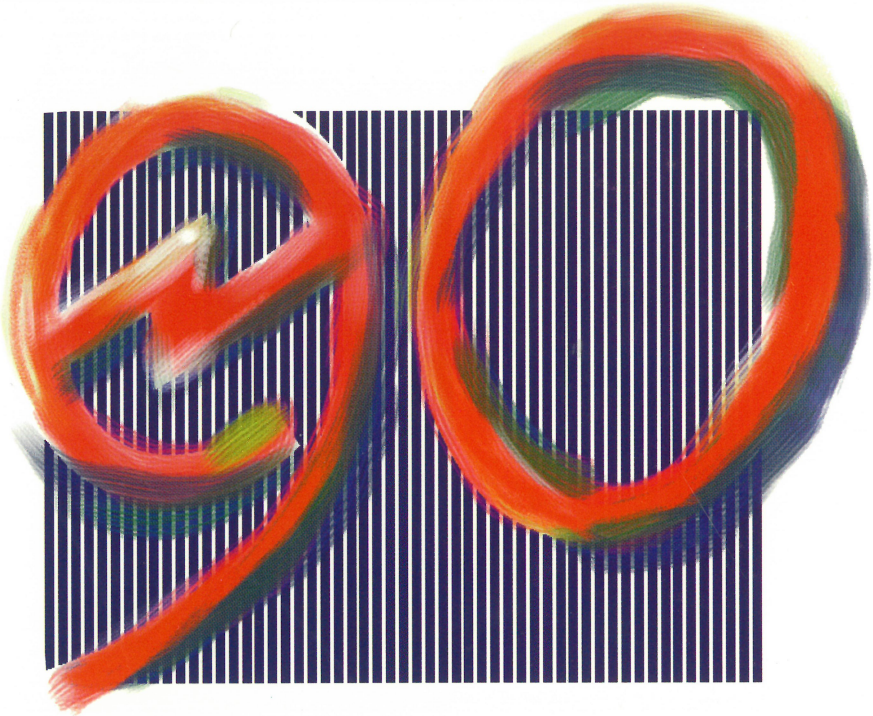


LIGHT IN ZAGREB

90 Years of Elektra Zagreb

HRVATSKA ELEKTROPRIVREDA d.d.

ELEKTRA ZAGREB

1907. - 1997.

LIGHT IN ZAGREB

90 Years of Elektra Zagreb

HRVATSKA ELEKTROPRIVREDA d.d.

HRVATSKA ELEKTROPRIVREDA d.d. ZAGREB
DISTRIBUCIJSKO PODRUČJE ELEKTRA ZAGREB

90 Years of Elektra Zagreb

Its Contribution to the History of Zagreb

No doubt, almost a centenary role of our DA "Elektra" Zagreb in the life of the Croatian metropolis represents a specific value and respect. Zagreb, an important European town already at the beginning of the century, had demanding consumers. It had industrial plants, cultural, educational and political institutions as well as lighting.

In the pioneering time of Elektra Zagreb was the center of many well developed crafts and, copying the European trends, it accepted and developed industries typical for the beginning of the 20th century. So, from the very beginning till present, our company, now solemnizing its anniversary, had to take daily care of the growth of Zagreb and of its necessities for electricity. At present, even more convincingly, Elektra is manifested not only by its statistical power, but also by its true and expert efficiency in reaching the highest standards of the trade in its distributional activity within our power supplying system. It represents an infrastructural potential in the Hrvatska elektroprivreda which may set a good example and confirm the seriousness of our function.

DA Elektra Zagreb, covering almost a quarter of the consumers in our country, represents an important support to the Hrvatska elektroprivreda management and administration in making and bringing the basic legal acts concerning the power supply activities.

Presently, Elektra Zagreb is a part of the Hrvatska elektroprivreda which creates a good image of our company in the widest sense of meaning. This is achieved by education of its expert staff, by its personnel and technical organization, which provide the present Zagreb, the capital of Croatia, with a good quality supply of electric power. Not only supply, but also every other detail: from providing capacities to giving approvals and services on the highest civilized level. The present Zagreb, being the center of all relevant political and administrative, economical, cultural and diplomatic institutions, has the right to expect and to demand it.

During the home country war, as it is known, Zagreb was less exposed to demolition and suffering. But the men of Elektra Zagreb have both smelt the gun-powder and seen the devastation scenes in all parts of Croatia run over by the enemy feet and hands. They were in the south and in the east, on the rivers of Una, Kupa, Korana, Bosut and Sava - everywhere. They showed the unity and the kinship of electricity supply and patriotic spirit, thus building their deep trace and contribution into the history and the future of Croatia and of the Hrvatska elektroprivreda. Particularly, according to the nature of their function, in the life of Zagreb they make a constitutional part of security and civilisational convenience for each of its inhabitants.

General Manager

Damir Begović, B. S.

FOREWORD

Not by chance, but only upon establishment of the free and democratic Croatian state, in all its activity areas, Elektra - Zagreb has become a source of electric energy for the distribution consumers in the City of Zagreb and in the County of Zagreb.

Today, on 7 November 1997, over one million of population within our distribution area is using electricity generated by an electricity system of all levels up to 110 kV, which provides them with light, warmth and power.

Incorporated in the Hrvarska elektroprivreda, we had a particular privilege to make our contribution to the establishment of our home country Croatia, which in 1991 became an independent and sovereign country threatened by enemies from within and on its frontiers. The winds of war carried our employees all over our country to marry their courage and skill in bringing back light and warmth to homes from Konavle in the south through villages and settlements of Dalmatia, Lika, Banovina and western Slavonia up to Vukovar and Ilok. They all stayed alive and we are taking this opportunity to show them our full appreciation for their efforts and merits in the renewal of the electricity supplying system of the Hrvatska elektroprivreda.

At the end of this development period we have made an electricity supply development program for the next decade, i.e. for the beginning of the 21st century, and this program has been approved by the City of Zagreb.

We left behind the time for history and the achievements which may make us proud. That what remains, what people are referring to, are not only events and documents, but our consciousness of how much history has been developing us and keeping us all together as a nation.

With all my esteem I thank my fellow-managers and all employees of Elektra-Zagreb for the exemplary performance of their business and human tasks during the past tough years. My sincere thanks to the families of our workers engaged in the renewal activities for their patience and self-denials shown towards their dearest inmates.

Manager

Mladen Ježić, B. S.

ELECTRIC POWER IN ZAGREB

FROM IDEA TO REALISATION

ZAGREB - CROATIAN METROPOLIS

The city of Zagreb, situated in between the Middle and Southern Europe, is bordered by the Alps and the Danube valley on one side and by the Balkans and the Adriatic on the other one.

The establishment of the democratic and independent Croatian state in 1990 fully displayed the everlasting aspiration of the Croatian people to be itself on its own land and not a part of a foreign state community. Zagreb has become the Croatian metropolis in the proper sense of the word. It has always been considered as such in the heart of both local and evicted Croatia, it has been the cultural and political center of all Croats, the soul of the Croatian nation.

Zagreb became the capital a long time ago, in 1094 the bishop's diocese was founded in it, it was the seat of herzegs and bans, its Parliament meetings were frequent, and from the Parliament meeting on 7th March 1557 Zagreb became town - the metropolis of the Kingdom of Croatia and Slavonia. So in 16th century Zagreb became the capital of the Croatian kingdom, the seat of the ban of Croatia, who was also vice-ban of the kingdom, it also hosted viceban who is the head of the counties of Zagreb and Križevci.

The area of Zagreb was inhabited even before the first written documents on Zagreb by the end of 9th century. There are many remains from the Roman period, although there was no larger settlement in the Zagreb area. The one that existed was not far from Zagreb, named ANDAUTONIA (in the place of the present Ščitarjevo village). From 4th to 7th century the migration of peoples took place and with its end came the end of Andautonia. From 7th century on the area is inhabited by the Croats. The first settlements were situated in the area of the existing Kaptol and Opatovina, and later on Vlaška Ves ("VICUS LATINORUM") was founded.

Very early Zagreb became the seat of the parish or of the county and the fortification built for its protection gave the place name Gradec.

The stormy history of Zagreb was marked by the invasion of the Tartars, by disputes between Kaptol and Gradec, by inter-dynastic conflicts and by the danger from Turks which lasted almost up to the end of 16th century. The end of Turkish threat in the area of Croatia started a swing of economy, what also means the development of Zagreb, i.e. of its settlements Gradec and Kaptol.

The separation of the two parts of Zagreb lasted full 600 years. Only by the end of the first half of 19th century the dispute was overcome and the king Franz Josef I issued a patent on 7 September 1850, uniting all Zagreb districts into one free and royal City of Zagreb.

Menci K. Crnčić:
Ban Josip Jelačić Square (1911)

Development of Contractor's Business

In the second half of 19th century Zagreb was transformed from a small (18,000 population), although capital town of an Austrian and Hungarian country, into a town with all features of a modern urban entity.From the middle of the past century Zagreb has been going through deeper social and economic changes. The contractor's business is started, to be true, within a very modest range, but with an increasing tendency.

Particularly important for the development of the town and its industry was the construction of railroad from Sisak via Zagreb to Zidani most, a branching-off road of so-called Southern Railroad (in 1862). This railroad was primarily constructed for the Austrian trade interests, as the section to Sisak was meant to direct all merchandise transports by the river of Sava towards the port of Triest. In 1865 a section from Zagreb to Karlovac was built for the same purpose. In 1873 the main Hungarian exporting railroad was constructed leading to Rijeka via Zagreb.

This is the time of foundation of savings-banks and banks with the main task to concentrate local and foreign investments into industrial and traffic facilities. Major impediments for a quicker industrialization were the lack of tradition, of capital, of techniques and of skilled labor.

In the period between the sixties and the seventies the development of mostly processing industry begins. The first larger factories are noted - the tobacco factory, two tanneries, the steam-mill, the parquet factory and municipal gas-works.

The developing requirements, as well as the wish not to lag behind other towns, stimulated the town-council to work on as good town arrangement as possible.

After the construction of the gas-works in 1862, in 1878 Zagreb was provided with waterworks, nine years after with the first telephone set, in 1891 with horse-tram, while in 1893 a systematic construction of the sewage system was started. Already in 1863, besides with kerosene lamps, the streets of Zagreb were lit by gas lamps in 312 lighting spots.

Soon, the development of the town and the results of the technical progress have made the gas-works and waterworks capacities inadequate. An idea was conceived about supplying the town with electricity.

Daylight Shining in the Night

The first electric light shone in Zagreb streets on 20 January 1877. On that night, together with the existing gas lighting, an electric lamp was lit on the corner of Gundulićeva Street and Ilica. The lamp was set by Professor Ivo Stožir on the occasion of the Sokol ball in the Hrvatski glazbeni zavod. As per the newspaper reporter: "... at the beginning, during two hours, an electric device set on a house in Ilica was pouring out the brightness of the day, showing the way to the Glazbeni zavod".

Four years before that event, on 14 March 1873 Professor Stožir was managing the lighting during the performance of Faust in the Croatian National Theater, what was the first application of the electric light in Zagreb. In the same year the Society for Electric Lighting, i.e. for the electrification of private houses, was founded.

The first street lighting at the Gundulićeva Str. and Ilica corner, 1877 (photo early 20th century)

The festivity exhibition of the Croatian-Slavonic Economical Society, in August 1891, was accompanied by the first important public lighting. The exhibition was set in the present building of the Faculty of Law and on the Theater Square in front of the building. The exhibition space was lit by 30 lamps of 2000 candle-powers each, fed by the generator run by two each 7 HP locomobiles. This lighting was installed by the Vienna "Siemens and Halske" Company, which will, several years later (1899) and together with other bidders, submit to the Municipal Economical Committee its offer for the electric power plant, electric lighting and electric tram design.

In 1883 the Municipal Shooting Gallery introduced electric lighting and so did the Municipal Steam-Mill three years later.

In 1891 the City-Council discussed the installation of electric lighting.

Fischer and Bothe

The first discussion on the public electric lighting took place in the Zagreb City-Council on 10 April 1888. The city-councilor Hudovski informed the councilors that Franjo Fischer, "the owner of the first concessionary electrotechnical bureau in Vienna" had submitted an application, based on a proposed agreement design "to be granted the approval for the realization of the electric light in Zagreb".

The reporter Hudovski suggested in the name of the Construction Board that "the application be directed to a meritory discussion". At the same time he proposed a committee to deal with the matter including Altman, Grahor, Siebenschein, Dr. Frank, Stanković and Krešić, as well as Professors Janaček and Stožir. The suggestion was accepted unanimously.

Within several months the Electric Lighting Committee had two sessions. On the second session, in September 1888, the decision was brought that the Vienna Municipal Administration would be required to show their agreement with F. Fischer. The Committee was also asked some questions: is the base of the agreement offered by Fischer favorable, are there any objections with regard to the system and whether the safety measures would require the cable to be run underground or above it?

Upon completion of preparatory work and of the agreement amendments, by the end of November F. Fischer was invited to Zagreb. That was the occasion for making the final form of the agreement to be discussed by the City-Council in January 1889.

But, on 26 January this topic was put off from the city-council agenda due to the economy head's demand for the Legal Board to investigate "whether the municipality was entitled to grant to anyone the exclusive usufruct right of its land and whether this act would restrict the rights of the municipality to its ways".

§. 73. (br 32152. iz 1887.) Grad viećnik Hudovski izvješćuje, da je F. Fischer, vlastnik prvoga koncessioniranoga elektro-tehničkoga bireaua u Beču, podnio molbu, da mu se na temelju predloženoga nacrta ugovora podieli dozvola za ostvaranje električnoga svjetla u Zagrebu. Na ime gradjevnoga odbora predlaže izvjestitelj: „da se ovaj podnesak za meritornu razpravu odputi na odbor ad hoc, u koji neka se izaberu gospoda zastupnici: Altman, Grahor, Siebenschein, Folnegović, dr. Frank, Stanković i Krešić; te gospoda professori: dr. Janeček i Stožir". — *Predlog prima se jednoglasno.*

An application to the Zagreb City-Council for "electric light installation" submitted in 1887

In January 1889 the Legal Board met again and "based on clever juridical reasons, it was unanimously decided that this fear had to be regarded as unsubstantiated".

In the meantime the situation had slightly changed. There was another applicant for the realization of public lighting in Zagreb. That was E.F. Bothe, contractor from Zagreb. On 25 March 1889 he applied to the municipal authorities "to be issued the license for installing the cable network in the area of the city of Zagreb". He already had the preliminary approval by the Royal Hungarian Ministry for Public Communications and Works saying that this Ministry "had no objections for the electricity supply network to be performed in the way as proposed by Mr. Bothe".

In the document of 25 March Bothe took the obligation "to provide electric light and lighting power under far more favorable conditions than Fischer and asked for this topic to be taken off the agenda ..."

City-councilors accepted this offer and invited Bothe to materialize it in the form of an agreement with a lime-limit till June.

Bothe did this only after having examined Fischer's agreement and he simply made some minor amendments.

The city expert for the city-council compared the two offers. His report says:

- The crucial difference between the offers by Mr. Bothe and by Mr. Fischer is that Mr. Bothe requires the exclusive usufruct right of the city land for electric cables for the period of 50 years, while Mr. Fisher requires only 50 years of usufruct right, where from the exclusive usufruct right of 11 years, furthermore Mr. Bothe offers to provide free electric power for four lamps of 500 normal candle-powers each till 31 December 1899, while Mr. Fischer offers no present whatsoever to the town".

Further difference was in technical details. The city expert's description was rather picturesque:

- In order to get a comparison base I wrote a letter to Mr. F. Fischer wishing to learn about the system he intended to apply. He replied that he would introduce uninterrupted current and battery system, while Mr. Bothe said

The first major use of public lighting was during Croatian-Slavonic Economical Society in 1891

that his system would include transformers which cause interrupted current.

Furthermore, he says:

-Electric current may be used for lighting either having small volume but very high tension or having larger volume by lower tension.

The very tense thin current may be compared to the current ejected from fireman's jet, while the current with low tense and wide volume looks like the power of water running in a wide channel".

When deciding whether public electric lighting would be introduced in Zagreb the city-councilors had in mind the fact that already since 1862 Zagreb had been lit by gas lamps.

Gas Restricts Electricity

The agreement between the municipalities and A. Riedinger, owner of the gas-works, which then passed to a joint-stock company, was rather unfavorable for the City of Zagreb.

Namely, the city expert's report (probably from 1891) says: "The agreement with Riedinger of 5 July 1862 is very favorable for the company. At that time there was no experience yet, in order to get good lighting with little investments, towns accepted the most difficult agreements still considering them easy.

Throughout decades the towns felt the burden they had taken, but the contractors had been clear-sighted and had restricted the town in the way that they could escape the burden of gas agreements only with great difficulties".

The city expert further puts some questions:

"Let us investigate how much has the liberty of the city of Zagreb been restricted for such a long time? Is the town bound to have exclusively gas and oil public lighting for 30 years more?"

Having studied the agreement with the gas-works, the city expert found that only one article (Art. 33) "mentioned the new method of gas lighting", and that the gas-works reserved the right of gas lighting also in the case "if during the 35-year duration of this agreement a new method of gas lighting would be invented".

And finally:

"In my opinion, the only obligation of the city of Zagreb is not to grant anyone else the right of the public gas lighting, but it has free hands when it comes to the electric lighting".

He also suggests:

"1) The Legal Board should meet as soon as possible to give its opinion on whether the town with the existing gas lighting may introduce also electric lighting

   a) in the streets and in the shops
   b) in the municipal closed premises

2) If the Legal Board gives its positive opinion, it is suggested that the city-council should answer the questions whether it will

   a) build a power plant
   b) have a power plant built by a contractor and repay it by amortization

c) or it will take the electricity from a contractor who would be granted the power plant building concession

3) For the case of 2 c) preliminary negotiations regarding price should be started immediately with Fischer and Bothe, so that the concession might be granted to the one who will provide the town with a cheaper lighting".

On 3 March 1891 the city-council had a discussion "regarding introduction of the electric lighting into the city of Zagreb and granting of licenses for this introduction". The proposal was presented by Dr. Isidor Kršnjavi and it was accepted with 17 against 5 votes.

In April 1891 the Municipality submitted a draft of agreement with Bothe, which was accepted by the city-council.

At the beginning of July of the same year Bothe asked the municipal community to let him have "without charge or at an adequate price the land along Savska cesta (approx. 2800 sq.m.) for the construction of power plant".

His request was denied. Several months after there were no discussions on the concession and in January 1892 the proposal was made for the concession to be canceled. This was done on a secret session in February, when it was also decided that "the town would take the matter of lighting in its own hands".

In May of the same year Nikola Tesla came to Zagreb. He read a paper on alternate currents to city-councilors and suggested an alternate current power plant.

One month after Nikola Tesla's lecture to city-councilors, on 20 June 1892, the ill-famed ban Khuen Hedervary dissolved the City-Council. The new city-council was elected by the end of August of the same year and till November 1893 there was no mention of electric lighting in the city of Zagreb.

On 6 November the city-council agenda included the application of Eugen Ferdinand Bothe (who was granted the concession for the installation of electric lighting in Zagreb in 1891, but it was canceled in 1892 due to Bothe's request for the concession to be ceded to the International Electricity Society in Vienna). In his application Bothe asked the city-council to re-examine this decision and "to put its conclusion of 11 February 1892 out of validity". At the same time he required the time-limit for construction of the power plant to be extended for the time he had lost due to the said decision. This request was unanimously denied and this proved the failure of the private contractors' last attempt to install electric lighting in Zagreb.

On the same session the Zagreb Tram Company submitted its offer to "use electric power for running trams" if a power plant is built in Zagreb. The representatives of the Tram Company presented an offer by "Kremenski, Majer and Co." of Vienna to which drawings and cost estimate for an "electricity generating plant" were enclosed.

City-councilors did not directly answer that request, instead they asked the Municipality to declare themselves for or against it as soon as possible. In the city-council minutes of 1884 the electricity was mentioned two times.

The October minutes show the decision about the subvention of 150 Austrian silver coins to the Zagreb Workers' Society in order to enable some of their members to visit the "electricity show" in Budapest.

In November house owners and shopkeepers from Ilica required the Council to grant the concession to Bothe. This shows again the local contractors' interests, as only a year before the old gas lamps in Ilica were replaced by Auer's gas lamps with greater lighting power. This request was also refused.

Obviously, although the introduction of electric lighting was contemplated, the modernization of gas lighting was still actual. So, in 1897 the municipal engineer Mihalj Ursini visited several European towns in order to study their gas lighting systems.

In September 1897 the city-council agenda included again the question of gas-works. The reporter drew the councilors' attention to the fact that the agreement with the Zagreb Gas Company would expire on 1 July 1900 and

§. 86. (br. 5052) Gradski zastupnik dr. **Kršnjavi** izvješćuje glede uvedenja električne razsvjete u gradu Zagrebu odnosno podieljenja dozvole za to uvedenje. Na ime komb. gradj.-gosp. odbora predlaže izvjestitelj prije svega: *da se načelno dozvoli podieljenje koncesije za uvedenje električne razsvjete. — Predlog prima se jednoglasno.*

Zatim izvješćuje izvjestitelj, da predleže dvie ponude za podieljenje koncesije i to: F. R. Fischera i E. F. Bothea. Nakon poduljega obrazloženja predlaže izvjestitelj na ime komb. gradj.-gosp. odbora: „da se podieli koncesija E. F. Bothe-u i s njim sklopi ugovor, koji se ima prav. odboru na razpravu, a zatim zastupstvu na prihvat predložiti."

Zastupnik **Grahor** stavlja protupredlog: „da se za podieljenje koncesije razpiše javna jeftimba."

Zastupnik **Folnegović** predlaže predlogu odbora izpravak: „da koncesija imade trajati dok izmine rok ugovora, koji je grad. občina sklopila sa plinarom." — *Kod glasovanja bje sa 17 proti 5 glasova primljen predlog odbora s izpravkom zastup. Folnegovića.*

§. 87. Gradski viećnik **Hudovski** izvješćuje: da je smrću gr. zastupnika Hondla izpražnjeno mjesto odbornika u odboru za gradnju crkve sv. Blaža. Na ime komb. gradj.-gosp. odbora predlaže izvjestitelj: „da se u rečeni odbor izabere zastupnik dr. Kršnjavi." — *Predlog prima se jednoglasno.*

Buduć da se ostali predmeti dnevnoga reda razpraviti mogli nisu, jer nisu prisutne bile $^2/_3$ gr. zastupnika, to zaključi *gradski načelnik* sjednicu u 8 sati na večer.

Discussion on installation of electric lighting in Zagreb during March 1891 City-Council session

Gas-works Committee of the City-Council in charge of the POWER PLANT construction

III. Zastupstvo slob. i kr. glavnoga Zagreba u ime občine grada Zagreba ovlašćuje odbor ad hoc za plinaru, da preduzme i provede sve predradnje u svrhu, da se istodobno sa gradskom plinarom ostvari i gradski središnji zavod za električnu razsvjetu i prenos električne sile, te se poziva gradsko poglavarstvo. da prema uputi odbora ad hoc prigotovi sve za takovu centralu

that they should decide whether to extend it or not. A committee of eight was appointed for this purpose.

After a several months long contemplation of the gas-works problem, in March 1898 the committee proposed for the agreement with the gas-works not to be extended.

The councilors accepted this attitude of the committee and required "the Zagreb Gas Company to take note that on 30 June 1900 the said agreement is considered canceled". They further required that "within 45 days the Zagreb Gas Company should inform the Municipality about the price at which the gas-works with all its facilities would be ceded to the city of Zagreb".

This request provoked a severe reaction of the gas company, which sent a written protest to the city-council for "the premature cancellation". This protest did not effect the decision by the city-council.

New Century - New Swing of Development

The beginning of the new century was welcomed by Zagreb as a town of 60,000 population. "And now, on the passing to the new century, there is a modern town ... And the present Zagreb is the child of the past ten years" - says the beginning of the "Zagreb from 1892 to 1902" memorial book dedicated to one decade of Adolf Mošinski's mayoralty.

Indeed, the official data in the said book clearly show the fast development of Zagreb during the ten years.

1890 Zagreb had 40,000 population in the territory of 5,675 acres. After ten years the surface was doubled and the population was increased for a half. For instance, in 1892 there were 384 marriages and 1,473 births in Zagreb and in 1902 about 500 marriages and 2,000 newborns.

Within this period not only many new streets (now Hatzova, Mihanovićeva, Bogovićeva, Šenoina etc.) and squares (now Maršal Tito Square, Flower Market, Tomislav Square, Roosevelt Square etc.) were constructed, but also a series of communal facilities.

The municipal waterworks was built already in 1875 and an average flow rate was 22,327 hl of water. Till the end of 19th century this quantity was trebled. Every year the municipal budget procured considerable means for waterworks extensions (in 1901 even 820,000 crowns).

During the last decades of the past century Zagreb had particular problems with its sewage system, which was the cause of a large percentage of infections. Due to bad residential conditions the mortality caused by "the most perilous enemy of the mankind" - tuberculosis - was very high.

Thanks to the efforts of the municipal authorities the situation was considerably improved: several streamlets were transposed (in 1897 the streamlet of Medveščak), the sewage system was modernized.

Strangely enough, the publication does not mention any trials of introducing electric lighting in Zagreb, although the final decision for the construction of the power plant was made in 1898.

This silence lasted through several first years of the new 20th century. Only when Dr. Milan Amruš was elected mayor in 1904 (let us not forget that he was mayor also within the period of 1890 to 1892, when the concession for electric lighting was very much spoken about), the discussion on the electric power plant construction is revived.

Upon his election for mayor M. Amruš said in his address to the city-councilors: "... There is no progress without investments. But in investments the right place has to be given to the ones that are necessary and useful... The question that we have to study and realize on the whole in my opinion is the question of the power plant. Here we have to consider the relocation of the gas-works ... it is in the interest of a good administration that the electric power plant and the gas-works are merged into one management".

Tenderers Invited for the Electric Power Plant

At the beginning of 1905 a special committee was elected with the task "to study the invitation of tenderers for construction of the electric power plant. The tenderers were invited through Bohemian and Berlin newspapers and important companies received the demand for the power plant construction. The demands included general data on the existing situation with gas lighting, on the use of gas in industries, as well as data on horse-tram and possible expansion of tram network. The city-council explicitly emphasized that the community of Zagreb would not take any responsibility towards the invited tenderers.

As at that time there was no expert in Zagreb who could give a meritory appreciation of the tenders, the assistance was called in the person of Friedrich Ross, engineer and electricity technician from Vienna. He was elected expert judge on the base of recommendations from Brno and Bratislava "by which he was marked as a diligent and reliable expert in an extremely flattering way" (as put in the municipality report for 1905).

The offers were divided in five groups. The first one envisaged construction of the power plant in Zagreb (tenderers were Ganz and Co. Kolben, Siemens-Schuckert Werke). The second one envisaged a hydro-electric power plant on the river Sava by Podsused (Ganz and Co.), the third one on the river of Sava by Krško (teneder was Josip Lenarčič from Vrhnika). The fourth solution was offered by the First Mining Company of Zagorje envisaging a steam power plant to be built near the mine of Konjščina, while the fifth group offered construction of a hydro-electric power plant on the river Kupa by Ozalj.

F. Ross himself offered the Vienna company "N. Rella and Nephew" to make a basic design for a hydro-electric power plant at Plitvice Lakes. "But fortunately enough, the government was not inclined to this idea - says the municipality report - as it would ruin the fascinating charm of the Plitvice Lakes, the most ravishing scenery in Croatia".

By studying the tenders, the municipal expert came to the conclusion "that it was an imperative interest of the capital to envisage construction of a hydro-electric power plant".

The most favorable solution was chosen to be the offer by Ganz and Siemens envisaging a hydro-electric power plant to be built on the river Kupa waterfall by Ozalj.

In May 1905 the application was sent to the Royal County in Zagreb to start the procedure enabling the municipal community to ensure the utilization of this water power, as required by the Law on Water Rights. The Zagreb Municipality was authorized to represent the city of Zagreb in this procedure.

On the base of this authorization, the Municipality had "the base of water facilities to be built on the river Kupa by Ozalj" prepared.

At the same time the tenderers were required to prove the profitability of this project. After this had been done, in December 1905 a discussion on water management was held in the community office of Ozalj. Besides the representatives of Zagreb, the participants of the discussion were the representatives of Karlovac and of Črnomelj, at that time the boundary district.

As the town of Karlovac was owner of the mill on Kupa, and as it also had the intention to build a hydro-electric power plant, it was obvious that Zagreb would hardly gain its point.

Indeed, the representatives of Črnomelj made no obstacles, "but the local population had such demands that the resulting difficulties would practically prevent the design of the municipal community and the town of Karlovac as the main interested party, which also proposed construction of water facilities by Ozalj, had such objections as to disable the efforts of Zagreb to get the concession" (as put in the municipality report).

In December 1905 the majority of the city-council rejected the proposed budget of Zagreb for 1906, for what reason the city-council was dismissed on 15 December.

The electric power plant was frequently mentioned in pre-election speeches for the new city-council.

So, jeweler and ex-councilor Slavoljub Buhin was decidedly against the construction of the electric power plant. As read in "Obzor", he emphatically said he was against dead investments. We quote his words:

"As for the electric power plant, this idea existed already during the former city-council lead by Mošinski, but its realization was envisaged in a different way. First the municipal community took the gas-works... As this company proved profitable for the municipal community, it was understandable that the priority was given to the repayment of the debt (1.1 million crowns) and that new gas-works and electric power plant would be built later, using the net income of the old gas-works. This is now troubled by the last year's overthrow and it will be necessary to start anew. An electrical power plant has no purpose at all as long as either the municipal community lacks an agreement with the tram company or the municipality takes the tram in its own management. As we all know, the legal proceedings regarding the tram are still in course and if the municipal community fails the only possibilities will be a compromise or buying off."

Another ex-councilor Josip Siebenschein. "industrialist engineer", set forth his opinion to the newspapers:

"Our first and main necessity is an electric power plant for lighting of the town, electric tram, industry etc. But, the building of the big power plant in Ozalj will take three years. We cannot wait so long, so we must immediately

After the decision on the power plant construction was brought, the City-Council discussed its profitability

Rasprava o predmetima, o kojima odlučuje gr. zastupstvo.

Čl. **164.** (Br. 44.762/IV.—1906.) Gr. tajnik Milovan **Hajdinjak** na ime samoupravnog odbora predlaže na osnovu zaključka skupštine gr. zastupstva od 29. ko o-voza 1906. čl. 139, koji je zaključak odobren po kr. zem. vladi otpisom od 7. listopada 1906. br. III/C. 291/4., prema čemu otpada uvjet stavljen u sjednici samoupravnog odbora od 3. listopada 1906. glede izdanja radnja oko gradnje centrale — da slavno gr. zastupstvo izvoli zaključiti:

1. da se ima graditi munjara na paru po osnovi gr. stručnjaka F. Rossa;

2. da se prihvate ove ponude:

a) strojna uredba za centralu i za upotpunjenje vodovoda predaje se „Praškoj tvornici strojeva, dioničkom društvu" u Pragu na osnovu njezine ponude od 28. kolovoza 1906.;

b) izvedenje kabela povjerava se tvrci „Felten i Guilleaume" u Budimpešti, na osnovu njezine ponude;

c) električna uredba centrale i vodovodne mreže predaje se „Ganzovu električnom društvu" u Budimpešti na osnovu ponude od 28. kolovoza 1906.;

3. Gradsko se poglavarstvo ovlašćuje, da odnosne pogodbe s navedenim tvrtkama sklopi uvjetno uz opazku, da zaključak gr. zastupstva o gradnji munjare ima potvrditi kr. zem. vlada, odnosno koncesiju za položenje kabela podijeliti kr. ug. ministarstvo trgovine.

Iza toga čita **izvjestitelj** u cijelosti otpis kr. zem. vlade, kojim se odobrava zaključak gr. zastupstva od 29. kolovoza 1906. čl. 139.; našto gr. **načelnik** predlaže, da ovim odobrenjem onaj uvjet stavljen u predlogu samoupravnog odbora, koji taj zaključak čini ovisnim o odobrenju kr. zem. vlade — otpada, *što je glasovanjem jednoglasno prihvaćeno.*

Ujedno priopćuje gr. **načelnik**, da je stigla naknadna ponuda tvrdke Siemes-Schuckerwerke k njezinoj prvobitnoj ponudi glede dobave nekih dijelova električne centrale, pa predlaže, da se ta ponuda s načelnih razloga ne prihvati, što je također jednoglasno odobreno.

Gr. zastupnik g. **Bulvan** predlaže, da se ovaj predlog samoupravnog odbora skine s dnevnog reda, pošto da nije nigdje dokazan rentabilitet buduće električne centrale.

Gr. zastupnik g. **Stern** predlaže, da se prije odluke o gradnji ove centrale raspravi i prouči točno pitanje ne bi li grad. općini bolje konvenirala izgradnja koje vodne snage, kako je gr. općini i u tom pogledu bila stavljena ponuda.

Nakon odulje rasprave u kojoj su učestvovala gg. gr. zastupnici Hrustić, Krešić, Gavella, Hörer, Siebenschein, Alexander i Timet, i pošto je g. načelnik ponovno zagovarao predlog samoupravnog odbora, prešlo se je na glasovanje i to ponajprije o odgodnom predlogu zastupnika Bulvana i Sterna, koja su oba predloga sa svima proti jednom glasu zabačena, dočim je predlog samoupravnog odbora primljen sa 37 proti 3 glasa.

Čl. **165.** (Br. 44763/IV.—1906.) Gr. tajnik Milovan **Hajdinjak** na ime samoupravnog odbora predlaže, da slavno gr. zastupstvo izvoli zaključiti slijedeće:

I. Za namaknuće glavnica potrebnih za investicije u g. 1907. i to:

a) već dozvoljene investicije posebnim odlukama grad. zastupstva:

1. gradnja električne centrale i upotpunjenje strojne uredbe gr. vodovoda (skupštinski zaključak od 29./8 1906. čl. 139. iznosom od . . . . . 1,300.000 K

2. nabaki zemljišta za svrhe gr. općine (skupštinski zaključak od 11./6. 1906. čl. 32.) iznosom od . . . . . 300.000 K

start building another power plant of some 5 to 6 hundred HP to serve the town and handicraft. Upon completion of the big power plant in Ozalj the one of Zagreb would be kept as spare one for smaller needs, as a coal power plant is certainly too expensive for big industries such as municipal waterworks, paper mill, ice-factory, railway workshops etc."

The Ozalj power plant will cost four million crowns, the Zagreb one about 800,000 crowns, the sewage system about half a million crowns - this will all have to be covered by a new loan.

It is odd that in March 1906 J. Siebenschein was speaking about construction of the power plant on Kupa by Ozalj, since by the end of 1905 a water management discussion was held in Ozalj, on what occasion Zagreb failed to get the concession for construction of the power plant.

Increasing Energy Requirements

The elections took place by the end of March and Dr. Milan Amruš was elected mayor again. In May the new Electric Power Plant and Gas-Works Committee was elected, including: Dr. Milan Amruš, Ferdo Šaj, Aleksandar Šandor, Srećko Bošnjaković, Vladimir Krešić, Ivo Mallin, Gustav Pongratz, Josip Siebenschein, Julije Stanisavljević, Franjo Šandor, Nikola Tomašić, Antun Brusina, Pavao Gašparović and Bolle.

In the middle of May the Committee decided to have drawings made for both new electric power plant and new gas-works, "as the requirements for gas increase every day, making the present gas-works inadequate to meet them".

The gas-lighting was rather poor and in majority of side-streets it was extinguished before midnight. So, the daily "Obzor", under the headline "Darkness in Some Streets", said that some of the lamps that need not be put out are nevertheless extinguished. For instance, after 11 p.m. the present Prilaz Đure Deželića was pitch-dark, "what could be useful only to villains and certainly not to the citizens".

Although the public lighting was not yet installed in Zagreb, daily papers of that time were abundantly advertising electric lighting equipment.

"R. Eisenhut and Co. Engineering and Electrotechnical Works" founded in 1900 advertised its activities as being manufacturing of iron structures, of equipment for mills, for bakeries, for central heating and for ELECTRIC LIGHTING AND POWER TRANSMISSION.

An interesting detail in this advertisement from 1906 is the mention of an abbreviation for telegram reading "ELEKTRA" Zagreb.

The advertisements for hotels, besides a skilled service, lift and bath, emphasized electric lighting as a special amenity.

So, in 1906 the electricity was becoming more and more a part of the everyday life of Zagreb, although one more year had to pass before the first electric public lighting was put on.

The basic critical remark published in the daily "Obzor" by the author signed I.F. regarded the profitability of the electric power plant. The author claimed that the net profit calculation was wrong and that the power plant would only suffer losses, as the installation of electricity would reduce the consumption of gas and that, at the same time, the future water flow rate estimate for the municipal waterworks was also wrong.

He also tried to prove that the cost of electric lighting compared to the one of gas lighting was double.

There was no reaction to those objections. The tenderers were invited till 30 August 1906 and, based on the proposal by the municipal expert, the City-Council of Zagreb concluded on 8 October 1906:

1 That a steam power plant should be built following the design of the municipal expert F. Ross,

2 That the following bids should be accepted:

a) equipment for power plant and waterworks - the Machine Works from Prague
b) installation of cables - "Felten and Guilleaume" from Budapest
c) power plant electric installations - "Ganz Electric Ltd." from Budapest.

At the beginning of 1907 (on 11 January) the city-council discussed the prices, i.e. the "way and conditions of distribution of electricity from the municipal power plant". The Councilor Hoerer required for such an important matter not to be voted immediately, but asked for the conditions to be distributed to the councilors which "may get good information on prices which are very vague and vary from 8 to 40 filirs a kW". His proposal was not accepted, the prices were confirmed without much discussion and the councilor Hoerer said: "And then you will rail against expensive electricity!" By the end of January the Installation Department was open in Gundulićeva Street. Director of this Department, appointed by the city-council, was Josip Brunnenschekel "who has been working in this field already for 17 years(!?)".

"He already opened this office and readily supplied the citizens with every required instruction, either regarding indoor installation of electricity or regarding the supplying conditions" - writes "Obzor" of 29 January.

The same office was selling various electricity consuming devices - table lamps, chandeliers - as well as installation materials and electric motors. There was noted an advertisement for cheap electric lighting due to the new OSRAM LAMP.

Construction of Electric Power Plant Started

In mid-February preparatory works for construction of the power plant were started and the municipal engineer Rudolf Vrbanić was appointed temporary head of the municipal power plant.

Construction works were performed by the company owned by the Zagreb contractor Ljudevit Deutsch and the site employed 80 workers.

In April the City Council elected a committee with the task to "determine lines in all streets where the electric cables would be laid".

By the end of May laying of cables was started. The newspapers reported the works in detail. So, on 23 May "Obzor" wrote the following under the headline "Municipal Affairs":

"Nice weather is extremely favorable for the works that are going on in Zagreb.

The installation of electricity, i.e. laying of cables in the streets of the town, has been developing stupendously. As soon as they dig a ditch they put in a cable, cover it with bricks, fill it up with earth and level the street, and all this so fast that could be hardly believed. The citizens are particularly curious to see joining of several cables and arrangement of branching-off cables, so these works are always closely watched by groups of spectators".

In June laying of cables was completed and installation of indoor connections was started. A day when the first electric lighting fed by the municipal power plant would shine was nearer and nearer.

In July 1907 the Municipal Power Plant Office received a relatively large number of applications for electric installations. The Office was in the ground-floor of so-called Shareholders' Printing House (corner of Gundulićeva and Masarykova Streets). Two offices housed 22 employees (wherefrom four foreigners). Due to the increasing volume of works, two more premises were rented in the neighborhood.

By the end of July 159 applications for electric installations were received, 53 of them were covered by contracts for 2,497 electric bulbs (20 candle-power each), 18 arc lamps and 9 electric motors. The total cost of these installations was 43,698 crowns. Besides 53 contracts which still had to be completed, 27 buildings were already provided with electric installations (at the cost of 28,075 crowns) and 165 cost estimates were made.

The Municipal Power Plant workshop was also very busy. The inhabitants of Zagreb were bringing gas chandeliers and kerosene lamps to be adapted for electric lighting and "the costs of such adaptations were very low".

In August a competition was published standing for temporary positions of electric cable inspector and electric meter fitter.

What were the conditions for the jobs?

"An electric cable inspector must be completely skilled in all works concerning laying and maintenance of air network cables, performance of indoor connections and all necessary repairs.

An electric meter fitter must be completely skilled in all works concerning testing and maintenance of electric meters as well as lighting and power transmitting installations..."

The advertisement emphasized the wish for local men, and not foreigners, to fulfill the vacancies:

"Citizens of Croatia and Slavonia, as well as all those speaking Croatian language or any other Slavic language will have advantage from foreign competitors."

The competition was signed in the name and on behalf of the Municipal Power Plant by its director, Rudolf Vrbanić, B.S.

In August 1907 daily newspapers we find advertisements of several tradesmen and contractors who had been offering lighting devices, electric motors etc. to the inhabitants of Zagreb even before the electric power plant was put into operation.

So, ODEON in Gundulićeva Street 8 was selling not only records, but also chandeliers, arc lamps, electric bulbs, electric fans etc.; VOLTA - the first Croatian institute for electric power and lighting, was offering chandeliers and lamps, GANZ ELECTRIC LTD. - construction management in Preradovićeva Street was fitting installations, and in Gundulićeva Street 7 FACTORY WAREHOUSE FOR GLOWING LIGHT LTD., besides selling electric equipment, was "lighting entertainment premises and parks".

In September the works were closing to an end - transformers were installed and hooks for "big" arc lamps were fitted. The works were supervised, together with the mayor Dr. Amruš and the power plant director Mr. Vrbanić, by the "municipal expert", a Viennese F. Ross, B.S., in person. But, accidents were unavoidable.

On 25 September "Obzor" reported:

"Yesterday the employees of the municipal electric power plant were engaged in fitting circular lamps. An accident that occurred on the occasion nearly took a human life. The worker who was building-in the lamp hook by the "Bauer" coffee-room, at the corner of Frankopanska Street, was standing on the ladder at the first floor level. As the ladder was improperly fixed, he shifted away and fell on the pavement, fortunately suffering no serious injury. We would avail ourselves of the occasion to remark that in these works the security of both workers and passers-by is paid a rather negligible attention".

By end of September rumor went in Zagreb, as we put it nowadays "from reliable sources", that the electric lighting will probably start shining on 15 October.

But, this time-limit was also extended for twenty odd days.

October 1907 in Zagreb was rather tumultuous due to many strikes. This was the main feature of 1907.

Civil engineering workers were particularly persistent in demanding their rights. They requested working hours for all other workers from 6 a.m. to 6 p.m., and not from 6 a.m. to 7 p.m. So, construction works on the electric power plant were interrupted for a certain period of time due to masons' strike.

In spite of all those problems, the interest in the installation of electric lighting did not decrease.

As announced, it should have shone on 15 October, but the morning edition of "Obzor" reported that "the information was received by a competent source that the electric light would not shine this year at all". And further: "The fact is that we are in the middle of October and the lamp-posts have been lying on the streets for two months.

They say that even machines are defective and in some places the cable is being replaced. We hope that the competent sources will give an explanation to the public".

We do not know whether "the competent sources" did as required, but by the end of October, in the presence of F. Toss and R. Vrbanić, "the power plant functioning was tried, i.e. so-called high tension current was tested", and on 24 October the first steam-engine was put into several hours operation.

Flame Born Above Water

As for the trial load of the power plant, we will quote the report from "Obzor":

"Yesterday, in the presence of the municipal expert F. Ross, a trial loading by current up to 100 kilowatts was performed. The means for loading was water in which the electricity effected in a chemical way, dividing it into hydrogen and oxygen. When the tension reached 5,000 volts a flame was born above the water and shortly caught the cask, producing wonderful light effects. This trial under the open skies was attended by numerous spectators..."

At the same time the inhabitants of Zagreb were advised to be more careful with the new electrical devices:

"During this entire week the whole cable network will be under tension and the illustrious general public is kindly requested to avoid touching electric installations. It happened lately that a cable was taken out and opened for mere fun and this could cause an accident.

All owners of indoor installations are kindly requested to provide themselves with chandeliers as soon as possible in order not to be deprived of lighting during the electric current circulation". One week prior to the putting the power plant into operation lamp posts and lamps were

fitted, and "the electric technical staff was engaged in final works in the power plant". This was happening in the beginning of November 1907. The "D-day" - lighting of Zagreb by means of electric current followed several days later.

From the economy standpoint, in 1907 Zagreb was a rather developed town. According to the statistic data, it had 65 manufacturers and about 3,000 craftsmen. It was a town with brisk urban and physical development. Its strict center, still under construction, was lined by Mihanovićeva Street on the south, by Draškovićeva Street on the east, by the Austrian Republic Street on the west and by Ilica on the north.

Although this was the period of general economic depression, building was in a relative swing. Besides the electric power plant, the steam-mill was built, as well as several banks (Croatian-Slavonian Central Savings Bank at the corner of Ilica and Gundulićeva Street, Austrian-Hungarian Bank at the corner of Jurišićeva and Palmotićeva Streets), Palace Hotel on the Strossmayer Square, schools etc.

This same year two important cultural institutions were opened: the Municipal Library and the Museum of the City of Zagreb.

However, not only building was in course. The old medieval fortification wall with the Bakač Tower in front of the Cathedral was pulled down. The demolition lasted four months, as the fortifications were extremely strong and the "demolished material could load hundreds of wagons". This material was used for the regulation of the Sava (which was in course) and for the construction of the western part of the present Medveščak. It should be said that already at that time there were many opponents to the demolition of this cultural and historic building.

There were demolitions in Gornji grad, too. In the place of the present Parliament of the Republic of Croatia (built in 1910), in the surface of 2,200 sq.m., a complex of 18th and 19th century houses was pulled down and the architectural harmony of this part of Gornji grad was destroyed.

In 1907 regulation designs for many streets in and off the center were made, as they were, by the way, all alike. They had a common feature after rains - mud and suddenness, and in summer the air was full of dust.

But 1907 is the beginning of covering the streets with asphalt. The first ones were Mihanovićeva Street and the northern part of Ban Jelačić Square.

There were building plans that did not come true - a new hospital at Šalata, the regulation of Strossmayer Promenade, a market-hall in Martićeva Street and cheap workers' quarters. But the event that was doubted till the last moment by many residents of Zagreb - the putting into operation of the electric power plant - eventually did happen.

Zagreb - Megalopolis

On 5 November, about 3 p.m., arc lamps had shone for a short time as an opening for the big show that begun that evening about 6.30 p.m. One after another shone the "flame-lamps" from Frankopanska Street, throughout Ilica, Ban Jelačić Square, Praška Street and Zrinjevac. According to newspaper reporters, Ilica and Ban Jelačić Square were in red light and Praška Street and Zrinjevac in purple one.

"The effect made by the street lighting was excellent. All of a sudden, Zagreb looked like a real megalopolis. The creators of this electric facility may well be congratulated" - the "Agramer Zeitung" reporter praised the power plant staff in the name of the residents of Zagreb.

However, only a few days after this "excellent debut of the electric lighting" first objections were made.

Zagreb u električnom svjetlu. Sinoć je ipak nakon tolikog izčekivanja i odgadjanja Zagreb zasjao u električnom svjetlu. Pošto su sve pripreme dogotovljene neke male pogrieške odstranjene, sinule su velike ulične žarulje oko 6 sati u večer na veliko začudjenje občinstva. Naravno, da su uslied toga ulice i trgovi, u kojima je provedena razsvieta bili mnogo živahniji no obično.

Small mote on major event "Zagreb in electric light" (OBZOR)

The position of lamps was not found the best, many busiest streets were alleged wanting in electric lighting and installation of at least twelve more lamps was suggested.

The objections were answered to by the power plant director R. Vrbanić, saying that "there was hope for a soon favorable solution" and that "the other resentments will be removed within the due time".

This was the end of early days of the electrification of Zagreb. People started to reproach and, as we all know, there still are objections, with good cause or without it ; in other words, a usual life of a communal benefit facility begun.

Although the municipal power plant was put into operation in November 1907, it was run in trial operation till March 1908.

The city-council report for 1908, under the Municipal Community Economy, says that from March of the same year the power plant was in the normal 24-hour operation, "thus offering to the consumers all amenities it is bound to by the regulations".

Data on installed consumers are interesting. Pedantic statistic records show 10,028 electric bulbs with metal filament and 1,715 ones with carbon filament. There were 274 arc lamps, and the initiating 706 customers had 52 fans, 17 irons, 16 cookers, 10 heaters and 5 movie projectors. Craftsmen had also 70 electric motors.

In spite of difficulties with coal (due to the 6-week strike of Konjščina miners), "the engines were running uninterrupted throughout the year and the effect of the whole plant was favorable". Also, the business of the Installation Department was "very brisk and successful".

Buildings in Gundulićeva 18 and 16, by the Obzor printing house, where the Municipal Power Plant headquarters were located

The business development continued in 1908. The quantity of electric bulbs (from 20 to 1,000 candle-powers) was increased for 5,284 units, reaching the total of 17,027. The quantity of arc lamps was also increased.

They were 334 in total. From these 53 of them (of 2,000 and 1,600 candle-powers) were used for public lighting with 77 electric bulbs of 50 candle-powers. It has to be said that at the time Zagreb still had a certain number of public gas and kerosene lamps. In 1909, for instance, 45 new street gas lamp-posts were fitted.

In the same year (1909) more new consumers were connected, among which also the first X-ray machine. The total value of the connected facilities was 1,223 kilowatts (where from the municipal waterworks engines 230 kW).

The number of customers was increased to 1,129. The following 1910 was not worse from the preceding years. The consumption kept increasing. As per the 1910 report, "this is completely in compliance with the practice of other modern towns".

In 1910 the number of customers increased to 1422. By the end of 1910 the number of meters was 1,759, i.e. 596 more than in the year before.

The electricity production was increased from 2,434,989.0 to 3,064,385.0 kW/h and the private consumption from 434,812.6 to 740,331 kW/h. The increase of so-called "private" consumption was contributed also by the electrification of tram, put into operation on 18 August 1910.

Such a development required expansion of network and of power plant.

"The power plant management, rejoicing such a strong development of this young municipal company, has not forgotten to take care of its expansion. The distribution grid has been extended and the transformer stations in the center, having the largest consumption, have been strengthened... Finally, by the end of the year works for expansion of the power plant were started by installation of a steam turbine and its necessary equipment ..."

"Hopefully, this development will continue soon requiring further extensions of the network and of the power plant, which will go on operating for the benefit of the town and of its residents" (as put in the 1910 Report).

At the end of this review of a hard but unbridled way into the modern times, featured by an increasing consumption of electric power, let us mention the prophetic words of Grga Tuškan, member of the Croatian Parliament, who said in the eve of the first New Year of 20th century: "...we are entering the century in which electrical engineering will bring to the world a technical progress which we are even unable to dream of..."

Speaking in the way of Bible, we may well say:

"SO WAS IT".

MILESTONES IN THE ELEKTRA HISTORY

1906 On August 29, the Municipality decided to start a thermal power plant construction.

1907 On January 1, the Installation Department involved in installation of services and street lighting network started its work.

On February 18, the first stage of the power plant construction started.

On October 17, the cable routing was finished.

On November 5, the power plant trial run started.

On November 7, the power plant was commissioned and the complete grid with the consumers was connected.

1910 The second stage of the power plant construction was finished and commissioned.

The Zagreb tram was connected to power grid.

August 18, the rectifier station in the power plant was started up.

1914 The third stage of the power plant (extension) was built due to increased power demand.

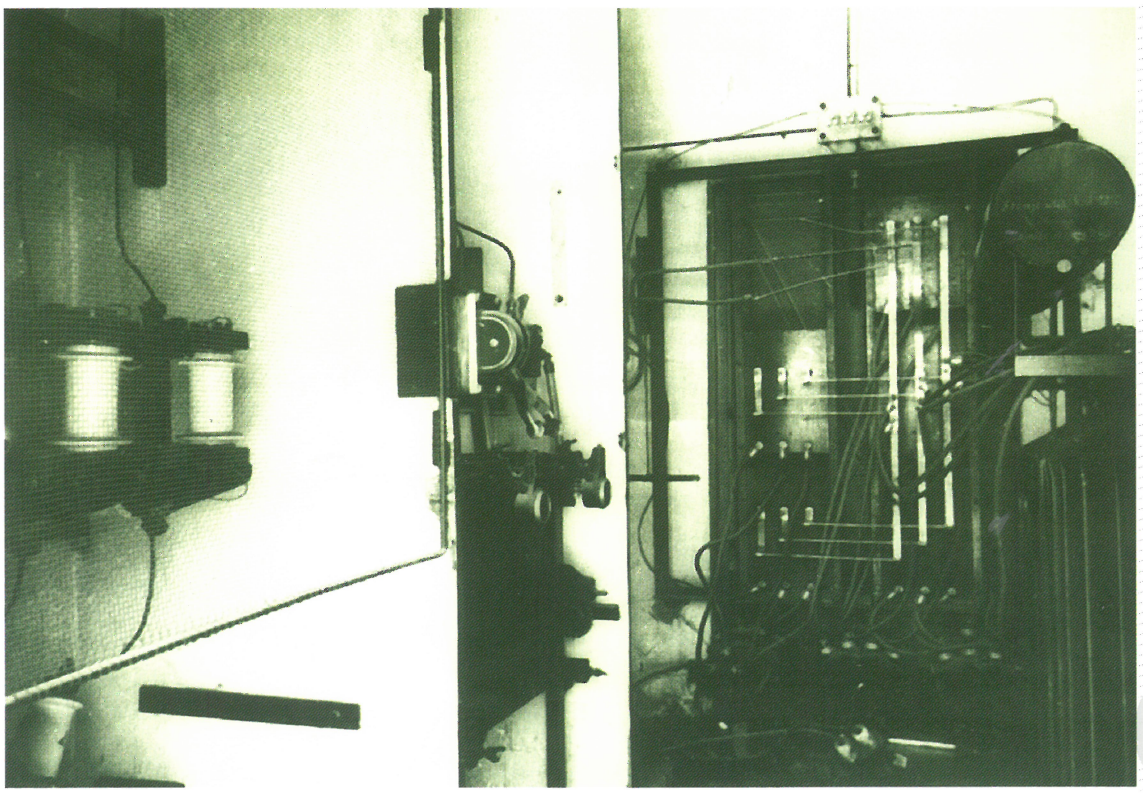
1922 The fourth stage of the power plant was built due to increased power demand.

Rudolf Vrbanić, the first Municipal Power Plant director (1907 - 1932)

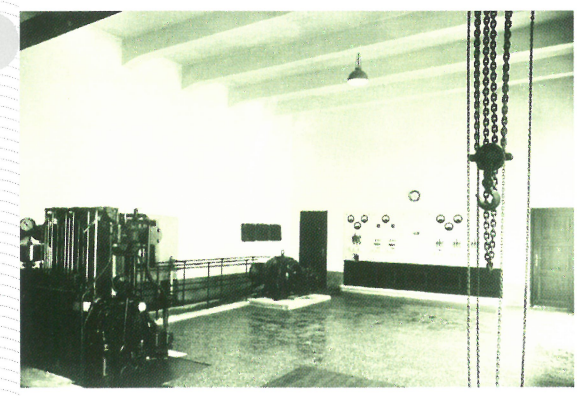
1923 The annual power consumption exceeded 10 GWh and reached 10.800 GWh.

1924 The first power grid analysis was made. The initial stage of the LV grid transition from the 2x55 V single-phase system to 3x380/220 V three-phase system.

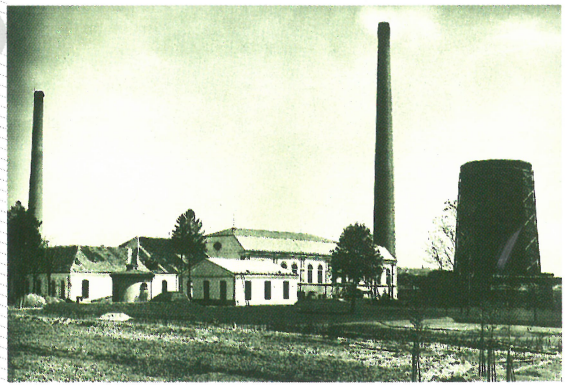
1926 The fifth power plant extension stage was completed.



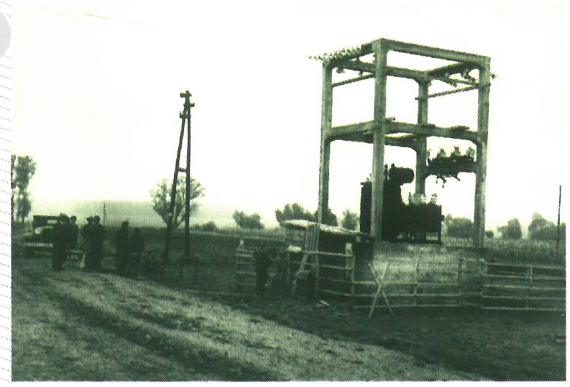
1924 - 1932. 5/0.4 kV transformer station: metering bay, oil transformer disconnecting switch and LV distribution panel rear



October 13, 1928, Samobor Municipal Power Plant machine hall



1930, Zagreb Municipal Power Plant



1930, 30/10 kV Kerestinec transformer station

1934, 30/10 kV Božjakovina transformer station

1927 The transition to the new LV 3x380/220 V system was completed in the entire grid.

On December 1, new rectifier station in the Patačićkina Street was put into operation.

1928 On February 6, the Management Board of the Municipal Power Plant decided to expand its activities off the City limits.

1929 On March 12, the contract was signed between the Zagreb Municipal Power Plant and the Karlovac Electrical Power Plant on establishment of the United Power Plants.

1930 On February 16, 30 kV Zagreb-Karlovac transmission line and 30/5 kV transformer station within the power plant put into operation.

30/10 kV Podsused and Kerestinec transformer stations put into operation.

1931 30/5 kV Uklopna II transformer station in Branimirova Street put into operation and 30 kV cable lied from the Elektrana to the Uklopna II.

10 kV line from the Kerestinec transformer station to Samobor (the town shuts down its diesel power plant).

1932 Early in November, two 5/0.38 kV transformer stations in the Preradović Square and Frankopanska Street burned down due to overload.

1934 30 kV transmission line between the Uklopna II and Božjakovina transformer stations installed and 30/10 kV Božjakovina transformer station built.

30 kV transmission line between the Kerestinec transformer station and Gradići (Velika Gorica) installed, 10 kV switchyard was built and the first three 10/0.38 kV transformer stations in Velika Gorica put into operation.

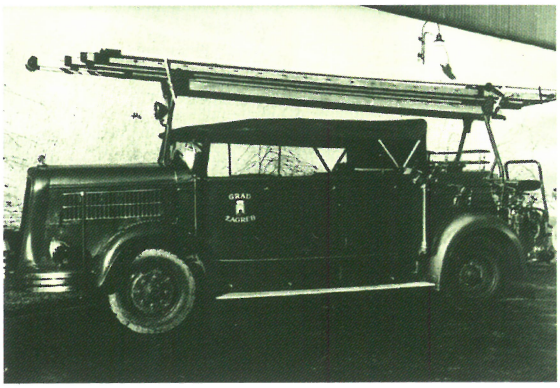
A study was prepared for the downtown municipal power grid, construction of LV grid started.

1935 The Office Building in 32 Gundulićeva Street finished, the offices moved from 16 and 18 Gundulićeva Street.

Grid analyzer with 150 nodes ordered for the grid calculation.

1938 30 kV transmission line from Božjakovina to Križevci extended; 30/10 kV Križevci transformer station and 10 kV overhead line to Bjelovar put into operation.

Meter Testing Station moved from 16 Gundulićeva Street to the new annex of the 32 Gundulićeva Office Building built in its courtyard.



About 1932, Street lighting installation and maintenance ledder

1942 30/10 kV Gradići transformer station near Velika Gorica put into operation through the existing 30 kV Kerestinec-Velika Gorica transmission line.

1943 110 kV transmission line from Rakitje to Brestanica (Slovenia) put into operation at 30 kV level and connected to the northern system of the 30 kV Zagreb-Karlovac transmission line.

1947 110 kV Rakitje-Brestanica transmission line extended to Sv. Klara.

Temporary transformer station in St. Klara put into operation at 80/30 kV level.

On July 1, establishment of Elektra, the company for introduction of power into the Northern Croatia, power transmission and distribution.

1932, Municipal Power Plant advertising domestic electricity use in 32 Gundulićeva Street window

1948 110 kV Brestanica-Klara transmission line put into operation.

30 kV transmission lines:

- Klara-Elektrana
- Klara-Žitnjak put into operation

30/10 kV Žitnjak transformer station put into operation.

On July 1, Elektrane Zagreb company founded; encompassed the City of Zagreb power distribution.

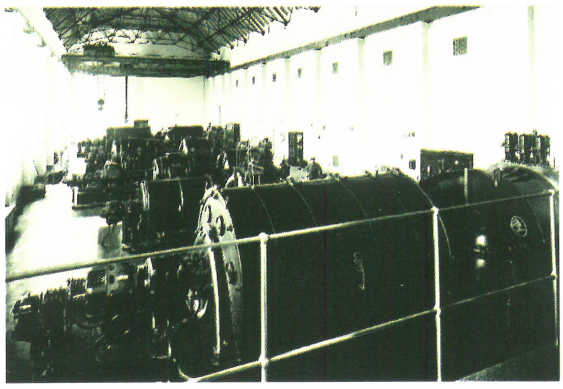
1935, Selska cesta railway crossing public lighting

1949 Elektra Zagreb company founded; scope of activities included power introduction, transmission and distribution in Northern Croatia.

30 kV Žitnjak-Dubrava transmission line constructed and put into operation, together with the temporary Dubrava transformer station. 30 kV Božjakovina-Zelina transmission line constructed and put into operation, together with the 30/10 kV Zelina transformer station

30 kV Uklopna II-Žitnjak cable put into operation.

Annual consumption exceeded 100 GWh (100.500 GWh).



About 1937, Municipal Power Plant machine hall in Zagorska Street

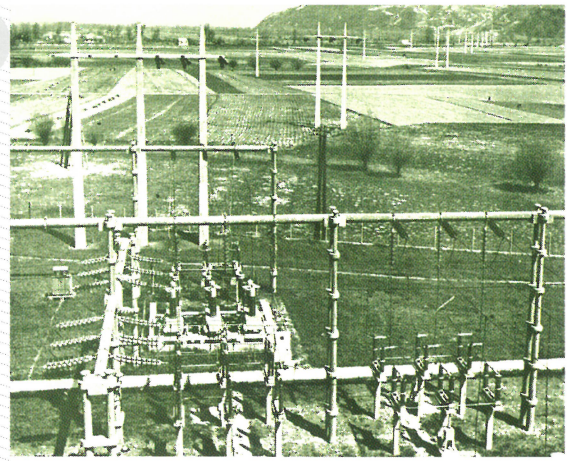
1951 The first fluorescent lamps in street lighting (Praška Street).

1952 110 kV/30 kV Rakitje transformer station put into operation.

1953 30 kV Novi Dvori transformer station and 30 kV Rakitje-Novi Dvori transmission line put into operation.

1954 Temporary 30 kV Dubrava transformer station relocated and put into operation.

1955 30/10 kV Podsused transformer station and 30 kV Rakitje transmission line put into operation.



1952, 110/30 kV Rakitje transformer station servicing Zagreb (detail)

110/30 kV Resnik transformer station put into operation.

1956 30/5 kV Uklopna III transformer station put into operation.

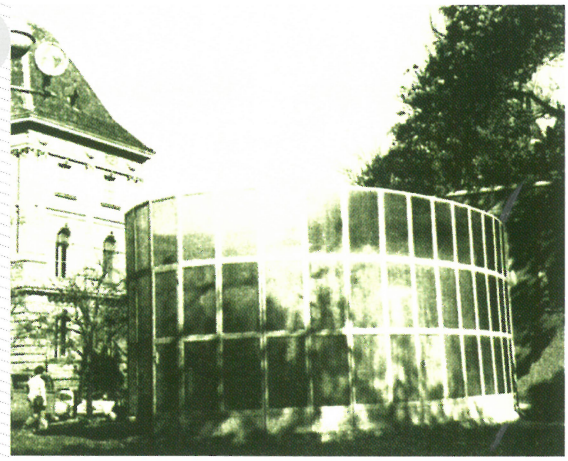
Power demand (consumption) exceeds 200 GWh.

30/10 kV Novi Velesajam transformer station and 30 kV Klara transmission line put into operation.

30/10 kV Samobor transformer station and 30 kV Rakitje transmission line put into operation.

Over loading of the majority of the grid caused considerable power supply reductions by disconnecting of consumers.

30 kV Resnik-Dubrava transmission line put into operation.



1956, 30/10 kV Uklopna I temporary transformer station at Roosevelt Square

1957 Reorganization of March 12 leaves Elektra Zagreb with only Božjakovina, Klara, Velika Gorica, Zaprešić and Zelina operating areas.

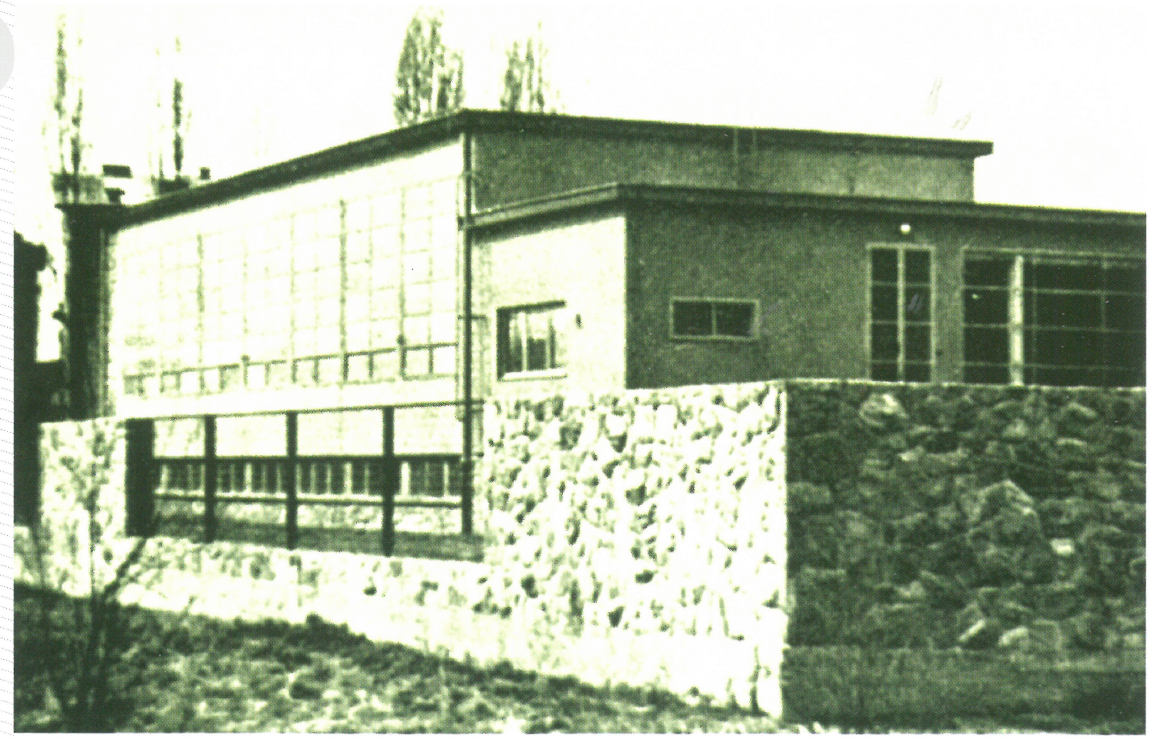
30/5 kV Uklopna IV transformer station put into operation.

30/5 kV Uklopna I transformer station (temporary) put into operation.

30 kV Uklopna III-Resnik cable laid.

Zagreb Grid Development Study prepared at the Power Industry Institute (authors Miroslav Balling and Vladimir Štengl).

Rectifier station in Daničićeva Street put into operation.



1956, The first 30/10 kV transformer station built after the World War II based on recent technical concepts

1957.
Fluorescent street lighting in Ulica grada Vukovara Street

1958 30 kV Uklopna III-Uklopna V (temporary) cable laid.

30/5 kV Uklopna V transformer station (temporary) put into operation.

First HP mercury vapor lamps used for street lighting (Highway between the Savska and Radnička Streets).

1959 30/5 kV Uklopna V transformer station put into operation.

Routing of two 30 kV cables between Termoelektrana-toplana and Uklopna VI and one 30 kV cable between Uklopna VI and Uklopna II.

Ružmarinka-Uklopna III rectifier station put into operation.

1960 30/5 kV Uklopna VI transformer station put into operation.

110/30 kV Termoelektrana-toplana (TE-TO) transformer station put into operation.

30 kV TE-TO - Uklopna II cable put into operation.

30 kV Uklopna I - Uklopna VII (temporary) cable put into operation.

Transformer workshop from Magazinska Street moved into the new workshop in Meršićeva Street.

1961 Držićeva-Uklopna VI rectifier station put into operation.

1962 30 kV Uklopna IV - TE-TO cable put into operation.

30 kV Dubrava-Sesvete cable put into operation.

1960.
30/10 kV Uklopna VII transformer station in a residential block

1963 Temporary 30/10 kV Uklopna VIII (Voltino naselje) transformer station energized; 30 kV cable from the Elektrana.

Workshops and warehouses moved from the Pierottijeva Street to the premises finished at the corner of Daničićeva and Petračićeva Streets.

Elektra employees (47 of them) helped reconstruction of the City of Skopje damaged in an earthquake.

Systematic transition from 5 kV to 10 kV level started within the narrow city area.

New reorganization in which the operating facilities in Bjelovar, Čakovec, Koprivnica, Križ, Varaždin and Zabok merged with Elektra Zagreb.

1964 The great flood in November submerged 104 transformer stations and HV and LV grid. 30/5 kV Uklopna IV transformer station was also flooded.

1962 - 1967, 10/0.4 kV municipal transformer station

30 kV cables laid between Uklopna II and Uklopna V, and between Resnik and Dubrava.

The first VHF system introduced with 4 radio stations (4 m range).

1965 30 kV Elektrana-Uklopna IV cable put into operation.

30 kV TE-TO - Uklopna II cable put into operation.

1966 30 kV cable laid between the temporary Uklopna VIII transformer station and Pliva Pharmaceutical Industry.

Temporary 30/10 kV Botinec transformer station and 30 kV Klara-Botinec and Rakitje-Botinec transmission lines put into operation.

Zvijezda-Radićevo šetalište rectifier station put into operation.

1967 30 kV Resnik-Uklopna III cable put into operation.

Operating building built in Zaprešić.

The first Croatian distribution Dispatching Center open in 32 Gundulićeva Street (remote control, measurement and signalling).

Four transformer stations: Uklopna III, Uklopna IV, Uklopna V, and Uklopna VI

1968 30 kV Sesvete transformer station put into operation.

30 kV Žitnjak 2 transformer station put into operation.

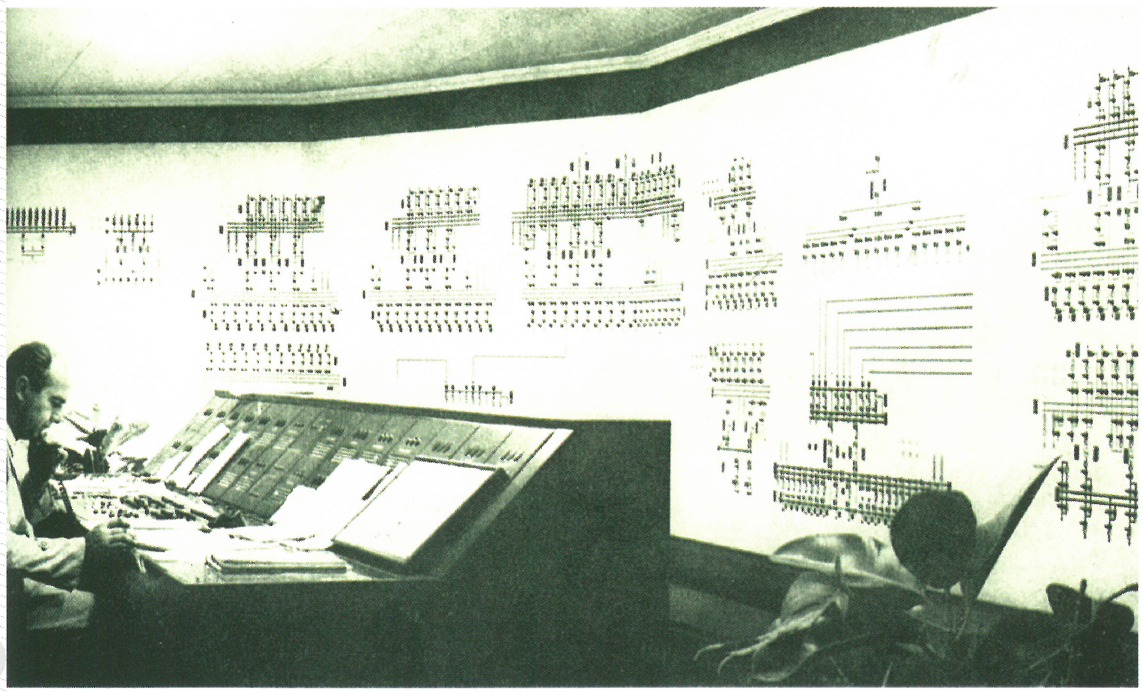
30 kV Dubrava-Sesvete cable put into operation.

30 kV TE-TO - Žitnjak 1 cable put into operation.

30 kV Resnik- Žitnjak 2 cable put into operation.

Southern Zagreb Grid Development Study prepared by the Elektra employees Balling, Brkljačić, Kamenski.

1969 Uklopna II transformer station (new) put into



1967, ELEKTRA Dispatching Center

operation; the old station, from 1931, dismantled.

30/10 kV Vrbovec transformer station put into operation.

ZET handed over all rectifier stations (Daničićeva, Patačićkina, Uklopna III and Uklopna VI).

Cooperation with Stadtwerke Mainz started.

The street lighting system started using the LP sodium (SOX 180 W) at the Savska and Ulica Grada Vukovara intersection.

1970 30/10 kV Uklopna VIII-Selska transformer station put into operation.

Three 30 kV cables laid between Jarun and Elektrana.

Two 30 kV cables laid between Jarun and Uklopna VIII.

Three 30 kV cables laid between Jarun and Elektrana.

110/30/10 kV Jarun transformer station put into operation.

Transition to 10 kV completed within the MV grid (the last three transformer stations were 274 Vodovod Daničićeva, 715 Zimsko plivalište and 208 Vodovod-Zagorska).

New operating building in Samobor opened.

1971 The first Ripple Control grid control system (283.3 Hz) in Croatia.

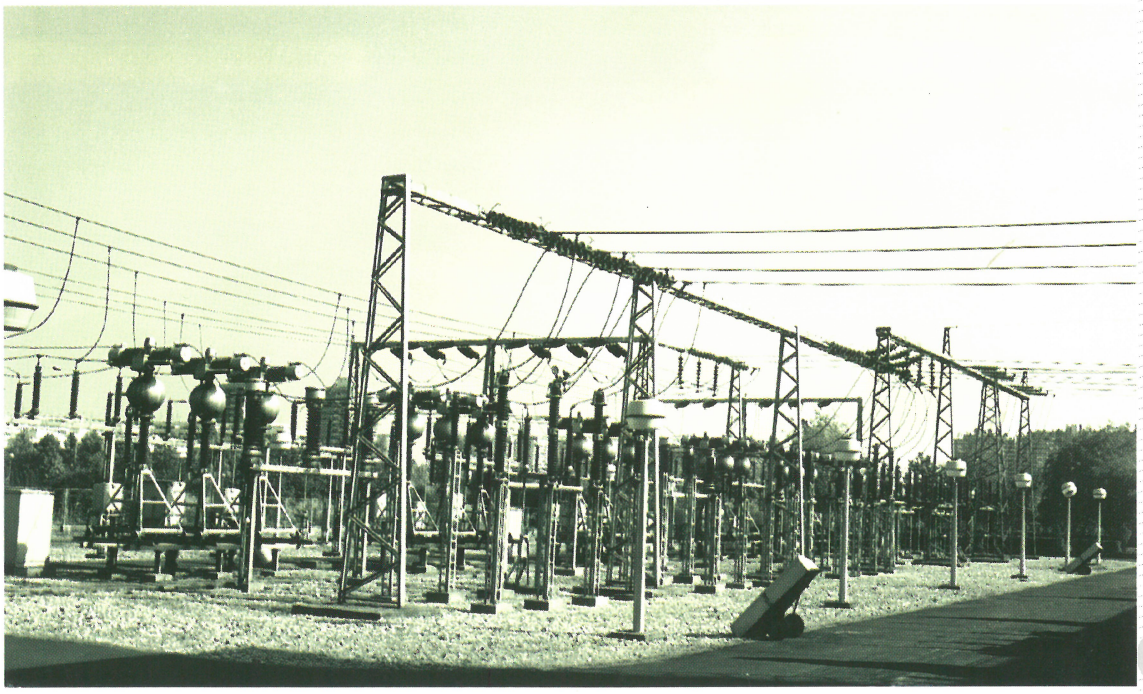
30 kV cables laid (Resnik-Volovčica, Resnik-Žitnjak 2, Žitnjak 2-Volovčica, and Resnik-Dubrava).

1967, 30/10 kV transformer station prefabricated switchgear

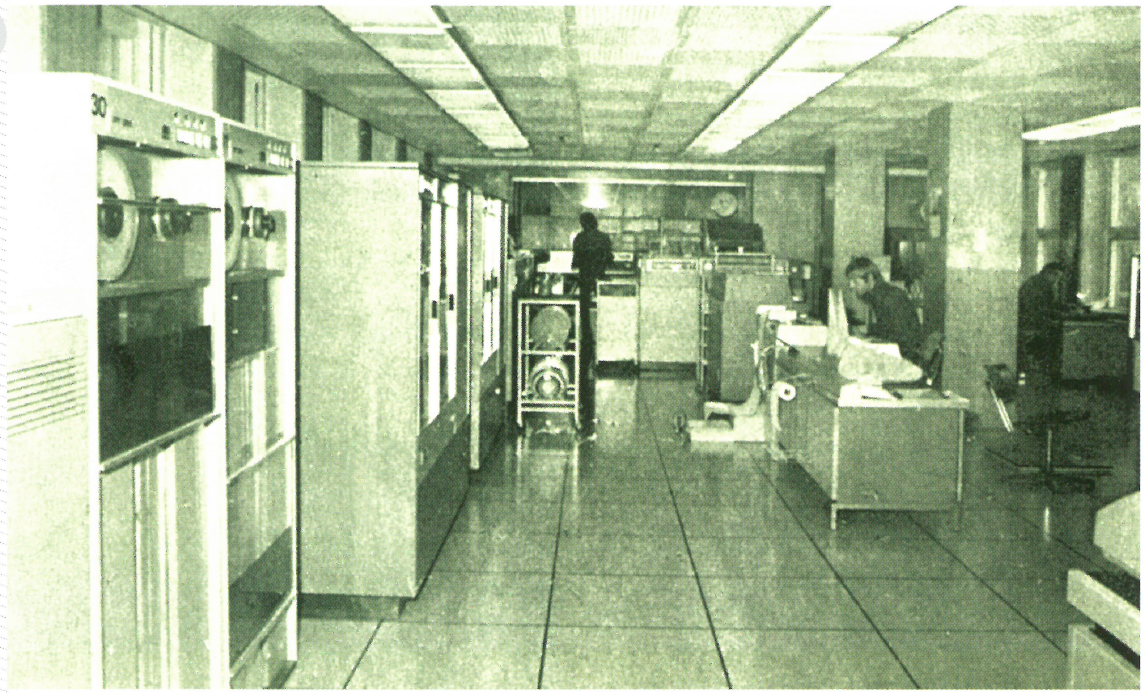
The first City of Zagreb Street Lighting Study prepared (Author Edo Širola, IPZ).

1972 The first Electronic Computing Center (ICL hardware).

110/10 kV Sopot transformer station and double 110 kV Jarun - Sopot - TE-TO transmission line put into operation.



1971, 110/10 kV Sopot transformer station



1974
ELEKTRA Electronic Computing Center

1973 30/10 kV Volovčica transformer station put into operation.

Audio-frequency grid control system in Resnik and Jarun transformer stations.

Three 30 kV Jarun-Trnje cables laid.

Three 30 kV Jarun-Uklopna I (temporary, 10 kV level) cables laid.

The street lighting system started using the HP sodium in Držićeva Street.

30 kV cable laid between TE-TO and Uklopna VI and from TE-TO to Uklopna II.

Basic Concept of 30, 110, 220, 380 kV Power Grid within the Elektra Zagreb Area (Power Industry Institute, author Josip Moser).

1974 Operating building finished in Velika Gorica.

30 kV cables laid from Žitnjak 1 to Žitnjak 2.

1975 Operating building finished in Dugo Selo.

Operating building in Zelina annexed.

110/(20)10 kV Velika Gorica transformer station and two 110 kV Mraclin-Velika Gorica transmission lines put into operation.

New 20 kV cables within the Velika Gorica transformer station arrangement put into operation.

Self-standing cable bundles introduced into the LV overhead grid.

Basic Concept of 20 (10), 110 and 220 kV Power Grid within the Elektra Zagreb Area and Comparison with the 10, 35, 110, kV Power Grid Concept (Power Industry Institute, authors Schenner, Zlatar, Markovčić, Tonković, Hartl).

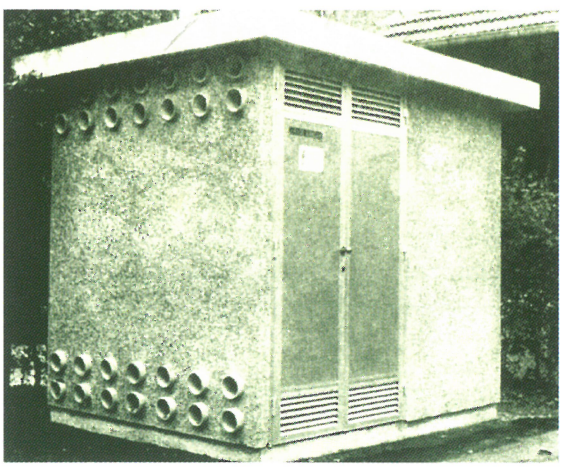
1977 30/10 kV Trnje transformer station put into operation.

Two 30 kV cables laid from Resnik to INA-OKI and from TE-TO to INA-OKI.

Analysis of 20 kV Level Introduction into the City of Zagreb (West) Area (M. Vidmar Power Industry Institute Ljubljana, authors Zaplotnik, Pehani, Uršić, Weber).

30/10 kV Soblinec transformer station and 30 kV Sesvete-Soblinec transmission line put into operation.

1978 The first MV transformer station fitted with 20 kV equipment (TS 1232 Tunel Podsused) put into operation.



1976,
10/0.4 kV prefabricated transformer station planned for the city area

1981, 30/10 kV Uklopna I transformer station in Izidora Kršnjavoga Street

Elektroopskrba moved from 32 Gundulićeva Street office building and Elektra remains alone on the premises.

1979. 30/10 kV Trnje transformer station put into operation.

1980 110/(20)10 kV Stenjevec transformer station and double 110 kV Rakitje-Stenjevec transmission line put into operation.

110/(20)10 kV Samobor transformer station put into operation and connected to 110 kV Rakitje-Brestanica transmission line.

30/10 kV Žitnjak I transformer station put into operation (temporary facility from 1948 dismantled).

Basic Concept of 110 kV and 30 kV Power Distribution Grid for the City of Zagreb (Power Industry Institute, author Rihard Schenner).

1981 30/10 kV Uklopna I transformer station put into operation (fully insulated 10 kV end).

30 kV OKI switchyard put into operation.

The investment resources available for the first time to the Croatian power industry (Self-Management Agreement 1981-1985).

On October 16, the Jarun transformer station accident (five 30 kV feeder bays and 30 kV Jarun-Pliva cable burned down).

New 30 kV Jarun-Pliva cable put into operation.

1982 30/10 kV Elektrana-toplana (EL-TO) transformer station put into operation and the old facility from 1930 abandoned.

Extended Jertovec transformer station, 30 kV Jertovec-Vinično and 30/10 kV Vinično transformer station put into operation.

1983 110/20 kV Zaprešić transformer station and 110 kV Rakitje-Zaprešić transmission line put into operation.

1984 110/(20)10 kV Ksaver transformer station put into operation. The first 110 kV SF6 design equipment in Croatia, double 110 kV transmission line between Resnik and Remete switchyard and double 110 kV cable from Remete to Ksaver. The first 110 kV cable in the Croatian distribution grid

110/30/10 kV Dugo Selo transformer station put into operation.

1981, 110/10 kV Stenjevec transformer station

1984. 110/10/20 kV Ksaver transformer station (SF - 6 design)

1986 The investment resources available for the first time for the Zagreb distribution grid (period 1986-1990).

The Study on Reactive Power Compensation and Impact of Higher Harmonics on the Zagreb Power Distribution Grid (Power Industry Institute, Baldassari, Dr. Milun, Božičković).

1987 New warehouse built in Velika Gorica.

110/(20)10 kV Botinec transformer station put into operation.

New Dispatching Center started working in the Kršnjavoga Street Office Building.

The office building and operating premises in Zelina annexed.

1988 110/(20)10 kV Trpimirova transformer station and 110 kV cable TE-TO - Trpimirova - Jarun put into operation.

30/20 kV Brezovica transformer station put into operation.

1987. 110/20 kV Botinec transformer station

Meršićeva Street transformer station

1989 The operating station for the eastern part of the City built in Retkovec (Stage I).

110/(20)10 kV Dubec transformer station with 110 kV connection to the 110 kV Resnik-Remete switchyard transmission line put into operation.

1990 On July 26, 1990, the Croatian Parliament passed the new Power Industry Act and founded the Croatian Power Board which encompassed the Elektra Zagreb Distribution Area with its facilities in Zaprešić, Samobor, Velika Gorica, Dugo Selo, Zelina and Zagreb.

Sv. Klara distribution area switched to 20 kV level.

1991 Comprehensive reconstruction of the power grid, street lighting in the Frankopanska Street.

1992 Comprehensive reconstruction of the power grid and street lighting in the Ilica Street between the Frankopanska Street and Jelačić Square.

The first (20)10/0.4 kV transformer station, SF6 design (14 Štrosmajer Square) put into operation.

1993 Reconstruction of the power grid and street lighting in the Vlaška Street between the Draškovićeva Street and Kvaternik Square. Bilateral power supply realized at Sljeme by laying of 20 kV cable on the route Šestine-Medvedgrad-Grafičar

1994 Comprehensive reconstruction of the power grid and street lighting in the Jurišićeva Street and part of the Draškovićeva Street, including the Burza Square.

1995 Comprehensive reconstruction of the power grid and street lighting in the Ilica Street from the Frankopanska Street to the Republic of Austria Street and Preradović Square. Civil reconstruction of the Transformer Workshop in Mertića Street

Hardware in Electronic Computing Center replaced.

1996 Reconstruction of the power grid and street lighting at the Slavonia Avenue and Savska Street

Velika Gorica storage arranging transformers

intersection within the underpass construction scope of works.

Comprehensive reconstruction of the power grid and street lighting in the Ribnjak Street.

1997 Comprehensive reconstruction of the power grid and street lighting in Mihanovićeva-Vodnikova Streets, Branimirova Street extension and Zagrebačka Street.

Reconstructed street lighting in Jurišićeva Street

POWER GRID CONSTRUCTION AND DEVELOPMENT HISTORY

ZAGREB ELECTRIC POWER GRID DEVELOPMENT 1907-1997

PERIOD 1907-1917

The City-Council decision on construction of the thermal plant brought on August 29, 1906 was immediately followed by project preparations. The Installation Department for installation of services and street lighting network started its work on January 1, 1907, based on the CODE ON IMPLEMENTATION OF POWER GUIDELINES by which the General Conditions for Power Supply were set up along with the regulations regarding electrical facilities. Construction of the power plant, in the vicinity of Vodovod (Water Supply Utility) in the Zagorska Street started on February 18. Cable routing through the city streets was finished already on October 17, and the power plant was commissioned on November 7, when the finished grid was connected as well. The equipment installed in the power plant included:

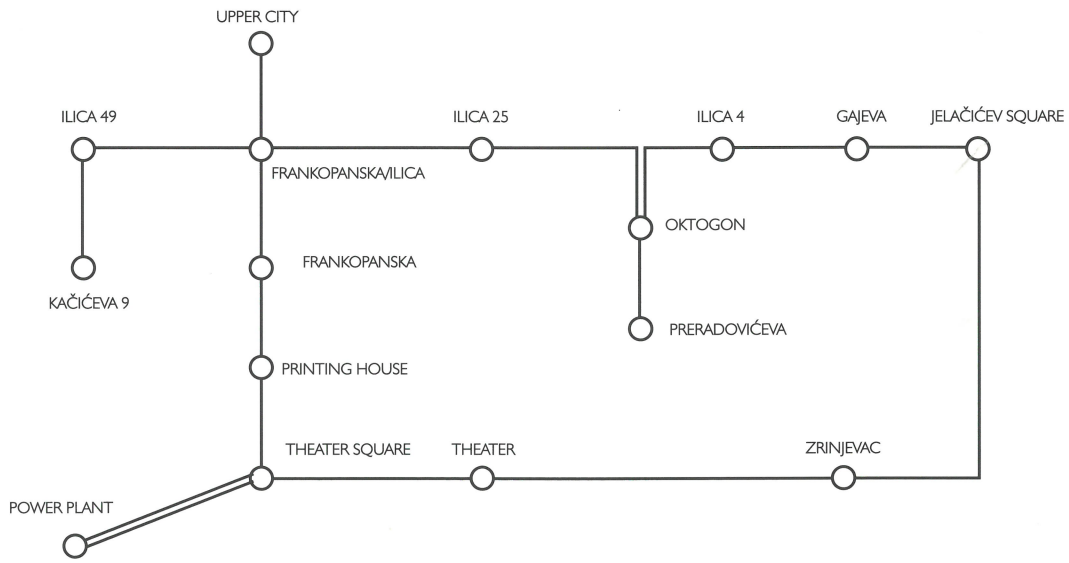
- three-phase generator GANZ 865 kVA, 100 A, 5000 V, 50 Hz and
- DC generator GANZ 200 kW, 333/243 A, 600/820 V

The DC generator was a 5 kV power supply source for water pumps and MV municipal grid consisting of nine 5,000/500/55 V transformer stations, six with installed power of 60 kVA and three with installed power of 30 kVA. The 7,440 m long HV grid consisted of 5,860 m of 3x50 mm^2 Cu cable, and 1,580 m of 3x25 mm^2 Cu cable.

The 5,000/500 V transformers were single-phase.

The LV grid included 8,500 m of 2x50 mm^2 Cu cable and 11,000 m of 2x25 mm^2 Cu cable. Some buildings were connected to the LV grid through their own 500/2x55 V transformers of 1, 2, 5, 10 and 15 kW.

5 kV grid in 1907



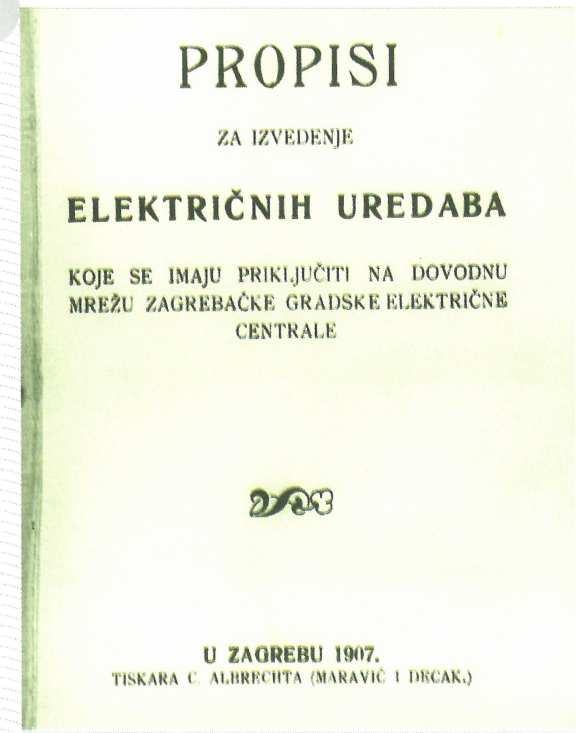
1907 - 1924, 5/0.4 kV transformer station (typical)

The street lighting arc lamps were connected through 500/65 V transformers.

Altogether 247 connections were realized by 3x25 mm^2 Cu cables. In addition to the Water Supply Utility in the Zagorska Street, the first three electric motors with total power of 7 HP were connected by the end of the year. And that was the beginning.

Until the beginning of the World War I the power plant had been extended twice, in 1910 and 1914, because of the rapid increase in demand and connection of the Zagreb tram to the grid on August 18, 1910. The extensions included:

The first regulations on installation of electrical facilities, conditions for connection to the Municipal Power Station grid


PROPISI

ZA IZVEDENJE

ELEKTRIČNIH UREDABA

KOJE SE IMAJU PRIKLJUČITI NA DOVODNU MREŽU ZAGREBAČKE GRADSKE ELEKTRIČNE CENTRALE

U ZAGREBU 1907.
TISKARA C. ALBRECHTA (MARAVIĆ I DECAK.)

- three-phase generator, 1250 kVA, 144.5 A, 5000 V, 50 Hz, cos phi = 0.80
- DC generator, 200 kW, 364 A, 550 V
- three-phase generator, 3000 kVA, 5000 V, 350 A, 50 Hz, cos ø = 0.80

Before the World War I, the demand profile was as follows:

- consumers lighting rated power 1,528 kW (42,221 bulbs)
- street lighting rated power 67 kW (267 lamps)
- water supply system rated power 444 kW
- tram rated power 1,011 kW
- rated power of other engines within the grid 1,261 kW
- rated power of appliances and small motors 159 kW

Total: 4.47 MW

PERIOD 1918-1927

The war affected power demand development. Late in 1918 the demand profile was as follows:

- consumers lighting rated power 2,269 kW (70,956 bulbs)
- street lighting rated power 75 kW (304 lamps)
- water supply system rated power 444 kW
- tram rated power 1,011 kW
- rated power of other engines within the grid 1,839 kW
- rated power of appliances and small motors 289 kW.

Total installed power of equipment, in addition to the service consumption of 128 kW, was 6,055 kW. Such a large increase continued after the war, so the power plant capacity had to be increased in additional three stages. By the end of 1926, total power generation capacity was 25,365 kW of installed power.

It is important that after the crisis caused by a very cold winter of 1,923, which caused troubles in the gas supply system as well, the first power grid analysis was made in 1,924.

The remedial activities included:

- increase in 5 kV grid capacity by two new cables routed from the Elektrana to the Uklopna I (Roosevelt Square transformer station) and Uklopna II (Branimirova St. Market transformer station);
- transition from 110 V single-phase grid to a 3x380/220V three-phase grid;
- retrofitting of the existing transformer stations and construction of several new ones;
- retrofitting of the 5 kV switch gear within the power plant.

The works started immediately, so the activities related to transition to the 380/220 V were finished by the end of 1927.

As regards street lighting, the arc lamps were abandoned in 1924 and replaced with incandescent-filament lamps.

The tram transport load had also grown, so a new rectifier station with two mercury rectifiers, 500 kW each, had to be built at the Patačićkina Street.

PERIOD 1928-1938

On February 6, 1928, the Management Board of the Municipal Power Plant concluded that "due to exceptional conditions and reasons, and in order to achieve full exploitation of the equipment capacity, the power plant management is allowed to expand off the City of Zagreb limits".

This decision triggered expansion of the Zagreb power industry beyond the municipal boundaries and made it the core of power system development in the NW part of Croatia regarding the conceptual, technical, organizational and human resources aspects.

The next step was establishment of the UNITED POWER PLANTS by signing of a contract between the Zagreb Municipal Power Plant and the Karlovac Power Plant on March 12, 1929. The purpose of the contract was to join forces on construction of a transmission line between the cities of Zagreb and Karlovac, exchange of power between the two cities, and introduce the electric power into the regions through which the transmission line was passing. A 55 km long 35 kV Zagreb-Karlovac transmission line (3x50 mm^2 Cu + 25 mm^2 Fe) was energized already on March 16, 1930, along with another 9.3 km long 3x70 mm^2 Cu system between Podsused and the Elektrana, intended for later connection to the Slovenian grid. The transmission line was on reinforced-concrete pylons, and the distance between the conductors adequate for 60 kV level. The Zagreb Power Plant was fitted with 30/5 kV, 6000 kVA transformer with adequate 30 and 5 kV switchgears.

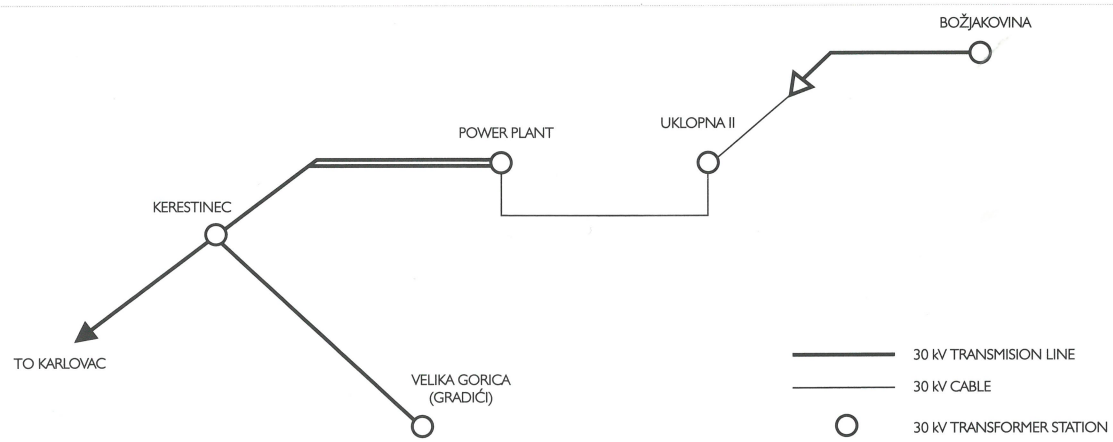
Two 30/10 kV transformer stations were constructed along the transmission lines, in Cvetković and Kerestinec. A 10 kV transmission line from the Kerestinec transformer station to the town of Samobor was built in 1931. Samobor closes down its diesel power plant.

1924 - 1932, 5/0.4 kV transformer station (typical)

During the same year, the first 30 kV cable (3x50 mm^2 Cu) was routed from the power plant to the Uklopna II transformer station in the Branimirova Street where the first 30/5 kV transformer was installed with a temporary 30 kV switchyard. This transformer station took over 50% of the total municipal load.

In spite of all undertaken measures, the grid overloading was frequent, particularly during the winter of 1932 when two transformer stations in the Preradović Square and Frankopanska Street burned down. Implementation of new standardization started, and construction of street transformer stations was abandoned. In the future, the transformer stations are to be placed in either existing or new buildings (mainly in the basements). HV cells were built, housing the 150 MVA oil disconnecting switches, mechanically driven three-pole isolators, and LV distribution on open metal supports where the cable bushings were protected by heavy-duty safety fuses.

30 kV grid in 1937



Thirties
Municipal Power Plant control room

In 1934, it was decided to make a final concept of the municipal grid. The prepared study has shown all the advantages and disadvantages of the distribution power mesh network which was brought to Europe from America, using the Berlin network as a study case. A decision was brought to install the mesh network within the area bordered by the Draškovićeva Street on the east and the Republic of Austria Street on the west. The network consisted of LV underground cables (70 mm^2 Cu) and HV cables with 10 kV insulation (95 mm^2 Cu). On trip of one transformer, the two adjacent transformers take over the load, so that the normal transformer (400 kVA) operating load is 60% of the rated power. In transformer stations, the motor-operated backup switches are installed at the LV transformer end.

1936. Carrying brick to the Mt. Sljeme for covering of 10 kV cable

The construction of the grid was stopped early in 1941, and it has not become operative after the war.

The LV cable grid nodes are fitted with underground cabinets.

A DC analyzer for 150 nodes was ordered in 1935 for grid calculation. The equipment was supplied before the war, but it was not put into operation before 1956.

During this period, the 30 kV grid was expanded from Uklopna II transformer station to the Božjakovina by a transmission line (4.8 km cable, 3x50 mm^2 Cu + 21.6 km overhead line 3x70 mm^2 Cu). The electric power was introduced into the Dugo Selo community through the 10 kV transmission line from Božjakovina.

One of the milestones from this period was moving from the premises in 16 and 18 Gundulićeva Street into a new office building in 32 Gundulićeva Street in 1935. The building was designed by architect Denzler. It was the most modern office building in Zagreb at the time. Today it is protected as a historical monument.

PERIOD 1938-1947

In 1938, the 30 kV transmission line was extended from Božjakovina to Križevci, so the town of Bjelovar was supplied from Križevci through the 10 kV transmission line. The Installation Department in Bjelovar became a part of the Zagreb Municipal Power Plant.

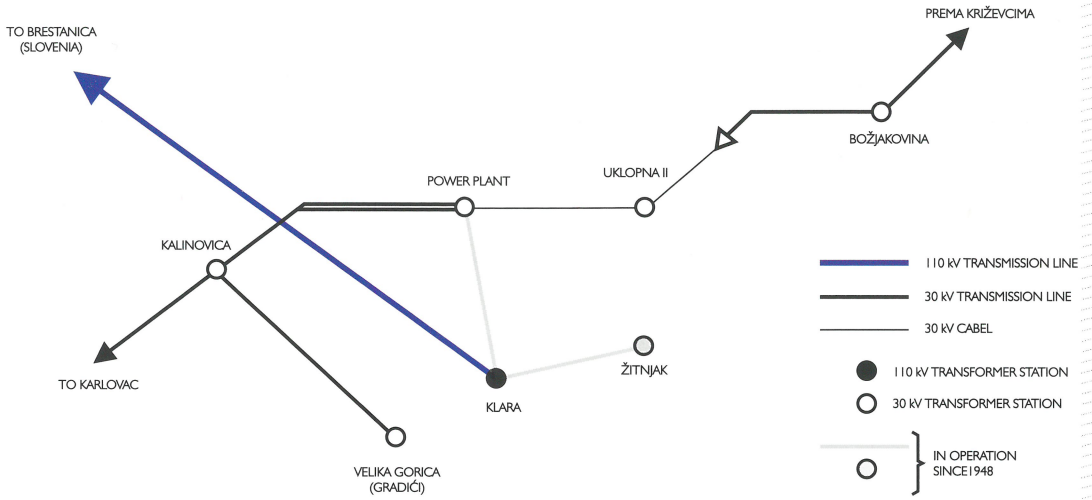
During this year, the Meter Testing Station Unit was moved from 16 Gundulićeva Street to the new annex of the 32 Gundulićeva Office Building built in its courtyard.

During the war, a 30 kV transmission line from Kerestinec (Kalinovica) to Velika Gorica (Gradići) was energized and the 30/10 kV transformer was installed which resulted in increased power supply of the area.

However, the most important step is realization of interties with the Slovenian grid by construction of the 110 kV transmission line from Bresatanica (Rajhenburg) to Rakitje; however, the voltage level was 30 kV. The 40 km long transmission line was designed and funded by the Croatian Power Company, as the legal successor of the pre-war Banat Power Company.

The transmission line (3x120 mm^2 Al cables) was installed on wooden portal frames and intertied with the northern system of the transmission line between the Elektrana and Podsused which was put into operation in 1943. After the World War II, in 1947, this transmission line was extended to the Sv. Klara village and reached the voltage level of 80 kV.

The temporary transformer station in Sv. Klara was built in immediate vicinity of the railway, so the step-down



30 kV grid in 1947

transformer was placed on one, and the 35 MVA power transformer on the other side of the railway. The transformers were procured in 1941-1942 for the Vinodol Hydroelectric Power Plant. On the eve of the World War II, in 1939-1940, the Municipal Power Plant grid profile was as follows:

- 181 transformer stations, installed capacity 45,692 kVA
- 402,530 m of underground cables
- 574,081 m of overhead lines (154,703 HV and 419,378 LV)
- 6564 lighting fixtures with installed capacity of 912.0 kW
- seven passenger cars, one transportation vehicle, one motorbike and five bicycles;

while at the end of the period, in 1947, it was:

LV underground cables	307,748	m
HV underground cables	174,192	m
LV overhead lines	530,479	m
HV overhead lines	360,542	m
5 and 10 kV transformer stations	349	pcs
30 kV transformer stations	4	pcs

The 5 and 10 kV transformer stations include 243 pcs in Zagreb, 18 in Velika Gorica, 16 in Sv. Klara, 17 in Samobor, 12 in Dugo Selo, 12 in Zaprešić, and 31 in Zelina. The vehicles fleet includes seven transportation vehicles, two passenger cars, and four motorbikes.

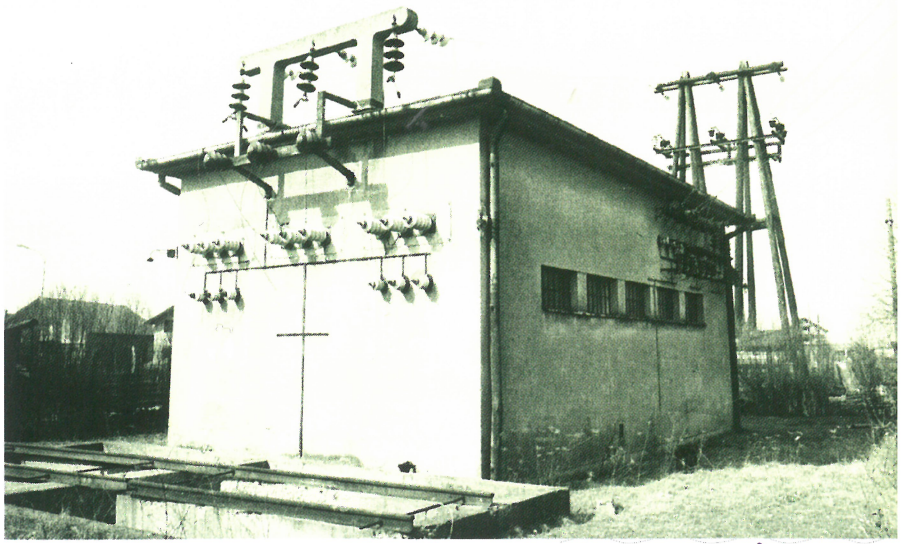
Total number of employees 1299.

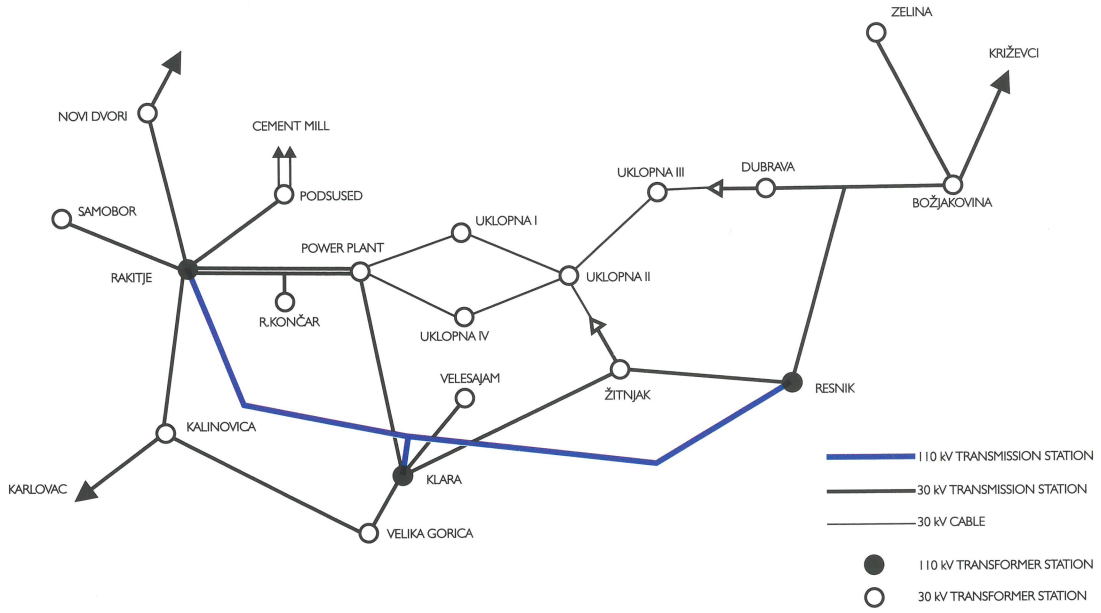
On May 1, 1947, Elektra was established as a company for introduction of electricity in the Northern Croatia. Its activities included power generation, transmission and distribution, and it encompassed the towns of Sisak, Karlovac, Križ, Bjelovar, Koprivnica, Varaždin, Čakovec and Zabok.

PERIOD 1948-1957

Elektrane Zagreb company was established on July 1, 1948. The company encompassed the City of Zagreb power distribution. A year later, on April 1, 1949, the power industry was reorganized and Elektra Zagreb company founded as a carrier of power introduction for the Northern Croatia (activities including transmission and distribution). At the end of this period, on March 12, the power industry was reorganized again, and the separate companies were established in the towns of Bjelovar, Gospić, Karlovac, Koprivnica, Križ, Sisak, Varaždin, Zabok and the City of Zagreb. During this period, the 110 kV feeding points in Rakitje, Klara and Resnik were con-

1942. 30/10 kV
Gradići (Velika Gorica) transformer station





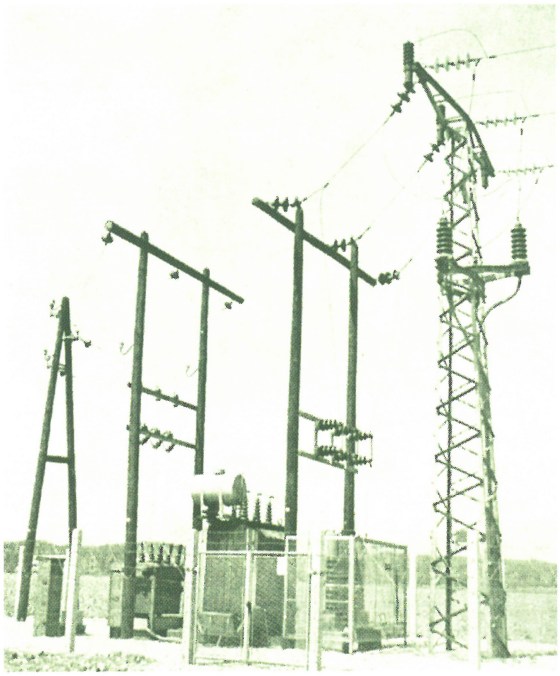
30 kV grid in 1957

structed, as well as 30 kV cable arrangement, including the 30 kV transformer stations Dubrava, Žitnjak, Zelina, Novi Dvori, Novi Velesajam, Uklopna I, Uklopna III, Uklopna IV, Samobor and Uklopna V. This was the period of rapid demand increase, so the 100 GWh consumption in 1949 doubled in 1956, and the 200 GWh margin was exceeded.

Overloading at all grid levels was recorded almost every year, the power reductions were frequent, and the grid construction could not keep pace with the demand growth.

The logical outcome was a requirement for development of the Zagreb Grid Development Study (prepared at the Institut za elektroprivredu (Power Industry Institute), authors Miroslav Balling and Vladimir Štengl). The study analyzed the current situation, forecasted the demand and specified facilities which needed to be constructed, including:

1957, Transportation of the first prefabricated metal-clad 10/0.4 kV tranformer stations



1945 - 1955, 30/10 kV transformer station (temporary) fitted with equipment from UNRRA

- 30 kV transformer stations, 3x8 MVA with rectifying unit or 2x8 MVA without rectifying unit
- 30 kV cables, 3x150 mm^2 Cu
- 10 kV transformer stations, 1x400 kVA, 2x400 kVA
- LV cables, 4x95 mm^2 Cu.

This period is also characteristic for shortage of equipment. The local industry was not developed, so the equipment from war reparations as well as the one from the prewar period was installed, and the built structures were temporary. Such is the rectifier station in Daničićeva Street where the old damaged rectifiers were brought in from Germany, repaired in Končar and put into operation because the tram network load was increasing.

PERIOD 1958-1967

Rapid increase in number of consumers, demand and load was recorded during this period. In order to cope with the new situation, two larger actions were undertaken:

- installation of the first prefabricated metal-clad transformer stations into the MV grid (1958),
- initiation of systematic transition from 5 kV to 10 kV level (1963).

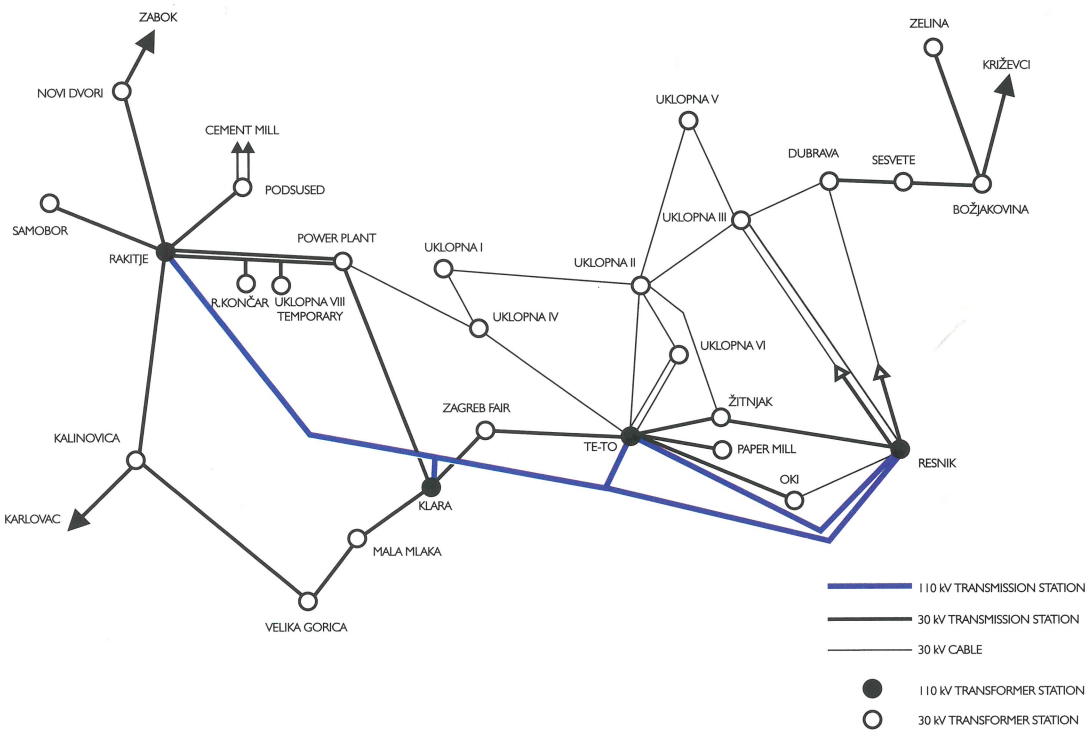
The transformer stations construction schedules become considerably shorter, and transition to 10 kV level in doubled the capacity of the MV grid.

The new 30 kV feeding point, Termoelektrana-toplana Žitnjak (cogeneration plant) was put into operation, as well as new 30 kV cables and overhead lines and Uklopna V, Uklopna VI, Uklopna VII, temporary Uklopna VIII and temporary Botinec 30 kV transformer stations.

Two important operating facilities were also built, i.e. the transformer repair shop (1960) and storage and operating building at the corner of Andrije Žaje and Petračićeva Streets.

In 1963, the power industry underwent another reorganization in which the Elektra Zagreb system was joined by

30 kV grid in 1967



1957. Ban Josip Jelačić Square street lighting maintenance

former facilities (companies) in Bjelovar, Čakovec, Koprivnica, Križ, Varaždin and Zabok.

In November 1964, the City of Zagreb was flooded by the Sava River. This disastrous flood submerged 104 transformer stations and partly one 30 kV transformer station. All these facilities suffered damage on their cables because the water infiltrated the cables through the cable heads and 10 kV transformer circuit breakers. The damage on other equipment was of smaller extent. The repair was carried out so that all the cables were cut at approx. 10 m distance from the transformer station, the new ones were laid, the junction boxes and cable heads installed along with the new 10 kV breakers. Reconnecting of the services in flooded buildings caused many problems.

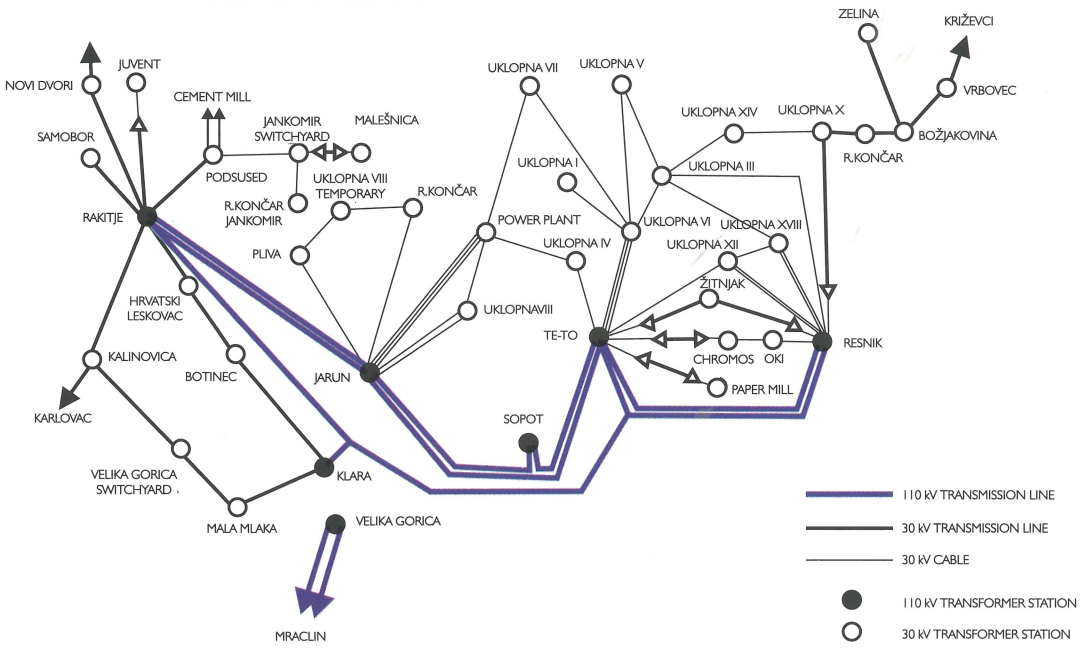
By the end of this period, a developed standard design was used for remedial activities performed on operating buildings within the power plants. The first building was constructed in Zaprešić in 1967. In 1964, the first four VHF stations were procured for the operational staff. Compared to the earlier connections (telephone only), this was a big step towards improvement and quality of the operating teams works.

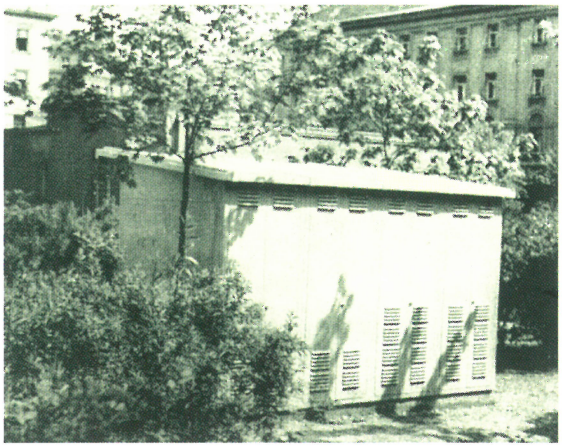
PERIOD 1968 - 1977

Putting into operation of the first dispatching center with remote control, signaling and measurement equipment (in 1968) was the first significant event in this period. At that time, it was not only the most modern dispatching center of this sort in Croatia, but it also considerably improved quality of work and control of the Zagreb grid. Putting into operation of two new feeding points, 110/30/10 kV Jarun transformer station and 110/10 kV Sopot transformer station, significantly helped consolidation of the HV grid in the areas of intensive construction and development after the flood.

These facilities are characteristic for the fact that Jarun was built in cooperation with the Elektroprenos Distribution Company and it was for the first time that Elektra purchased power from the 110 kV level, so the investment was recovered already in 4-5 years of operation. In Sopot, the first distribution transformer station for direct transformation was built in 1972, based on the Southern

30 and 110 kV grid in 1977





1957 - 1962,
10/0.4 kV city transfomer station
("can")

Zagreb Grid Development Study prepared by the Elektra employees Balling, Brkljačić, Kamenski in 1968.

In 1971, the first Ripple Control grid control system in Croatia was introduced for control of double-rate meters and street lighting switching on/off.

The City of Zagreb Street Lighting Study was prepared in 1971 (Author E. Širola, IPZ). Its result was the European state-of-the-art calculation system. The street lighting was classified and its quality was determined on the basis of the public traffic parameters.

The street lighting started using the two most modern light sources, HP (1969) and LP (1973) sodium.

During this period, namely in 1972, electronics entered Elektra in grand style with opening of the Electronic Computing Center which meant modernization of the commercial operations of the company.

The MV grid was successfully switched from 5 kV to 10 kV level in 1970. Replacement of old 6 kV 3x25 mm^2 cables took another several years (so some of the cables survived in operation for over 50 years).

After five years, in 1975, the concept of the new 20 kV level was confirmed by two studies (prepared by the Power Industry Institute Zagreb and M. Vidmar Institute Ljubljana), and by construction of the first 110/20 kV transformer station in Velika Gorica and introduction of the first 20 kV single-core cables.

An important improvement from this period in introduction of self-supporting cable bundles into construction of LV grids and connections which considerably improved quality of this widespread segment of the grid.

One of milestones from this period is an onset of cooperation with the Stadwerke Mainz in 1969, which was the result of twinning between the cities of Zagreb and Mainz. This continued cooperation resulted in relationship which widely opened the door to the City of Mainz for all important events in Elektra and its generous support in all its actions and activities, such as construction of the Electronic Computing Center, construction of the first 110 kV transformer station of SF6 design, aid during the recent war in Croatia, etc.

An accident in the Jarun transformer station triggered the introduction of operation with grounded neutral point. The action to be finished during this year shall result in grounding of neutral points in all 110/30 kV and 110/(20)/10 kV facilities and therefore reduction in failures within the grid and increased operating safety and quality of power supply. The Jarun transformer station failure also initiated retrofitting of the DC distribution systems in all 110.x and 30/10 kV transformer stations. Such an action considerably increased selectivity of protection of DC circuits which are grouped, while the conductors on the routes between the distribution and individual cells, namely appliances are protected against electric arc. All these measures have considerably increased the level of operational safety in these facilities.

And finally, during this period (1969) all the rectifier stations (Daničićeva, Patačićkina, Uklopna III and Uklopna VI) were handed over to the ZET (Zagreb Tram System). The ZET paid 10 kV level tariff, although the power was delivered at 660 V DC. This resulted in considerable reduction in maintenance costs (estimated to approximately DEM 200,000 a year) and abandoning of power transformation for traction which started in 1910.

PERIOD 1978-1987

In realization of the basic idea of transition to the direct 110/20 kV transformation and introduction of the 20 kV

1972
Part of 110/10 kV transformer station in
Southern Zagreb

1982, 10/0.4 kV transformer station, typical concrete 630 kVA

level during the previous period, the first transformer station for MV/LV transformation was put into operation using 20 kV equipment. This was TS 1232 Tunel Podsused transformer station, followed by 110/(20)/10 kV transformer stations at Stenjevec, Zaprešić, Samobor and Ksaver.

The SF6 design 110 kV equipment of was first used in Croatia during the Ksaver transformer station construction, and the first 110 kV double underground cable was laid between Remete and Ksaver.

An interesting design was the one of the 30/10 kV Uklopna I transformer station in which the 10 kV end is fully insulated (put into operation in 1981).

This facility is completed with the new modern office premises, and the entire building is a historical monument (since 1980).

The Dugo Selo grid was fitted with the new 110/30/10 kV feeding point, same as the Zelina grid which was installed 110/30 kV transformer in Jertovec for 30/10 kV Vinično transformer station power supply.

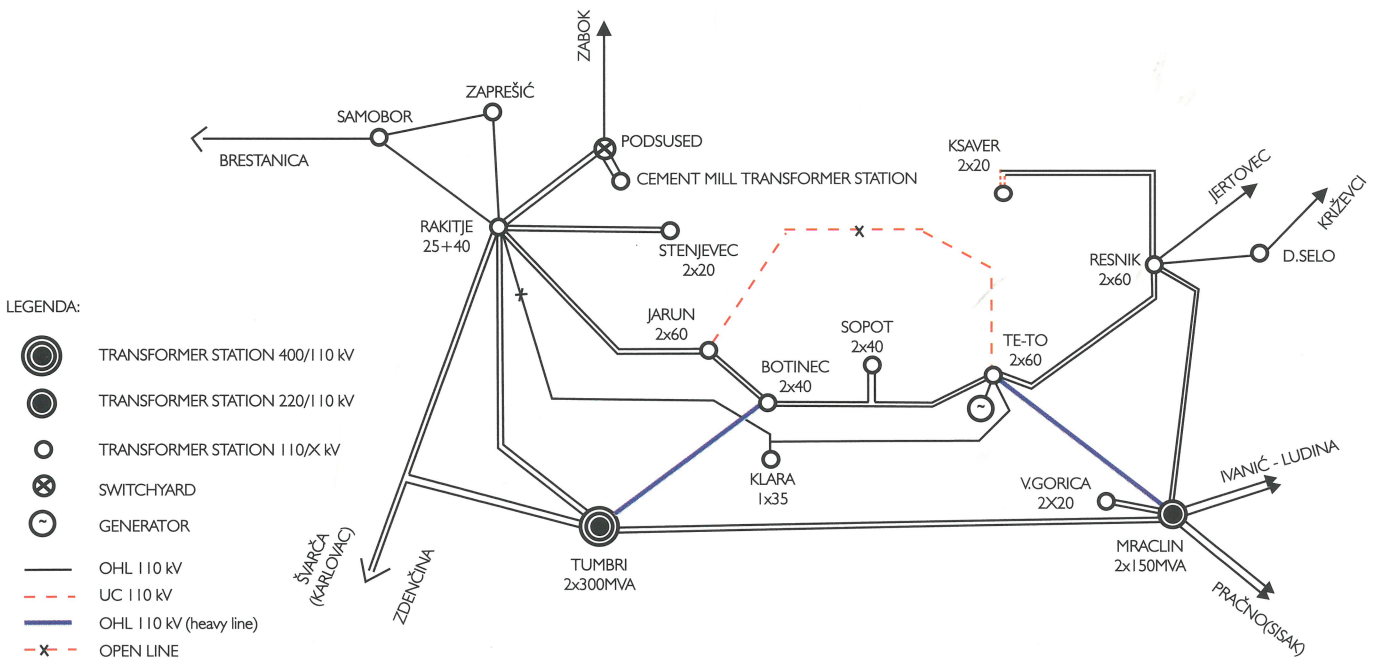
Permanent lack of investment capital drove Electra in 1979 to introduce the so called "demand charge". The charge was based on the results of the future grid construction costs analyses per kW of power demanded by the consumer (author M. Staničić).

Two years later, a Self-Management Agreement was accepted on the state level (for the periods 1981-1985 and 1986-1990) by which the demand charge was introduced into the then republic law. In addition to the 4% investment tax, this charge was the basis for financing of the entire power industry activities. A large portion of these moneys was spent on construction of power sources (particularly outside Croatia). The Elektra focused on signing of a special Self-Management Agreement with its customers for the period 1986-1990 in order to ensure the funds, particularly for power supply to the structures needed for the 1987 University Games. It was not easy, but we succeeded. The drive in which the consumers paid 8.5% contribution on the power bill resulted in intensive development of the power grid.

A number of facilities was built which were started up at the end of this and the beginning of the next period (Velika Gorica warehouse, 110 kV Botinec transformer station, new dispatching center, new VHF links, all in 1978).

However, the background of the development was the study titled The Basic Concept of 110 kV and 30 kV Power Distribution Grid for the City of Zagreb (Power Industry Institute, author Rihard Schenner 1980). The MV and LV grid development was based on numerous analy-

110 kV grid in 1987



sis of solutions for the gray areas with low voltage level prepared by the Elektra development department.

The above study is important for being the first document in the Croatian power distribution history to be prepared on the basis of the actual town planning consents for all the 110 kV cable routes, overhead lines, and all 110 kV transformer stations, so it actually was not only a concept but the project document as well.

At the end of this period, systematic replacement of obsolete facilities was initiated, particularly of the 10/0.4 kV transformer stations and cables.

The Study on Reactive Power Compensation and Impact of Higher Harmonics on the Zagreb Power Distribution Grid (Power Industry Institute, Baldassari, Dr. Milun, Božičković) was the starting point for an important activity on compensations in the MV and LV grid which, along with other activities undertaken on the grid, shall result in 7.01% reduction in losses, which is the lowest value in 50 years.

PERIOD 1988 - 1997

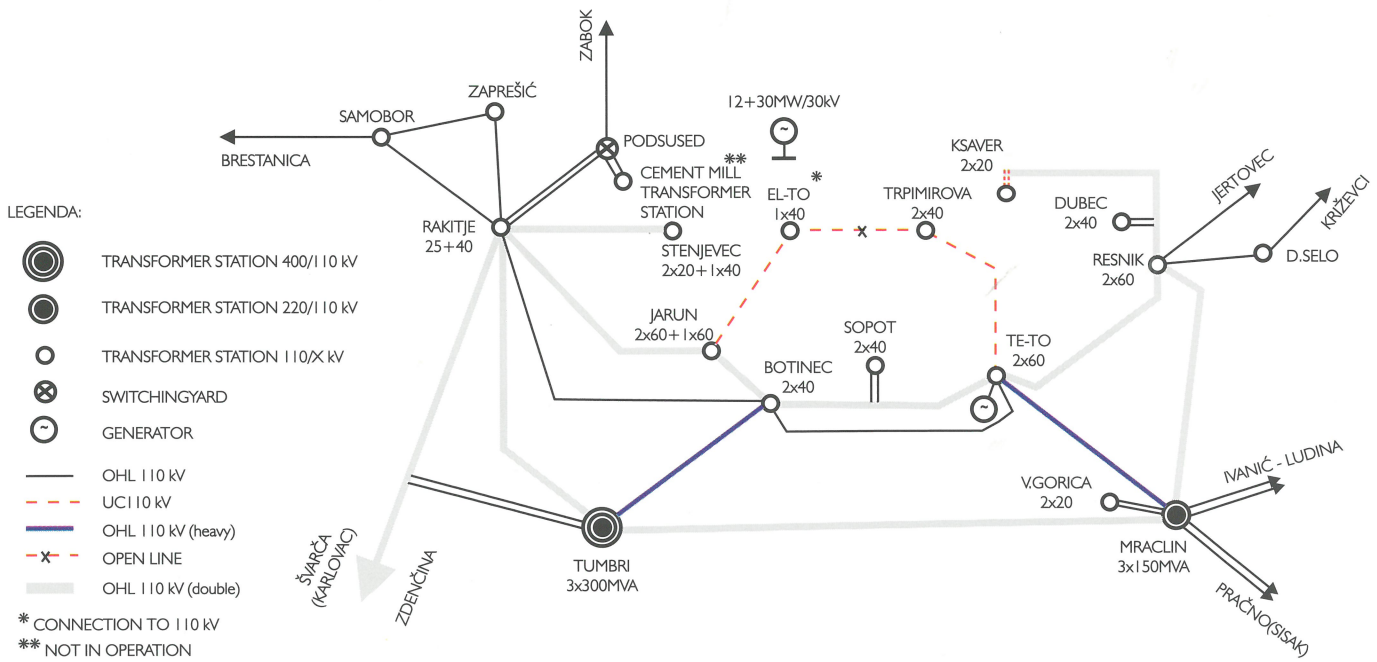
Two new 110 kV transformer stations were built in Trpimirova Street and Dubec, and a 110 kV cable was laid on the route Termoelektrana-toplana - Trpimirova - Elektrana - Jarun. These facilities enabled the 110 kV grid to enter the city center. It was particularly difficult to obtain the building permit for the 110 kV Trpimirova transformer station where the battle over the site was fought for almost three years. A specific and highly complicated task was cable arrangement for this facility through which the advantages of 20 kV grid were reconfirmed.

1987, 110/20 kV
Dubec transformer station

Construction of the first stage of the operating station in Retkovec in 1989 meant start of implementation of the maintenance organization for the MV and LV grid based on sectors (zones), requested because of the size of the city, and for shortening of the transportation routes and time loss reduction, which lead to more efficient work organization (the city was planned to be divided into four sectors: East-Retkovec, Center-Žajina, West and South).

So, the Elektra witnessed birth of our independent state, the Republic of Croatia. On July 26, 1990, the Croatian Parliament passed the new Power Industry Act and founded the Croatian Power Board which encompassed the Elektra Zagreb Distribution Area with its facilities in Zap-

110 kV grid in 1997



rešić, Samobor, Velika Gorica, Dugo Selo, Zelina and Zagreb.

At the Sv. Klara distribution area the entire grid (approx. 130 transformer stations) was switched to 20 kV level in 1990, which was enabled by construction of the 30/20 kV Brezovica support point in 1988.

An intensive introduction of SF6 gas-insulated equipment into the 10(20)/0.4 kV transformer stations started in 1992. Together with insulated 0.4 kV distribution, these gave new quality to the transformer stations. Since it is still difficult to provide new sites, the 1000 kVA transformers have been used more often.

The beginning of the war stopped the majority of the capital investment projects, so the period 1991-1997 was mainly dedicated to reconstruction of the downtown streets, particularly the tram rails and other municipal services. Such comprehensive and large projects are certainly advantageous as regards reduction in excavation costs and repair of street surfaces, while properly planned installation sequence prevents damage of replaced installations.

These activities included replacement of cable terminal boxes in the buildings, connection cables, LV cables and distribution cabinets, HV cables and transformer station equipment, as well as signal cables.

As far as the financial situation enabled, the poor voltage conditions were repaired and obsolete facilities within the MV and LV grid replaced. For example, about 160 10(20)/0.4 kV transformer stations were constructed or reconstructed. The reconstruction of the LV grid included replacement of about 6,000 lamps.

Introduction of computer systems has been intensified during and since the war, so the hardware has been replaced in the Elektra Zagreb Electronic Computing Center.

The crossroad in the vicinity of the National and University Library, repair of floodlights

DISTRIBUTION AREA ELEKTRA ZAGREB AS THE PART OF HRVATSKA ELEKTROPRIVREDA SINCE 1990

IN HOMELAND WAR

War Surroundings

In Croatia 1990 was the year of big and fatal changes, in which Elektra - Zagreb took an important role in fighting the cruel and treacherous enemy. The dictatorship of the Yugoslav communist state was facing its end. On 25 July 1990 the Croatian Parliament amended the existing constitution in a way of making Croatia no longer a "socialist state" and becoming the Republic of Croatia. On 22 December 1990 the Croatian Parliament accepted and formally proclaimed the new democratic Constitution of the Republic of Croatia. The so far existing Presidency was canceled and Dr. Franjo Tuđman was elected President of the Republic of Croatia. The Croatian historical coat of arms was determined, as well as the flag and the "Lijepa naša" anthem. In the beginning of its administration, on 8 October 1991 the Croatian Parliament declared breaking of all state and legal connections which had been the base for Croatia and other republics and counties to form the ex SFRJ. These dates made Croatia an independent and sovereign country. Its international recognition started by the end of 1991 and went on in 1992.

Through our own Crisis Headquarters directly co-operating with the Municipal Crisis Headquarters, police and military authorities of the state we took part in liberation of barracks and Yugoslav Army facilities by cutting out the electric power supply. Defying the dangers of their lives, the employees of dispatching centers and permanent operational services of our plants in Zagreb, Samobor, Zaprešić, Zelina, Dugo Selo and Velika Gorica performed their mission without failure, thus starting "their own war" against the common enemy of Croatia.

1991, damage installations near the Forest Management building in Pokupsko

1992, electrical installations at the front line

Crisis Headquarters

In the continuity of its existence the Croatian state strengthened its organization, primarily its military force supported by logistics and public facilities including Hrvatska elektroprivreda (Croatian Power Board). An efficient watching and alarm system was established in municipal and residential territories. Operating teams of Elektra - Zagreb had an important role in these activities, particularly in black-outs and in providing electric power generating sources to support actions of our army and police. The time was more and more beneficial to Croatia than for Serbia and its adherents in Croatian territories. A new Croatia was born which used its own will and power to control the development of political events. In those events we at Hrvatska elektroprivreda felt a new strength and determination to fight all evils and misfortunes caused by the enemy. Soon the time showed who would be the real winner on the Croatian land.

On 16 September 1991, the Crisis Headquarters of the Elektra - Zagreb distribution territory was formed at 6 a.m. in the premises of Gundulićeva 32 in Zagreb. War working conditions were established with the proclamation of crisis in the City of Zagreb and its surroundings, so the headquarters was in charge of complete co-ordination with the Municipal Crisis Headquarters and with headquarters of the surrounding places where Elektra - Zagreb plants were operating. Particular attention was paid to black-outs and to public lighting. The right and duty of operatives in charge was to engage all available men in order to perform orders given by the manager or by the relevant crisis headquarters. In case of damaged and endangered plants and facilities of Hrvatska elektroprivreda they informed the general manager, the technical manager and the relevant plant manager. One of the

Crisis Headquarters activities was also the co-ordination of our teams in repairing and reconstruction of plants and networks during and after the war throughout the entire territory of Croatia. Upon completion of "Flash" and "Storm" military actions the activity of the Crisis Headquarters was ended on 6 September 1995.

The Crisis Headquarters was in charge of the necessary co-ordination and execution of orders by the Ministry of Defense, the Ministry of Internal Affairs, the Municipality of Zagreb, the Municipal Headquarters of Civil Guards and Hrvatska elektroprivreda. This was its way of contributing to the defense of Croatia. In the peace time actions it proved itself on the occasion of the visit of the Pope John Paul II to Zagreb, on 10 September 1994, when, in co-ordination with the mission headquarters, security headquarters, municipal authorities and Hrvatska elektroprivreda, it provided electric power and public lighting in all Pope's routes and dwellings during his stay in Zagreb. 900-year old Zagreb and the whole homeland of Croatia have fully acknowledged our services in insuring the Pope's visit and our citizens who welcomed him and attended the Eucharistic celebration on the horse race-course.

Way to Success

We have shown our power within Hrvatska elektroprivreda in all assistance and reconstruction enterprises. This power was born from our patriotic enthusiasm and determination to show our skill and willingness regardless of working conditions and our personal safety. Our way to success was strewn with thorns and mines, under target of our enemies. Our operational triumphs are due only to our operatives' good organization, skill and courage. Our field teams were well supported by logistics from Zagreb, as well as by materials, tools and accommodation on sites or near them. The management of the company, in a close co-operation with the Croatian Army, was following the developments on the battlefield and informed the teams in time about possible enemy actions in the locations of their work. This showed particularly important in Konavli and Briševo, where our men left the dangerous zone in time. In the reconstruction areas the teams of our plants in Zagreb, Samobor, Velika Gorica, Zaprešić, Dugo Selo and Zelina distinguished themselves by winning their war victory in the toughest locations. The maintenance teams of Technical Services from Zagreb have shown their efficiency and high professional skills on complicated tasks of fitting out the transformer-stations in Vukovar and Ilok. We have always been prepared to perform quickly and well any task to be set to Elektra - Zagreb and to its employees.

In the Homeland War Croatia has won its complete victory. In a relatively short period of time and under extremely unfavorable and hard war conditions Croatia has built a strong and powerful army which, by its amazing victories in the Homeland War, became a respectable regional power and an important stabilizing factor in this part of Europe. Following this path of success, it is our task within Hrvatska elektroprivreda to give it our full support in development and maintenance of the electric power system supplying customers, large and small industries, as well as households. The reconstruction has not yet been completed, but the experience has shown that our teams are ready to serve our Homeland.

1992.
Dr. Franjo Tuđman, the President of the Republic of Croatia, addresses the UN

RECONSTRUCTION OF TERRITORIES DESTROYED DURING AGGRESSION

Hrvatska elektroprivreda as a whole, what includes all its parts, has fully demonstrated its perfect functioning in almost all war circumstances during the Homeland War. All parts that were not directly affected by the war were helping the destroyed territories in the form of expert assistance as well as material and equipment supplies. A particular role in these tasks was played by Elektra - Zagreb Distribution Area and among them the operatives of the Overhead Network Department of Zagreb Plant. Their 90 men walked over the various territories throughout Croatia and from August 1991 they have been in the field all the time. They worked on Pokupje battlefield, in Nova Gradiška, Konavli, Brest by Petrinja, Ribnik by Gospić, Bogičevci, Davor and many other places. Very often they worked not far from the enemy, who was not more than 150 m away in some cases. They stood all the strain very well. There were no problems with the discipline, no wonder there as they volunteered for the jobs. In the sites they worked 12 hours a day, taking their tasks very seriously and gaining universal experience. The same self-denial was shown by the Distribution Area operatives, particularly by the ones from the Transformer-Station Department, Cable Department, Technical Documentation Department, drivers and many others. Their zeal made them legendary in the war affected areas and a synonym for the efficiency of Hrvatska elektroprivreda.

Individually listed, the following areas have been reconstructed:

- **Pokupsko** (August 1991), 2,200 m of 10 kV cable and line separator.
- **Bogičevci** (June-December 1992), high voltage cable (HV) 7,400 m, HV above ground cable 7,800 m, low voltage (LV) network with self-supporting bunched cables (SSBC) 5,850 m, LV network connections 4,700 m, 2 cable transformer-stations (CTS), 2 overhead transformer-stations (OTS) as well as 124 public lighting lamps and 127 pylons.
- **Gorice** (September-October 1992), HV overhead transmission line 4,500 m, LV network with SSBC 2,000 m, LV network connections 500 m, two OTS, 65 public lighting lamps and 65 pylons.
- **Konavle - Dubrovnik** (January 1993-August 1994), HV above ground transmission line 18,000 m, LV network with SSBC 18,000 m, LV network connections 10,000 m, 12 repairs on overhead transformer-stations, 8 repairs on Tornjić type TS, fitting of 160 lights and 702 pylons.
- **Zvečaj** (April-May 1994) replacement of 20 kV lattice steel tower and 20 kV cable passing under the Zagreb-Rijeka railway
- **Ribnik** (September-October 1994), LV network with SSBC 8,000 m, LN network connection 3,000 m, 40 public lighting lamps, 72 pylons.

LV grid reconstruction in Kozibrod

Zelina Elektra staff in reconstruction of services

- **Sisak - Brest** (October 1994-February 1995), LV networks with SSBC 5,000m, LV network connections 3,000 m, 1 Tornjić type TS, 135 public lighting lamps, 135 pylons.
- **Petrinja** (September 1995-June 1997), HV cable 6,000 m, LV network with SSBC 18,600 m, LV new connections 11,540 m, LV cable connection 8,230 m, three CTS, 237 public lighting lamps, 385 pylons.
- **Kozibrod** (June 1996), HV cable 600 m, LV network with SSBC 1,400 m, LV network connections 1,000 m, one CTS, 38 public lighting lamps, 82 pylons.

Reconstructed LV grid in Gornji Bogičevci

Onset of Voćin grid reconstruction

- **Banska Struga** (June 1996), HV cable 600 m, LV network with SSBC 1,900 m, LV network connections 300 m, one OTS, 48 public lighting lamps, 92 pylons.

- **Mekušje** (April-August 1996), HV cable 3,000 m, LV network with SSBC 5,200 m, LV network connections 3,200 m, one CTS, 87 public lighting lamps and 147 pylons.

Final works on Mekušje grid

Reconstructed LV grid and street lighting in Polača

- **Drenčina** (June-July 1996), HV cable 1,000 m, LV network with SSBC 2,100 m, LV network connections 300 m, LV cable connections 1,500 m, one OTS, 40 public lighting lamps, 72 pylons.
- **Polača** (July-December 1996), LV above ground cable 1,700 m, LV network with SSBC 15,000 m, LV network connections 6,000 m, LV cable connections 11,000 m, two CTS, five OTS, 290 public lighting lamps, 430 pylons.

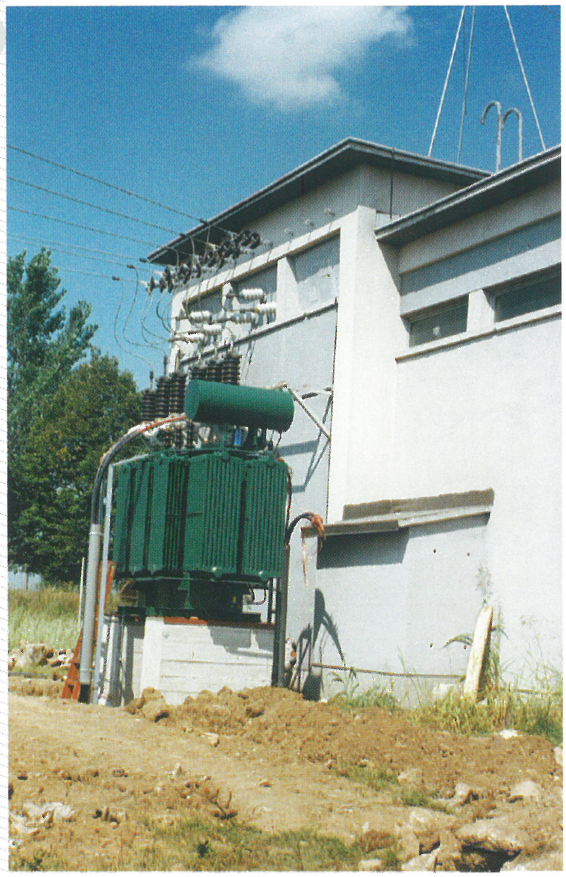
PLANTS ALSO CONTRIBUTED TO RECONSTRUCTION

The operatives of Elektra - Zagreb Distribution Area plants have also contributed to the reconstruction of territories affected by the aggression.

- **Pogon Dugo Selo** - one 40/0.4 kV OTS and low voltage network in Satrić (near Sinj); one 10/0.4 kV CTS, LV network and public lighting in Pakrac.
- **Pogon Samobor** - already in 1993 a team from this plant was reconstructing electric cables in Brkiševina and Šišinac on the Kupa. In the following year they were engaged in reconstruction of Biševo by Zadar and in Sonkovićevi (Skradin) and in 1996 they reconstructed the network in Lasinje.
- **Pogon Velika Gorica** - part was taken in the reconstruction of war affected areas in Skradin, Glina and in Pokupsko (a section of Velika Gorica Plant) 10 km of LV network was built and 7 pylon-mounted TS.
- **Pogon Zaprešić** - in 1993 reconstruction of HV and LV network in Brkiševina gornja (Pokupsko) was made. One 10/0.4 kV pylon-mounted TS was constructed as well as about 1,000 m of HV cable and about 2,000 m of LV network. In November 1995 the operators of Zaprešić Plant were reconstructing HV and LV network in Sonkovići - Skradin hinterland, where one 10/0.4 kV TS was constructed as well as about 1,500 m of LV network. In June 1996 they were working in Lasinja, reconstructing one 10/0.4 kV TS and constructing of about 2,000 m of new LV network.
- **Pogon Zelina** - together with Dugo Selo Plant they took part in reconstruction of Satrić, where 3.5 km of overhead LV network with connection were constructed, and together they worked on reconstruction of Pakrac network, constructing about 3 km of network with connections. In Okučani they made about 100 household connections.
- **All (peripheral) plants together** were engaged in reconstruction of the network in Voćin, where 15 km of LV network with connections and public lighting have been constructed as well as one 630 kVA OTS with the connecting transmission line.

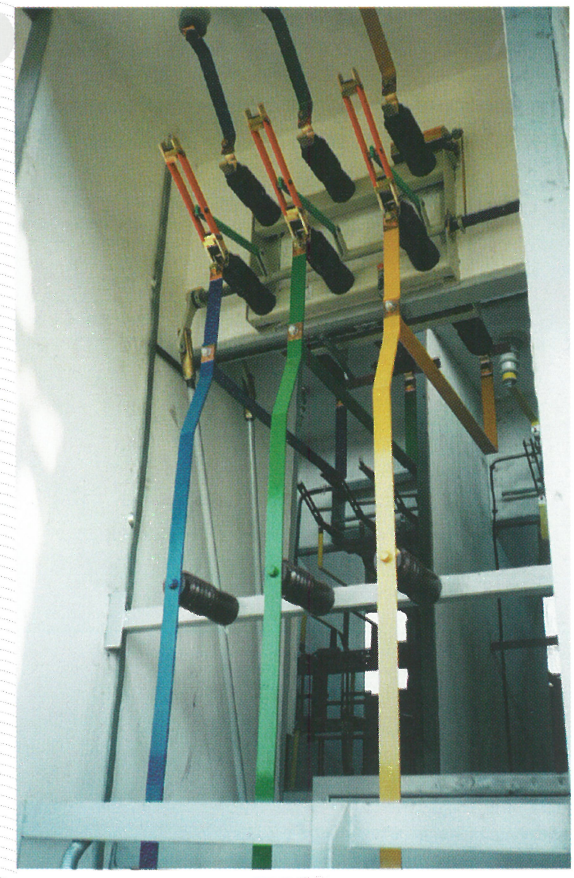
FINALLY VUKOVAR

The undivided wish of all people working on the reconstruction of war affected territories, and not only theirs, was to complete the reconstruction in the Croatian terri-



Rehabilitated transformer in Opatovac near Ilok transformer station

tories along the Danube. The peaceful re-integration comprised also electric power re-integration, so by the end of August this territory was completely included into the Hrvatska elektroprivreda electric power supply and all connections with the electric power system of Serbia, or SR of Yugoslavia, were disconnected. The "Dalmatian" diesel power-plants, bought at the time of darkness in the south of Croatia, have been fitted out in Dalj, Vukovar, Tovarnik and Ilok. They are already supplying the whole territory with electricity. Before connecting the diesel power-plants it was necessary to repair transformer stations and people of Elektra - Zagreb were engaged in 110/30/10 kV Vukovar 2 TS. In preparatory works temporary cable connections were eliminated and defective parts in four cells were dismantled. After that thermic scanning of the complete 35 kV and 10 kV plant (Vukovar 3) was made, functioning of monitoring and alarm system was tested, damaged and missing feed-through insulators (21 units) were replaced and 6 strain insulators were fitted. In three cells the connections were made from feed-through insulators to separators, in nine cells from bus bars to feed-through insulators, in two cells 10 kV switches in transformer fields were replaced and many other repairs were also made. In this way fields No. 1 (for connection of the "Block 3" set) and 6 (for connection of the "Block 2" set) were completed, together with the connecting field No. 7 etc. A trial operation has confirmed the quality of works performed.



Reconstructed 30 kV cell in the Vukovar 2 transformer station

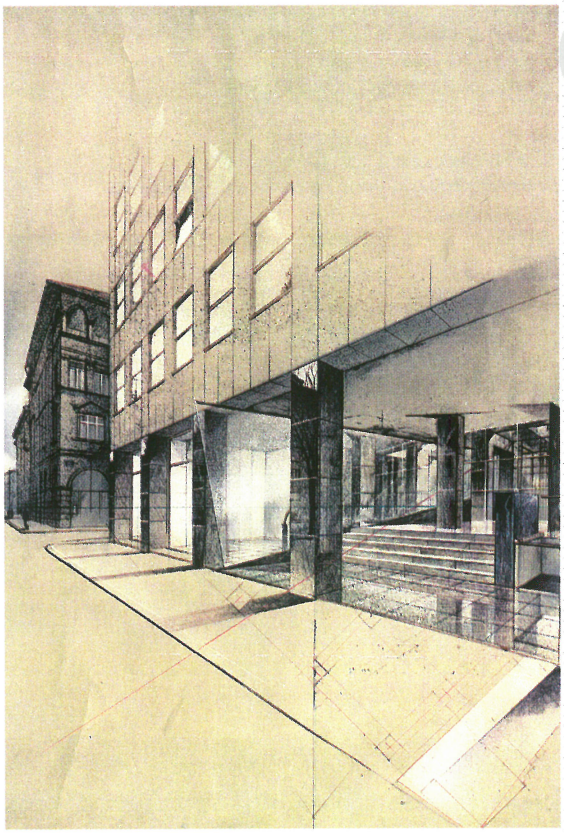
In 35/10(20) TS near Ilok the men of Elektra - Zagreb have completely equipped the 35 and 20 kV transformer fields and connected a new 35/20 kV, 4 MVA transformer.

The historic review of the electric power distribution in Croatian capital, starting with 7 November 1907 and going on till its 1997 anniversary, ends with works in the suffering but also heroic town of VUKOVAR. This is not a coincidence, as throughout its long history, and particularly in the recent one, Zagreb has always been helping others, showing its big and widely open Croatian heart.

POWER DISTRIBUTION GRID DEVELOPMENT IN THE ELEKTRA ZAGREB DISTRIBUTION AREA

Power supply to all consumers is the primary task of any power distribution grid. The power supply must be of high quality and performed under maximum safety. The grid development has been in the focus of our interest for years because we are committed to ensure quality and timely covering of the urban development needs and power demand. The majority of related activities has been conducted by the Elektra personnel, and the long-lasting and successful cooperation has been established with specialized institutions such as Institut za elektroprivredu Zagreb (Power Industry Institute), Energetski institut Hrvoje Požar (Energy Institute), former Rade Končar Institute, and College of Electronics and Computer Sciences of the University of Zagreb. Numerous studies and analyses were developed along with program packages and tools which facilitate and provide for comprehensive grid and demand-side analysis, planning of future grid development on all voltage levels, and the like.

However, despite of all our endeavors the lack of financial resources during the previous years caused deterioration of some segments of the power distribution network of the City of Zagreb and the towns and villages in its vicinity. The MV and LV grid age and write-off level is disturbing, with the exception of the new residential areas and those city districts in which the grid has been reconstructed within the streets and squares reconstruction projects. There are still grid segments in which the transmission line capacity is fully exploited or those where there is no possibility of standby supply in case of the power plant failure or overhaul.

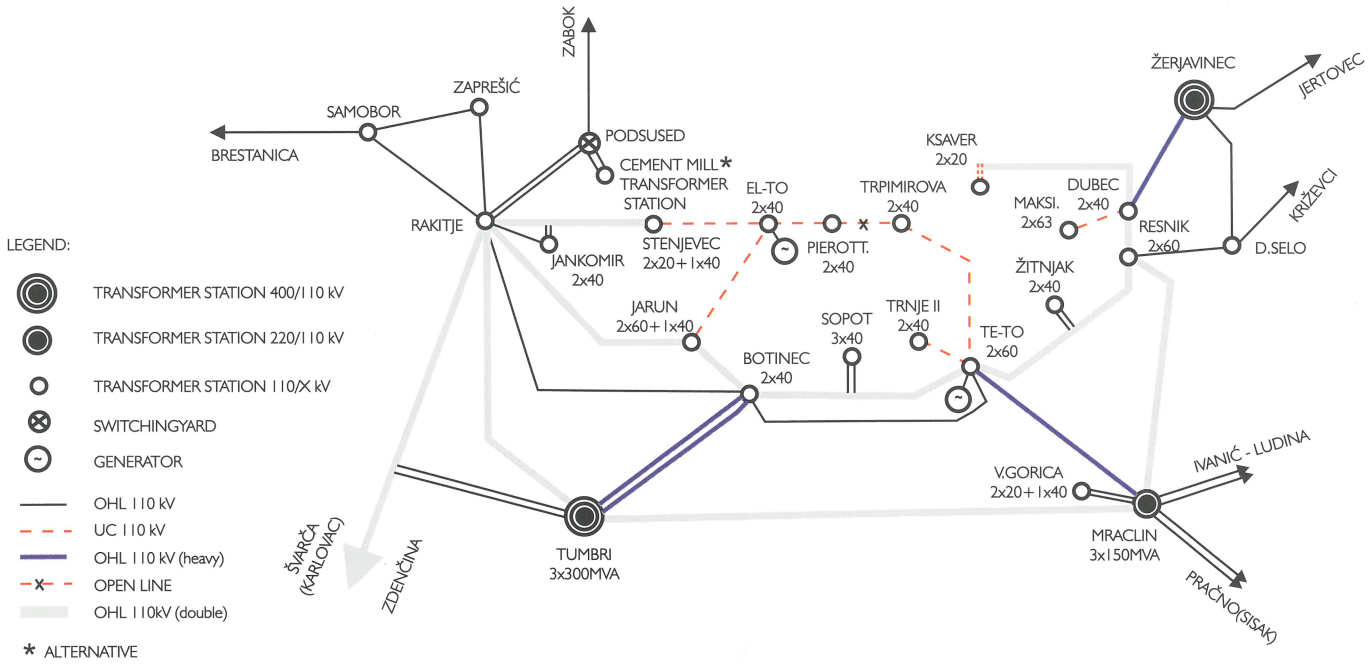


Future design of 32 Gundulićeva Street Office Building, entrance from Hebrangova Street (author: Milan Šosterić)

A large number of overloaded LV current circuits and poor voltage conditions suffered by the end users are due to insufficient investment into the power distribution grid. Such areas with low-quality and unsafe power supply at intolerably low voltage level are known as "gray zones". They are not feasible for connection of new consumers to the grid. The best, and often the only possible solution of such a problem is integration of new 10(20)/0.4 kV transformer stations into the MV grid and simultaneous reconstruction of appurtenant LV grid (increase in conductor cross-section, namely use of self - supported cable bundles).

Power indicators - Elektra Zagreb Distribution Area

Year		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Power purchase	MWh	-	-	-	-	2,573,399	2,611,719	2,635,334	2,634,044	2,772,436	2,881,779
Increase rel. to previous year	%	-	-	-	-	-	1.49	0.90	-0.05	5.25	3.94
Power sales - consumption	MWh	2,366,845	2,362,884	2,390,232	2,357,153	2,289,206	2,310,941	2,290,221	2,314,623	2,464,054	2,506,898
Increase rel. to previous year	%	4.13	-0.17	1.16	-1.38	-2.88	0.95	-0.90	1.07	6.46	1.74
Losses	%	-	-	-	-	11.04	11.52	13.1	12.13	11.12	13.01
Maximum load	MW	-	-	-	-	500	513	497	513	535	576

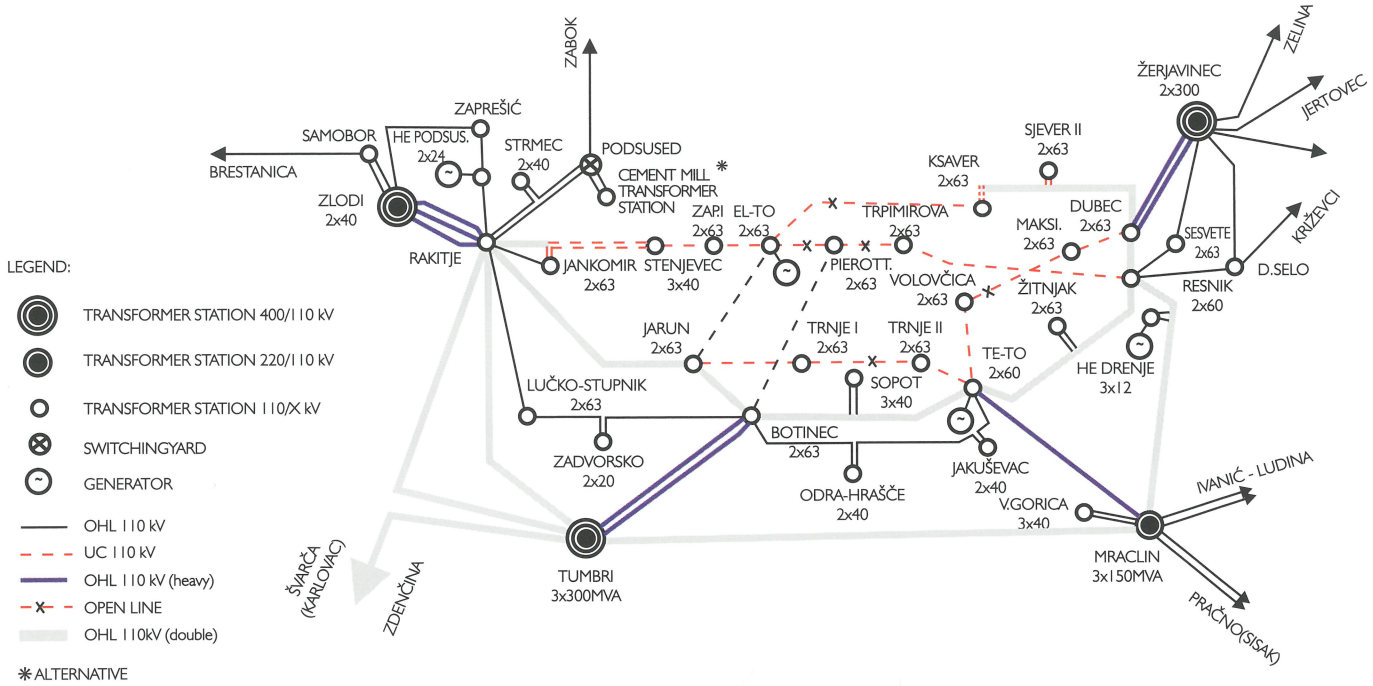


110 kV grid in 2005

Integration of new transformer stations results in shorter current circuits and consequently improvement in voltage level at the end user, it provides for required protection and enables granting of power interconnect approvals to the new consumers in such parts of the city.

The gray zones have most frequently been a consequence of insufficient resources for normal maintenance and construction of the power distribution grid, time-consuming processes related to the property relations, and issues related to acquisition of sites for integration of transformer stations. Not even the voluntary local taxes from

Finishing works in reconstructed transformer station



110 kV grid final status

the eighties could help resolve issues, so the "gray zones" noticed and recorded in those days remained unsolved while the new ones emerged.

Therefore, we shall be faced with large investment into the grid rehabilitation in the near future, which shall certainly impede further development and covering of power demand of the city and its population. Necessary investments into the new plants and the grid are high, as is most explicitly illustrated by the basic power indicators tabulated below. After the recession and falling power demand and load during the war years, we are witness-

Cable error measurements in mobile metering station

Year		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Power purchase	MWh	2,081,117	2,086,849	2,105,369	2,082,258	2,059,707	2,087,624	2,099,966	2,092,094	2,173,920	2,259,540
Increase rel. to previous year	%	-	0.28	0.89	-1.1	-1.08	1.36	1.00	-0.37	3.91	3.94
Power sales - consumption	MWh	1,927,101	1,922,213	1,955,018	1,916,976	1,842,120	1,863,972	1,839,483	1,861,139	1,942,716	1,993,819
Increase rel. to previous year	%	3.9	- 0.25	1.71	-1.95	-3.91	1.19	-1.31	1.2	4.38	2.63
Losses	%	8	7.9	7.1	7.94	10.56	10.71	12.4	11.04	10.64	11.76
Maximum load	MW	403	384	426	445	420	433	423	423	443	454

Power indicators ZAGREB DIVISION

ing a considerable growth that promises faster development and increase in demand.

The below figures illustrate necessary construction of the Elektra Zagreb Distribution Area grid facilities as forecasted by approximately 2005. The repair and rehabilitation measures required on the existing grid are the result of daily monitoring of the grid operation and condition, while the presented requirements for construction of new power supply 110/20 kV transformer stations and the appurtenant HV and MV grid are based on the study Update of the Basic Concept for 110 kV and 30 kV Power Distribution Grid for the City of Zagreb (Hrvoje Požar Energy Institute, 1996). The study elaborated a draft plan for development of 110 kV power distribution grid for the City of Zagreb based on the detailed analysis of the demand-side, 110/10(20) kV and 30/10 kV transformer station analysis, short-circuit current and power flow calculations, as well as from accepted plans for construction of power transmission and generation facilities on the area supplied by Elektra Zagreb or in its vicinity and, finally, all other relevant analyses and data.

Realization of the above plans for repair and construction of the power distribution grid within the Elektra Zagreb Distribution Area would considerably increase quality and reliability of electricity supply to the consumers. This would

Ilica - Frankopanska junction reconstruction

No.	Plant/facility	Project scope
1.	EL-TO TRANSFORMER STATION	110 kV switchgear + one 40 MVA transformer
2.	DUBEC TRANSFORMER STATION	remaining half of the 20 kV switchyard
3.	TRNJE II TRANSFORMER STATION	new transformer station, 2x40 MVA
4.	JANKOMIR TRANSFORMER STATION *	new transformer station, 2x40 MVA
5.	V. GORICA TRANSFORMER STATION	installation of the third 40 MVA transformer
6.	ŽERJAVINEC TRANSFORMER STATION	transformation 110/20 kV, 2x20 MVA for distribution
7.	PIEROTTIJEVA TRANSFORMER STATION	new transformer station, 2x40 MVA
8.	MAKSIMIR TRANSFORMER STATION	new transformer station, 2x40 MVA
9.	ŽITNJAK TRANSFORMER STATION	new transformer station, 2x40 MVA
10.	SOPOT TRANSFORMER STATION	installation of the third 40 MVA transformer
11.	JARUN TRANSFORMER STATION	installation of one direct transformation transformer, 40 MVA, 110/20 kV
12.	TE-TO - TRNJE II UNDERGROUND LINE	new 110 kV cable (approx. 3 km)
13.	DUBEC - MAKSIMIR UNDERGROUND LINE	new 110 kV cable (approx. 17 km)
14.	OVERHEAD LINE FOR ŽITNJAK TRANS. STAT.	new 110 kV OHL - double (approx. 2 km)
15.	EL-TO - STENJEVEC UNDERGROUND LINE	new 110 kV cable (approx. 5 km)
16.	RAKITJE - JANKOMIR OVERHEAD LINE *	new 110 kV OHL (approx. 5 km)

** The Cement Mill transformer station is an alternative for the Jankomir transformer station (a building and part of 110 kV switchyard exists)*

Power supply 110/10(20) kV and 110 kV grid transformer stations

bring us another step closer to an objective set in the late seventies, i.e. introduction of direct 110/10(20) kV transformation and abandoning of 30 kV level. Construction of all needed new power supply 110/10(20) kV transformer stations and implementation of all measures planned for the existing ones would put out of service at least another three 30/10 kV transformer stations (Ružmarinka, Jagodnjak, Kukuljevićeva) by the year 2005.

Early in 1997, Hrvatska elektroprivreda prepared the Program for Construction and Rehabilitation of Power and Heat Supply within the Greater Zagreb Area by 2010. Its section on power distribution is based on the results of the earlier mentioned study, namely on needs presented in the above figures. In March 1997, Hrvatska elektroprivreda and the Municipal Government signed the Letter of Intent (March 19, 1997) by which they

Šubićeva Street reconstruction, street lighting works

Area	Project background	1997 - 2000 period (pcs)	2000 - 2005 period (pcs)	1997 - 2005 period (pcs)
CITY	GRAY ZONES RETROFIT	100	-	100
PLANTS	DEMAND DEVELOPMENT	68	85	153
CITY	GRAY ZONES RETROFIT	186	-	186
PLANTS	DEMAND DEVELOPMENT	100	125	225
TOTAL	RETROFIT	286	-	286
	DEMAND	168	210	378
TOTAL:		**454**	**210**	**664**

accepted the Program and assumed the obligation for implementation (HEP) and support (City) in its implementation.

Signing of the Letter of Intent made the realization of the construction and rehabilitation programs for the Elektra Zagreb distribution grid more realistic, regarding both rising of necessary funds and acquisition of necessary sites and rights-of-way for the transformer stations and cables, respectively, as well as conducting of administrative/legal procedures, resolving of property-right relations, and the like.

No.	Power supply transformer station	Total length (km)
1.	EL-TO TS	32
2.	TRNJE II TS	45
3.	DUBEC TS	40
4.	JANKOMIR/CEMENT MILL TS	34
5.	ŽERJAVINEC TS	16
6.	KSAVER TS	15
7.	PIEROTTIJEVA TS	40
8.	MAKSIMIR TS	45
9.	ŽITNJAK TS	50
Total:		**317**

Public lighting at the Ban Jelačić Square

ORGANIZATION OF DA ELEKTRA-ZAGREB TODAY

On 8 August, 1990, "Elektra" poduzece za distribuciju elektricne energije was deleted from the Economic Court register and according to the provisions of the Electric Power Industry Act it became a part of the public enterprise Hrvatska elektroprivreda.

On 26 April, 1991, by virtue of the Articles of Association of this enterprise, the registration at the Regional Economic Court of the new enterprise Hrvatska elektroprivreda s.p.o. was made.

On 21 December, 1994, by the decision of the Commercial Court in Zagreb, Hrvatska elektroprivreda s.p.o. became a joint stock company - HEP d.d. Zagreb, and Elektra - Zagreb became a distribution area of HEP d.d.

According to the Organization and Systematization By-law of Hrvatska elektroprivreda d.d., effective since 1 April 1997, DA Elektra Zagreb in its present form is organized as the Distribution Area Elektra Zagreb (Figure 1) which consists of six plants:

1. Zagreb (with the Plant Office Sv.Klara) - Figure 8
2. Velika Gorica (with the Plant Office Pokupsko) - - Figure 9
3. Dugo Selo (with the Plant Office Vrbovec) - Figure 10
4. Samobor - Figure 11
5. Zaprešić - Figure 11
6. Sv.Ivan Zelina - Figure 11

The jobs of the Distribution Area are organized in the Services that delegate a part of their jobs to the Plants and Plant Offices in their area.

Technically, the Distribution Area Services have above them corresponding organizational units of the Distribution Management.

32 Gundulićeva Street
Consumers counter

Organizational Units of the Distribution Area

1. Distribution Area Office (Figure1)
2. Technical Service (Figure 2)
3. Sales and Customer Relations Service (Figure 3)
4. Economic Affairs Service (Figure 4)
5. Legal, Personnel and General Administrative Services (Figure 5)
6. Construction and Workshop Service (Figure 6)
7. Business Information Services Department (Figure 7)

The jobs of the Distribution Area Office include defence and security, purchase and maintenance of security and civil defence means, organization of physical protection of facilities; quality assurance and internal inspection jobs,

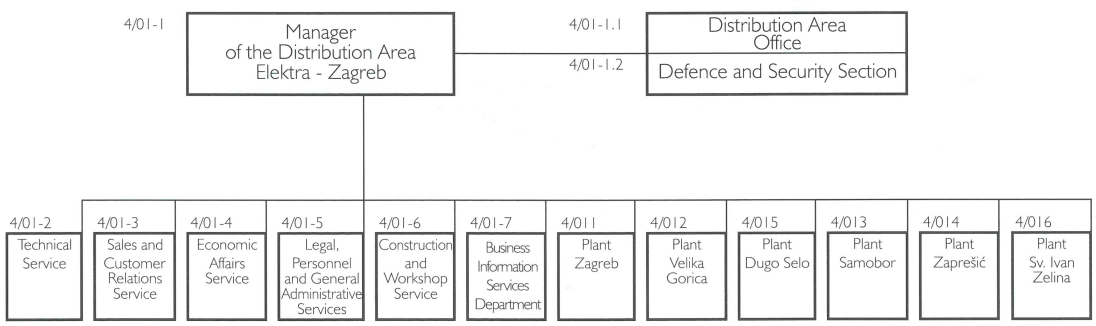


Figure 1
DA Elektra Zagreb
Organization Chart

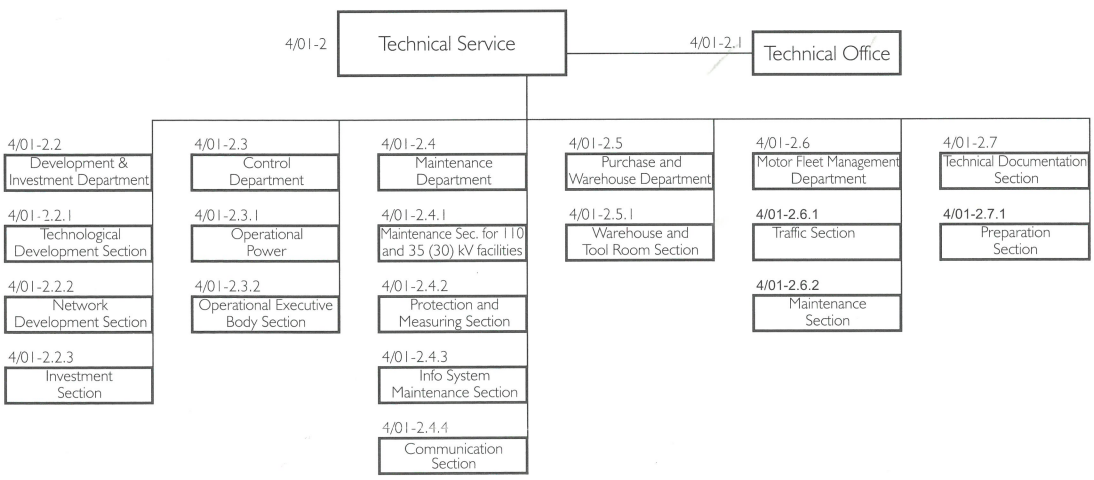
Customer Relations Department
Dial 9820

information and relations with local authorities and chambers, as well as various secretarial and advisory jobs.

The jobs performed by the Technical Service include safety at work and fire protection; electric power inspection; general technical jobs; development and investment; operational electric power and network control; maintenance of electric power network, plants and public lighting; keeping of documents and operational records; motor fleet management; purchase of materials and services and warehouse running.

The Technical Service jobs are carried out in the following departments:

Figure 2
Technical Service organization chart



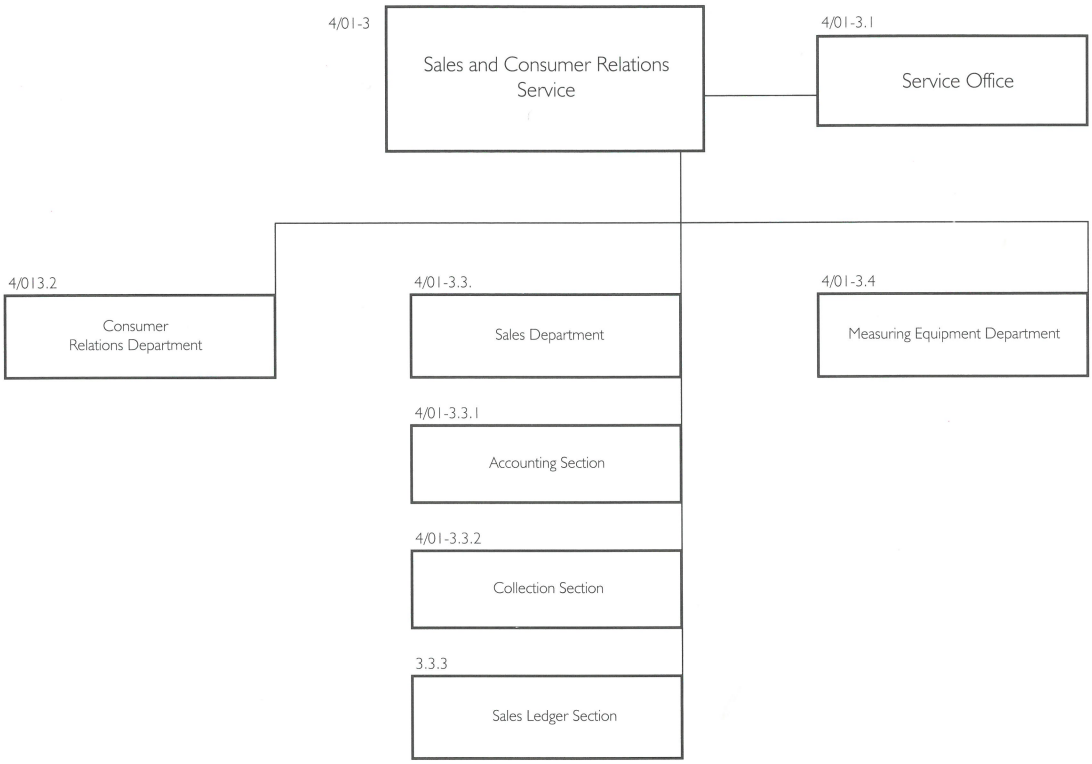


Figure 3
Sales and Consumer Relations Service organization chart

- Technical Department,
- Development and Investment Department,
- Management Department,
- Maintenance Department,
- Purchase and Warehouse Department,
- Motor Fleet Management Department,
- Technical Documentation Department.

The jobs of the Sales and Consumer Relations Service include electric power purchase and sales planning,

10 and 20 kV
MV grid Dispatching Center

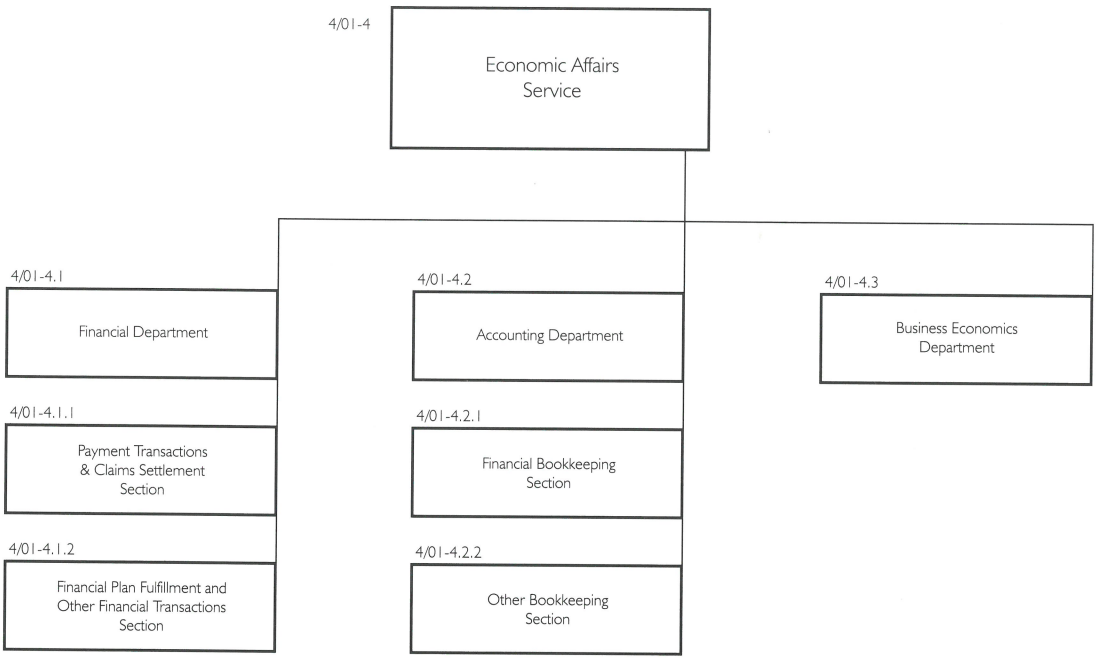


Figure 4
Economic Affairs Service organization chart

making electric power supply contracts with consumers, registration of consumers and consumer records keeping; reading, accounting and collection of the supplied electric power; keeping the sales ledger; keeping records of measuring equipment and taking care of its calibration, supervision of measuring equipment accuracy and consumption supervision; counter jobs, giving information to consumers, complaints, receipt of cash payments.

The jobs of the Sales and Consumer Relations Service are done in the following departments:

- Service Office
- Customer Relations Department
- Sales Department
- Measuring Equipment Department.

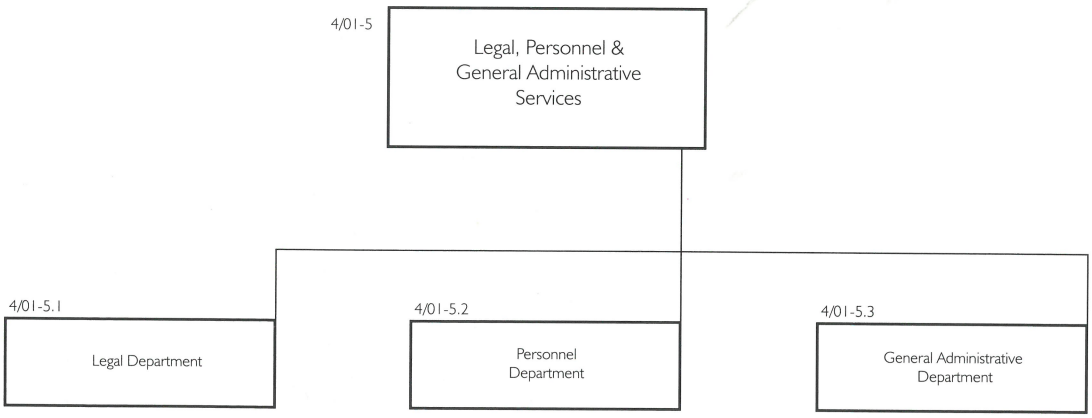
The Economic Affairs Service performs all jobs involving payment transactions and salaries; claim settlements; financial plan fulfillment and other financial transactions; financial and other bookkeeping; business economics jobs.

The jobs of the Economic Affairs Service are done in the following departments:

- Financial Department,
- Accounting Department,
- Business Economics Department

The Legal, Personnel and General Administrative Services perform the jobs involving contract making, agency, insurance of persons and properties, and property rights; jobs in the field of labour - legal relations such as required by the Area and the Plants; personnel records and reports required by the system; jobs concerning social welfare and health protection, training of personnel, standard of personnel; administrative and typewriting jobs, entry registration and filing jobs.

Figure 5
Legal, Personel & General Administrative Services organization chart



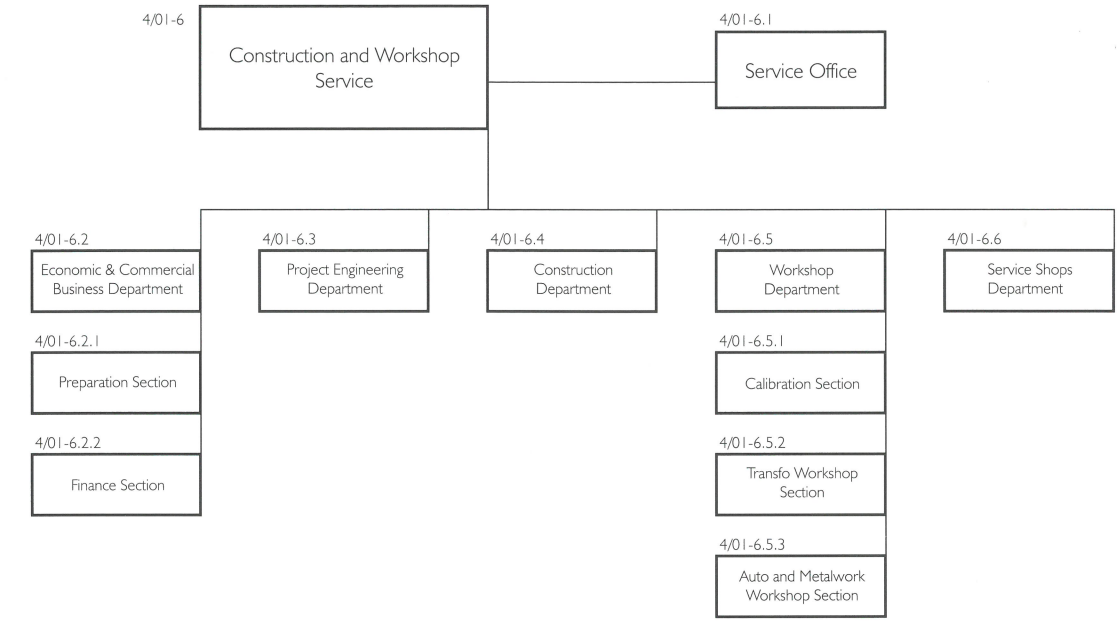


Figure 6
Construction and Workshop Service organization chart

The jobs of the Legal, Personnel and General Administrative Services are carried out in the following departments:

- Legal Department,
- Personnel Department,
- General Administrative Department

The Construction and Workshop Service performs jobs involving preparation and sales of services; management of materials, equipment and means of production; making contracts and invoicing as well as financial and accounting jobs within its activities; project engineering for construction and electrical installation works, supervisory works, geodetic works, the construction of electric power plants, public lighting and connections; measuring equipment calibration; servicing and repair of transformers and other equipment, servicing and repair of vehicles and mechanization.

The jobs of the Construction and Workshop Service are carried out in the following departments:

- Service Office
- Economic and Commercial Department
- Project Engineering Department,
- Construction Department,
- Workshop Department,
- Servicing Department.

The Business Information Services Department provides a computer support for all business activities, collects and analyzes requests from users, prepares and develops computer applications, organizes and maintains the computer support system, operates equipment exploitation and assures distribution of results.

The territorial units of the Distribution Area are:

- Plant in the headquarters,
- Plant outside the headquarters,
- Plant office.

In the Plant in the Distribution Area headquarters the following jobs are performed: supervision and control of the 10 and 0.4 kW network and plants, as well as the 35 and 110 kW ones by the order and for the needs of the

47 Heinzelova Street
The offices of Construction and Workshop Service and collection services for the western part of the City

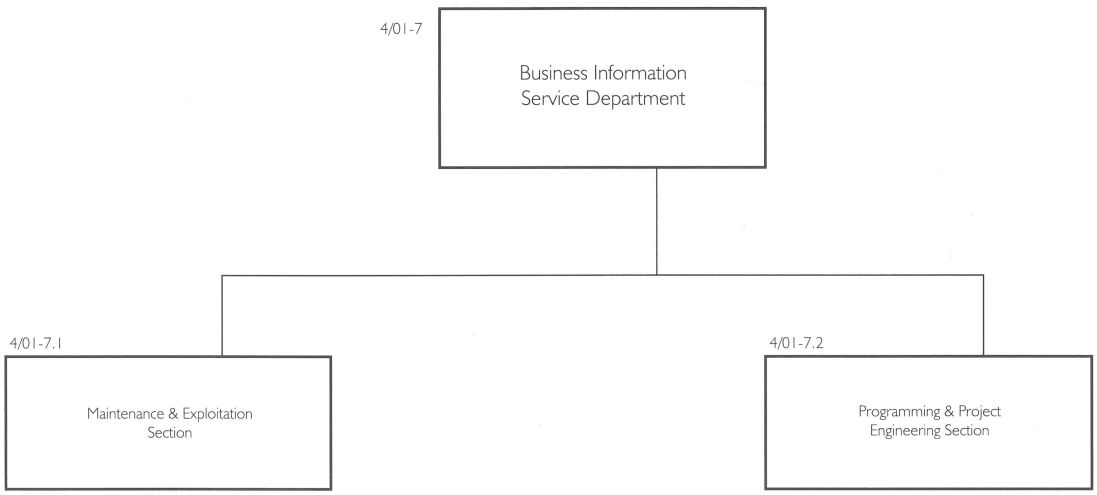


Figure 7
Business Information Systems Department organization chart

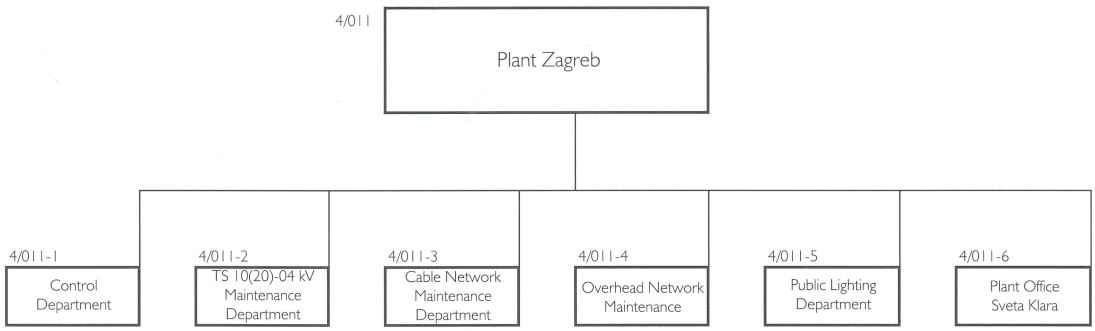


Figure 8
Zagreb Plant organization chart (incl. Plant Office Sv. Klara)

Special meters calibration

Tiskanje računa za električnu energiju

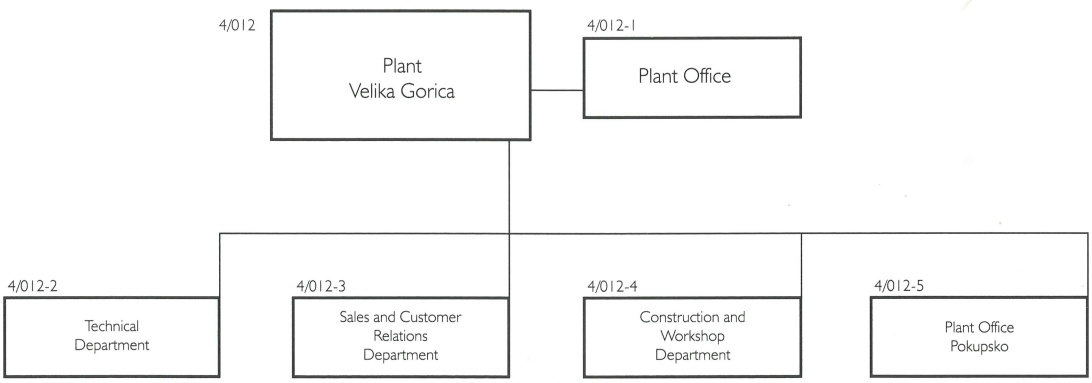
Technical Service, operational manipulations, maintenance of electric power plants and public lighting, planning of works and material needs, recording and processing of operational events, current power status monitoring and analysis, operational interventions and removal of defects.

In the Plant in the headquarters of the Distribution Area Elektra-Zagreb, the jobs are done in the following departments:

- Control Department,
- 10 (20) / 0.4 kW TS Maintenance Department,
- Cable Network Maintenance Department,
- Overhead Network Maintenance Department,
- Public Lighting Department.

In the Plant outside the Distribution Area headquarters in addition to the jobs identical to those performed in the Plant in the headquarters there are also carried out the

Figure 9
Plant Velika Gorica organization chart (incl. Plant Office Pokupsko)



Collection and Customer Relations Office in the western part of the City

defence and security jobs, economic jobs, jobs of legal, personnel and general administrative nature, sales and relations with customers, construction works and services, everything within the scope such as delegated by the corresponding Distribution Area Services.

In the Plant outside the headquarters, the jobs are carried out in the following organizational units:

- Plant Office,
- Technical Department,
- Sales and Customer Relations Department,
- Construction and Service Department.

The jobs performed in the Plant Office include control and maintenance of electric power facilities and public lighting, sales and relations with customers, as well as construction works and services, everything within the scope delegated by the parent Plant and Service in the Distribution Area.

Figure 10
Plant Dugo Selo organization chart (incl. Plant Office Vrbovec)

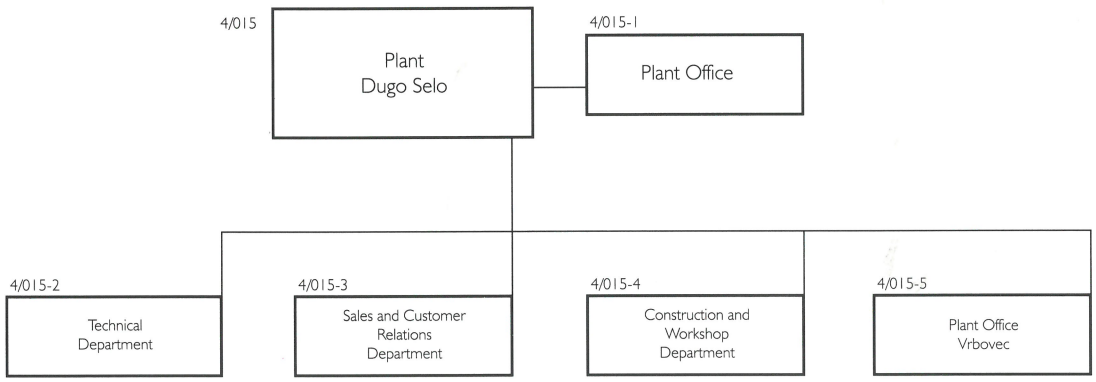
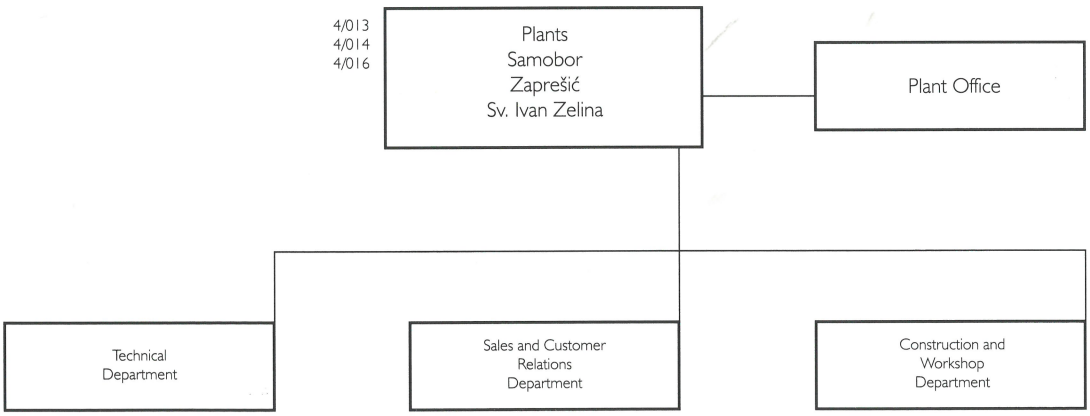


Figure 11
Plants Samobor, Zaprešić and Sv. Ivan Zelina organization chart



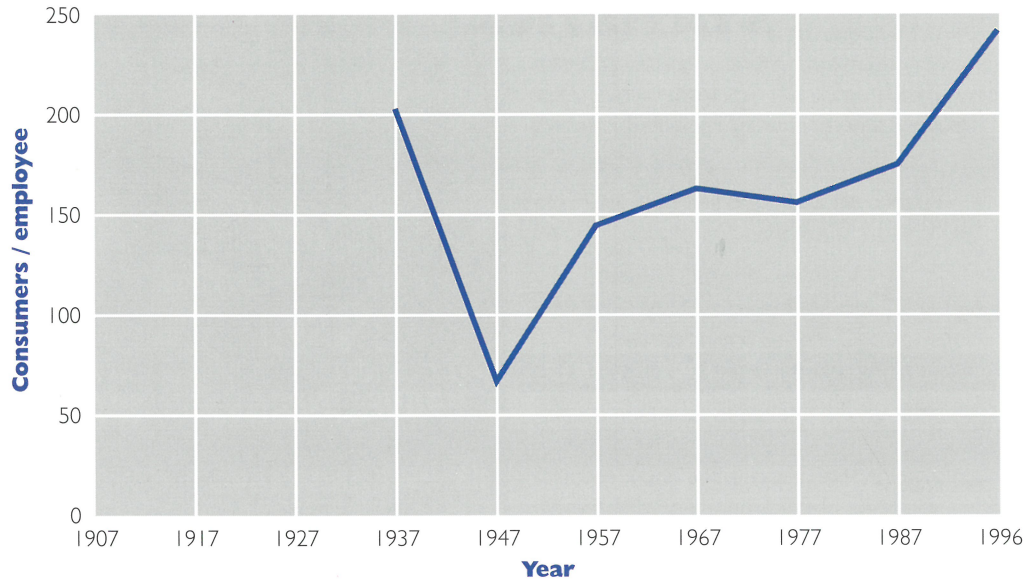
STATISTICAL DATA

Statistical data for 10-year periods

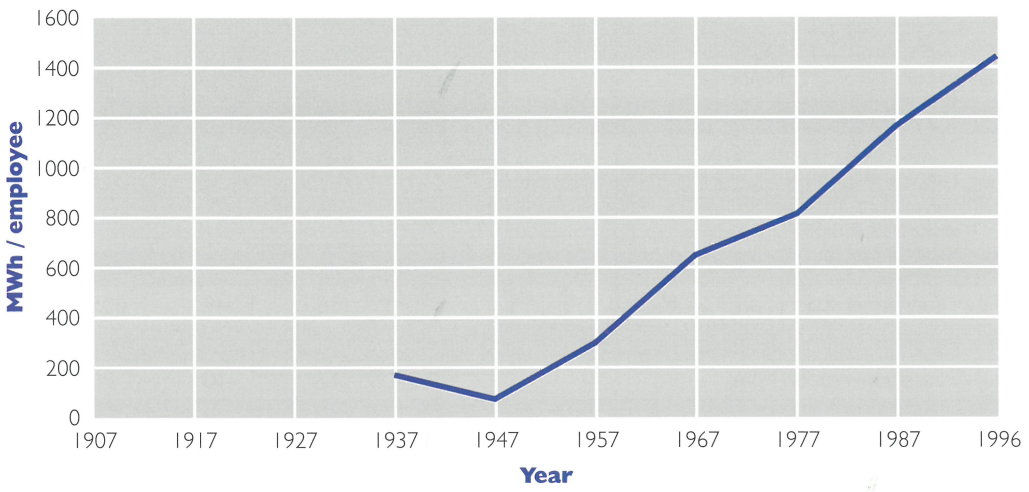
Year		1907	1917	1927	1937	1947	1957	1967	1977	1987	1996
No. of consumers					48413	84483	124481	209609	281087	362300	413139
Consumption	MWh	300	5640	15500	38860	89887	245916	811072	1442623	2376845	2506898
110 kV consumption	MWh	-	-	-	-	-	-	-	-	-	30697
30 kV consumption	MWh							123737	156657	278018	172761
10(20) kV consumption	MWh							213315	361078	587776	529717
Domestic consumption	MWh							307274	563482	1014529	1163011
Street lighting consumption	MWh							15697	39251	53773	73762
Other consumption on 0.4 kV	MWh							151049	322155	432649	536950
Purchased power	MWh					98221	290238	902810	1630478	2576977	2881779
Losses	MWh					8334	44322	91738	187855	200132	374881
Losses	%				9.66	8.48	15.27	10.16	11.52	7.77	13.01
Peak load	MW			5	15	23	63	194	340	450	576
110/x kV transformer station	pcs	-	-	-	-	-	-	-	2	11	11
30/10(20) kV transformer station	pcs				4	5	16	22	28	28	28
10(20/0.4 kV transformer station	pcs	15			156	349	605	1225	1873	2564	2794
110/x kV transformer station	MVA	-	-	-	-	-	-	-	120	380	620
30/10(20) kV transformer station	MVA				12	10	96	259	413	512	529
10(20/0.4 kV transformer station	MVA				38	80	128	424	840	1255	1384
Total MVA	MVA				50	90	224	683	1373	2147	2533
110 kV underground cables	km	-	-	-	-	-	-	-	-	3.6	3.6
110 kV overhead lines	km	-	-	-	-	-	-	-	38.5	44.0	44.0
30 kV underground cables	km					13.9	18.5	64.7	161.9	194.2	202.1
30 kV overhead lines	km					124.1	135.0	144.5	141.5	188.7	184.3
20 kV underground cables	km	-	-	-	-	-	-	-	120.0	374.0	836.3
20 kV overhead lines	km	-	-	-	-	-	-	-	-	124.9	746.7
10 kV underground cables	km					160.3	198.4	404.1	904.9	895.6	782.1
10 kV overhead lines	km					236.5	500.1	708.3	1052.3	1228.0	732.3
0.4 kV underground cables (with conn.)	km				363*	307.7	295.8	523.5	883.4	1635.5	2092.9
0.4 kV overhead lines (with conn.)	km				420*	530.5	1914.1	3512.0	5133.6	6632.3	7288.6
Total conductors	km				783	1373.0	3061.9	5357.1	8436.1	11330.8	12912.9
Employees					237	1299	878	1271	1777	2092	1740
MVA/MW					3.3	3.9	3.6	3.5	4.0	4.8	4.4
MWh/km					49.6	65.5	80.3	151.4	171.0	209.8	194.1
MWh/employee					164.0	69.2	280.1	638.1	811.8	1136.2	1440.7
km/employee					3.3	1.1	3.5	4.2	4.7	5.4	7.4
No. of consumers/employee					204.3	65.0	141.8	164.9	158.2	173.2	237.4

**total length of HV and LV overhead lines and underground cables*

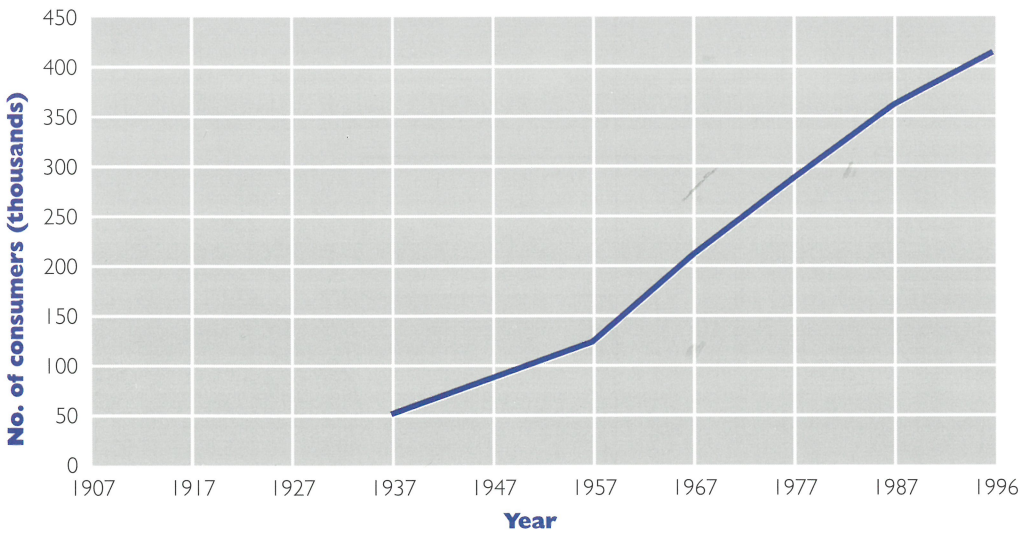
Consumers per employee



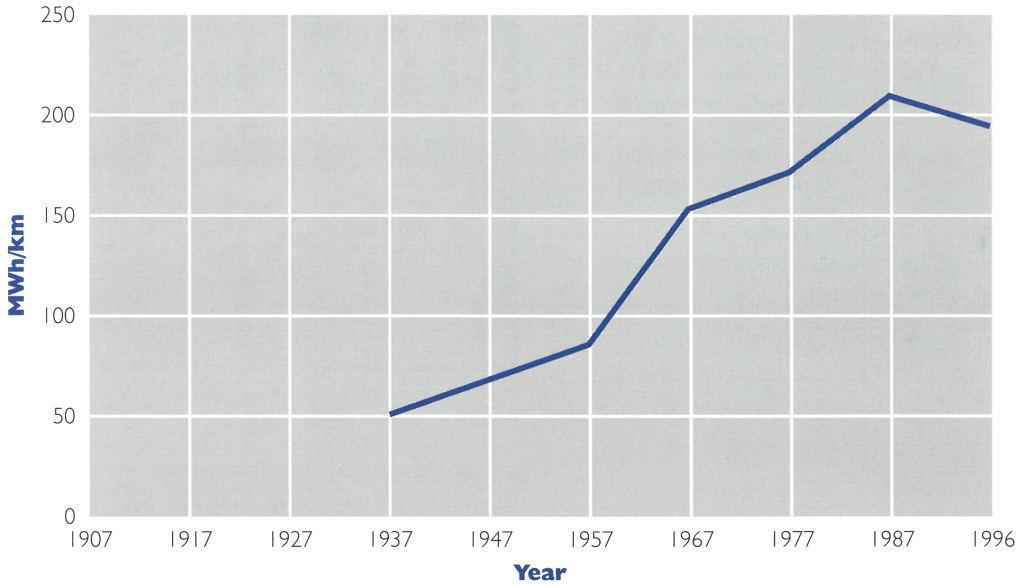
Consumption per employee (MWh / employee)



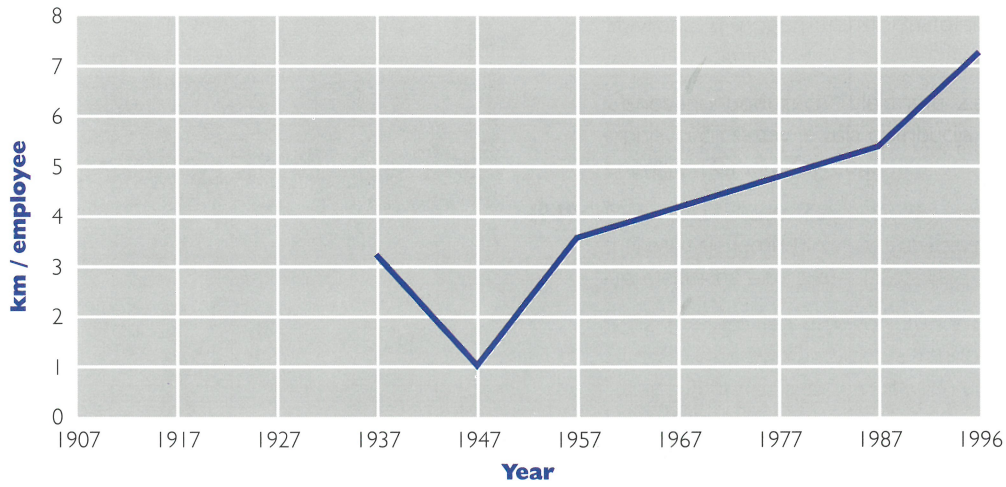
No. of consumers



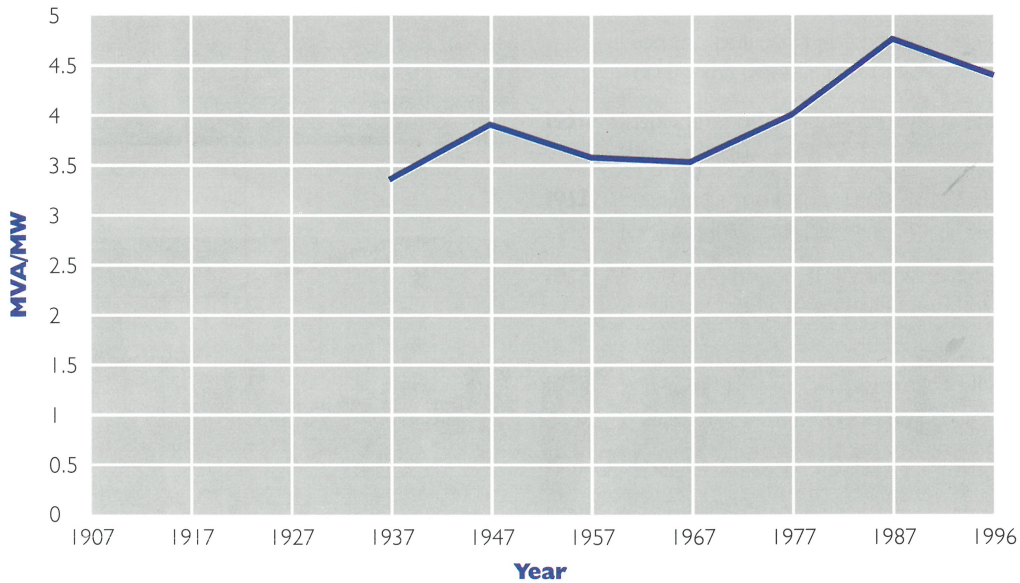
Consumption per km of grid (MWh/km)



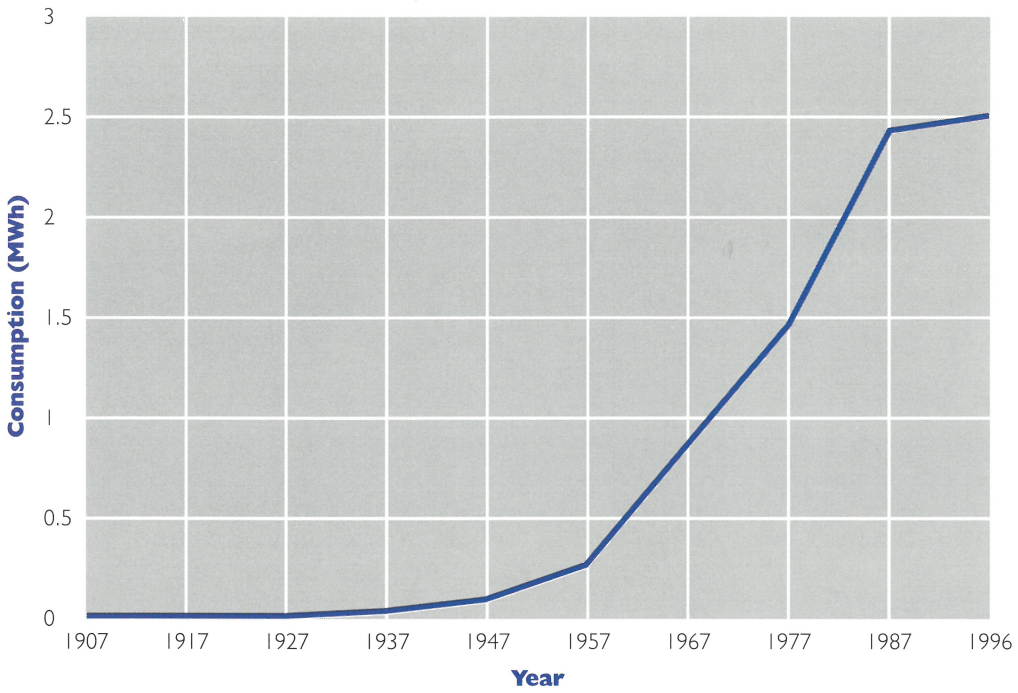
Grid length per employee (km/employee)



Installed transformation power per MW of load (MVA/MV)



Consumption (MWh)



Handling 30 m ladder

Connecting LV grid cables

Year		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Power purchase	MWh	-	-	-	-	2.573.399	2.611.719	2.635.334	2.634.044	2.772.436	2.881.779
Increase rel. to previous year	%	-	-	-	-	-	1.49	0.90	-0.05	5.25	3.94
Power sales - - consumption	MWh	2,366,845	2,362,884	2,390,232	2,357,153	2,289,206	2,310,941	2,290,221	2,314,623	2,464,054	2,506,898
Increase rel. to previous year	%	4.13	-0.17	1.16	-1.38	-2.88	0.95	-0.90	1.07	6.46	1.74
Losses	%	-	-	-	-	11.04	11.52	13.1	12.13	11.12	13.01
Maximum load	MW	-	-	-	-	500	513	497	513	535	576

Year		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Power purchase	MWh	2,081,117	2,086,849	2,105,369	2,082,258	2,059,707	2,087,624	2,099,966	2,092,094	2,173,920	2,259,540
Increase rel. to previous year	%	-	0.28	0.89	-1.1	-1.08	1.36	1.00	-0.37	3.91	3.94
Power sales - - consumption	MWh	1,927,101	1,922,213	1,955,018	1,916,976	1,842,120	1,863,972	1,839,483	1,861,139	1,942,716	1,993,819
Increase rel. to previous year	%	3.9	-0.25	1.71	-1.95	-3.91	1.19	-1.31	1.2	4.38	2.63
Losses	%	8	7.9	7.1	7.94	10.56	10.71	12.4	11.04	10.64	11.76
Maximum load	MW	403	384	426	445	420	433	423	423	443	454

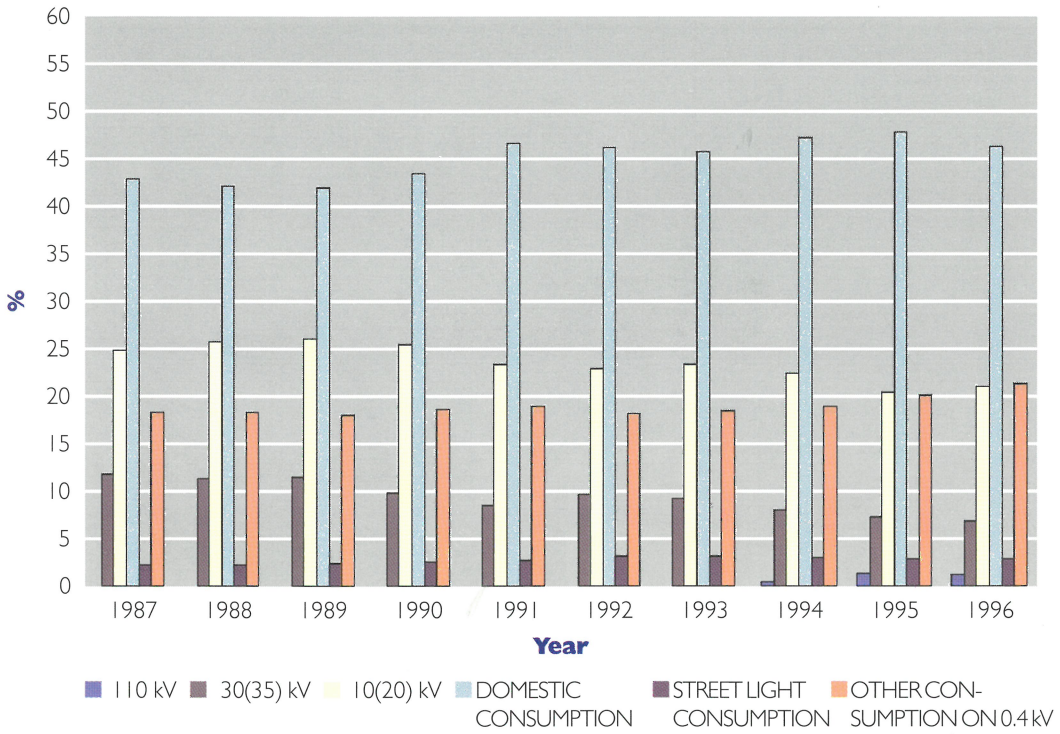
		DUGO SELO	SAMOBOR	SV. I. ZELINA	V. GORICA	ZAPREŠIC
Power purchased in 1987-96	MWh	77516/94966	130000/152000	43600/82600	114800/174000	150851/149604
Total consumers in 1987-96		14074/17048	14500/19800	13489/15459	21981/26890	16117/18946
Domestic consumers in 1987-96		12935/15579	13300/17941	12550/14173	20586/25013	15169/17484
Employees in 1987-96		75/72	70/67	75/79	76/86	77/76
110 kV transformer stations	pcs	1	1	1	1	1
30-35 kV transformer stations	pcs	2	3	3	-	2*
10-20 kV transformer stations	pcs	223	228	224	244	214
35 kV overhead lines	km	33	16	57	-	9
35 kV underground lines	km	0.3	-	2	-	4
10-20 kV overhead lines	km	207	165	225	347	196
10-20 kV underground lines	km	51	60	5	111	41
0,4 kV overhead lines	km	434	344	524	634	416
0,4 kV underground lines	km	-	22	4	52	29
0.4 kV overhead connections	km	313	269	338	433	342
0.4 kV cable connections	km	-	174	43	52	54
Street lighting	km	17	12	1.2	xx	16

*One 20/6 kV TS xx N.A.

1997 Burza Square

1997, grid reconstruction at Ante Starčević Square

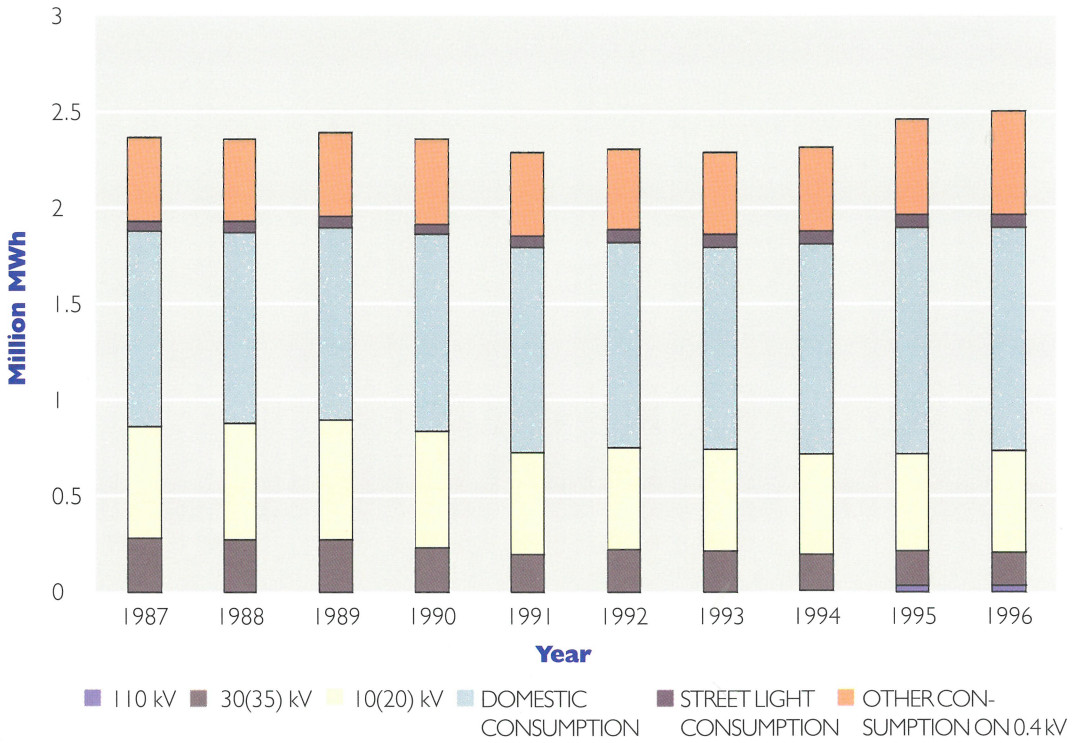
POWER CONSUMPTION STRUCTURE AT THE ELEKTRA ZAGREB DISTRIBUTION AREA

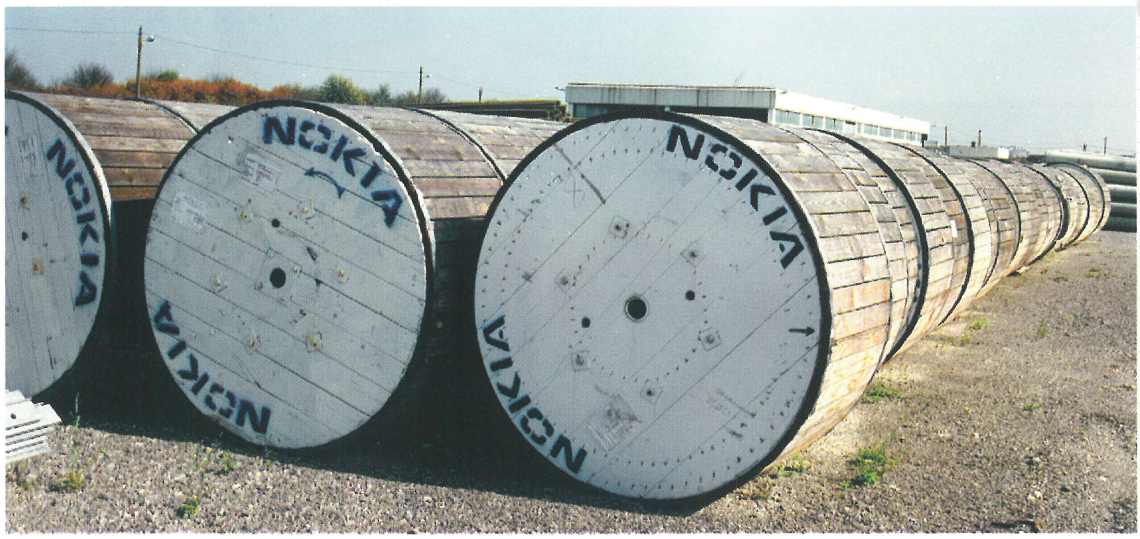


POWER CONSUMPTION (MWh)	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
110 kV										9.111	34.350	30.697
30 (35) kV	260,274	269,857	278,018	270,139	273,499	232,930	192,921	223,304	211,667	185,461	178,179	172,761
10(20) kV	529,874	564,342	587,876	608,820	621,458	600,854	532,848	527,485	533,969	520,685	503,342	529,717
DOMESTIC CONSUMPTION	958,887	990,384	1,014,529	996,485	1,004,495	1,025,638	1,066,875	1,066,477	1,047,401	1,093,275	1,179,892	1,163,011
STREET LIGHTING CONS.	49,131	48,444	53,773	55,488	58,412	59,182	63,424	73,085	72,114	68,446	71,654	73,762
OTHER CONS. ON 0.4 kV	382,191	399,977	432,649	431,952	432,368	438,549	433,138	420,590	425,070	437,645	496,637	536,950
TOTAL	**2,180,357**	**2,273,004**	**2,366,845**	**2,362,884**	**2,390,232**	**2,357,153**	**2,289,206**	**2,310,941**	**2,290,221**	**2,314,623**	**2,464,054**	**2,506,898**

CONSUMPTION BREAKDOWN (%)	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
110 kV										0.39	1.39	1.22
30(35) kV	11.94	11.87	11.75	11.43	11.44	9.88	8.43	9.66	9.24	8.01	7.23	6.89
10(20) kV	24.30	24.83	24.84	25.77	26.00	25.49	23.28	22.83	23.32	22.50	20.43	21.13
DOMESTIC CONSUMPTION	43.98	43.57	42.86	42.17	42.03	43.51	46.60	46.15	45.73	47.23	47.88	46.39
STREET LIGHTING CONS.	2.25	2.13	2.27	2.35	2.44	2.51	2.77	3.16	3.15	2.96	2.91	2.94
OTHER CONS. ON 0.4 kV	17.53	17.60	18.28	18.28	18.09	18.61	18.92	18.20	18.56	18.91	20.16	21.42
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

POWER CONSUMPTION AT THE ELEKTRA ZAGREB DISTRIBUTION AREA

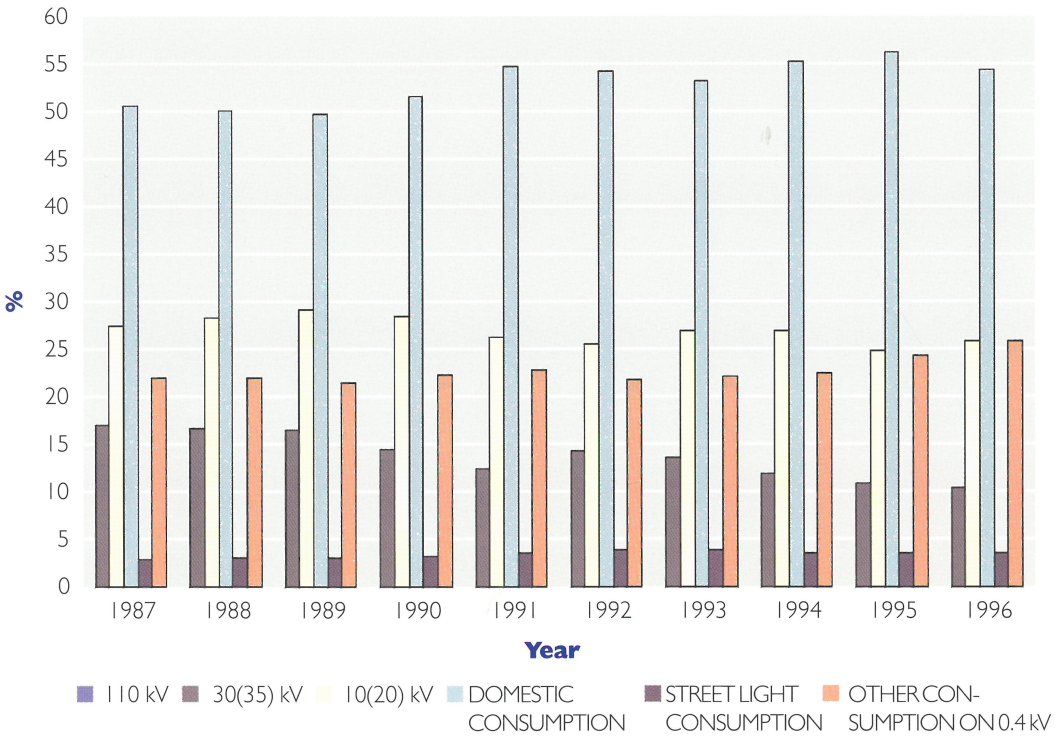




Cables in Velika Gorica warehouse

INCREASE REL. TO PREVIOUS YEAR (%)	85/84	86/85	87/86	88/87	89/88	90/89	91/90	92/91	93/92	94/93	95/94	96/95
110 kV											277.02	-10.63
30(35) kV		3.68	3.02	-2.83	1.24	-14.83	-17.18	15.75	-5.21	-12.38	-3.93	-3.04
10(20) kV		6.50	4.17	3.56	2.08	-3.32	-11.32	-1.01	1.23	-2.49	-3.33	5.24
DOMESTIC CONSUMPTION		3.28	2.44	-1.78	0.80	2.10	4.02	-0.03	-1.79	4.38	7.92	-1.43
STREET LIGHTING CONS.		-1.40	11.00	3.19	5.27	1.32	7.17	15.23	-1.33	-5.09	4.69	2.94
OTHER CONS. ON 0.4 kV		4.65	8.17	-0.16	0.10	1.43	-1.23	-2.90	1.07	2.96	13.48	8.12
TOTAL		**4.25**	**4.13**	**-0.17**	**1.16**	**-1.38**	**-2.88**	**0.95**	**-0.90**	**1.07**	**6.46**	**1.74**

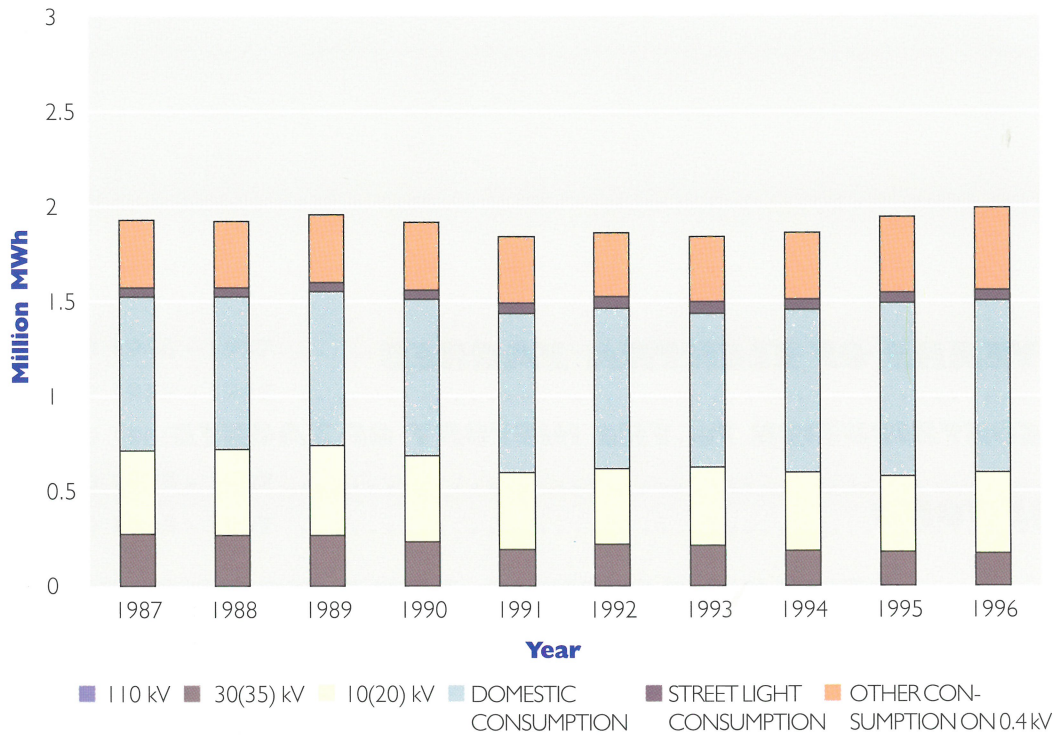
POWER CONSUMPTION STRUCTURE IN THE CITY OF ZAGREB (ZAGREB DIVISION)



POWER CONSUMPTION (MWh)	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
110 kV											
30 (35) kV	266,010	274,306	266,643	270,391	230,219	191,232	221,897	210,227	184,512	177,062	171,591
10(20) kV	416,261	440,518	453,301	473,431	454,097	403,363	398,218	412,383	416,406	402,470	429,189
DOMESTIC CONSUMPTION	804,874	812,923	802,610	809,579	825,161	841,093	842,395	816,219	856,227	911,062	902,058
STREET LIGHTING CONS.	42,214	47,165	47,938	50,157	51,099	54,726	61,298	59,981	55,789	57,862	59,549
OTHER CONS. ON 0.4 kV	325,937	352,186	351,721	351,100	356,400	351,706	340,164	340,673	348,205	394,260	431,432
TOTAL	**1,855,296**	**1,927,098**	**1,922,213**	**1,954,658**	**1,916,976**	**1,842,120**	**1,863,972**	**1,839,483**	**1,861,139**	**1,942,716**	**1,993,819**

CONSUMPTION BREAKDOWN (%)	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
110 kV											
30(35) kV	14.34	14.23	13.87	13.83	12.01	10.38	11.90	11.43	9.91	9.11	8.61
10(20) kV	22.44	22.86	23.58	24.22	23.69	21.90	21.36	22.42	22.37	20.72	21.53
DOMESTIC CONSUMPTION	43.38	42.18	41.75	41.42	43.04	45.66	45.19	44.37	46.01	46.90	45.24
STREET LIGHTING CONS.	2.28	2.45	2.49	2.57	2.67	2.97	3.29	3.26	3.00	2.98	2.99
OTHER CONS. ON 0.4 kV	17.57	18.28	18.30	17.96	18.59	19.09	18.25	18.52	18.71	20.29	21.64
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

POWER CONSUMPTION IN THE CITY OF ZAGREB (ZAGREB DIVISION)



GPS device (satellite global positioning system)

INCREASE REL. TO PREVIOUS YEAR (%)	86/85	87/86	88/87	89/88	90/89	91/90	92/91	93/92	94/93	95/94	96/95
110 kV											
30(35) kV	3.50	3.00	-2.80	1.41	-14.86	-16.93	16.04	-5.26	-13.25	-4.04	-3.09
10(20) kV	5.80	5.80	2.90	4.44	-4.08	-11.17	-1.28	3.56	0.98	-3.35	6.64
DOMESTIC CONSUMPTION	4.60	1.10	-1.30	0.87	1.92	-0.93	0.16	-3.11	4.90	6.40	-0.99
STREET LIGHTING CONS.	-2.50	11.90	1.60	5.38	1.15	7.09	12.01	-2.15	-6.99	3.72	2.92
OTHER CONS. ON 0.4 kV	4.00	8.30	-0.10	-0.18	1.15	-1.32	-3.28	0.15	2.21	13.23	9.43
TOTAL	**4.30**	**3.90**	**-0.25**	**1.71**	**-1.95**	**-3.91**	**1.19**	**-1.31**	**1.18**	**4.38**	**2.63**

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