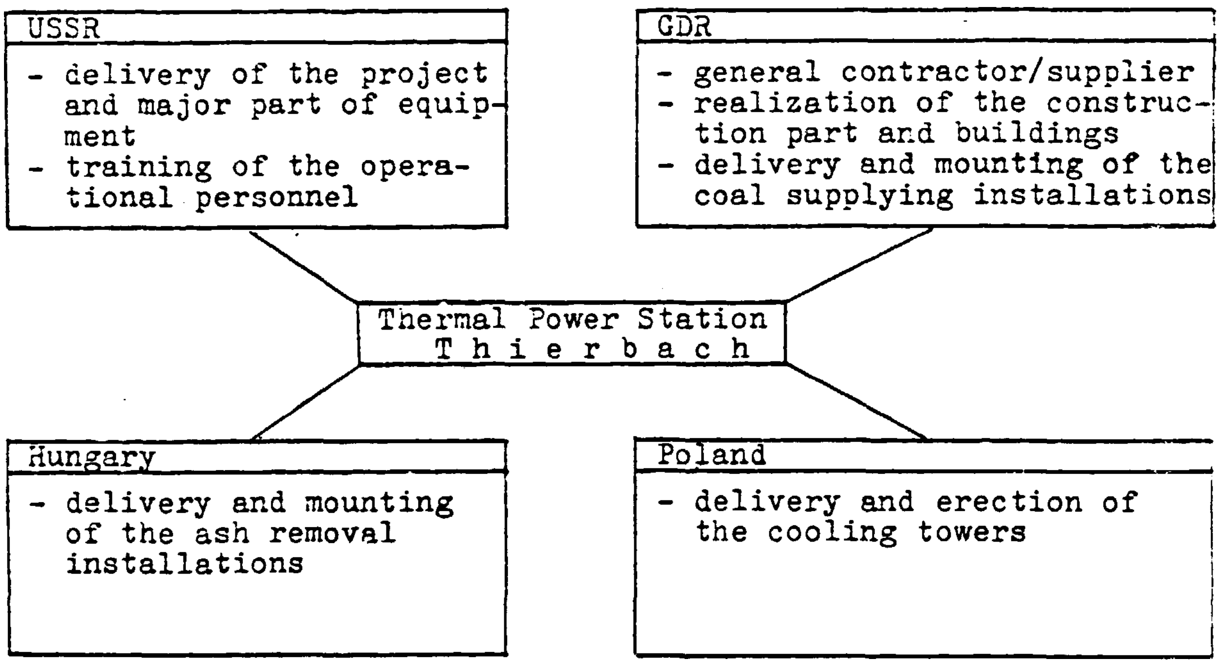


Figure 9 : Co-operation with CMEA countries in power plant construction (Thermal Power Station Thierbach)

Proceeding from considerations how to use primary energy resources most economically, KAB has developed and tested in practice special solutions for the substitution of heating oil by solid fuels, especially raw lignite. According to requirements steam generators with a capacity of 6.5 ... 64 t/h are used. In all cases technological standard solutions are applied which make possible adaptations to various local conditions.

In accordance with the demands of customers KAB has developed an assortment of largly preassembled mini power stations. Their advantages are short terms of delivery, low transport volume, small expenditure of capacities for the erection of the plants and a reliable operation. KAB's peformance programme in the field of mini power stations includes boilers and power generating sets starting with a capacity of 1.6 t/h and 1 MW respectively.

The application of such mini power stations is also suitable for remote industrial and municipal areas, in particular in case that there exists not only a demand for electricity but also for thermal energy for production processes and/or refrigeration engineering.

The combine has also rich experience in utilizing bagasse as fuel. In the course of more than 15 years, some 200 bagasse steam generators took up operation. They are working in Indonesia, Egypt and Cuba. In addition to that KAB offers very efficient procedures for other dirty, low-quality fuels rich in slag such as rice shells, coconut shells and wood waste but also for oil and gas as well as for mixed fuels.

Power -generating plants from KAB are today operating at home and abroad, among others in enterprises of the foodstuffs industry, textile industry and chemical industry as well as in factories for alkohol production, pulp production and cement production.

Hitherto, the GDR's power plant building industry has exported almost 120 entire industrial power stations. In general they are operating with outstanding availability and high efficiency in all CMEA countries, in Cuba, Finland, Turkey, Iran, Iraq, Syria, Egypt, Algeria, Sri Lanka, Indonesia, Mexico, Uruguay and China.

However, VEB Kombinat Kraftwerksanlagenbau does not only offer complete systems or system parts, but it delivers also high-quality secondary systems, subassemblies and single equipment parts for power plants including all piping systems. Furthermore, it has a production and export programme of sophisticated single products for the most different public consumers at home and abroad.

This involves:
- marine auxiliary boilers,
- subassemblies for steam generators,
- oil and gas firing systems for power plant equipment,
- small gas turbines, emergency generator sets,
- hydraulic fluid drives, torque converters and
- tanks and filters for water-treatment equipment.

Equipment which reflects a part of the export programme in the field of power station installations is shown in table 15 (Annex 8).

In addition to this, the following deliveries have been realized for investment projects for condensation, industrial and heating power stations in the GDR within the period of 1955 to 1980:

equipment	specification	units
Steam generator	125 t/h oil	22
	220 t/h oil	10
	125 t/h lignite	17
	160 t/h lignite	4
	200 t/h pit coal	7
	220 t/h pit coal	4
	230 t/h lignite	12
	330 t/h lignite	4
	350 t/h lignite	12
	420 t/h lignite	8
	815 t/h lignite	16
Condensing turbo-generator sets/ Extraction condensing turbo-generator sets	0.3 to 5 MW	41
	6 to 20 MW	65
	25/32/40 MW	64
	50/64/80 MW	19
	100/125 MW	32
Backpressure turbo-generator sets/ Extraction backpressure turbo-generator sets	0.3 to MW	298
	6 to 20 MW	48
	25/32/40 MW	52
	50/64/80 MW	14
Gas turbines	25 MW	2
	27 MW	24
Generators	12.5 to 137.5 MVA	189
Axial-flow compressor plant	250,000 Nm^3/h	3

Table 16 : Deliveries for condensation, industrial and heating power stations in the GDR by the factories of KAB (1955-1980)

Thus, KAB represents an industrial branch of GDR economy in which experienced scientists, engineers and skilled workers have proved their high capability in the development and production of all equipment relevant to the process of power generation.

3.2.2 Equipment for electric power transmission and distribution plants

The GDR's main capacities of equipment production in the field of electric power transmission and distribution plants are represented by the VEB Kombinat Elektroenergieanlagenbau (KEA). The combine's enterprises and the foreign trade companies, which solve the problems in close co-operation with KEA for their partners concerned, are named in figure 10.

KEA's production profile is very extensive. It includes the planning, delivery, mounting and commissioning of

- complete systems of electric power transmission and distribution on all internationally used voltage levels up to 420 kV;
- complete electrotechnical plants and equipment for all branches of industry (i.e. chemical, metallurgical, textile, printing and food industry), agriculture, and civil engineering;
- complete repair shops for transformers and motors;
- complete systems of low-voltage engineering including low-voltage testing facilities;
- complete high-voltage testing plants and equipment as well as scientific- technical performances of the high-voltage testing technique;
- plants and equipment of X-ray technique and electromedicine

and partial plants and deliveries of devices for the applications mentioned.

This production programme sets criterion to the techno-economic performance of KEA's enterprises as well as to the scientific and professional power of all staff members.

The great share of the export of projected and delivered plants and equipment of most different systems and sizes stands for confidence and reliability as well as for quality and efficiency of power-engineering performances and products from KEA.

The combine's list of references reflects performances for or with foreign partners from more than 40 countries between 1961 and 1984 including the realization of

- sub-stations and projects for electrification programmes,
- electrotechnical equipment for industrial plants and

other selected equipment and plants.

Value and structure of KEA's exports and imports related to 1983 are shown in table 17 and table 18 (Annex 9), respectively.

In case of special plant systems, for instance, for electrotechnical plants with voltage-levels different from standards, the share of imports can amount up to 20 or 30 per cent of the complete power transmission and distribution plant to be installed.

The close co-operation with national and international universities and academies and particularly with the own research centre, the Institute "Prüffeld für elektrische Hochleistungstechnik" (IPH), is one of the prerequisites for the high performance level reached.

The combine and its export enterprises	Foreign trade enterprises (exporters)
VEB Kombinat Elektroenergieanlagenbau GDR-7010 Leipzig Humboldtstrasse 2a VEB Starkstrom-Anlagenbau+) Leipzig-Halle (parent enterprise) GDR-7010 Leipzig Schützenstrasse 4-6 VEB "Otto Buchwitz" Starkstrom-Anlagenbau Dresden GDR-8060 Dresden Industriegelände, Eingang G	Elektrotechnik EXPORT-IMPORT People-owned foreign trade enterprise of the GDR GDR-1026 Berlin-Alexanderplatz Haus der Elektroindustrie Intermed-export-import people-owned foreign trade enterprise of the GDR GDR-1020 Berlin Schicklerstrasse 5/7
VEB Starkstrom-Anlagenbau Magdeburg GDR-3014 Magdeburg Blankenburger Strasse 58/70 VEB Transformatorenwerk "Karl Liebknecht" Berlin GDR-1160 Berlin Wilhelminenhofstrasse 83-85 VEB Transformatoren- und Röntgenwerk "Hermann Matern" Dresden GDR-8030 Dresden Overbeckstrasse 48 VEB Transformatorenwerk Reichenbach GDR-9800 Reichenbach/Vogtland Untere Dunkelgasse 20 VEB Schaltgerätewerk Muskau GDR-7582 Bad Muskau Strasse der Solidarität 78 VEB Schaltgerätewerk Werder GDR-1512 Werder/Havel Eisenbahnstrasse 31-33 VEB Hochspannungs-Armaturenwerk Radebeul GDR-8122 Radebeul 2 Fabrikstrasse 27 Institut "Prüffeld für elektrische Hochleistungstechnik" GDR-1130 Berlin Leninallee 376	

+) SALH is general supplier of electrotechnical systems for
- power transmission and distribution plants
- repair shops for transformers

at home and abroad

Figure 10 : The combine Elektroenergieanlagenbau , export enterprises and exporters

3.2.2.1 Complete electric power transmission plants

The design and construction of transformer stations depends from the technical point of view, on the construction and extent of the system, i.e. on

- the size of power to be transmitted, the number of connected lines and their operating voltage which determines the size of the transformer station;
- the parameters inherent in the system which influence the selection of devices and their arrangement due to their function in the transformer station and
- the requirements regarding reliability in supply of electric power and regarding the necessity of systematic maintenance from aspects of system engineering.

These conditions are taken into consideration when designing transformer stations. Compliance with international and with national standards, such as the recommendations of IEC, of GDR-Standards (TGL), of Soviet Standards (GOST) and British Standard Specifications (BSS) as well as the Specifications of FRG (VDE) can be fulfilled.

The enterprises VEB "Otto Buchwitz" Starkstrom-Anlagenbau Dresden (SAD) and VEB Starkstrom-Anlagenbau Leipzig-Halle (SALH) (see figure 10) act as general suppliers of complete transformer stations. They are responsible for all activities from the technical clearance via projection, supply and mounting up to commissioning of the plant.

a) Outdoor switching stations

Transformer stations of 245 kV and 420 kV are designed in tandem arrangement or in construction with mixed phases. The most essential differences between these two kinds of constructions consists in the arrangement of transformers and isolators. Transformer stations of 72.5 kV and 123 kV can be erected as simplified transformer stations or in traditional design, where the simplified transformer station represents a particularly cost saving plant as the need of devices and steel frames is very low.

b) Indoor switching stations

Climatic and technical conditions as well as local circumstances can require switching stations for 72.5 kV and 123 kV as indoor plants. Their different forms depend on the purpose of their application, on the arrangement of the switching station into the total concept as well as on the degree of freedom in arranging and selecting the site of erection. An economically favourable solution well-proved in practice represents the hangar construction which is preferred particularly in countries having a dry-warm climate. The whole installation is distinguished by its small floor space required, by its good clean layout and by its safe management. As voltages of 72.5 kV and 123 kV develop more and more to distribution voltages, the necessity exists and with these plants also the prerequisite, to include such installations into construction of cities and city areas without further ado.

It is no more possible to reduce switching stations of 123 kV in their volume by using traditional switchgears. Thus, in case of need it is necessary to apply gas-blast, completely clad switchboards. Their prefabricated manufacture comprises the whole control panel. SF_6 (sulphur hexaflouride) is used for insulation. Such a gas-blast switch panel of type GSAS comprises the busbar section in single or double busbar design, the busbar isolators and busbar earthing isolators, the circuit-breakers, the outgoing earthing switches as well as the current and voltage transformers. Together with solid-insulated switching stations for 36 kV or 40.5 kV it is then possible to erect a completely safe installation protected against accidental contact needing a minimum of space to supplement it in case of need with indoor switching stations of 6 kV ... 20 kV.

From 1972 to 1983 there have been manufactured about 179,000 air-insulated and 2,400 solid-insulated switchgear cubicles. This amounts to roughly 14,900 and 2,400 switchgear cubicles per year, respectively.

c) Main equipment

The main equipment is essentially products from the enterprises VEB Transformatorenwerk "Karl Liebknecht" Berlin (TRO) and VEB Transformatoren- und Röntgenwerk "Hermann Matern" Dresden (TRD).

- Transformers

As main transformers for all transformer stations approved designs of oil-immersed three-phase transformers up to 420 kV primary voltage having outputs up to 600 MVA per unit are applied.

Whilst generally up to a primary voltage of 245 kV multi-winding transformers are applied, units of more than 245 kV are designed as autotransformers. Besides the three-phase types of 250 MVA, 310 MVA and 400 MVA for transformer stations of 420 kV, a standard design is available for 800 MVA three-phase output, comprising three single-phase units.

The average annual output of transformers during the last few years related to different rated power is given in table 19:

Rated power (MVA)	Average output per year (MVA/year)
63 - 630	5432
1 - 63	6100
0.05 - 0.63	1855

Table 19: Average output of transformers per year

Auxiliary transformers can be applied as air-insulated transformers, so that they can be installed directly within buildings and with smaller transformer stations directly within the switching station.

- Circuit-breakers

According to the case of need it is possible to erect air-blast circuit-breakers for rated voltages from 72.5 kV up to 420 kV, operating on the principle of pressure chambers, or also oil-poor circuit-breakers. The circuit-breakers for rated voltages from 12 kV up to 36 kV are approved design with oil-poor high-capacity quenching chambers which are used in prefabricated switchgears. On special request it is also possible to apply a prefabricated SF_6-switchgear for rated voltages from 72.5 kV up to 145 kV.

- Isolators

Double lever-type isolators with double blades in two column construction are used for 245 kV and 420 kV, having their conductor path in horizontal plane in closed condition.

A pantograph-type construction with horizontal pantograph is available for 123 kV which can be adapted also in its insulation to systems of 145 kV.

All isolators can be operated by compressed-air or by motor force always according to the case of need so that uniform driving systems are possible for all switchgear. The isolators of 72.5 kV can be driven, moreover, by hand.

- Current and voltage transformers

Always according to the requirements, it is possible to erect instrument transformers as separate units or as so called instrument transformer combinations. All transformers are designed in pot-typ insulator construction. It is also possible to install current transformers into the transformer bushing for branch circuits with transformers of higher outputs.

- Surge diverters

The surge diverters are equipped with ceramic leakage resistors and with magnetically blast spark gaps and with tell-tale spark gaps which permit to make conclusions to the load and to the condition of spark gaps.

d) Subsidiary plants

The safety of supply of a transformer station depends essentially on the safe serviceability of the necessary subsidiary plants. These subsidiary installations include

- auxiliary installations (e.g. standardized metal-clad or plastic-clad switchgear cubicles produced by SAD, emergency generating sets in greater transformer stations, stationary lead batteries together with metal rectifiers for safe supply d.c. voltage for control-, protective- and monitoring equipment);
- compressed-air generating and distributing systems (e.g. for air-blast high-capacity circuit-breakers)
- protective equipment for protection, measurement and control as well as for monitoring of the switching stations on the basis of an extensively available assortment of suitable divices of the heavy- and light-current engineering as well as of electrical and semi-electronic modules;
- communication channels for data- and signal transmission (e.g. the carrier transmission via high-voltage lines), fire-extinguishing systems and control rooms.

3.2.2.2 Single units and equipment for electric power transmission and distribution plants

KEA offers an extensive assortment of main equipment for the electric power and electrotechnical fields, including

- gas-blast high-voltage switchgears GSAS 1-123,
- solid-insulated high-voltage switchgears ASIF 36,
- high-voltage divider LHTCIG-12/400,
- metal-clad air-insulated high-voltage switchgear cubicles,
- high-voltage switchgears CSIM 3-12,
- compact transformer station,
- low-voltage switchgear cubicles ISA 2000 W,
- low-voltage capacitor systems of 70 up to 960 kvar,
- transformers (transformers of maximum output, generator transformers, mains transformers, local network and other transformers),
- circuit-breakers (air-blast heavy-duty circuit-breaker system D3AF7/D3AF8, oil-poor indoor circuit-breakers SCI, load isolating switches LHTCI 4-12/400 and LHTCI 4-24/300, oil-poor circuit-breakers HPF),
- isolators,
- instrument transformers (current transformers, voltage transformers) and
- other equipment for subsidiary plants.

Selected technical characteristics and the manufacturers of these products are shown in table 20 (Annex 10).
Due to their technical and economical advantages with the formation of power transmission and distribution systems prefabricated systems of switching stations for high- and low-voltage become more and more important. Compact, space saving types, high degree of standardization as well as simple and unproblematic facilities of addition contribute to increase the realiability in service, thus reducing cost and time for planning, mounting, management and maintenance.

3.2.2.3 Repair shops for transformers and motors

The scope of offer which is incorporated in the delivery programme of SALH includes the performances as follows:

- projecting, supply, mounting and commissioning of technical equipment for repair and testing of transformers and electric motors including the electrical and general supply systems;
- project of the construction of buildings and advisory co-operation for execution of building construction;
- supply of repair and test technologies (know-how) for products of GDR-production;
- training of skilled labours for repair and test of transformers andelectric motors of GDR-production.

3.2.2.4 Testing stations and laboratories as well as testing performances for high and low-voltage

The tasks of research and development to master transmission and distribution of electric power increase owing to the continuously rising demands in the field of high and low-voltage engineering. These tasks can only be solved connected with practice in modern testing stations and laboratories which are able to test thoroughly materials and devices within the state of development but also during manufacture for their future conditions of application.
SALH projects, supplies and mounts in close co-operation with the manufacturer TRD since more than 20 years electrotechnical equipment for complete high-voltage testing stations and laboratories. Individual units and devices of high-voltage testing technique and appropriate testing performances executed by the IPH can be taken from table 21 (Annex 11). The equipment allows generally to carry out tests according to international and national electrotechnical standards in force (TGL, CEE, GOST, VDE, IEC and others).

3.2.3 Cable industry

The GDR cable industry is based on enterprises with traditions reaching back to 1858. The 13 enterprises today forming the Kombinat VEB Kabelwerk Oberspree (KWO) "Wilhelm Pieck" (see figure 11) have become efficient socialist producers over the past 35 years. KWO has workforce of about 17,000. Long -year experience, high scientific and technical efficiency and proved quality work are the basis for the good international reputation of this branch of the GDR electrotechnical industry. Since its foundation in 1967 the combine has more than doubled the production of cables and lines which are major investment goods in the following main areas of application: Energy transmission and distribution, electrical engineering industry, electrotechnical and telecommunication plants, communication systems, control engineering, housing construction, sub-contracting for producers of electrical consumer goods, electronic data processing, etc. Major product groups include:

- power cables in ranges of up 150 kV;
- interlaced PE-insulated power cables for 10-30 kV;
- power lines;
- connecting lines for electrical appliances;
- winding wire for electrical engineering construction;
- power and telecommunication accessories;
- symmetrical and coaxial telecommunication cables for long-distance traffic (up to 60 MHz);
- plastic-insulated local telecommunication cables;
- radio-frequency cables for transmission and reception;
- ship's cables.

Major materials: Copper, aluminium, lead, PVC, polyethylene, styroflex, synthetic rubber, cable paper, steel band.

A survey on the production programme is given in table 22 (Annex 12). The comprehensive application of aluminium and plastics dominates. Over 80 per cent of the combine's output comes from exclusive producers. Proceeding from latest scientific and technological knowledge and taking account of economic requirements, the combine has developed a new range of cable products since its inception. Today not a single product manufactured at the combine has more than 5 years on its back. 90 per cent of the products bear comparison with world standard, and of these 25 per cent are international top-class products.

The scientific-technological achievments of the combine in the production and assembly of cables with aluminium conductors and sheaths deserve special mention. Good electric conductivity, low weight, high shock resistance , low reduction factor, easier cable-laying and installation are the generally recognized advantages of aluminium cables.

The combine's steadily rising export of cables (1970= 264.3 and 1980= 455.7 million valuta marks, respectively) reflects the high scientific and technological standard and quality of the KWO products. Table 23 (Annex 13) shows KWO's export programme of power cables. The entire range of products included there is exported by KWO to more than 40 countries. According to selected projects and countries the combine delivered the following power cables 10-150 kV to foreign buyers between 1960 and 1981:

Typ	Length
- oil-filled power cables 66 kV - 150 kV, standardized and custom-made	351,600 m
- paper-insulated power cables 10 kV - 35 kV, standardized and custom made, including non-draining cables	10,120,000 m
- XLPE power cables 10 kV - 24 kV, standardized (as of 1976)	593,600 m

Table 24 : Delivered power cables 10-150 kV between 1960 and 1981 (according to selected projects and countries)
Source: Reference list KWO

As regards oil-filled cables, large-scale projects of power engineering realized inside the GDR have been included in this table. In the scope of the deliveries included in table 24 , numerous power engineering projects in various countries have been realized with the assistance of sub-contract construction by the KWO.

The products destined for export are made either to the specifications of the buyers or in accordance with foreign standards and regulations (BS, VDE, NEN, NEMKO, etc.). The combine's major export contractors include the parent factory KWO and VEB Kabelwerk Köpenick, as well as VEB Kabelwerk Nord (see figure 11). These specialized works produce paper-compound-insulated and plastic-insulated power cables, rubber-insulated power lines, symmetric and coaxial long-distance telecommunication cables, plastic-insulated local telecommunication cables, etc.

Some 60 per cent of the combine's industrial goods production are being produced at the four plants in Berlin. The parent enterprise- the biggest individual plant of the combine- has a staff of 6.500 people. VEB Kabelwerk Nord employs about 2.200 workers and the other plants have a workforce of several hundred each. The combine has acquired extensive experience regarding the supply of know how for cable production and construction of complete cable works abroad. Its service for foreign buyers includes planning and construction of cable plants as well as subcontract construction for specific products.

Important factors of the successful development of the combine are the close connections with the cable industries of other socialist countries based on plans and treaties on both bilateral and multilateral cooperation in the international organization "INTERELECTRO" founded in 1973.

VEB Kabelwerk Oberspree (KWO) "Wilhelm Pieck", (parent enterprise)
GDR- 1160 Berlin, Wilhelminenhofstrasse 76/77
Telephone: 63 30, Telex 01 12308

VEB Kabelwerk Nord, 2700 Schwerin
VEB Kabelwerk Köpenick, 1170 Berlin
VEB Kabelwerk Meissen, 8250 Meissen
VEB Kabelwerk Adlershof, 1199 Berlin
VEB Kabelwerk Vacha, 6220 Vacha (Rhön)
VEB Kabelwerk Schönow, 1282 Schönow
VEB Kabelwerk Plauen, 9900 Plauen/Vogtland
VEB Kabelwerk Lausitz, 880_ Niedeoderwitz (OL)
VEB Kabelwerk Kranichfeld, 5305 Kranichfeld
VEB Kabelwerk Beelitz, 1504 Beelitz
VEB Kabelwerk Schlettau, 9316 Schlettau (Erzgebirge)
VEB Schnellflechter, 1120 Berlin

Exporter
Elektrotechnik
EXPORT-IMPORT
Volkseigener
Aussenhandelsbetrieb der DDR
DDR-1026 Berlin
Am Alexanderplatz
Haus der Elektroindustrie

Figure 11 : The combine Kabelwerk Oberspree, enterprises and exporter

3.2.4 Electric machines

The GDR has great traditions and long-standing experience in the field of manufacturing electric machines. In the factories of the today's VEB Kombinat Elektromaschinenbau (KEM) were produced electric machines already in the year of their invention, i.e. more than 100 years ago. Actually, the KEM which was founded in 1971 with its 15 enterprises (see figure 12) and 27,000 workers is realizing an annual commodity production of about 2.5 thousand millions of marks. Within the past 10 years production and sales have increased steadily by some 7 per cent yearly. Per day 38,000 electric machines of outstanding quality are leaving the production lines. In 1982 there were manufactured some 8.5 million units of electric machines. About 11 millions of electric machines are to be produced in 1985. Till now, more than 25 millions standard motors, 5 millions geared motors, 15 millions single-phase motors, nearly 20 millions refrigerator motors- this are numbers of pieces which represent international peak values and demonstrate both continuity and efficiency as well as constant quality and reliability. Between 1975 and 1980, for instance, more than 85 per cent of the KEM's overall production range were covered by newly and further developed products.
The GDR's electrical engineering branch, i.e. KEM with its specialized factories,manufactures electric motors, generators and sets of machines. 80 per cent of these products have been awarded design, quality and fair diplomas of international exhibitions. The productions of the combine's plants which, apart from insignificant exceptions, include all types of electric machines is largely specialized in product kinds and sizes. This specialization was a prerequisite for the application of highly productive manufacturing techniques.
Highly developed basic series of electric drives form the basis of production. This permits the derivation of a multitude of electrical and constructional variants which meet the respective requirements of customers in the form of modified or special designs with respect to different applications and extreme driving specifications. In this connection, efficient standard ranges of AC and DC machines are decisive starting points. Table 25 (Annex 14) contains the sales programme of electric machines delivered by the GDR's electrical engineering branch.

The combine and its
15 specialized branch factories

Exporter

Elektrotechnik
EXPORT-IMPORT
Volkseigener
Außenhandels-
betrieb der DDR
GDR-1026 Berlin
Alexanderplatz
Haus der
Elektroindustrie

VEB Kombinat Elektromaschinenbau
GDR- 8017 Dresden, Hennigsdorfer Strasse 25
Telephone: 22 90, Telex: 2115 kem dd

VEB Forschungs- und Entwicklungszentrum für Elektromaschinen
- Scientifico-technological potential including research, development and test facilities
- General contractor for the export of complete plants

VEB Elektromaschinenbau Sachsenwerk
- Three-phase high-voltage motors
- DC machines
- Generators
- Motor-generators
- Stepping drives

VEB Elbtalwerk Heidenau
- DC machines
- DC change-speed motors in NC machine tools

VEB Elektromotorenwerk Dresden
- Main and auxiliary drives for rail vehicle construction
- DC servomotors for industrial robots

VEB Elektromotorenwerk Großenhain
- Three-phase dynamos for motor cars and utility vehicles

VEB Elektromotorenwerke Thurm
- Three-phase standard and geared motors

VEB Elektromotorenwerk Grünhain
- Single phase motors

VEB Elektromotorenwerk Eggesin
- External-rotor motors
- AC change-speed drive

VEB Elektromotorenwerk Hartha
- Small-type and precision miniature machines
- DC change-speed motors in NC machine tools

VEB Elektromotorenwerk Dessau
- Generators
- Clutches and brakes

VEB Finsterwalder Maschinen-, Aggregate- und Generatorenwerk
- Diesel and gasoline-driven generating sets
- Generators
- Commutators

VEB Elektromaschinenwerk Wernigerode
- Three-phase standard motors

VEB Elektromotorenwerk Oschersleben
- Electro-hydraulic linear drives

VEB Elektromotorenwerk Barleben
- Protective relays for transformers
- Induction motors
- DC change-speed drives

VEB Gießerei und Maschinenbau Berlin
- Castings for electrical engineering

Figure 12 : The combine Elektromaschinenbau, enterprises and exporter

Electrical engineering is a significant supplier especially for the metal working industry. Its products are supplied to approximately 80 branches of the national industry. About two thirds of the domestic sales are required by engineering and vehicle construction industries, whereas almost one third is supplied for electrotechnical and electronic applications. Rotary electric machines are used in all fields of industry.

80 per cent of all sequences of motions- and this tendency is still on the rise- are nowadays realized by electric drives. A single conveyor bridge unit from TAKRAF[5] in a brown coal strip mine moves with the aid of almost 1,000 electric motors of different designs. Considering the fact that, for the present, approximately half the lignite quantity produced in the world is mined by means of TAKRAF machineries from the GDR, it is imaginable what an impressive number of GDR made electric motors is installed in this field only. On the average, a large-scale enterprise in the GDR nowadays uses some 20,000 electric motors.

The supply programme of the GDR's electrical engineering includes, above all, the following:

- Electric machines of most different modes of operation the power output of which is between 0.5 W and 16.0 MW, for the construction of plants and apparatus, i.e. electromotive drive systems, the control system included, of such branches as conveying machinery, ship-building, machine tool and processing machine building, plastic machinery, in rail vehicle and printing machine building, in the farm machinery industry as well as in the consumer goods industry and in the field of optics and precision mechanics (a wide range of standardized series of electromotors, generators, aggregates and a system of unified electric machines as well as special drives);
- Consultation and projecting of assembly- and manufacturing lines for motors, generators and aggregates;
- Erection of complete factories for electromotors and technical assistance in the preparation of manufacture and the manufacture itself by an own general contractor;
- Guidance and assistance in the organization of servicing stations and the training of the technical operating personnel;
- Exports of scientific and technical results as well as transmission of the experience and know-how gained in the field of electric machine building by industrial co-operation (licence, patents for construction and technology, consulting and engineering);
- Realization of long-range tasks in electrical engineering industry together with partners in the CMEA countries.

Electric motors from the GDR can be found in almost 100 countries of the world, in all continents and in all climate zones. Direct exportation is effected into 45 countries including all major European markets. In all major markets the GDR is represented by

[5] TAKRAF is the GDR association of nationally owned enterprises manufacturing strip mine equipment, cranes and conveying machinery

national general agents who are able to provide for on-the-spot safeguarding of essential sale functions to the consumers by means of a comprehensive range of services. Besides the significant trade relations with socialist countries, above all with the USSR, the trade relations with Western European industrial countries have also been continuously extending for the past few years. This also applies to the relations with developing countries to give them support in the industrialization process of their countries.

Thus, the GDR's electrical engineering is known and appreciated in countries such as the FRG, Italy, France, Austria, Switzerland, all Scandinavian countries, all BENELUX countries, as well as in overseas markets such as Australia, Egypt, the Lebanon, Turkey or Iran.

3.2.5 Automation plants and control equipment

The GDR's main capacities in the field of planning, production, delivery, mounting and commissioning of automation plants and control equipment relevant to the subject of this case study is concentrated in the VEB Kombinat Automatisierungsanlagenbau (KAA) with its 12 enterprises (see figure 13). The combine was formed in 1979 and has 28,000 employees. The application of modern components of micro- and power electronics, component parts and device systems for data collection, data processing and control engineering guarantees a high efficiency, quality and reliability of plants and equipment for process automation and rationalization projects.

KAA's production and export programmes include automation plants and electrotechnical equipment for

- power stations;
- industrial process engineering;
- open-cast engineering;
- winning of raw material and processing plants in chemistry,
- rolling and cement mills,
- railway energy supply in rectifier substations of industrial railways and traffic means;
- traffic control systems;
- agriculture ;
- protection of environment and water supply and
- industrial, social and house-building.

Furthermore, the scope of deliveries comprises

- signal, communication and power plants for control and supervision of rail-bound traffic;
- controls for working and processing machinery as well as industrial robots;
- current generating sets and
- licences and know-how,

for customers at home and abroad.

The combine's services cover all stages of projects, i.e. from the quotation stage, via the preparation, implementation, operation and maintenance of complete equipment up to the training of native experts and the continuous supply with spare parts for all plants and equipment. Automation plants and equipment produced by KAA and its enterprises have been delivered to the USSR and the other CMEA-countries as well as to the USA, Iraq, Finland and many other countries, too.

VEB Kombinat Automatisierungsanlagenbau
GDR- 1140 Berlin, Rhinstrasse 100
Telefon: 5450, Telex 113297

Exporter
Elektrotechnik
EXPORT-IMPORT
Volkseigener
Aussenhandels-
betrieb der DDR
GDR- 1026 Berli
Alexanderplatz
Haus der
Elektroindustrie

VEB Elektroprojekt und Anlagenbau Berlin
(parent enterprise)
GDR- 1140 Berlin, Rhinstrasse 100

VEB Geräte- und Regler-Werke Teltow
GDR- 1530 Teltow, Oderstrasse 74-76

VEB Werk für Signal- und Sicherungstechnik Berlin
GDR- 1193 Berlin, Elsenstrasse 87-96

VEB Numerik "Karl Marx" Karl-Marx-Stadt
GDR- 9010 Karl-Marx-Stadt,
Bornaer Strasse 205

VEB Starkstrom-Anlagenbau Cottbus
GDR- 7500 Cottbus, Briesmannstrasse 2

VEB Starkstrom-Anlagenbau Rostock
GDR- 2500 Rostock, Postfach 8

VEB Elektroschaltgeräte Eisenach
GDR- 5900 Eisenach, Heinrichstrasse 47

VEB Schaltgerüstbau Sperenberg
GDR- 1631 Sperenberg, Strasse der Freundschaft 10

VEB Metallwarenfabrik Bad Köstritz
GDR- 6504 Bad Köstritz, Elsterstrasse 89

VEB Elektrodyn Berlin
GDR- 1170 Berlin, Salvador-Allende-Strasse 76

Institut für Elektroanlagen
GDR- 1136 Berlin, Strasse der Befreiung 1

Figure 13 : The combine Automatisierungsanlagenbau, enterprises and exporter

3.2.5.1 Automation plants and electrotechnical equipment for power stations

Under the condition of the continuously growing demand in energy and the steadily extending power system it becomes more and more necessary to operate the system and parts of it as well as single components with modern electrotechnical equipment in connection with automation systems. The requirement to ensure permanently, with regard to the power system, a balance between generation and consumption and to enable short times of response to operational changes of the technological process of power supply, especially in case of emergency situations, underlines this fact, too. Furthermore, a great number of processes of power station technology must run in co-ordination with each other to obtain optimum safety and economy. All elements, i.e.

generators, transformers, motors, high-, medium- and low-voltage switchgear, drives, controls, protection and measuring etc. must be integral components of the complete system of electrotechnical equipment themselves.

In order to fulfil this task the scope of KAA's deliveries comprises

- energy generating plants with additional system for energy generation;
- start-up plants;
- energy distributing plants;
- electric control room with equipment;
- complete cable systems with assembly accessories;
- gaining of measured values and signal treatment for all occuring process data;
- measured value and information processing by means of the most practicable technical solution;
- modern measured value and information representation;
- all kinds of final control devices with power amplification;
- supply of software for all the user's processes incl. installed micro-computer systems and
- equipment for process automation.

Further details are given in table 26 (Annex 15).

3.2.5.2 Automatic current generating sets as emergency power and mains replacement plants

KAA's performance programme includes:

- Machine sets with diesel-engine or gas turbine and three-phase constant volte generator;
- Automaticity units fed by diesel sets to supervise the operational media, for fault signalling,start preparation, start and stop of sets;
- Mains cubicles fed by diesel sets to supervise the mains voltage by automaticity unit, control and measurement of generator connection, consumer connections as charger and charge-storage equipment;
- Control units for specific control and regulating functions using modern micro-electronic components and micro-computers.

Information about other deliveries mentioned on page 44 or more details concerning the points 3.2.5.1and3.2.5.2 can be given on special inquiries.

3.2.6 Electroceramics and other electrotechnical/electronic components

Electroceramics and other electrotechnical/electronic components are supplied- often as vital elements for the power equipment industry- by Kombinat VEB Keramische Werke Hermsdorf (KKWH). The KKWH with its 20 factories (see figure 14) and 23,000 employees is one of the biggest manufacturers of supply parts in the GDR. In its capacity as supplier, KKWH produces more than 60,000 single products. Thus, the combine also participates directly or indirectly in numerous deliveries of electric power plants and equipment.

The production programme includes, above all

- insulator bodies and insulators for devices and overhead lines, valve-type arresters, insulated supports for switchgears and devices;
- low-voltage switching devices for industry, inclusive of distribution units, couplers, circuit-breakers, load switches;
- materials for electrical installations in houses or industry;
- electronic/microelectronic componenets made from soft and hard magnetic ferrite materials, ceramic semiconductor resistors and others for electronic or microelectronic units used in the fields of process instrumentation and control engineering, data processing, etc.;
- insulating parts and components for electrical engineering and for gas, heat and lighting fixtures as well as arc shields for switching devices, insulating parts for general needs in the field of electrical engineering, etc.;
- highly wear-resistant, high-temperature resistant, non-corrosive and electrically optimum oxid-ceramic products for the most varied industries;
- components for the field of high-frequency engineering;
- sintered contact and current transmission elements, built-in units for valve-type devices, superheavy metals to shield from gamma rays;
- spark plugs of any thread size and heat value for petrol engines, special-typ plugs;

In the field of electroceramics, the following major product groups should be mentioned:

- overhead-line insulators in the form of the reliable rod-type suspension insulators for high and medium-high-voltage lines;
- insulated supports and pressure pipes for the construction of high and medium-high-voltage switching devices and plants;
- bushings for medium-high-voltage to be used on transformers, sub-stations and within installations;
- porcelain jackets (up to 4 m high) for 400 kV systems to protect the active electric parts of transformers and bushings.

Figure 14:
The combine Keramische Werke Hermsdorf, enterprises, and exporters

KOMBINAT
VEB KERAMISCHE
WERKE HERMSDORF

DDR – 6530 Hermsdorf,
Friedrich-Engels-Straße 79
Telefon: 5 10 – Telex: 058246

HEIM-ELECTRIC
Export-Import

Volkseigener Außenhandelsbetrieb
der Deutschen Demokratischen Republik
DDR – 1026 Berlin, Alexanderplatz 6
Haus der Elektroindustrie
Telefon 21 80 – Telex 114555-59

ELEKTRONIK
Export-Import

Volkseigener Außenhandelsbetrieb
der Deutschen Demokratischen Republik
DDR – 1026 Berlin, Alexanderplatz 6
Haus der Elektroindustrie – Telefon 21 80

TECHNOCOMMERZ GmbH

DDR – 1050 Berlin, Johannes-Dieckmann-Straße 11/13
Telefon: 22 40 – Telex: 011-4861

GLAS KERAMIK

Volkseigener Außenhandelsbetrieb
der Deutschen Demokratischen Republik
DDR – 1080 Berlin, Kronenstraße 19–19a

VEB KERAMISCHE WERKE HERMSDORF
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 6530 Hermsdorf/Thür., Friedrich-Engels-Straße 79
Telefon: 5 10 – Telex: 058 246

VEB ELEKTROKERAMISCHE WERKE SONNEBERG
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 6400 Sonneberg 3 (Bezirk Suhl), Malmerzer Straße 84
Telefon: 7 30 – Telex: 628 833

VEB ELEKTROINSTALLATION SONDERSHAUSEN
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 5400 Sondershausen, Frankenhäuser Straße 64
Telefon: 4 30 – Telex: 617 735

VEB ELEKTROSCHALTGERÄTE GRIMMA
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 7240 Grimma, Karl-Marx-Straße 6–8
Telefon: 6 50 – Telex: 518 422

VEB ELEKTROINSTALLATION RUHLA
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 5906 Ruhla, Straße der DSF 22–40
Telefon: 4 40 – Telex: 618 836

VEB SCHIFFSARMATUREN- UND LEUCHTENBAU FINOW
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 1302 Eberswalde-Finow, Schmidtstraße 5
Telefon: 9 80 – Telex: 168 334

VEB ELEKTROINSTALLATION ANNABERG
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 9300 Annaberg, Straße der Arbeit 5
Telefon: 8 50 – Telex: 77 427

VEB PORZELLANWERK VEILSDORF
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 6116 Veilsdorf (Werra)
Telefon: Hildburghausen 2 67 01 – Telex: 628 750

VEB ELEKTROPORZELLANWERK „MARGARETENHÜTTE"
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 8612 Großdubrau (Kreis Bautzen)
Telefon: 30 – Telex: 028 730

VEB ELEKTROINSTALLATION OBERWEIMAR
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 5300 Oberweimar, Steinbrückenweg 5–7
Telefon: Weimar 38 31 – Telex: 618 940

VEB ELEKTROINSTALLATION WITTENBERG
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 4600 Wittenberg, Straße der DSF 127
Telefon: 75 31 – Telex: 48 640

VEB ELEKTROSCHALTGERÄTE MEERANE
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 9612 Meerane, Karl-Schiefer-Straße 1
Telefon: 23 53 – Telex: 78 632

VEB STEINZEUGWERK KRAUSCHWITZ
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 7583 Krauschwitz (O. L.)
Telefon: Bad Muskau 3 91–3 93 – Telex: 0 178 561

VEB ELEKTROTECHNISCHE GERÄTE BÖHLITZ-EHRENBERG
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 7152 Böhlitz-Ehrenberg, Rudolf-Hartig-Straße 6
Telefon: Leipzig 4 45 81 – Telex: 51 527

VEB ELEKTROINSTALLATION WISMAR
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 2400 Wismar, E.-Fischer-Straße
Telefon: 40 11 – Telex: 318 889

VEB ELEKTROKERAMIK „ARTHUR WINZER"
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 1100 Berlin-Pankow, Gaillardstraße 34–38
Telefon: 4 80 08 81 – Telex: 112 294

VEB SONDERMASCHINENBAU ENGELSDORF
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 7023 Engelsdorf, Arnoldplatz 41
Telefon: 6 41 81 oder 6 10 09 – Telex: 51 601

VEB KLEINMETALLWAREN PAPPENHEIM
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 6086 Pappenheim, Friedrichrodaer Straße 49
Telefon: 4 90 – Telex: 628 541

VEB ELEKTROINSTALLATION DEUTSCHNEUDORF
Betrieb des Kombinates VEB Keramische Werke Hermsdorf
DDR – 9331 Deutschkatharinenberg
Telefon: 2 13 – Telex: 78 339

As various porcelains (inclusive of high-strength porcelains), which meet all the known international requirements and standards, are available, the mechanical and electrical parameters as required by the customer can easily be reached.
Annex 16 contains a selected range of electroceramic products and their parameters (rod-type insulators for rated voltages of 10 to 400 kV, overhead pin-type insulators for rated voltages of 10 to 30 kV, insulators and bushings for switching devices, i.e., insulated supports for 1-30 kV indoor electrical equipment and 10-380 kV outdoor equipment, outdoor-to-indoor and indoor-to-indoor wall bushings, insulators and bushings for installations to be used indoor or outdoor, equipment porcelains, overvoltage arresters for low, medium and high-voltage, and contacts for high and low-voltage switches).
In its new and further developments, KKWH is following the tradition of adapting its products and services to the requirements of international trade, using latest scientific and technological findings and guaranteeing favourable terms to its customers from all over the world.

3.3 Mastering of technology

Science and technology have always been a major prerequisite for a sustained increase in economic performance and the improvement of efficiency in a national economy.

The GDR has assigned constantly growing funds to science and technology as it can be seen from table 27 . Referring to the years 1978 - 1982 these were 3.8o, 3.86, 3.92, 4.07 and 4.10 per cent of the national income produced (at 1980 prices).

Year	Million marks	1975=100
1972	4,941.2	94
1973	5,070.4	96
1974	5,121.0	97
1975	5,274.9	100
1976	5,613.3	106
1977	6,097.2	116
1978	6,543.7	124
1979	6,928.7	131
1980	7,348.9	139
1981	7,976.5	151
1982+)	8,232.5	156

Table 27 : Funds assigned to science and tecnnology
Source: Statistical Pocket Book 1983
+): provisional figure

The further acceleration of scientific and technological progress and the widespread application of its result is the key issue in enhancing the role of the qualitative factors on the way to an intensive development of production. According to the "Economic Strategy of the Eighties" (see page 6) the GDR's research and development potential will be concentrated on:

- new energy-saving processes which give the best possible yields from resources, techniques for recovering metallic and basic chemical materials, and non-waste technologies;
- expansion of nuclear power production, the production and storage of hydrogen and biogas as sources of energy, new and more efficient processes of energy conservation, and the development of new primary and secondary electrochemical power sources;
- new basic technologies for microelectronic circuits incorporating extra large-scale integration and for the manufacture of optoelectronic components to be used in optical fibres and laser technologies;
- flexible automation systems using industrial robots of the third generation and fully integrated measuring and control equipment;
- highly productive processes designed to make more chemical feedstocks from oil, natural gas and lignite, to be employed for the industrial utilization of microbiological substances and biotechnology, and for the development of new and highly refined chemical products such as special-purpose plastics and high-purity chemicals.

As far as the energy sector and the power equipment industry are concerned, some results so far achieved find their reflection within the chapters outlined before. They clearly show that the GDR is able to cope successfully with the great technological challenges in the research-intensive sector of the power equipment industry.

Such products, techniques or technologies as, for instance

- the substitution of fuel oil by solid fuels for power generation
- the solid-insulated high-voltage switchegears ASIF 36 and the compact transformer station TKS 10-20/0.4 kV for electric power transmission and distribution;
- the production and assembly of cables with aluminium conductors and sheats in the GDR's cable industry;
- the three-phase industrial standard motors, i.e. the Standard Squirrel Cage Motors KMER series to IEC 0.12 - 160 kW in the field of electric machines;
- the new universal microcomputer-controlled automation system "audatec", a decentralized automation system with freely programmable microcomputing technique within a consistently modular concept in hardware and software

and the production of electronic/microelectronic components exemplify the high technological standard of the GDR's power equipment industry mentioned.

Factors as , for instance

- priority given to the development of the GDR's power equipment industry including the creation and expansion of its own scientific and technological capacities;
- the concentration of the research and development potential of the power equipment industry in combines and the creation of research centres within the appropriate industrial ministries;
- the close combination of science and technology with the production process;
- a consistent conception of desired results equivalent to international development levels;
- the concentration of technological potentials on key areas of power equipment industry in accordance with national economic plans and in line with the programme of specialization and cooperation among CMEA member countries;
- the existing educational and training facilities in the integrated socialist education system, including vocational training , advanced level education, engineering and technical schools, universities and colleges, as well as adult education and advanced job training

have decisively been in applying scientific and technological progress in the GDR's power equipment industry.

The tasks to be fulfilled are fixed in the science and technology plans for research and development and for the introduction of new scientific and technological results. Tasks of special priority are contained in the State Science and Technology Plan for the development of products and techniques.

State Contracts awarded by the state and other tasks included in the State Science and Technology Plan focus the GDR's scientific and technological potential on economic top priorities. As a result, the degree of innovation in industry attained 17 per cent in 1983. The practical application of research and development results gave rise to a 16 per cent increase over 1982 in the manufacture of goods with the "Q"top quality mark, which are to broaden the range of high-quality consumer goods and to meet export and domestic economic requirements. Compared with 1982, the number of inventions for which patents were sought went up by 20 per cent [6].

Detailed individual research assignments and special achievment-oriented incentives for innovators, inventors and experts have also proved an effective instrument in raising the standard of scientific and technological results and improving the cost-benefit ratio.

As to the import of technology in the power equipment sector the GDR restricts itself to licence-manufactured products related to special applications, i.e. where the development of indigenous technology would be inappropriate.

Examples:
- High-voltage divider LHTCIG-12/400 (licence manufacture after the ISOPONT-Calor Emag system);
  Manufacturer: VEB Schaltgerätewerk Werder
- Oil-poor circuit-breakers HPF (licence manufacture after a SPRECHER + SCHUH design);
  Manufacturer: VEB Transformatorenwerk "Karl Liebknecht" Berlin
  In future this typ of circuit-breakers will be replaced by indigenous circuit-breakers based on SF_6-technology.

In case of special inquiries made by customers secondary techniques (selected control and protective equipment) are used from manufacturers abroad.

Furthermore, the GDR concentrates its efforts in accordance with the specialization process among CMEA member countries on selected main products. In this respect, the production of tap changers can be seen as an example for international division of labour: Whereas Bulgaria manufactures tap changers up to the nominal amperage of 400 A, the GDR manufactures types starting from 630 A and higher.

6) Report by the Central Statistical Office of the GDR on the fulfilment of the 1983 National Economic Plan

3.4 Constraints

3.4.1 Historical aspects

The energy policy before the Second World War created conditions in the field of power supply which did not meet the post-war requirements. Extremely severe imbalances in industry inherited from the past and aggravated by the division of Germany proved a heavy burden hampering the GDR's economic reconstruction. A particular discrepancy existed between the relatively advanced metal-working industry and the weak metallurgical base. Furthermore, the GDR depended heavily on imports, especially raw materials.

There were also no preconditions of manufacturing power related equipment needed since there were no important companies able to produce and to erect the necessary power system installations. Among others, large size machinery and experts with appropriate experience in the production of power generating equipment or in the construction of transmission lines were not available although among the major concerns converted into national property were also enterprises belonging to the AEG and Siemens electrical companies.

Under such unfavourable starting-points the GDR began,despite of lack of experience and training, to create a domestic metallurgical basis, to expand the heavy engineering sector and to develop the country's raw materials potential. In addition, great efforts had been undertaken to increase exports, above all, machinery and manufactured goods.

First developments in this direction had been initiated by the Two-Year Plan 1949/50.

Also the manufacture of transformers had been developed. The first transformer of larger size- a power transformer of 31.5 MVA, put into operation after the World War II,was installed at the end of 1951.

The electricity generation and transmission systems were nearly completely nationalized in 1950. Regarding the distribution networks at that time there was still a considerable part in the possession of the so called Elektrizitätsgenossenschaften (electricity societies), Lichtgemeinschaften (light communities) or other ones acting in the capacity of purchasers and vendors of electricity.

The first Five-Year Plan 1951-1955 was based on a powerful nationally owned sector of industry which emerged (in 1955 this sector accounted for 87.6 per cent of gross industrial production) strengthened the long-term economic planning and set the target to overcome disproportions in the GDR's economy mentioned above. Industry had to fulfil the following 4 main targets[7]:

(1) Finishing the reconstruction work in the field of power and fuel industry which had been started in the Two-Year Plan and safeguarding its further growth,

(2) Reconstruction and development of metallurgy in the field of manufacturing crude iron, steel and rolled steel materials to an extent guaranteeing a better supply of the mechanical engineering sector with metal products manufactured by the domestic industry,

(3) Reconstruction and utilization of all capacities of the most important and leading enterprises of the machine-building industry and the erection of new plants producing equipment for the power and coal industry and the metallurgical sector,

(4) Reconstruction and full utilization of the export producing factories.

In the second half of the 1950s one of the main aims was to increase the energy output. Several major power stations were built during those years and the transmission and distribution networks had been extended considerably. Significant branches of industry such as power engineering, electrical engineering, chemical engineering, the plastics and semiconductors industries, control engineering and other ones, which also play an important role in producing power related equipment, were either expanded or newly established.

Parallel to the creation of the material- technological base in the field of power industry including various power related equipment, the GDR started to develop its own scientific and research capacities. Special scientific bodies, new institutions of higher and technical education were founded to train cadres needed. Great efforts were also devoted to vocational training and the upgrading of skills.

Co-operation with the CMEA countries (the GDR's membership dated back to 1953) was vital for strengthening the GDR's economic and technological independence.

Structural changes in the management of power industry on different levels and administrative reorganizations promoted the reconstruction process, too.

Thus, due to such balanced approach aimed at the gradual transformation of the economic conditions in industry along socialist lines, it was possible to overcome the historical constraints during the transitional stage of GDR's development.

7) Sechs Jahrzehnte Elektroenergieübertragung, Verlag Tribüne Berlin, 1976

3.4.2 Natural resources

The GDR is not well-endowed with industrial raw materials and fuels, with the exception of lignite, the GDR's primary energy source No.1. Besides lignite the GDR is self-sufficient in potash, rock-salt, flourspar and heavy spar, stone and earth for building materials and raw materials for the production of glass and ceramics. Tin and copper mining are of great domestic importance in the GDR although the quantities produced are negligible in international terms. As a consequence, the GDR heavily depends on imports of raw materials which are essential for its industrial development and economic growth.

Consequently, as already mentioned, the government has placed great emphasis on the further reinforcement of the GDR's energy and raw materials base and on the reduction in consumption of fuel and raw materials. The results so far achieved have proved the rightness of the GDR's policies and strategies. 2 examples:

(1) The GDR succeeded in increasing its commodity production and, at the same time, reducing the absolute consumption of energy in the last few years. Increased efforts in using secondary sources of energy have also contributed to this result. As to 1983 the extent to which technologically and economically suitable sources of secondary energy were put to use attained over two thirds. This is the equivalent, in energy terms, of 28 million tonnes of raw lignite[6].
The high value of economizing energy is underlined by the fact, that in the 1980's the extraction of one tonne of lignite will require twice as much investment as in the 1976-1980 period.

(2) In the engineering sector, in 1983 unit consumption of rolled steel decreased by 9 per cent and the input of rolled steel was 4 per cent below the 1982 level, with output rising at the same time. The input/output ratio has been improved for many products. The consumption of a number of important raw materials such as non-ferrous metals, fibres, wooden and leather materials, paper and card board has also been cut down in 1983.[7].

Reductions in the unit consumption of fuels, raw materials and feedstocks and higher refining levels have been encouraged by changes in industrial prices. This method has been used as an impetus for lowering specific expenditure.

An important fact which helps the GDR to cope with its constraints in the field of fuels and raw materials is the situation to have long-term contracts with CMEA countries, especially the Soviet Union, which provides the GDR with considerable quantities of oil and gas on favourable conditions.

However, greater expenditure is called for, due to trends in current world market prices.

[6] Report by the Central Statistical Office of the GDR on the fulfilment of the 1983 National Economic Plan

The GDR has responded to rising prices for raw materials, fuels and semi-manufactures on the world market, inter alia, by greater exports, especially in the GDR's export intensive branches like machine building, electrical engineering, electronics and chemistry.

Countries like the GDR, which are deficient in natural resources, are particularly urged to use scientific and technological progress in order to solve economic problems they are faced with. In this respect progress has been made, for instance, towards the introduction of important refining techniques in coal processing, metal manufacture, the chemical industry and glass and ceramics manufacture. The GDR is observing close continuity in pursuing its course of improving the efficiency of the national economy through the utilization of modern science and technology as the prime way to cope with the challenge to the energy and raw materials sectors. Therefore the government has developed a whole programme of practical tasks on which the scientific and technological efforts have to be concentrated.

For instance, science and technology serve as an essential means in creating the necessary conditions for cutting the specific energy consumption by the equivalent of 65 to 70 million tonnes of lignite in the period 1980-1985. Furthermore, according to the Five-Year Plan 1981-85, there are targets for the saving of approximately 2.2 million tonnes of rolled steel, over 50,000 tonnes of aluminium, about 15,000 tonnes of copper, 1.9 million tonnes of cement as well as other raw materials, too.

3.4.3 Manpower

year	population (at the end of the year)	persons employed (excluding apprentices) 1000 Total	Industry
1975	16,820,249	7,948	3,033
1976	16,767,030	8,018	3,071
1977	16,757,857	8,058	3,083
1978	16,751,375	8,118	3,101
1979	16,740,324	8,184	3,121
1980	16,739,538	8,225	3,128
1981	16,705,635	8,296	3,157
1982	16,702,306	8,368	3,177

Table 28 : GDR's population and persons employed, 1975-1982

Source: Statistical Pocket Book 1983

As can be seen from table 28 the GDR's total population decreased from 1975 to 1982 at an annual average rate of 0.1 per cent and

although the number of persons employed increased at a slow rate over this period (0.7 per cent at an annual average rate between 1975 and 1982), the GDR's labour force is very limited.
All the more attention is devoted to employing work force rationally, and the economic growth had and has to be achieved mainly through higher labour productivity and more efficient use of resources. This has always been one of the priorities of the GDR's plans for the national economy.
One approach of raising productivity is to save scarce labour through rationalization, in a way different from countries with market economies, and automation, especially the accelerated development and application of microelectronics and robots.
By mid-1983 there were approximately 26,000 robots in operation and it is foreseen to have 45,000 of them functioning by 1985.
On an average, per one introduced industrial robot 2.5 working people have to be set free for other jobs.
In this way the introduction of new technological methods contributes decisively to saving man-hours (see table 29), while simultaneously releasing manpower for other more productive tasks.

	1981	1982+)	1983	1984+)	1985+)
Saving of working hours by science and technology in industry and construction (million)	490	492,7	545	572	over 600

Table 29: Saving of working hours by science and technology in the GDR's national economy
Source: National plans and reports by the Central Statistical Office of the GDR
+): According to plans

In the five years from 1981 to 1985 a total of 2,854 million working hours have to be saved in the national economy corresponding to the work done in a year by 300,000 workers during this period (1976-80: 1,664 million hours or the labour of 180,000 workers).
Working hours saved in such ways find reflection in increased labour productivity (see table 30).

1960	1970	1975	1980	1981	1982
47.0	23.0	18.0	13.8	13.3	13.0

Table 30: Hours worked by one production worker per 1,000 marks of gross industrial production (at 1975 prices)
Source: Statistical Pocket Book 1983

4. Linkages with the other capital goods industries

The process of manufacturing electric power equipment is a very complex one depending on the type of equipment to be produced. Most of energy-related capital goods demand high-level and sophisticated technology, long-standing experience and relatively widespread activities of co-operation.
Therefore, characterizing the conditions which should be met to develop the electric power equipment industry,and concluding from the experience gathered in the GDR,the following requirements should be stressed:

(1) Power-equipment manufacturing requires a strong development of the key branches, i.e.
- the "classical" electrotechnical industry,
- the industry of power machinery,
- the electronic industry,
- the industry of measurement, control and regulation engineering

or selected industrial capacities of these areas which are indispensable for the capital goods to be manufactured. Owing to the variety of electric power equipment due consideration should be given to the process of specialization and co-operation.

(2) The production of electric power equipment requires a fairly well developed metallurgical base and metal processing industry including, above all,
- the production of key intermediate inputs such as iron and steel as well as non-ferrous metals (copper, aluminium etc.)
- the availability of basic facilities for the manufacture of power equipment (casting, forging),
- the existence of industrial capacities for producing high-quality semi-finished products needed.

The quality of semi-finished products is decisive for the qualitative standard of capital goods as final products.

(3) The manufacture of energy-related equipment requires the supply with necessary means of production and by-products delivered by such industrial branches like
- the mechanical engineering sector,
- the machine tool building and tool making industry,
- the precision mechanics industry

and the provision of different materials vital for the production of electric equipment and related to

- the chemical industry (e.g. plastics and synthetic resins),
- the light industry (insulating materials etc.),
- the glass and ceramics industry.

The role of industrial sectors fulfilling co-operative or even auxiliary functions in the process of production of electric power equipment should not be underestimated This also refers to the continuity of deliveries of materials in all stages of production.

(4) The production of power equipment requires, as a characteristic feature of the energy-related capital goods, specialized equipment and installation of sophisticated testing and production-control devices.

The figure 15 demonstrates existing linkages with industrial branches, firms and institutions in case of manufacturing high/ medium-voltage equipment.

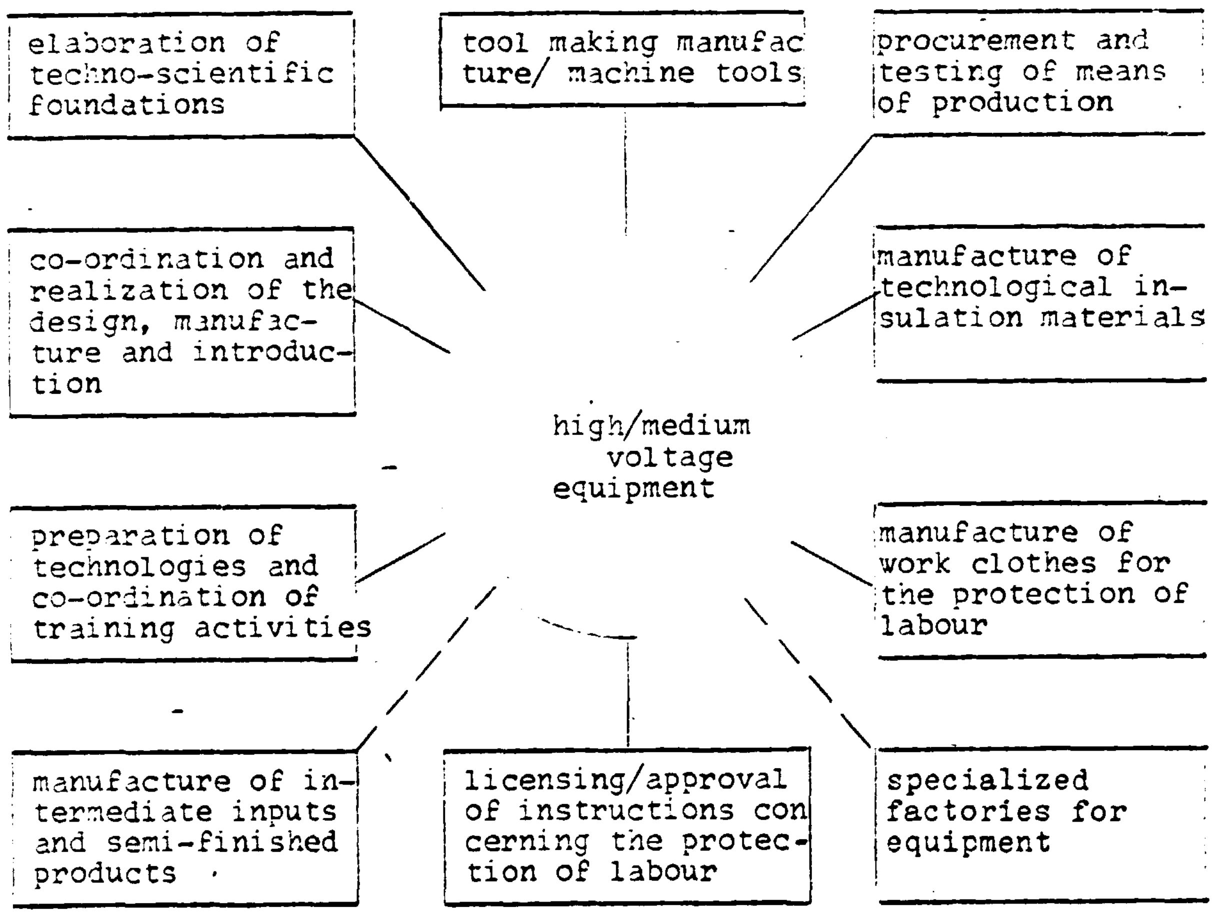


Figure 15 : Co-operative linkages in case of manufacturing high/medium-voltage equipment (simplified)

In addition to figure 15, figure 16 shows, as an example, the technological sequence of manufacturing three-phase oil-immersed transformers up to 630 kVA, giving a general survey of the comprehensive range of deliveries and performances:

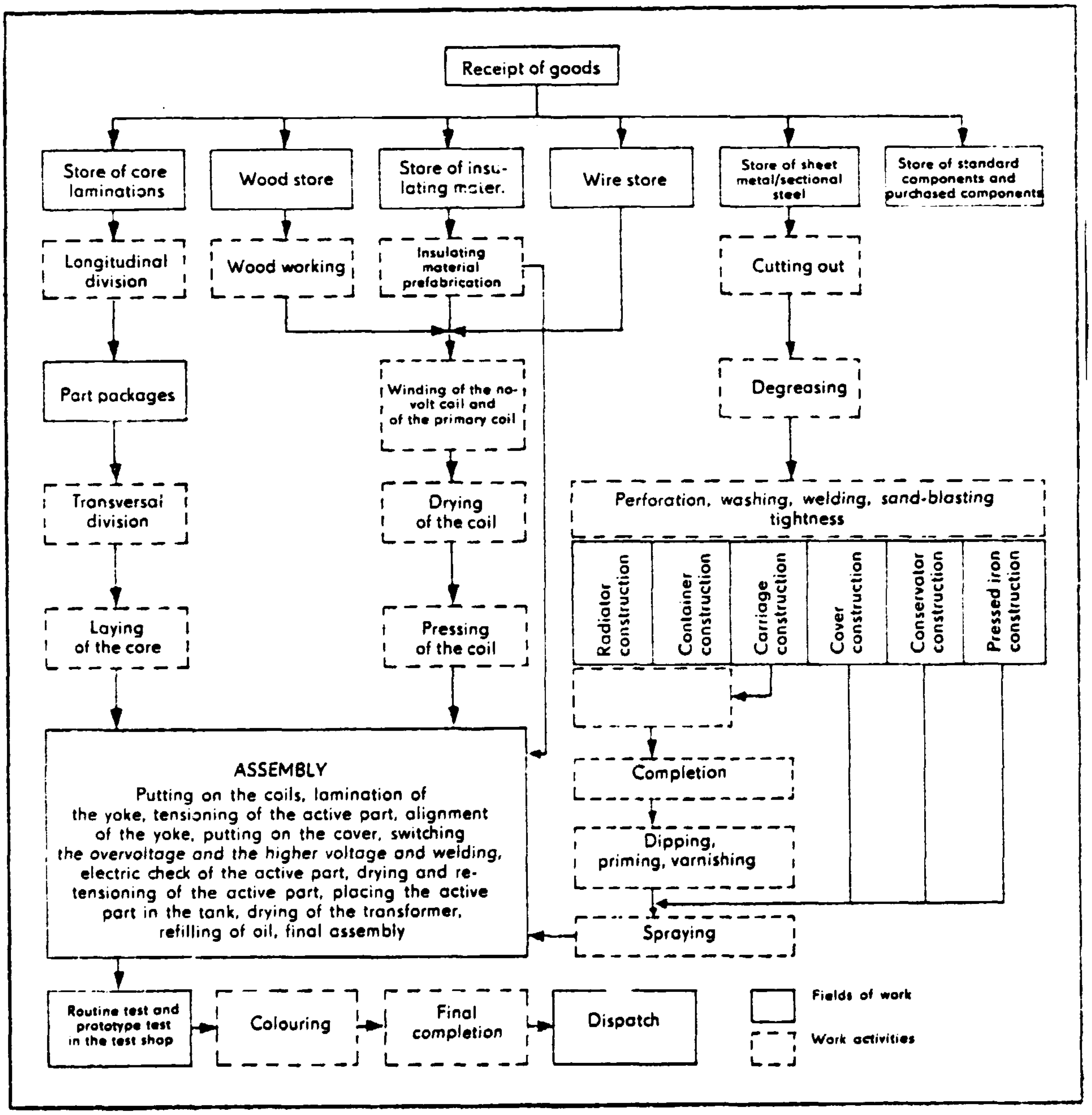


Figure 16: Technological sequence of manufacturing three-phase oil-immersed transformers

Linkages with other capital goods industries, judging from their very nature, that is to say co-operation, require legal regulations and a definite sub-contracting system in the domestic economy. All that has been created in the GDR.

As a matter of fact, the linkages with other capital goods industries are changing, depending on the typ of equipment, its technological variability and the development of the diversified production units themselves. But, nevertheless, there is a tendency that this process becomes a more comprehensive and more complex one, bearing in mind the objective character of the division of labour and the requirement of mastering techno-scientific revolution. The extent of co-operation in the field of electrical engineering and electronics, especially microelectronics, is increasing, owing to the growing drive of performance and the mechanization and automation level of products. More electrical motors, microelectronic control systems, computers of different performance characteristics and peripheral devices etc. are used[8].

Size and complexity of co-operation activities among enterprises which have been amalgamated into one combine (Kombinat), are mostly much more expanded than among firms belonging to different combines or companies from other industrial branches.

This takes into consideration that

- the manufacturing process should be organized in line with optimum conditions for the reproduction cycle of power equipment concerned,
- the interrelated process of techno-scientific progress should be accelerated,
- management and planning should be possible in a very effective and co-ordinated manner

so that the production and development of energy related capital goods can be arranged flexible enough in accordance with existing requirements.

Last, but not least the question of standardization should be mentioned which is an important means to foster effective solutions in the production of power equipment, especially under conditions where linkages with other capital goods industries, i.e. co-operation activities play increasingly a dominating role.

8) Kooperation zwischen Betrieben und Kombinaten, Rouscik/Steinert, Verlag Die Wirtschaft, 1981

5. Possibilities of co-operation

5.1 Principles

In its efforts to establish and develop economic, scientific and technological relations with other countries, the GDR has always been guided by the generally accepted principles of international law which includ sovereign equality, non-interfer ence in internal affairs and mutual advantage.

The GDR considers the close economic and scientific-technical co-operation with the developing countries an important contribution to supporting these countries in their struggle for achieving and strengthening economic independence.

Starting out from the above principles the GDR will

- extend its relation in particular with those countries which accept the principles of international law, and especially with the developing countries;
- develop such co-operation on a long-term basis;
- comprehensively combine such long-term co-operation, particularly with regard to its exports and imports, with forms of scientific and technological co-operation, users' advice, after-sales services and the training and further education of personnel.

In accordance with the simultaneously declared intention to continuously develop these relations still further, the GDR has carried on numerous concrete activities in the recent past.

5.2 Technical and economic institutional framework

The GDR's economic relations are developing particularly intensively on the basis of inter-governmental agreements. In the economic field the GDR had concluded until 1982 61 trade agreements with developing countries, 4 payments agreements, 28 agreements on scientific and technological co-operation, and 48 agreements on economic, scientific and industrial co-operation. The last kind of agreements came into existence in the 70's and aims at establishing co-operation on a comprehensive and long-term basis. Such agreements or programmes are valid for a period of 5 to 10 years, and aim at a further deepening of relations and at using the economic, industrial, scientific, technological and financial potentials of the partner countries in an effective manner to their mutual advantage.

During the past ten years, Joint Economic Committees (JEC) and other forms of inter-governmental bodies have proved to be effective elements of interstate economic relations.

Fifteen JECs had been established with developing countries by April 20, 1984, including such countries like Egypt, Syria, Algeria, Kuwait, Libya, Angola, Ethiopia, Mozambique, Nigeria, Zambia, Sao Tome and Principe, Zimbabwe and other countries. The existing JECs and/or permanent committees are engaged in bringing about a planned, stable and effective intensification of relations and are also increasingly dedicating themselves to analyzing and identifying the main areas of co-operation.
For instance, the Joint Committee for Economic, Scientific and Technological Co-operation between the GDR and Syria agreed upon their long-term co-operation until 1985 within the framework of the two countries' five-year plans. The main areas agreed upon comprise also production facilities for electrification equipment, including rural and urban electrification. In addition to that, an agreement on co-operation between the State Planning Commissions of the two countries was concluded.
Syria, Iraq, Iran, Egypt, Angola, Mozambique and Algeria can be cited as other examples for a succesful implementation of mutual interests through the activities of the JECs and other intergovernmental bodies in the field of electric power transmission and distribution networks.
Priority is given to the exchange of views and information on planning procedures, the organization of the planning system as well as on the use of appropriate methods of planning in the developing countries.
By concluding such long-term inter-governmental agreements on economic, scientific and technological co-operation the activities agreed upon are directed, to a great extent, at the public sector in the developing countries, at large-scale co-operation contributing to a comprehensive solution of the economic main task.
Meetings and agreements between representatives of the GDR and the developing countries at the highest level where measures were laid down with a view to deepening economic, scientific, technological and industrial co-operation taking into account the ideas, requirements and the long-term possibilities of the GDR and of the partner countries, have had a considerable effect on intensifying and expanding the GDR's relations with the developing countries in the areas concerned. In addition to such programmes on the further expansion of economic, scientific and technological co-operation, programmes of action and agreements on the deepening of co-operation in special areas were signed between the respective ministries.

Such co-operation also includes, inter alia, the exploration, opening-up, extraction and processing of raw materials, the preparation of feasibility studies, the assignment of experts, training and upgrading, the setting up of training centres as well as co-operation in the field of research. For example, the high-voltage testing centre in the University of Damascus was built by the GDR.

The activities mentioned cover also the co-operation in the execution of projects in third countries.

Within the framework of its overall relationship with developing countries, the GDR also pays great attention to the least developed countries (LDC). An expression of its manifold activities is the establishment and development in the course of the 70s of relations with 29 of the then 31 LDC.

Relations with some of the LDC have already reached a high level covering economic, scientific-technical, industrial co-operation and other areas of social life. Relations are particularly intensive with Afghanistan, Ethiopia, Guinea, Guinea-Bissau, the PDR of Yemen, the PDR of Laos and Tanzania. They are based on long-term government-to-government agreements, and promoted and controlled through the active work of joint commissions at government level.

5.3 Sale and purchase of equipment on favourable terms

Complete plant and equipment are delivered on internationally customary terms of payment. Payment by the developing countries for the deliveries of equipment can be made through the delivery of domestic products or of products manufactured in the newly established production facilities where this is in the mutual interest. The factories established by the GDR in the developing countries will become their property with no strings being attached, and there is no transfer of profits.

In this connection should be mentioned that the activities of TNCs in power equipment industry follow another pattern as it is outlined, for instance, in the UNCTC study ST/CTC/22 (Transnational Corporations in the Power Equipment Industry). One of the TNC's main activities is directed towards the conservation of their effective control over the production potential by subsidiaries and affiliates through appropriate patterns of ownership, conditions of licensing of technology and contractual provisions. Even in countries, where there are considerable restrictions on foreign ownership, TNCs in the power equipment sector retain this control.

Elektrotechnical plants and equipment made in the GDR for the generation, transmission and distribution of electric energy and offered on favourable terms have won international reputation by a high reliability and economy. The equipment, plants and devices manufactured on the basis of international standards can be adapted to the most varied climatic conditions.
In the field of energy transmission and distribution, the GDR has supplied 68 countries with products such as

- power substations;
- switching and transformer stations;
- cubicles, low-voltage switchgear;
- switchgear for power plants;
- high-voltage laboratories and high-voltage test departments.

Electricity transmission and distribution systems with an overall capacity of more than 20,000 MVA have been delivered to developing countries. The Syrian Arab Republic is an example in this respect. Deliveries to the SAR included more than 40 66/20kV substations with an overall capacity of over 1,100 MVA and equipment for the extension of the country's distribution network, with the GDR being involved in the setting-up and extension of Syria's grid since 1970.
The GDR was also involved in solving Greece's energy problems which were complicated by the fact that about 50 per cent of the country's electricity was generated in the north, whereas the major consumer locations are Saloniki and the region in and around Athens. Among other equipment, the GDR delivered and assemblied 8 substations 400 kV, 2,000 MVA each.
Since the mid-1950s substations, switchgear for power plants and substations have been delivered to Egypt. In and around Alexandria, more than 30 66/11 kV substations made in the GDR are operational, with the 34th substation delivered in April 1984.
220/110 kV and 110/30 kV substations and equipment for a 220 km 220 and 110 kV overhead line have been delivered to Angola to supply its northern province of Uige with electricity.
In addition, the GDR has delivered devices and equipment for electricity transmission and distribution as well as as high-voltage and test laboratories to the following developing countries:
Iraq, Iran, Turkey, Cuba, Sudan, Mozambique, Mongolia, Algeria, India, Brazil.

5.4 Technology strategies

Services from the fields of science and technology, which the GDR makes available to the developing countries, are primarily designed to assist the institutions in charge of electricity supply and the electrical industry in their efforts to draw up projects for the overhaul and extension of the most varied systems.

An ever increasing number of licences from the GDR are being granted to developping countries with a view to promoting their national economies: With more than 30 developing countries 73 licence contracts were concluded in 1982 and 80 in 1983. During the past two years the majority of these contracts were signed with Mozambique, Egypt, Cuba, India, the Syrian Arab Republic, Iran, Iraq, Yugoslavia and Angola.

In addition to licences or technology, the required know how was passed on and numerous engineering performances rendered such as

- feasibility studies;
- preliminary studies;
- combined technical and economic studies;
- general studies.

The countries for which such studies have been compiled include Indonesia, India, Greece, Turkey, Guyana, Brazil and Colombia.

The GDR has gained great experience and effective results with regard to

- planning of extension,
- design and construction,
- operating management and maintenance

of electrical energy systems. For planning the extension of electrical power systems, efficient computer programmes meeting practical requirements are available, among them such for

- optimal planning of network extension over scheduled periods,
- calculation of load flow, short-circuit and stability parameters,
- automatic planning of distribution networks.

For designing and erection of transmission systems, solutions exist containing methods and device techniques, such as

- technology for efficient placing of high-voltage overhead line poles by means of heliocopter,
- driving technology for pile foundation in overhead line construction for voltages from 110 kV to 380 kV,
- computer-aided optimization of locations of transmission-line poles,
- cable line devices and equipment for high-voltage overhead line construction.

For operating management and maintenance of electrical energy transmission and distribution systems, a great number of technically matured solutions are available. These include

- technologies and tools for working under voltage up to 330 kV,
- microcomputer application for determination of admissible duration of overload of large transformers in transformer stations,
- methods and devices for testing electric-supply meters,
- methods for process computer controlled testing and trial of new systems of electronic protection and automation equipment,
- prophylactic methods to avoid failures of electric transmission lines due to pollution layers.

For regulation and control of electrical energy systems, solutions as to techniques and devices are available. Of special importance are

- methods for decentralized performance of system-compatible voltage/ reactive power mode of elements of the electric energy system inclusive of computer technology with microcomputers being applied,
- methods for incorporation of heat-generating stations into the automatic effective power control of electric energy systems.

In the field of rational energy application, the GDR, for instance, elaborates scientifico-technical solutions, of which the substitution of fuel oil by domestic lignite and the reduction of specific energy consumption in selected branches of national economy are of special relevance.

Out of the scientifico-technical results, the GDR introduces into practice together with partners of industry and agriculture, techniques in the field of

- substitution of fuel oil in energetic and technological processes by solid fuels or gas with unchanged or more favourable technological conditions,
- techniques for utilizing waste heat yielded by processes for heating drying, hot-water generation and preheating of air, specifically with compressor plant, large transformers, industrial furnaces, ventilation systems, cooling towers, briquette factories,
- development of a novel furnace construction material "artificially-porous refractory concrete" for improving the operating behaviour of industrial furnaces and lowering the specific energy demand in approximately 75 per cent,
- methods for gaining, preparation and evaluation of important energy data of operating equipment consuming energy in the whole national economy.

In addition, experience has been made with the techno-economic assessment of solar energy, wind energy, geothermal energy and small hydro-power stations as to their integration into total energy economy of future periods.

5.5 Scientific and technical co-operation

5.5.1 Technical assistance

In the field of scientific and technical co-operation with developing countries, the assignment of experts, the training of personnel and the exchange of experience concerning scientific and technical research results have to play a major role in the struggle for strengthening the countries' political and economic independence and promoting the GDR's trade relations with such countries.

Assigning technical advisers and specialists to economically important spheres and branches of the developing countries, training citizens from developing countries in enterprises and institutions of the GDR, the German Democratic Republic renders a major contribution to developing those countries' economies and alleviating the acute shortage of trained personnel. Taking into account the conditions of the individual countries, the GDR assists those countries by passing on them the experience it has gained in developing its own national economy.

As a rule, the scientific and technical co-operation of the GDR with developing countries rests on agreements concluded between the governments of the countries involved for long-term periods. Usually, such agreements contain clauses stipulating an automatic extension.

Agreements on scientific and technical co-operation have been concluded by the GDR government with 25 developing countries, including

- 8 Arab countries,
- 13 African countries,
- 2 South-East-Asian countries,
- 2 Latin-American countries.

Inter-governmental agreements concerning the co-operation in the field of vocational training have been concluded with Algeria, Mozambique, Angola and Zambia. In addition, scientific and technical relations have been established with Nicaragua, Grenada, Zambia, Guinea-Bissau and other countries.

The Academy of Sciences of the GDR developed a multifaceted scientific co-operation with its partner institutions, particularly in India, Egypt, Iraq, Ethiopia, Mozambique, Libya, the Syrian Arab Republic and Nigeria. Such co-operation in fields such as solid state physics and materials research, energy, automated process control and other areas helps increase the scientific and technical potential of the developing countries in a particular manner.

The measures of scientific and technical assistance agreed upon with the Socialist Republic of Viet Nam, the Democratic People's Republic of Korea, Cuba, Mongolia and the Lao People's Democratic Republic were implemented continuously in 1982 and 1983.

5.5.2 Training

The GDR attaches great importance to the training and upgrading of national cadres from the developing countries. It supports the efforts made by these countries to provide, through an efficient system of public education and vocational training, the skilled workers, foremen and management personnel required for the building-up and the growth of their national economies.
At the beginning of 1983 29,249 nationals from developing countries received vocational training or upgrading (excluding universities and technical colleges) in factories and institutions of the GDR. In conformity with the needs of the developing countries, priority is given to the training of cadres for different branches of industry including power industry, too.
In 1982 4,222 trainees from developing countries completed their training or upgrading course, bringing the number of citizens from developing countries who have completed their training in the GDR since 1970 to more than 45,000.
In 1982 1,435 nationals from developing countries graduated from universities, colleges and technical schools of the GDR. A total of about 14,500 citizens from these countries have so far graduated in the GDR since 1970. At the beginning of 1983 there were 5,951 students from developing countries in the GDR studying machine-building, electrical engineering, agrarian sciences, traffic engineering, civil engineering, economics, pedagogics and medicine.
Through the assignment of experts the GDR helps the developing countries directly in the preparation and execution of important programmes and projects designed to develop their national economies.
In 1982 814 experts financed by the GDR took up their assignment in developing countries. In accordance with the specific needs of the developing countries the majority of these experts are economists, engineers, teachers and vocational instructors, as well as doctors and medical personnel. Since 1970 more than 20,000 GDR-financed specialists have been assigned to developing countries.

The GDR has also supported measures of the developing countries which are aimed at building up and expanding their system of public education, of training and upgrading of skilled workers and foremen, of higher education and of scientific teaching and research. The number of experts from relevant institutions of the GDR assigned to developing countries in these fields amounted to 227 experts in 1982 and 201 in 1983 (as of November 1983). Their countries of assignment are mainly Ethiopia, Algeria, Mozambique and Angola.

As far as multilateral activities are concerned, the GDR has supported and is supporting the endeavour of UN bodies and/or its specialized agencies designed to promote the scientific and technical potential of the developing countries.

The examples mentioned from various fields illustrate how the GDR, with the means and possibilities at its disposal, continuously works towards the further strengthening of the scientific and technical potential of the developing countries and thus towards the attainment and consolidation of these countries' economic independence.

With respect to the coal and power industry of the GDR the following services are rendered in the field of training and continued education:

(1) Survey of the possibilities of training and continued education for foreign citizens

The coal and power industry of the GDR has modern and efficient facilities for realizing extensive and many-sided educational measures for training and further vocational instruction of skilled workers, engineers, technicians and specialists. To this end, the industrial branch has at its disposal 42 clearly outlined facilities for vocational training and continued education, 2 schools of engineering, 4 centres for continued education.

The high level in the educational institutions is determined by modern laboratories, technical cabinets, training equipment and programmable simultaneous devices.

Based on internationally acknowledged curricula, skilled workers and specialists are trained for operating and servicing

- coal mining and refining plant,
- thermal and nuclear power station plant,
- gas generation, transmission and distribution plant,
- electrical power transmission plant

and for energy application processes, and further instructed on the latest findings of science and engineering.

(2) Training of engineers

Possibilities for the training of foreign citizens for engineers exist for

- mining engineering/underground mining,
- mining engineering/surface mining,
- fuel refining engineering,
- power stations,
- electric power installations,
- maintenance of mining and energy installations,
- automation engineering,
- gas supply technology,
- heat engineering,
- energetics,
- engineering economy of mining,
- engineering economy of power industry.

The training for engineers is performed in a three years' direct study. Precondition is the lesving examination at a ten-form school or secondary school. The training is possible for individuals and groups.

(3) Training of skilled workers

Possibilities for the training of foreign citizens for skilled workers exist for

- maintenance of lignite mining plant,
- operation and maintenance of lignite refining plant,
- maintenance of thermal power station plant,
- operation and maintenance of nuclear power station plant,
- assembly and maintenance of electric power generation and distribution installations.

The vocational training takes 2 1/2 years, and is terminated with handing over the certificates on the vocational qualification. Precondition for the training is the leaving examination at a ten- or nine-form school. On the basis of existing curricula, training combinations can be scheduled and agreed upon if required.

(4) Continued vocational training

For foreign citizens, who have terminated a training as engineer or technician, there exists the possibility to acquire special knowledge in the fields of

- surface mining and technology,
- lignite refining and gas engineering,
- electric power generation, transmission and distribution,
- operation and maintenance of thermal power stations,
- operation at voltage-carrying installations,
- health services and labour safety.

The duration of continued training is agreed upon by contract.

Possibilities for the training of foreign citizens for masters exist in the fields of

- maintenance of machines and installations,
- operation of thermal power stations,
- maintenance of power stations,
- control engineering.

The qualification for masters includes a pedagogical and technical training and extends over 18 month, at a study of the German language preceding it, lasting five months. Precondition for the training is the leaving examination of a ten- or nine-form school, and a complete training in a vocation or as technician, respectively.

6. Conclusions

As this case study shows, energy-related equipment and technology are of crucial importance to the foundation and further reinforcement of the material and technological base in the field of electricity and to the national economy as a whole. According to the GDR's experience it has always proved to be the right approach to devote great attention to energy-related industrial development activities, especially in view of

- a long-term energy planning to attain a balanced, dynamic industrialization integrated in a strategy directed towards the gradual formation of national economic complexes and
- a proportional and efficient economic development of industrial sectors involved in manufacturing energy-related equipment, taking into account the complexity of existing linkages and interrelations among them.

Therefore, it is hoped that this study will give, among others, ideas and impulses for the creation and development of industrial capacities in the power equipment industry to other countries, especially those which are on an initial stage of industrialization.

Of course, although there are general elements which can be used, the specific conditions of each country concerned has to be taken into consideration when designing the own strategies and policies of practical nature by those countries themselves.

Finally, proceeding from the GDR's experience and results outlined in this study, the following conclusions can be summerized:

(1) The GDR's experience has shown that it is possible to increase output and national income over a longer period and at the same time to reduce the consumption of fuels, raw materials and feedstocks in absolute terms.
In view of the results obtained in the energy sector, the GDR's approach to the solution of energy problems can be regarded as an example several elements of which could be applicable not only in industrialized but also in developing countries.

(2) An electric power system as such can be considered a real indicator of the level and performance capabilities of the power equipment industry, provided that the country concerned has taken care of its own material basis and techno-

scientific capacities within the framework of international division of labour.
In doing so, the GDR has been able to create a modern national energy supply system which has significantly developed in size on the base of long-standing design and construction experience, technical progress in the manufacture of energy-related equipment, and attention to the operational requirements as well as possibilities for further expansion.

(3) The creation of the Interconnected Power Systems is an important practical result of multilateral co-operation among the CMEA countries in the field of electric energy and has confirmed the great advantages of parallel operation.
At the same time it shows real potentialities for further co-operation with other countries.

(4) Electricity is the key element for the efficient development of technical and technological progress and, in addition to that, has important consequences for socio-economic development, living conditions as well as for future economic growth and particularly labour productivity. This has to be taken into account when designing strategies and policies in the energy sector and other fields.

(5) Electricity generation, transmission and distribution and the power equipment industry itself are capital-intensive and research-intensive and require substantial financial and human resources. This requires a particular long-sighted approach to the design and erection of electric power systems or its single components taking into account the local conditions and long-term targets to be achieved.
Energy planning, where the GDR can offer extensive experience, has therefore to be in the focus of all management processes from the economic and the technical point of view, including technological and financial consequences as well as social implications.

(6) The power equipment industry should occupy key position within the structure of industry, which should be reflected, inter alia, by a high or above-average growth rate compared with other industrial branches, in particular with respect to high-quality products. Due regard should be given to the electrical and electronics branches as sectors of special importance for promoting growth in other industries.

(7) Irrespective of its specific conditions, each country should concentrate an essential part of its national income/gross national product on safeguarding the energy and raw materials base as a fundamental requirement of the systematic and balanced development of the economy, especially where the material and technological base has to be created in initial stages of industrialization. Priority should be given to a comprehensive utilization of domestic energy resources and to the development of a powerful nationally-owned sector of industry, including the power equipment industry.
The public sector in national economy creates favourable conditions for a planned development of the power industry in developing countries.

(8) The rational shaping of an advanced large-scale production requires powerful economic units of a social nature like those in the GDR's power equipment industry, with a relatively closed reproduction cycle, organized according to the production profile and structure required in order to make good use of advantages of co-operation and specialization and which are able to respond in a flexible way to the requirements of theeconomy, consumer demand and export markets.

(9) Most of the energy-related capital goods demand high-level and sophisticated technology, long-standing experience and relatively widespread co-operative arrangements. Therefore, power-equipment manufacturing presupposes a good development of the key industrial branches, involved, notably fairly well developed metallurgical and metal processing industries, the supply with the necessary means of production and auxiliary products.
Industrial sectors fulfilling co-operative or auxiliary functions in the production process should not be underestimated.

(10) The links with other capital goods industries are subject to change, depending on the type of equipment and its technological variability, and the development of diversified production units showing, at the same time, an extending tendency owing to the growing drive of performance and the mechanization and automation level of products.
The role of standardization is growing in this respect and the question of international standards has to be born in mind.

(11) The production of power equipment requires specialized equipment and the availability of sophisticated testing and production-control devices. The creation of appropriate conditions and technological capacities, including also equipment for maintenance operations, should therefore receive priority attention, taking into account the local requirements and future aspects.
Furthermore, it appears very important to channel appropriate parts of financial, material and human resources, in cases where a power system already fulfils basic needs and requirements, into measures promoting the rational use of energy and the improvement of energy conservation efficiency, especially in energy-intensive processes. This includes the necessity to devote special attention to the development of energy-saving equipment.

(12) Mastering of technology to an ever greater extent requires close combination of science and production, attention to the appropriate pattern of production and concentration on new products and technologies with high economic yields.
In this respect, it has proved to be the right way to create indigenous scientific and technological capacities in accordance with national economic requirements with the aim of strengthening technological independence and efficiency in key sectors decisive for the further increase of labour productivity.

(13) It has proved to be an effective strategy to concentrate the material and technological capacities and almost the entire research and development potential of industry in combines which have contracts with universities, colleges and research institutes or which maintain their own research institutions. This reflects the necessary intergration of science with production and creates favourable conditions for the scientific and technological progress. The creation of research and development centres within the industrial ministries promote this process, too.

(14) The science and technology potential concerning power equipment production has to be focussed in a right proportion on basic and applied research as well as on present and future economic, social and scientific priorities, taking into consideration local conditions and long-term targets to be achieved.

(15) The work of research and development units in the power equipment industry should be directed towards key technologies and equipment basic to the necessary conditions for the rational use and conservation of energy, the development of available and new sources of energy, better utilization of raw materials, primary and intermediate products, the increase of productivity through rationalization and automation, especially the accelerated development and application of microelectronics while promoting the further improvement of working and living conditions.

16) Countries with deficient natural resources, limited labour force or other objective constraints are particularly urged to use scientific and technological progress in order to solve economic problems they are faced with. In this case all the more countries should establish, parallel to the creation of the material-technological base in the field of power industry, their own research capacities and special scientific institutions of higher and technical education to train cadres needed. Great attention must also be devoted to vocational training and the upgrading of skills.

(17) The only yardstick for the assessment and evaluation of scientific and technological results can be the objective level of international development including short introduction periods of new findings into production, the rapid and extensive use of the available scientific results, and account of development trends and technological changes in the field of the power equipment industry.

(18) The promotion of top-quality results in research and development can be supported by using special incentives for creative activities of work teams, innovators, inventors and experts, including workers, engineers and scientists engaged in innovation and rationalization schemes, individual research assignments or planning provisions.

(19) The profile and production/export programmes of the GDR's power equipment industry as well as its experience and potentialities outlined demonstrate the GDR's comprehensive capabilities for international co-operation on favourable terms in bilateral and multilateral dealings which should also be used by UNIDO and other international organizations, especially for assistance in the industrialization process in developing countries.

(20) In contrast to Transnational Corporations in the power equipment industry the GDR's firms and enterprises follow in line with basic principles of international co-operation, such as respect for national souvereignty, non-interference in any given country's internal and external affairs, equality and mutual benefit. The economic organization of the GDR operate in accordance with national development plans and within the framework of trade agreements between states and strictly observe domestic law. In this respect their international co-operation is directed towards strengthening the economic and technological independence of the partner countries involved and to the promotion of their economies as a whole.
Due consideration should be given to an effective control over the TNCs in view of their practices in manufacturing, licensing, technology transfer and other areas of co-operation.

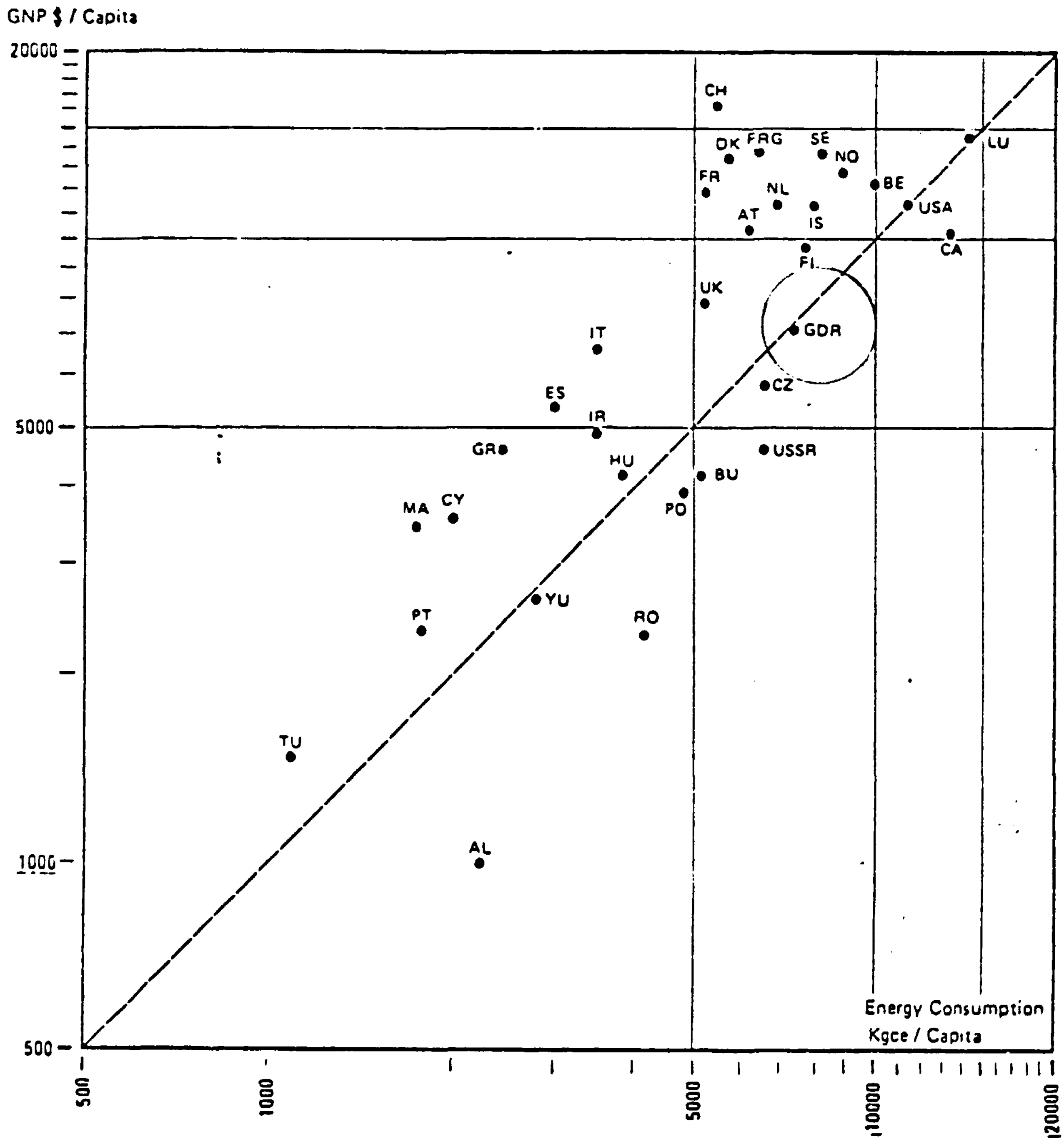
Table 2: ELECTRIC ENERGY PRODUCTION AND CONSUMPTION (GDR)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
INSTALLED CAPACITY (MW)											
Public and self-producer total	13554	14300	15041	16211	16735	17218	18085	18743	18792	20717	21190
Hydro	652	697	725	715	727	748	761	953	1496	1852	1845
Conventional thermal	12827	13528	13801	14546	15058	15520	15934	15960	16505	17035	17508
Nuclear	75	75	515	950	950	950	1390	1830	1830	1830	1830
Public total	9382	9822	10561	11748	12232	12756	13689	14357	15498	18547	19083
Hydro	642	687	715	705	719	740	753	941	1472	1828	1828
Conventional thermal	8665	9060	9331	10093	10563	11066	11546	11586	12196	14889	15425
Nuclear	75	75	515	950	950	950	1390	1830	1830	1830	1830
GENERATION (GWh)											
Public and self-producer total	72828	76908	80286	84505	89150	91996	95963	96845	98808	100720	102906
Hydro	1224	1268	1337	1272	1174	1249	1281	1331	1658	1736	1766
Conventional thermal	71219	75289	76768	80493	82705	85542	86751	85741	85261	87082	90291
Nuclear	385	351	2183	2740	5271	5205	7931	9773	11889	11902	10849
Public total	47991	51481	55342	59829	65069	67514	72107	73615	76819	91173	94016
Hydro	1148	1195	1250	1185	1113	1175	1211	1262	1576	1664	1706
Conventional thermal	46458	49935	51909	55904	58685	61134	62965	62580	63353	77607	81461
Nuclear	385	351	2183	2740	5271	5205	7931	9773	11889	11902	10849
Net production	66018	69682	72845	76344	80428	82993	85566	86409	88765	90146	92205
Transmission and distribution losses	5528	5147	5356	5583	5733	6246	6532	6504	6654	6937	7106
Imports	1415	1665	1742	1380	1452	2654	4008	3963	4150	4160	4292
Exports	465	395	635	697	1140	2149	3195	2679	2761	2522	3144
CONSUMPTION (GWh)											
Total	61440	65805	68596	71444	75007	77252	79847	81189	83576	84924	84247
Industry and Construction	31435	33253	34869	35834	37407	38205	38025	38672	39438	40476	41988
Transport	1335	1319	1299	1476	1596	1662	1716	1776	1845	1551	1690
Houshold and other consumers	19297	21652	22676	24116	26036	27553	30247	30710	31662	32030	30789
GENERATION PER INSTALLED CAPACITY	5.373	5.378	5.338	5.213	5.327	5.343	5.306	5.167	5.258	4.862	4.856

Sources: World Energy Supplies 1972-1976 (United Nations); Yearbook of World Energy Statistics 1980 (United Nations); Annual Bulletin of General Energy Statistics for Europe 1972 ... 1981; Annual Bulletin of Electric Energy Statistics for Europe 1982 (United Nations); Institut für Energetik (Leipzig);

FIGURE 1

GNP/NMP and energy consumption per capita, ECE countries, 1980



NOTE. Country labels are based on standard ISO throughout this paper as follows.
Albania: AL; Austria: AT; Belgium: BE, Bulgaria: BU; Canada: CA; Czechoslovakia: CZ; Cyprus: CY, Denmark: DK, Finland: FI; France: FR; German Democratic Republic: GDR; Germany, Federal Republic of: FRG; Greece: GR; Hungary: HU; Iceland: IS; Ireland: IR; Italy: IT, Luxembourg: LU, Malta: MA; Netherlands: NL; Norway: NO; Poland: PO; Portugal: PT; Romania: RO; Spain: SP; Sweden: SE; Switzerland: CH; Turkey: TU; Union of Soviet Socialist Republics: USSR, United Kingdom: UK; United States of America: USA; Yugoslavia: YU.

Source: Energy Transition in the ECE Region, United Nations, New York, 1983

Table 8 : MAIN CHARACTERISTICS OF GDR'S POWER SYSTEM

		Index		1962	1967	1972	1977	1982
POWER INDUSTRY	Thermal power plants	Installed capacity (31. 12.)	MW	4 121	7 042	8 911	12 270	14 890
		in this amount: nuclear power stations	MW	—	70	70	950	1 837
		Number of power stations	No.	53	51	46	54	49
		Average installed capacity of power stations	MW	78	138	194	227	304
		Maximum installed capacity of power stations	MW	600	1 300	1 470	2 520	3 520
		Average installed capacity of turbo-generator set/unit	MW	19	36	44	56	71
		Maximum unit capacity of turbo-generator set/unit	MW	100	100	210	500	500
		Number of turbo-generator sets of 200 MW and above	No.	—	—	10	22	30
		Specific consumption of equivalent fuel	g/kWh	508	472	433	420	433
	Hydro power plants	Installed capacity (31. 12.)	MW	274	578	628	648	1 718
		Number of power stations	No.	11	6	6	6	7
		Average installed capacity of power stations	MW	25	96	105	108	245
		Maximum installed capacity of power stations	MW	126	320	320	320	1 050
		Maximum unit capacity of hydro-generator sets	MW	21	40	40	40	175
POWER SYSTEM, total figures		Total installed capacity (31. 12.)	MW	8 362	11 543	14 190	17 912	21 887
		in this amount: power stations of the power industry	MW	4 395	7 620	9 539	12 918	16 608
		industrial power stations	MW	3 967	3 923	4 651	4 994	5 279
		Proportion of installed capacity of industrial power stations	%	47	34	33	28	24
		Annual peak load	MW	6 981	9 669	11 719	14 778	16 690
		Index (1962 – 100 %)	%	100	139	168	-	239
		Gross consumption of electric power	GWh	45 063	59 688	73 823	92 570	104 054
		Index (1962 – 100 %)	%	100	132	164	205	231
		Utilization time of annual peak	hours	6 226	6 173	6 299	6 264	6 235
		Total electricity generation	GWh	45 226	59 693	72 825	91 998	102 906
		in this amount: conventional thermal power stations	GWh	23 391	35 584	46 550	61 226	66 738
		nuclear power stations of the power industry	GWh	—	365	385	5 205	10 849
		hydro power stations of the power industry	GWh	378	819	1 094	1 130	1 681
		industrial power stations	GWh	21 457	22 925	24 796	24 437	23 638
		Electricity exchange balance (±)	GWh	—163	—5	+998	+572	+1 148
		Electricity exchange balance in % of gross consumption	%	0,4	—	1,4	0,6	1,1
		Total electricity supplies	GWh	1 409	1 645	1 831	4 736	7 436
		in this amount: between IPS countries	GWh	1 409	1 645	1 831	4 736	7 436
		Lenght of power transmis. lin. of 220 kV and above (31. 12.)	km	3 197	5 647	6 871	8 617	9 976
		in this amount: transmission lines of 330 kV and above	km	—	1 566	1 991	3 380	4 566
		Gross per capita consumption of electric power	kWh/head	2 635	3 494	4 332	5 522	6 219

Source: 20 years CDO IPS, Prague 1983

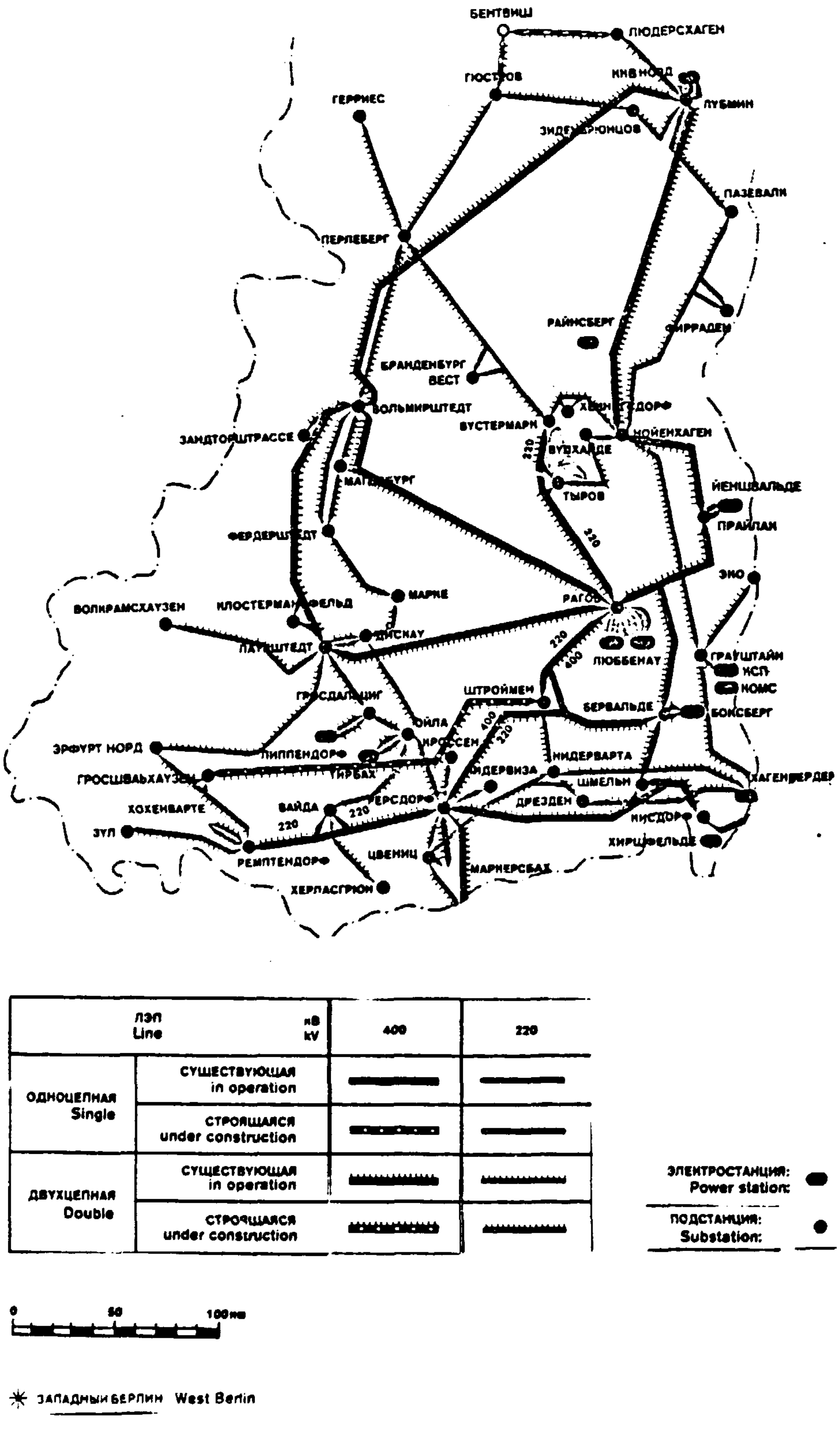


Figure 3: Survey of the GDR's energy grid system (January 1982) - part of the Interconnected Power Systems

Year	Total 1)	Energy and fuel industry	Chemical industry	Metallurgy	Building materials industry	Water supply
			1960 = 100			
1950	34	59	34	28	33	.
1955	65	81	66	69	58	.
1965	133	124	146	122	139	.
1970	183	146	212	165	186	.
1975	249	167	315	230	260	.
1980	318	210	399	279	291	.
1981	333	218	409	298	291	.
1982	343	224	432	305	282	.
			1970 = 100			
1971	106	101	106	108	107	107
1972	112	102	115	115	110	111
1973	120	106	125	123	117	114
1974	129	109	137	132	130	116
1975	137	11[illegible]	149	139	140	120
1976	145	121	159	147	147	125
1977	152	125	166	153	153	129
1978	159	132	175	159	159	133
1979	166	138	182	162	158	138
1980	174	144	188	169	157	142
1981	182	149	193	180	156	148
1982	188	153	204	185	151	154

Year	Mechanical engineering and vehicle construction	Electrical engineering, electronics, instrument manufacture	Light industry (excluding textile industry)	Textile industry	Foodstuffs industry
		1960 = 100			
1950	27	22	44	41	33
1955	57	50	69	72	72
1965	143	157	123	113	118
1970	201	248	165	140	147
1975	266	386	219	181	192
1980	358	584	269	219	220
1981	379	646	276	224	225
1982	395	691	283	230	224
		1970 = 100			
1971	105	110	105	104	106
1972	110	120	110	110	112
1973	117	132	118	115	118
1974	125	144	126	122	125
1975	132	155	133	129	131
1976	141	170	141	136	135
1977	149	183	146	141	138
1978	157	197	153	146	142
1979	166	217	159	150	146
1980	178	235	163	155	150
1981	189	260	167	159	153
1982	196	279	172	163	152

1) Industry and non-industrial sectors.

Table 10 : Index of gross industrial production by industrial sectors

Source: Statistical Pocket Book 1983

Year	Region \ Products (SITC rev.2 code)	Power Generating Machinery (71)	Rotating Electric Plant (716)	Electrical Machinery, N.E.S. (77)	Electric Power Machinery N.E.S. (771)	Electric Circuit Apparatus (772)	Equipment for Distributing Electricity (773)
1979	Africa	5.4	4.9	20.8	0.1	1.7	1.1
1980		5.8	5.0	25.8	0.0	2.9	0.4
1981		5.0	4.2	37.7	0.0	2.3	6.3
1979	North America	-	-	0.0	-	-	0.0
1980		0.0	-	0.0	-	0.0	-
1981		0.0	0.0	0.1	-	0.1	0.0
1979	Other America	18.1	0.2	6.2	0.1	1.4	1.4
1980		17.2	0.3	9.8	0.1	1.7	2.3
1981		19.8	1.3	11.2	0.0	1.4	2.6
1979	Oceania	0.1	0.1	0.0	-	-	-
1980		0.3	0.3	-	-	-	-
1981		0.3	0.3	0.1	-	-	-
1979	Asia Middle East	2.3	0.8	50.0	0.0	2.3	0.8
1980		3.3	2.4	80.1	0.0	1.7	0.0
1981		5.6	3.8	83.5	-	1.9	0.0
1979	Asia Far East	17.2	9.5	10.2	0.0	0.0	3.7
1980		27.1	13.2	19.2	0.1	0.0	3.4
1981		18.9	12.9	13.5	0.0	0.3	3.0
1979	Europe	181.4	73.2	637.0	18.5	162.8	143.0
1980		214.8	89.1	734.4	22.0	190.1	172.4
1981		229.4	96.0	752.4	18.4	203.1	178.2
1979	World	224.5	88.7	724.3	18.7	168.2	150.0
1980		268.5	110.3	869.3	22.2	196.4	173.5
1981		279.0	118.5	938.5	18.4	209.1	190.1

Table 13 : GDR Exports of Engineering Products (Millions of US $)

Source: Bulletin of Statistics on World Trade in Engineering Products, United Nations

Table 14: Power station installations and power station equipment

Generators

Manufacturer: VEB Bergmann-Borsig/Görlitzer Maschinenbau

Capacity: 12.5 to 137.5 MVA

Turbo-generator sets

Manufacturer: VEB Bergmann-Borsig/Görlitzer Maschinenbau

- Condensing turbo-generator sets: 50 to 125 MW
- Extraction condensing turbo-generator sets: 0.3 to 5 MW; 6 to 20 MW; 25/32/40 MW; 50/64/80 MW; 100/125 MW
- Extraction backpressure turbo-generator sets: 0.3 to 5 MW; 6 to 20 MW; 25/32/40 MW; 50/64/80 MW
- Backpressure turbo-generator sets: 1.5 to 32 MW
- Small steam turbines for driving pumps and other prime movers: 0.08 to 0.16 MW
- Gas turbines: up to 32 MW
- Generators with apparent power of 31.25 MVA to 137.5 MVA (10.5 kV)
- Axial-flow compressor installations for application in chemical engineering. Air flow rates of 150,000 to 700,000 m^3/h. Driven by steam turbines or electric motors.

Steam generators

Manufacturer: VEB Dampferzeugerbau Berlin

● Fuel basis: solid fuels

	Three-pass boiler DGK	Water tube boiler DWK	Modular steam generators
Capacity:	1,6 / 3,2 / 6,5 t/h	3,2/6,5/8,0/10,0/12,5 t/h	25 / 40 / 64 t/h
Licence pressure:	1 373 MPa	1,373 MPa, 2,648 MPa	1,4 MPa, 2,6 MPa, 5,2 MPa
Superheated steam temp.:	saturated steam and 220 °C	saturated steam and 220 °C, 300 °C, 425 °C	saturated steam and 220 °C to 460 °C

	Steam generators	Steam generators (bagasse)		
Capacity:	260, 320, 815 t/h	25/30	45/56	100/90 t/h
Licence pressure:	11,08 / 13,59 / 17,26 MPa	3,236	3,236	4,707 MPa
Superheated steam temp.:	530 °C, 535 °C, 535 °C	400 °C	400 °C	435 °C

Further steam generators on the basis of solid fuels: 125/160/200/220/230/ 330/350/ 420 t/h

● Fuel basis: oil or gas

Steam generators: Capacity 125 to 220 t/h, Licence pressure 11,082 MPa, Superheated steam temp. 525 °C

All steam generators up to a capacity of 100/90 (including Bagasse steam generators) can also be supplied for the fuels oil or gas.

Individual products:	Manufacturer:
Emergency power generating unit "Turbolekt" Small gas turbines Oil and gas firings for power station equipment Hydraulic transmissions Hydraulic couplings Flow converter	VEB Strömungsmaschinen
Assemblies for steam generators – Firing systems for solid fuels (pulverised firing and stoker firing) – seal welded tube walls – Boiler drums – Economisers and air heaters Marine auxiliary boilers from 0,32 to 10 t/h oil basis	VEB Dampferzeugerbau Berlin
Piping elements and insulation products Flanges, unmachined and machined according to DIN, TGL and ASA Compensators Piping and insulations for power stations Tanks and filters for water treatment plants	VEB Rohrleitungen und Isolierungen Leipzig
Water treatment plant	VEB Wasseraufbereitungsanlagen Markkleeberg and VEB Bergmann-Borsig

Table 15 : Export programme in power station installations and equipment (excerpt)

Turbo-generator sets

- Condensing turbo-generator sets 50 to 125 MW
- Extraction condensing turbo-generator sets 50 to 125 MW
- Extraction condensing turbo-generator sets 3 to 32 MW
- Backpressure turbo-generator sets 1,5 to 32 MW
- Small steam turbines for driving pumps and other prime movers 0,08 to 0,16 MW
- Backpressure turbo-generator sets 50/60 MW
- Extraction backpressure turbo-generator sets 50/60 MW
- Extraction backpressure turbo-generator sets 3 to 32 MW
- Gas turbines up to 32 MW
- Generators with apparent power of 31,25 MVA to 137,5 MVA, voltage 10,5 kV
- Axial-flow compressor installations for application in chemical engineering. Air flow rates of 150 000 to 700 000 m^3/h. Driven by steam turbines or electric motors.

Steam generators

- Fuel basis: solid fuels

	Three-pass boiler DGK	Water tube boiler DWK	Modular steam generators
Capacity: Licence pressure: Superheated steam temp.:	1,6 / 3,2 / 6,5 t/h 1,373 MPa saturated steam and 220 °C	3,2/6,5/8,0/10,0/12,5 t/h 1,373 MPa, 2,648 MPa saturated steam and 220 °C, 300 °C, 425 °C	25 / 40 / 64 t/h 1,4 MPa, 2,6 MPa, 5,2 MPa saturated steam and 220 °C to 460 °C

	Steam generators	Steam generators (bagasse)		
Capacity:	260, 320, 815 t/h	25/30	45/56	100/90 t/h
Licence pressure:	11,08 / 13,59 / 17,26 MPa	3,236	3,236	4,707 MPa
Superheated steam temp.:	530 °C, 535 °C, 535 °C	400 °C	400 °C	435 °C

- Fuel basis: oil or gas

  Steam generators: Capacity 125 to 220 t/h, Licence pressure 11,082 MPa, Superheated steam temp. 525 °C

All steam generators up to a capacity of 100/90 (including Bagasse steam generators) can also be supplied for the fuels oil or gas.

Technological equipment for the following installations

- Base load power stations with unit capacities of up to 125 MW
- Industrial power stations and electricity power and heat stations with unit capacities of up to 100 MW
- Heating stations with individual boiler capacity of 6.5 t/h up to 64 t/h on the fuel basis of raw lignite/oil/gas.

Individual products:

- Marine auxiliary boilers from 0,32 to 10 t/h oil basis
- Assemblies for steam generators
  - Firing systems for solid fuels (pulverised firing and stoker firing)
  - seal welded tube walls
  - Boiler drums
  - Economisers and air heaters
- Transport equipment for nuclear power stations
- Oil and gas firings for power station equipment
- Small gas turbines
- Emergency power generating unit "Turbolekt"
- Hydraulic transmissions
- Hydraulic couplings
- Flow converter
- Piping elements and insulation products
- Flanges, unmachined and machined according to DIN, TGL and ASA
- Compensators
- Piping and insulations for power stations
- Tanks and filters for water treatment plants

The products bear the highest quality mark of the GDR. Full or partial licences are granted for all products.

Countries	equipment/performance	valuta marks (million)	per cent
non-socialist countries (excl. X-ray technique and electromedicine)	- sub-stations	49.7	39,2
	- electrification projects	44.9	35.5
	- electrotechnical equipment for industrial plants	20.0	15.8
	- heavy-duty transformers	9.9	7.8
	- high-voltage testing technique	1.4	1.1
	- instrument transformers	0.4	0.3
	- high-voltage fittings	0.1	0.1
	- spare parts and others	0.3	0.2
total		126.7	100.0
socialist countries (excl. X-ray technique, electromedicine, lightening devices)	- medium-voltage switchgear cubicles	127.7	37.2
	- low-voltage capacitor systems	67.0	19.5
	- high-voltage testing equipment	51.6	15.0
	- low-voltage distributing plants	33.0	9.6
	- tap changer for heavy-duty transformers	17.3	5.0
	- high-voltage fittings	17.0	4.9
	- medium-voltage circuit-breakers and isolators	12.9	3.8
	- compact transformer stations and load switching stations	8.6	2.5
	- electrotechnical equipment for industrial plants and universities	3.8	1.1
	- heavy duty transformers	2.2	0.6
	- control equipment for industry	1.7	0.5
	- testing performances	0.7	0.2
total		343.5	100.0

Table 17: KEA exports in 1983

Source: KEA information

Equipment	valuta marks (million)
- component parts for oil-poor circuit-breakers	15
- capacitive voltage transformers	3
- component parts and devices for protective equipment	5
- SF_6-circuit-breakers	5
- earth-fault transformers	2
total	30

Table 18: KEA imports in 1983

Source: KEA information

Table 20 : Single units and equipment for electric power transmission and distribution plants

Prefabricated systems of switching stations for high- and low-voltage :

Gas-blast high-voltage switchgears GSAS 1-123

Manufacturer:
VEB Transformatorenwerk
"Karl Liebknecht" Berlin

Principal data	
Rated voltage	72.5; 123; 145 kV
Rated current – tap circuit	1,250 A
– busbar	1,600 A
Rated frequency	50 Hz
Rated breaking current	25 kA

Solid-insulated high-voltage switchgears ASIF 36

Manufacturer: VEB "Otto Buchwitz"
Starkstrom-Anlagenbau Dresden

Principal data Type	ASIF 36/16	ASIF 36/20
Rated voltage	36; 40.5 kV	36 kV
Rated current	800; 1,250 A	800; 1,250 A
Rated frequency	50 Hz	50 Hz
Rated breaking current	16 kV	20 kV

High-voltage divider LHTCIG-12/400

Manufacturer:
VEB Schaltgerätewerk Werder
(licence manufacture according to the system ISOPONT- Color Emag)

Principal data	
Rated voltage	12 kV
Rated current	400 A
Rated frequency	50 Hz
Rated breaking current	400 A

Metal-clad air-insulated high-voltage switchgear cubicles CSIM 1-20

Manufacturer: VEB "Otto Buchwitz"
Starkstrom-Anlagenbau Dresden

Principal data Type		CSIM 1-20/350	CSIM 1-20/500
Rated voltage		24 kV	24 kV
Rated current		630 A	630; 1,250 A
Rated frequency		50 Hz	50 Hz
Rated breaking current			
– circuit-breaker	at 15 kV	13.5 kA	19.2 kA
	at 20 kV	10.1 kA	14.4 kA
– load-isolating switch	at 15 kV	250 A	300 A
	at 20 kV	100 A	300 A

High-voltage switchgears
CSIM 3-12

Manufacturer: VEB "Otto Buchwitz" Starkstrom-Anlagenbau Dresden

Principal data

Type	CSIM 3-12 (up to I_N = 1,250 A)	CSIM 3-12 (up to I_N = 2,500 A)
Rated voltage	12; 12.5 kV	12; 12.5 kV
Rated current – busbar	630; 1,250 A	2,500; 3,150 A
– branch	400; 630; 1,250 A	2,500 A
Rated frequency	50; 60 Hz	50; 60 Hz
Rated breaking current		
– circuit-breaker	16; 25; 31.5 kA	31.5 kA
– load-isolating switch	400 A	–

Compact transformer station TKS 10-20/0.4 kV

Manufacturer:
VEB Starkstrom-Anlagenbau
Magdeburg

The station is designed for 10 to 20 kV of primary voltage and for 0.4 (0.23) kV of secondary voltage. Oil-immersed transformers up to 630 kV can be used.

Low-voltage switchgear cubicles
ISA 2000 W

Manufacturer:
VEB Starkstrom-Anlagenbau
Magdeburg

The systems ISA 2000 W comprises the type lines as follows:

- ISA 2000 W – SF control panels for feed-in facilities with circuit-breakers and load-isolating switches as well as with contactors and fuses in two rated sizes having different protection degrees for plants up to 1,000 A and 2,500 A; circuit-breakers from 160 A with manual or remote control;
- ISA 2000 W – SG contactor panels for manual and remote control of electrical drives and for other consumers in different combinations;
- ISA 2000 W – ST transformer boxes to clad air-cooled dry-type transformers of 250 up to 1,000 kVA, high-voltage 10 (6) kV, low-voltages 380, 500, 660 V
- ISA 2000 W – SK capacitor panels for reactive power compensation in two output sizes: 600 ... 120 kvar and 120 ... 240 kvar;
- ISA 2000 W – SL load centre stations made of panels SF, SG, SK, and ST of ISA-system;
- ISA 2000 W – EV power distributor with combinations of circuit-breakers (600 and 1,000 A) and fuse branches (6 x 3 – max. 400 A) on one panel; possibility of extension by left- or right-side attachment of fuse branches (4 x 3 – max. 400 A);
- ISA 2000 W – UV sub-distributions with feed-in and branches on one panel; available in two type lines:

a) with current-limiting circuit-breakers

b) with load switches, multisection rotary switches, fuse branches, switchable fuse branches

Low-voltage capacitor systems
of 70 up to 960 kvar

Manufacturer:
VEB Starkstrom-Anlagenbau
Magdeburg

Low-voltage capacitor systems in indoor construction for reactive power compensation of inductive consumer groups are manufactured in the capacity range from 70 to 960 kvar. This range is subdivided in:

- capacitor installations with rated outputs of 70 and 100 kvar
- capacitor installations with rated outputs of 140 up to 240 kvar
- capacitor installations with rated outputs of 240 up to 960 kvar

Transformers

Transformers of maximum output The manufacturing program of transformers of maximum output is concentrated to internationally common voltage levels up to 420 kV.	Manufacturer: VEB Transformatorenwerk "Karl Liebknecht" Berlin
Generator transformers for direct transformation from generator voltage to 240 kV or 420 kV with an output associated with the generator units between 235 MVA and 630 MVA in modifications for thermal-, pumped-storage or nuclear power stations.	
Mains transformers for a uniform distribution for voltage levels of 123 kV, 240 kV, and 420 kV. They can be supplied as single-phase units for three-phase transformer banks of 420/240 kV with bank outputs of 630 MVA or 800 MVA as well as three-phase transformers of 240/123 kV having outputs of 160 MVA or 250 MVA as well as for direct transformation of 420/123 kV or 400/150 kV respectively having an output of 250 MVA.	Manufacturer: VEB Transformatorenwerk "Karl Liebknecht" Berlin
A further standard series comprises three-phase oil-immersed transformers of voltage levels of 36 kV and 123 kV with rated outputs of 12.5 MVA up to 40 MVA.	Manufacturer: VEB Transformatoren- und Röntgenwerk "Hermann Matern" Dresden
Local network transformers The program of local network transformers comprises three-phase oil-immersed transformers in staggered type lines for rated voltages from 6 kV up to 30 kV with rated outputs of 800 kVA up to 1,600 kVA	Manufacturer: VEB Transformatoren- und Röntgenwerk "Hermann Matern" Dresden
as well as for rated voltages of 12 kV and 24 kV with rated outputs of 400 kVA and 630 kVA.	Manufacturer: VEB Transformatorenwerk Reichenbach
Other transformers The range of transformers is supplemented by – three-phase dry-type high-voltage transformers 16 kVA and 25 kVA as well as 63 kVA up to 1,000 kVA for rated voltages up to 12 kV – three-phase dry-type low-voltage transformers 16 kVA up to 400 kVA for rated voltages of 200 V, 380 V, 500 V, and 600 V	Manufacturer: VEB Transformatorenwerk Reichenbach

Circuit-breakers

Air-blast heavy-duty circuit-breaker system D3AF7/D3AF8

Manufacturer:
VEB Transformatorenwerk
"Karl Liebknecht" Berlin

A circuit-breaker type line from 66 kV up to 420 kV rated voltage is available

Each circuit-breaker comprises three equal single poles to be erected separately which have a common low-voltage control. An exception forms the circuit-breaker of 66 kV, the three poles of which are mounted on a common compressed-air receiver.
The circuit-breakers of 66 kV and 123 kV can also be supplied for indoor installation.

According to the system conditions it is possible to equip the circuit-breakers of 240 kV and 420 kV with two galvanically isolated breaking circuits. The type of 420 kV can obtain an equipment of low-inductance resistors to limit over-voltages, or it can be designed for a rated breaking current of 50 kA.

Oil-poor indoor circuit-breakers SCI

Manufacturer:
VEB Schaltgerätewerk Muskau

Principal data Type	SCI 4-12	SCI 4-24	SCI 3-36
Rated voltage	12 kV	24 kV	36 (40.5) kV
Rated current	800; 1,250 A (SCI 3-12 also 2,500 A)	800; 1,250 A	800; 1,250 A
Rated breaking current	20; 25; 31.5 kA	12.5; 14; 20 kA	20 (16) kA
Rated frequency	50 Hz	50 Hz	50 Hz

Load isolating switches LHTCI 4-12/400
LHTCI 4-24/300

Manufacturer:
VEB Schaltgerätewerk Werder

Principal data Type	LHTCI 4-12	LHTCI 4-24
Rated voltage	12 kV	24 kV
Rated current	400 A	300 A
Rated frequency	50 Hz	50 Hz

Oil-poor circuit-breakers HPF

Manufacturer:
VEB Transformatorenwerk
"Karl Liebknecht" Berlin

According to requirements by some territories, oil-poor circuit-breakers of design SPRECHER + SCHUH are also offered on a certain scale. At present these circuit-breakers include rated voltages of 72.5 kV and 245 kV. An extensio[illegible] program to other rated volt[illegible].
The [illegible] is designed for a rate[illegible] current of 20 kA or 40 kA The rated breaking current of the breaker type of 245 kV is designed for 31.5 kA.

Isolators

for rated voltages of 72.5 kV
up to 420 kV

Manufacturer:
VEB Transformatorenwerk
"Karl Liebknecht" Berlin

three series of isolators in two-supporting insulator construction are offered

1. Type KHAF-420 and 245
   with double-lever current path
2. Type PHA-170 and 123
   with pantograph-type current path
3. Type KHA-66
   with single-lever current path

The rated current has been determined uniformly for standard apparatuses with 2,000 A and for special constructions with 800 A, 1,200 A, 1,600 A, and 2,500 A.

Instrument transformers

Current transformers

for rated voltages 72.5 kV, 123 kV, 245 kV, and 420 kV

Manufacturer:
VEB Transformatorenwerk
"Karl Liebknecht" Berlin

For the range of rated voltages of 0.750 kV, 12 kV, 24 kV, and 36 kV

Manufacturer:
VEB Transformatoren- und Röntgenwerk
"Hermann Matern" Dresden

Voltage transformers

for outdoor installation for rated voltages of 72.5 kV, 123 kV, 245 kV and 420 kV

Manufacturer:
VEB Transformatorenwerk
"Karl Liebknecht" Berlin

For the range of rated voltages of 0.750 kV, 12 kV, 24 kV, and 36 kV a comprehensive assortment of cast resin voltage transformers is offered:

- Voltage transformer, single-pole insulated and two-pole insulated
- Precision voltage transformer (with oil insulation)

Manufacturer:
VEB Transformatoren- und Röntgenwerk
"Hermann Matern" Dresden

Compressed-air systems

Compressed-air systems can be supplied for application of air-blast circuit-breakers of type D3AF7/D3AF8 and for compressed-air-operated isolators as ancillary equipments.

Manufacturer:
VEB Transformatorenwerk
"Karl Liebknecht" Berlin

Air compressor system A2V1-1:23-R	Delivery per compressor	215 dm³/min
	Storage pressure	2.3 MPa
Air compressor systems A4HV1-1:F/160/2 . . . 5/20-V	Delivery	400 . . . 1,000 m³/24 h (acc. to quantity of compressors)
	Storage pressure	16 MPa

Electric control rooms

The electric control room with step selection control complies with all conditions of a modern control room technique. It is equipped with a revertive-signal panel, instrument and panel selecting cabinets as well as with a control desk.
The revertive-signal panel reproduces clearly the whole switching position of the plant by a symbol and/or mimic diagram. The voltage of busbars and load of branches indicate the measuring devices arranged on the symbolic diagram. The selected branch is shown by luminous annunciators of the revertive-signal board.
The control panels for step selection control are located in the control desk. A two-stage selection (panel and switch) is possible. Thus, a so-called panel-selecting key exists for each high-voltage branch on the control panel. Each kind of branch (transformer, cable outgoing section, coupling etc.) is represented by the mimic diagram. A common "ON–OFF" control switch only is provided for the whole plant which gives the switching order to the switch selected for the time being.

A step-selecting control allows also to combine selection measurements, synchronism and regulation.
The device-selecting cabinets are erected in a by-room of the control room, whilst the panel-selecting cabinets are directly mounted within the switchgear range, that is locally. The construction of the switchgear station determines the arrangement as indoor or outdoor installation.

Manufacturer
VEB Starkstrom-Anlagenbau
Magdeburg

Fittings and components

for connection, support and bracing of conductors in electrotechnical plants, such as
- fittings for cables and leads
- fitings for switching stations
- fittings for overhead lines
- fittings for trolley lines
- accessories and mounting tools

Manufacturer: VEB Hochspannungs-Armaturenwerk Radebeul

Table 21 : Individual units and devices of high-voltage testing technique and testing performances for high and low-voltage

1. High-voltage testing equipment and testing devices

(VEB StarkstromAnlagenbau Leipzig-Halle/VEB Transformatoren- und Röntgenwerk "Hermann Matern" Dresden)

High-voltage testing equipment

A.C. voltage-testing equipments up to 2.25 MV
for short-time tests on objets with great internal consumption, for endurance tests with higher currents, to feed-in corona test circuits and for all ranges of practical high-voltage testing technique and research.

Impulse voltage testing equipment up to 7.2 MV
to test component parts for electric power transmission systems; by means of additional resistor installation also to produce aperiodic testing surge voltages.

Switching voltage testing equipment up to 3.1 MV
to test component parts for electric strength of elements, sub-assemblies and components of power supply systems also of highest insulation voltages.

D.C. voltage testing equipment up to 2.25 MV
to test cables, capacitors and components of electrical engineering, especially of such elements of high-voltage d.c. transmission and high-voltage research.

Pulsation voltage testing equipment
for application in research in the field of high-voltage d.c. transmission.

High-voltage testing devices

to generate high a.c.-, d.c.- or impulse voltages and to perform special tests.

Portable a.c. voltage-testing device up to 2,500 V
for insulation test of electric domestic appliances, small motors, counters, measuring instruments, of small and intermediate transformers.

A.C. and d.c. voltage testing devices up to 100 kV a.c. 120 kV d.c.,
for insulation test of cables, electrical components and devices particularly for routine test and type test in workshops and in testing stations.

Movable impulse voltage testing devices up to 30 kV charging voltage
to test component parts and small devices of heavy current engineering by means of standardized lightning voltages 1/50.

Portable oil testing devices
to determine the dielectric strength of insulating oils; high voltage being adjustable up to 75 kV.

Portable relay testing devices
for primary and secondary relays to determine the operating current and pick-up voltage and switching times of relays.

Wire-testing devices
for non-contact insulation gauging of single-wire, unscreened, rubber or plastic insulated cables and lines during the *manufacturing*, rewinding, or coil-winding process; discharge voltage up to 50 kV d.c.

Movable testing devices for enamelled wire
for determination of dielectric strength of insulating varnish and coil impregnating varnish, for test of varnish-insulated wires and for investigation of electric qualities of plate insulants.

High-voltage testing transformers
for high-voltage tests to be made on transformers, instrument transformers, switchgears and insulators as well as for high-voltage experiments with high capacities in continuous and short time operation as single transformer or transformers in cascade-, three-phase or in parallel connection.

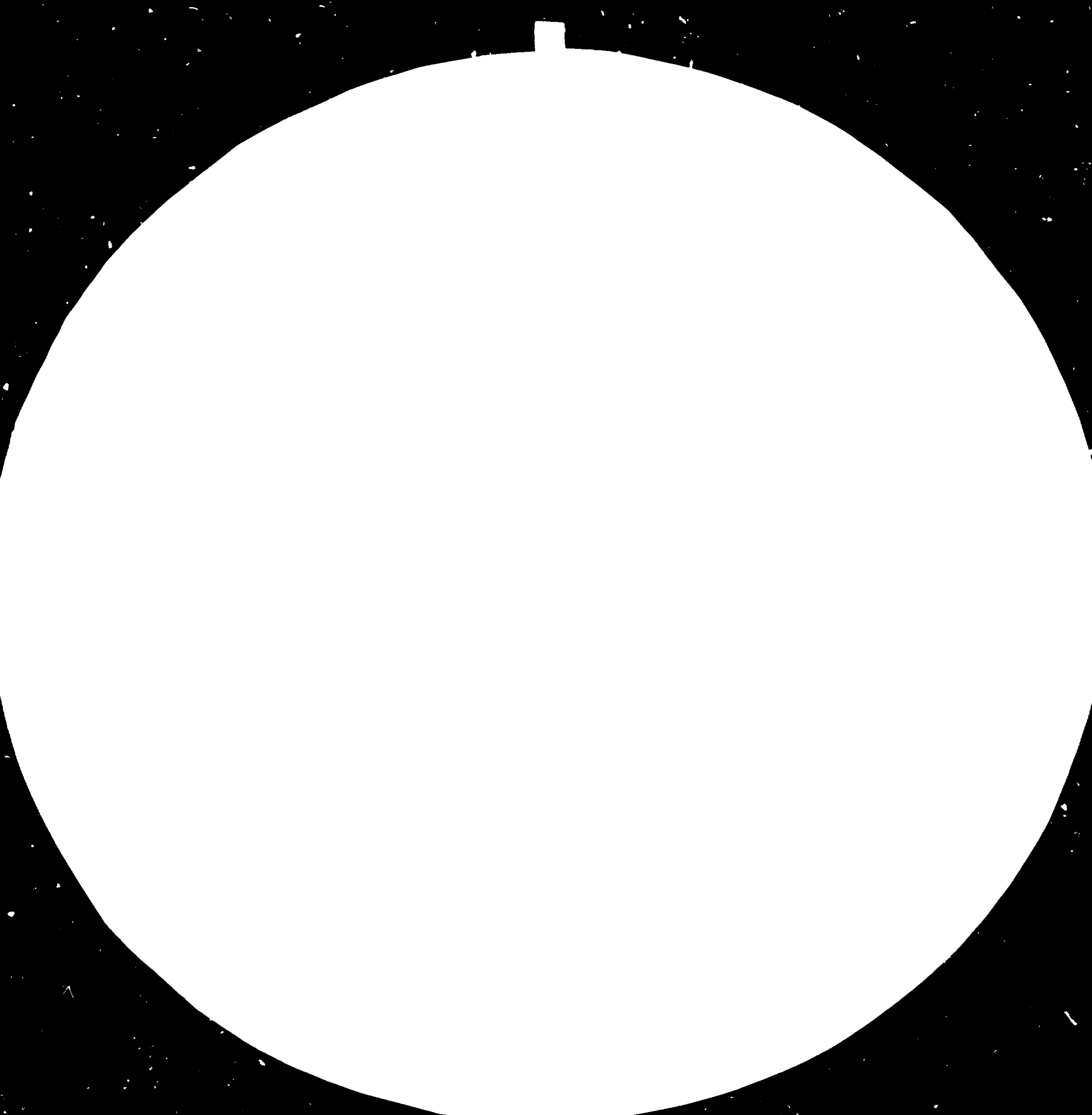
2. Testing performances (Institute "Prüffeld für elektrische Hochleistungstechnik"

Tests:

- High-voltage a.c. switching capacity (direct and indirect)
  rated making and breaking capacity
  double earth-fault
  phase asymmetry
  short-line fault
  critical current range
  cycle tests (high-speed reclosing)
  load currents
- processes on high-voltage devices
  disconnection of unloaded transformers, overhead lines and cables
  connection and disconnection of capacitor groups
  record of no-load and load characteristics
- low-voltage a.c. switching capacity
- high-voltage and low-voltage d.c. switching capacity
- short-circuit carrying capacity
- rated current carrying capacity
- mechanical endurance test
- fuses of all kinds
- insulating capacity
- *degree of protection*
- releasing times and operating currents

Measurements:

- current via special shunts
- voltage via RC-dividers
- pressure in the apparatus under test
- *current zero special measurements*
- and many other quantities



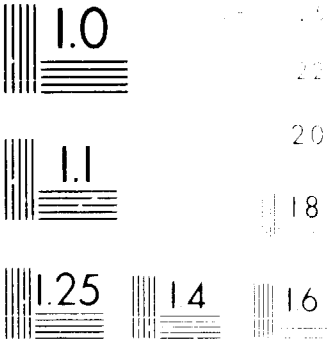

1.0
2.2
2.0
1.1
1.8
1.25
1.4
1.6

Table 22 : Survey of the production programme of the GDR's cable industry

Power Cables

Plastic cables and solid-type cables from 1 kV to 30 kV, with aluminium conductors, mass impregnated, PVC insulated or polyethylene insulated, lead sheathed, aluminium sheathed or PVC sheathed, armoured and unarmoured, cross-linked and non-cross-linked
Heat-resistant and cold resisting cables, plastic sheathed and plastic insulated
Non-draining cables
Oil-filled cables from 30 kV to 150 kV, with aluminium conductors, paper- and oil-insulated, lead or aluminium sheathed, protective coverings of coarse tow yarn or plastics, screened, steel tape or steel round wire armoured
Control cables, 1 kV, PVC insulated and PVC sheathed
Ship cables, 1 kV, PVC insulated and PVC sheathed, screened (the cables are in line with IEC Publication 92-3)

Plastic cable with aluminium conductor NAYY-J
Lead sheathed solid-type cable with aluminium conductor NAKY
Cross-linked polyethylene cable with aluminium conductor NA2XSY
Single oil-filled cable NAÖHKaY
Control cable with aluminium copper composite conductor N2AYY
Cold resisting plastic cable NAYBYk
Non-draining cable NAHKYBAh
Plastic cable with steel round wire armour NAYYRGY-J
Self-supporting cable EX
Self supporting cable ALUS
Polyethylene three-conductor mining cable NA2YHCaeBYT

Power Lines

Power lines for rated voltages of up to 30 kV, with copper and aluminium conductors, with rubber and plastics insulations
- for fixed installation
- for portable electrical equipment
- for special purposes
- confectioned lines

Welding cable NSchGöu
Heavy-duty rubber cable NTSCEöu
Rubber sheathed cable NQö-J
High-voltage X-ray line RGCY

Tele-communication Cables

Low-frequency cables (subscriber's, district, signalling cables) polyethylene and paper insulated, with lead, aluminium or polyethylene sheaths
Carrier-frequency cables acc. to CCITT Recommendations symmetrical and coaxial, lead or aluminium sheathed
Combined low-frequency/carrier-frequency cables with symmetrical and coaxial components

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Coaxial carrier-frequency cable with corrugated aluminium sheath 2YLDO2Y2Y
Combined carrier-frequency cable KMB 8 6
Carrier-frequency cable with aluminium sheath MKSABpSchp
Telecommunication cable, self-supporting 2YT2Y
Signalling cable with guaranteed reduction factor 2Y2Yirab2Y
Plastic insulated low-frequency cable 02Y2Y group stranded

Power Cable Accessories

Accessories for solid-type cables, plastic cables and heavy-duty rubber cables from 1 to 30 kV
Accessories for oil-filled cables from 60 to 150 kV
Terminal boxes for indoor and outdoor installations
Joint boxes and reducing sleeves
Mounting material

Joint box MBUD 10 for solid-type cables
Sealing end for indoor and outdoor use EGWE
Outdoor single-conductor sealing end EPWEY
Indoor single-conductor sealing end ERStY
Terminal box EPOW 4 – 110

Tele-communication Lines

Plastic insulated telecommunication lines PVC or polyurethane sheathed
- for fixed installation
- for portable electrical equipment
- for special purposes
- confectioned cables

Screened sheathed cable MY(St)Y
Miniaturized record player arm cable Li2Y(D)Y
Seismic testing wire GT2YY8Y
Plastic sheathed cable H2Y(CE)Y(C)Y
Cable shaft relay station
Flat connecting cable BVY

Tele-communication Accessories

Joint boxes for plastic- and metal-sheathed cables
Joint boxes to house electrically active elements (sleeves for Pupin coils, capacitors and line building-out networks)
Terminal boxes for low-frequency cable installations
Terminal boxes for carrier-frequency and PCM cable installations
Mounting material

Gas-pressure-tight terminal box FEAG-A
Longitudinally divided mechanical joint box FM-F 25
Soldering sleeve for coaxial pairs TFL 2.6 9.7 with special mounting tool
Gas-pressure-tight joint box FM-GP 1 2
Terminal box FECG – A 32

Winding Wires

Winding wires from copper and aluminium, round and flat, enamel-, silk-, paper-, or plastic-insulated, for measuring, controlling, regulating and communication engineering, for electrical equipment and machinery

Varnishing equipment for twisted conductors
Twisted conductor
Glass silk-braided flat wire 2Gsn
Enamel-insulated flat wire W155
Superfine round enamel-insulated wire from aluminium FINALAN(R)
12-channel light-beam recorder – equipped with miniature coils made from FINALAN(R)
Braided round strand PFI2Pti
Braided flat wire GsPti
Combined enamel glass silk-insulated wire LGsf

Radio-frequency Cables and Lines

Coaxial radio-frequency cables and lines for television and VHF radio transmission
Radio-frequency receiving cables
Combined radio-frequency cables and lines for various fields of application
Radio-frequency energy cables

Coaxial RF energy cable 75-78-D with plug
Combined RF cable 7082.1
Symmetrical RF line 240A4-1
Coaxial RF cable 75-7-8
Coaxial RF cable 100-2-A
Measuring set for RF energy cables

Export programme [illegible]

Power cables

Compound-impregnated and adhesive compound-impregnated cables, plastic cables

Rated voltage:	1, 10, 20, 30 kV
Conductor material:	aluminium, copper
Insulating material:	paper (compound-impregnated) polyvinylchloride polyethylene (interlaced, non-interlaced)
Sheathing material:	lead, aluminium, polyvinylchloride
Material of protective covering:	rope yarn, plastics

The cables are manufactured with or without armour

Oil-filled cables

Rated voltage:	30, 66, 110, 150 kV
Conductor material:	aluminium
Insulating material:	paper/oil
Sheathing material:	lead, aluminium
Material of protective covering:	rope yarn, plastics

The cable cores are complete with screen. The cables are manufactured either with steel band or with steel round wire armouring.

Control cables

Rated voltage:	1 kV
Conductor material:	copper
Insulating material:	polyvinylchloride
Sheathing material:	polyvinylchloride

Power cable accessories

Rated voltage: 1 kV up to 150 kV

Connection sleeves
Distribution sleeves
Protective sleeves
Cable terminals
Installation accessories

Power lines

Rated voltage: up to 30 kV

- for stationary laying
- for mobile operational stock
- for special purposes
- ready-made lines

Conductor material:	copper, aluminium, resistance metals
Insulating material:	polyvinylchloride, polyethylene, rubber mixtures

Telecommunication cables

Low-frequency cables

Subscriber's cables, exchange cables, signal cables

Conductor material:	copper
Insulating material:	polyethylene (solid and cellular polyethylene) paper
Sheathing material:	polyethylene, lead, aluminium
Material of protective cover:	rope yarn, plastics

Carrier frequency cables

Transmission characteristics correspond to the international CCITT recommendations.

Carrier cables, symmetrical construction

Conductor material:	copper
Insulating material:	paper, polystyrene
Sheathing material:	lead, aluminium
Material of protective cover:	rope yarn, plastics

Range of transmission:
Paper-insulated line circuits – up to 252 kHz
Polystyrene-insulated line circuits – up to 552 kHz

Carrier cables, coaxial construction

Conductor material:	copper
Insulating material:	polyethylene
Sheathing material:	lead, aluminium
Material of protective cover:	rope yarn, plastics

Range of transmission:
Coaxial pairs 1,2/4,4 – up to 12 MHz
Coaxial pairs 2,6/9,7 – up to 60 MHz

Symmetrical intermediate elements for service and supervision purposes.

Combined low-frequency carrier cables with symmetrical and coaxial constructional elements

Telecommunication cable accessories

Connection sleeves
Distribution sleeves
Protective sleeves
Cable terminals

Telecommunication lines

- for stationary laying
- for mobile operational stock
- for special purposes
- ready-made lines

Conductor material:	copper, resistance metals
Insulating material:	polyvinylchloride, polyethylene, polypropylene, rubber mixtures, silk, varnish
Sheathing material:	polyvinylchloride, polyurethane silk, varnish

The lines come either screened or unscreened.

Radio-fre.uency cables and lines

Radio-frequency power cables
Radio-frequency receiving cables and lines
TV camera cables

Winding wires

Conductor materials:	copper, aluminium, resistance metals
Conductor form:	– solid conductor, – stranded wire (round and flat); – twisted conductor
Insulating material:	– varnish (polyester, polyurethane, polyesterimide polyvinylformal, polyamide) – silk – chemical silk (polyester, polyesterimide) glass silk – paper – sheets (polyester) – plastics (polypropylene)
Heat resistance classes:	E, B, F, H, C
Special purpose winding wires:	– heat-bonding – coolant-resistant – transformer oil-resistant – tinnable
Diameter:	copper min. 12 µm aluminium min. 20 µm
Cross section:	max. 140 mm²

Table 25 : Sales programme of electric machines (VEB Kombinat Elektromaschinenbau)

AC MACHINES

Three-phase low-voltage induction motors
w. squirrel-cage and slip-ring rotors, available as standard model or in various modifications

High-voltage induction motors
unified range of motors w. squirrel-cage and slip-ring rotors

Three-phase induction motors
as brake motors w. one or two brake surfaces and w. built-in multi-disk brake

Three-phase induction motors
explosion-proof model also for use as air-duct ventilator motor

Three-phase and AC change-speed drives
almost lossless voltage control of three-phase and single-phase AC induction motors

Single-phase AC motors w. squirrel-cage, available as standard model or in varions modifications
for domestic appliances and washing machines

AC Machines
for special cases and fields of application
- Geared motors
- Three-phase shunt motors
- External-rotor motors
- Three-phase asynchronous alternators
- Special drives for hoisting and handling equipment, cranes, smelting plants, ship building, reciprocating compressors and refrigerating machines, and as stuff grinder drives
- Hermetic motors
- Hydro-extractor motors
- Travelling-field linear motors

Synchronous motors and generators

High voltage synchronous motors
unified range

DC MACHINES

DC motors and generators
standard models

DC motors
unified range of motors

DC marine motors

DC rolling mill and winder motors

DC motors for rail vehicles

DC lift motors

DC change-speed motors
industrial robots and as highly dynamic feed drives in NC machine tools

DC geared motors

DC fan motors

SPECIAL MACHINES AND APPLIANCES

Motor generator sets

Crane magnets

Electromagnetically operated clutches and brakes

Electrohydraulic linear drives

Centrifugal pumps

Three-phase sirens

Protective relays for transformers (Buchholz relays)
protective relays for liquid-insulated and liquid-cooled equipment

Brush-holders for electric machines

ENGINE DRIVEN GENERATING SETS

Petrol-engine driven generating sets
portable, w. hand starter

Diesel-engine driven generating set
stationary, w. electric starter
on wheels, w. electric starter

MACHINES OF THE SMALLEST CATEGORY

Split-pole motors
for domestic appliances, data processing and office equipment

Commutator motors
for single-phase AC and DC

Induction motors
for single-phase AC, standard models and special versions

DC tachometer generators
data converters for regulating and automatisation purposes

Resolvers
for controlling and regulating purposes

Servomotors
on the Ferraris principle

DC miniature motors
as drives in information processing equipment and in robots

Precision miniature motors
as drives in information precessing equipment and in robots

Stepping drives
various versions for controlling and regulating purposes

Ventilators units
for ventilating and de-aerating microelectronic computer systems, electrical and electronic equipment

Table 26: Automation plants and electrotechnical equipment for power stations (VEB Kombinat Automatisierungsanlagenbau)

Energy generating plants with additional system for energy generation, such as
- generator connections
- protective devices for generators
- unit-connected and intrinsic unit-connected transformers incl. protections, control and information systems

Start-up plants with
- starting and spare transformers incl. protection, control and information engineering
- high-voltage plants incl. all secondary plant parts

Energy distributing plants with
- medium and low-voltage plants compatible to all conducting plants for steam generator, tacho-set, auxiliary plant just as water treatment, dedusting, ashes-extraction, lighting
- primary and secondary protective equipment for consumers
- plants for d.c. current supply

Modern measured value and information representation incl.
- use of display technology for information aggregation on the basis of process and micro-computer engineering

All kinds of final control devices with power amplification

Supply of software for all the user's processes incl. installed micro-computer systems

electric control room with equipment, like
- protection, signalling, control of generators, transformers as well as for important supply equipment of most different sub-processes.

Complete cable systems with assembly accessories

Gaining of measured values and signal treatment for all occurring process data

Measured value and information processing by means of the most practicable technical solution, as e.g.
- application of firmly wired systems for regulation, control and protection on the basis of integrated electrotechnical devices
- application of freely programmable modular micro-computer systems for complex tasks with great processing depth
- construction of ready-made units of information processing of the plug-in type
- clearness and simple operation due to standardised module handling and symbols.

Equipement for process automation, like
- measuring, control, regulation, process control rooms
- process control engineering
- power station trainers
- remote control equipment
- control and regulating systems to automate starting-up and slowing down process of the unit

Annex 16 : Selected range of electroceramic products (Kombinat VEB Keramische Werke Hermsdorf)

Rod-type suspension insulators are delivered for all types of lines of between 10 and 400 kV. The LF series has been designed for low and medium pollution situations for the following rated voltages: 20, 30, 60 and 110 kV, with the insulation voltages being 24, 36, 72.5 and 123 kV. Insulator strings can be formed for higher voltage. The LS series has been designed for medium and heavy pollution situations for rated voltages of 20, 30, 60 and 123 kV, with insulator strings of any type composable. This type of insulators is puncture-proof even for steep lightning-stroke voltages.

Pin-type insulators are frequently being used for medium-high voltages lines, as the tower height can be minimized. The insulators for nominal voltages of 10, 20 and 30 kV have been designed for insulation voltages of 12, 24 and 36 kV. The insulators are manufactured in accordance with international standards.

Contact-line insulators for railway electrification. These insulators are suitable for voltages between 1 and 25 kV. In addition, strain-type insulators for bracket arms and insulators for transverse cables are manufactured. The contact-line insulators are completely puncture-proof and suited for use in a number of fields. The types of contact-line insulators manufactured include pine-type insulators and suspension or strain -type insulators.

Insulators for low-voltage overhead lines are used for tram or trolley lines, crane lines and electric fence installations.

Insulators and bushings for switchgear assemblies include a range of insulating supports for 1, 1.5, 3 and 6 kV indoor or 10, 20 and 30 kV outdoor installations with a nominal flexural strength of 4,000 to 7,000 N. Insulating supports for 10, 20 and 30 kV or 110, 220 and 380 kV outdoor installations are also available. The FS series has been designed for low-pollution areas, whereas the FNS series is used in foggy and high-pollution areas. Their flexural strength is between 6,000 and 12,500 N. Switchgear bushings are available in two types: outdoor-to-indoor and indoor-to-indoor. The rated voltages for outdoor-to-indoor wall bushings are 3, 10, 20, 30, 60 and 110 kV, with the insulation voltages 3.6, 12, 24, 36, 72.5 and 123 kV, respectively, and the nominal amperage being between 250 and 2,000 A. Round-conductor bushings are usually delivered, whereas below 36 kV flat conductors may be supplied.

Insulators and bushings for equipment are manufactured for outdoor and indoor use. Transformer bushings for outdoor and indoor use can be used for insulation voltages of between 0.5 and 3.6 kV at a nominal amperage of 50 to 630 A, insulation voltages of 1.2 to 3.6 kV at a nominal amperage of 1,000 to 3,150 A, and insulation voltages of 12 to 36 kV at a niminal amperage of 1,000 to 3,150 A. The range of products offered also includes transformer outdoor bushings for insulation voltages of between 72.5 and 123 kV at nominal amperages of 400 to 630 A. The bushings, withuot being oil-filled, are in full working order above the transformer tank.

Porcelains are used for the insulation of current and voltage transformers, bushings jackets, switch chambers of circuit-breakers, pressure pipes, compressed-air circuit-breakers, overvoltage arresters, jackets and casings of high-voltage test installations and capacitor enclosures. The dimensions of these porcelains have been adopted to the particular use, involving a high slenderness ratio, a length of up to 10 m, diameters of up to 750 mm for all voltages.

Overvoltage arresters are produced for low, medium and high-voltages. The low-voltage arresters are designed for nomonal extinction voltages of 280, 500 and 660 V, with a rated arrester current of 5 kA. Low-voltage arresters are housed in glass casings. Low-voltage arresters serve to protect electric installations below 1 kV.

The range of medium-high-voltage arresters include 5 kA controlled arresters for rated extinction voltages of up to 30 kV, uncontrolled 10 kA arresters for rated extinction voltages between 12 and 36 kV, controlled 10 kA arresters of pressure relief class B with a rated extinction voltage of 12 to 42.5 kV. 10 kA overvoltage arresters are primarily used in areas with an increased isoceramic level. The station type offered is a 5 kA arrester of pressure relief class D with a rated extinction voltage of 1.4 to 30 kV, and the line type is included in pressure relief class E. The high-voltage arresters are built in a traditional and a shortened design. In the traditional design, the high-voltage arrester is designed for 10 kA rated arrester current and rated extinction voltages between 48 and 135 kV in performance class 2. The shortened high-voltage arresters are built for 10 kA rated arrester current and rated extinction voltages of 72.5 to 390 kV in performance class 3. If so desired, the high-voltage arresters may be delivered with an increased leakage distance .

The range of overvoltage arresters includes also special-type arresters. Railway and direct-voltage arresters are such special-type arresters. The 2.5 and 5 kA railway arresters are on offer for 16 2/3 and 50 Hz with an rated extinction voltage of 12 to 29 kV. The 2.5, 5 and 10 kA direct voltage arresters have been designed for rated extinction voltages of 0.8 to 4 kV.

Contacts for high and low-voltage switches, made of sinter contact material, are used for a great number of switches. Kombinat VEB Keramische Werke Hermsdorf supplies its customers with "Hermet" contacts made of silver and tungsten combined materials.
The "Hermet" contacts from silver composite materials are suited for low-voltage line circuit-breakers, contractors, etc.
The Hermet tungsten contacts, which are made of copper and tungsten, are primarily used as arcing tips in high-voltage line circuit-breakers or, if made of copper/silver/nickel, as arcing contacts for low and medium -voltage switches.

List of tables and figures

1. Tables

2. Figures

ABBREVIATIONS +)

CDO	Central Dispatching Organization
CMEA	Council for Mutual Economic Assistance
ECE	Economic Commission for Europe
FRG	Germany, Federal Republic of
GDR	German Democratic Republic
GNP	Gross National Product
IAEA	International Atomic Energy Agency
IPS	Interconnected Power System
JEC	Joint Economic Committee
KAA	Kombinat Automatisierungsanlagenbau
KAB	Kombinat Kraftwerksanlagenbau
KEA	Kombinat Elektroenergieanlagenbau
KEM	Kombinat Elektromaschinenbau
KKWH	Kombinat Keramische Werke Hermsdorf
KWO	Kombinat Kabelwerk Oberspree
NMP	Net Material Product
SAD	Starkstromanlagenbau Dresden
SALH	Starkstromanlagenbau Leipzig-Halle
SAR	Syrian Arabic Republic
SITC	International Classification System
TCE	Tonnes of Coal Equivalent
TNC	Transnational Corporations
TRD	Transformatoren- und Röntgenwerk Dresden
TRO	Transformatorenwerk Berlin
UNCTC	United Nations Centre on Transnational Corporations
UNIDO	United Nations Industrial Development Organization
UNCTAD	United Nations Conference on Trade and Development
VEB	Nationally owned firm

+) excl. technical terms, units, and other symbols