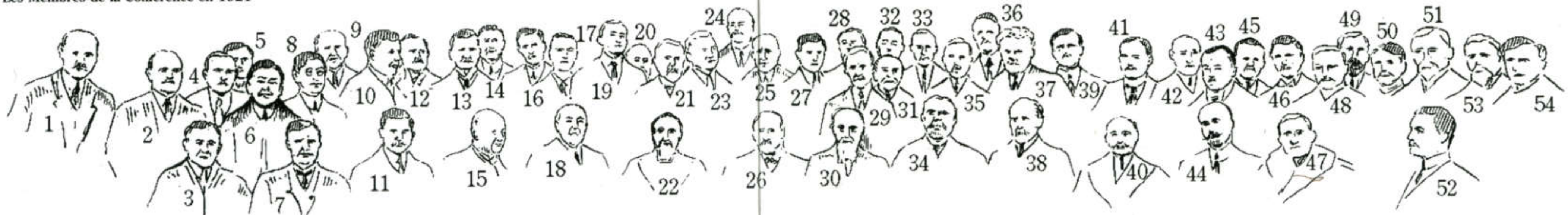
The History of CIGRE
(International Council on Large Electric Systems)

A key player in the development of electric power systems since 1921

CIGRE

Les Membres de la Conférence en 1921



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«Not enjoyment, and not sorrow,
Is our destined end or way;
But to act, that each tomorrow
Find us farther than today.»

Henry Wadsworth Longfellow
A Psalm of Life

Foreword

This year we celebrate the ninetieth anniversary of CIGRE, the International Council on Large Electric Systems, created during a meeting of 231 electrical engineers from 12 countries which took place in Paris in November 1921. This is indeed an appropriate occasion to confirm that we remain faithful to the work of the pioneers of 1921 and continue to cherish the values that CIGRE has upheld for almost a Century.

Aiming to develop and exchange technical information on electric power systems, CIGRE has always felt closely associated with the values of cooperation, impartiality and service. These values underline the meaning of our logo, a flash of lightning over the globe, symbolizing the domestication of electricity for the benefit of mankind.

In this perspective, the efforts in which I was involved together with my fellow CIGRE officers since I was elected Technical Committee Chairman in 1996 had the objective of further enhancing the role and international visibility of CIGRE through actions aimed towards the adaptation, modernization and strengthening of our organization. As President of CIGRE since 2008, I am delighted to see today how such actions have borne fruit, leading to a very significant increase in our membership and a particularly remarkable growth in Asia and Latin America.

While continuing to look towards the future we must however also take into account the memory of our past, highlighting the value of our heritage and promoting a culture elaborated by several generations of Cigreans. It is therefore appropriate for CIGRE to reflect on a journey of nine decades and provide testimony to the solid establishment of the CIGRE spirit.

Such is the objective, at once simple and ambitious, of this book, which, beyond outlining the fascinating history of our organization and our community, constitutes a confirmation of the important role CIGRE has played and intends to continue to play.

Electrification has been elected as one of the greatest engineering innovations of the 20th Century by the U.S. National Academy of Engineering and must continue to be one of the main vectors of progress in the 21st Century. Today a quarter of mankind still lacks access to electricity and many have only limited use of it : the nocturnal map of the Earth chosen as a cover for the book highlights this profound disparity.

Through its wide ranging technical activities, the increasing success of its Sessions, the work of its Study Committees and the relevance of its publications, CIGRE

continues to demonstrate its invaluable contribution to the development of electric power systems and hence to the betterment of life on our planet.
Looking forward, the worldwide growth of the electricity sector through the development of more intelligent and more powerful networks will constitute a major strategic axis for CIGRE activities in the years to come.
I thank the historian Christophe Bouneau for bringing back to life ninety years of a history so diversified and complex as that of CIGRE, highlighting both its technical and organizational dimensions as well as the place of CIGRE in the international history of electric power systems.
I also thank the International Committee that guided the preparation of this book with the coordination of Aldo Bolza and the cooperation of former Presidents of CIGRE Jerzy Lepecki and David Croft, of Virginia Sulzberger, of Professor Yasuji Sekine and of Vjacheslav Ishkin, regrettably departed.
Christophe Bouneau and the international Committee also benefited from the contribution of Secretary Generals Jean Kowal and François Meslier, of Liliane Ney, and of a working group of the French National Committee led by Philippe Adam.
In conclusion, my wish is that this reflection on our common heritage and rich experience of ninety years of history may become a springboard for the further development of CIGRE in the years to come.

André MERLIN
President of CIGRE

INTRODUCTION

Since its creation in 1921 CIGRE's fundamental role has always been to bring together an extremely varied community of players, both professionally and geographically, in the power system industry with the essential principle of constantly ensuring its international character. Through its expertise, sustained by the discussions and exchanges of views that it invites, its priority aim is to determine the best possible technical and economic conditions of the electricity transmission and interconnection service, from the power plants that generate electricity to the transformers from which it is distributed to its users.

From the 1880s, firstly in North America and in Europe, electricity established itself as a remarkable medium for distributing the energy produced in power plants. With the increase in size of hydraulic or thermal power stations which followed, illustrating the economic laws of an industry with increasing efficiencies, electricity gradually demonstrated to the served communities the comparative advantages of a multi-purpose and infinitely divisible form of energy, and therefore its greater ease and variety of use, particularly in relation to gas. However, this new form of energy only finally triumphed over the gas economy in North America in the 1900s and in Europe a decade later, during the Great War, which generally played a catalyst role.

From 1921, under the impetus of the industries concerned –system operators and equipment manufacturers – and initially under the aegis of the IEC *(International Electrotechnical Commission)*, a *"Conférence Internationale des Grands Réseaux Electriques à Haute Tension"* - International Conference on Large High Voltage Systems – commonly known as CIGRE was set up. Then, in the early 1930s, it was transformed quite rapidly into a permanent association. In 2000, it became the *"Conseil International des Grands Réseaux Electriques"* – that is, the International Council on Large Power systems – without changing its acronym (CIGRE) or profoundly modifying its method of operation.

Since then, without interruption, except during the Second World War[1], CIGRE, an international non-government Organization for technical cooperation, has

1- However, the activity of the Paris office was partially maintained during the Second World War.

provided a forum for pooling extensive, diversified and scientific technical knowledge, experience and feedback in various fields for all its members. These fields, which correspond to Study Committees with carefully defined areas of expertise[2], cover the following subjects:

- high voltage high power equipment and structures,
- protection devices, automatic systems, information systems and decision aid systems, essential for operating and running complex power systems, with closely interlinked and interdependent components,
- planning of large power systems, "living" organisms that must continually adapt to developing needs and social and environmental requirements, by rigorously applying existing technical progress and innovations.

CIGRE's aim has remained constant since its foundation in 1921: to search and/or define best practices for the planning, design, construction and operation of electricity transmission and interconnection systems, as well as the equipment, structures, automatic systems and monitoring and control systems used. The resulting information should allow interested parties to refer to these best practices according to their own specific geographic, economic and institutional situations, constraints and requirements.

The international extension of CIGRE's organization was continuous, as evidenced by the founding members and then by the growth of its membership beyond the initial core from North America, Europe and Japan. New countries joined, such as Brazil and Australia, as well as a very wide variety of developing countries, so that, from the 1970s, CIGRE reflected a global image of the world power industry[3]. From 19 member countries in 1923, CIGRE expanded to 45 countries in 1970 and 89 in 2010. This fourfold expansion reflected the strengthened identity and even emergence of new Nation States.

The extension beyond national boundaries undeniably strengthens the international legitimacy of an Organization such as CIGRE, which is continually seeking to improve the management of large power systems.

CIGRE's history is a response to clear problematics which, however, apply to a complex process.

For almost a Century now, in very different international contexts (world conflicts and the Cold War, the emergence of a multipolar world with new major powers, cycles of economic crisis and growth, cycles of technological and organizational innovation, and the dynamics of regulation, deregulation and re-regulation), how could CIGRE, an international non-profit non-government

2 - See Appendix 3
3 - As shown in Appendix 6

Organization for technical cooperation, contribute effectively and concurrently to the following?

- organising an international professional community of electrical engineers, while gradually widening its scope to lines of work and areas of expertise in both the upstream and downstream phases of power transmission systems;
- providing a forum for pooling scientific and technical information, experience and feedback concerning high voltage, in close coordination with the other major technological systems and sectors (telecommunications, electronics and information technology);
- orienting, through debates, forums and recommendations, the development and operation of large power systems, their planning, their management and the prevention of large disturbances.

How did CIGRE succeed in being of invaluable assistance to all those who, with very different technical expertise and lines of business, work together in the design and operation of large power systems, which are infrastructures of vital importance for all developed or developing communities?

These are the essential questions – concerning the past, present and future – which the following pages, set out in four Parts and in a mainly historical approach will attempt to answer.

Figure 1 - The founding congress in 1921

PART ONE:

Between David and Goliath:

the beginning of power transmission and power systems from the 1880s to the 1920s

The birth of the electric energy transmission industry and sector in the late 19th Century, from the 1880s to the First World War, rapidly became the subject of dialogue – or rather, confrontation – between David and Goliath. The inception of the electricity system and economy in North America and Europe gradually witnessed the emergence of a specific power transmission function and the construction of the first power systems. This took place initially on an urban scale and, as a priority, to supply large Western cities and conurbations of sufficient size that allowed adequate revenues for distributors.

As suggested in the title of this first Part, the dominant rationale was that of an immediate confrontation between a micro-economic approach, driven by the companies, the local government authorities and the sectorialization of business activities, and a macro-economic approach, driven by the expansion and the externalities of a new industrial system and/or State intervention.

Chapter I:

Electricity distributed by a grid system, a lever of the second industrial revolution (1880-1914).

After the electric telegraph, electro-plating and the first arc lamp lighting systems, electric technology entered a new historical phase of outstanding acceleration in the last quarter of the 19th Century. With limited yet important uses, electricity extended its possibilities through the discoveries made by scientists and technicians, but also by inventor-entrepreneurs. In 1884, however, in a French dictionary of industry and industrial techniques, electricity was still presented as an "extraordinary, little-known force, which is still so poorly controlled, so excessive and so enormous, but which has the aim of substituting mechanical action for the free action of the individual". Nevertheless, less than twenty years later, in the North American Review in 1901, H.G. Wells developed a complete vision of the future Century of electricity, when factories would operate and would be heated and ventilated by means of electricity, as would people's homes.

TABLE 1: The scientific foundations of electricity in the 19th Century - milestones

1800	Alessandro Volta (Italy) invents the electric battery cell.
1820	André-Marie Ampère (France) states the fundamental laws of electromagnetism.
1821	Thomas Johann Seebeck (Germany) discovers thermoelectricity. Michael Faraday (England) produces electro-magnetic rotation of a conductor or a magnet.
1822	Peter Barlow (England) invents the Barlow Wheel, considered the first electric motor.
1827	Georg Simon Ohm (Germany) states the fundamental law of electric currents, defining the concept of resistance.
1831	Michael Faraday discovers the laws of electromagnetic induction and creates the first direct current generator.
1832	Samuel Morse (America) designs the electric telegraph.
1839	Antoine Becquerel (France) invents the photovoltaic cell.
1851	Heinrich Ruhmkorff (Germany) makes the induction coil that is named after him.
1855	Léon Foucault (France) discovers currents induced in metal masses.
1859	Gaston Plant (France) invents the electric accumulator cell (or storage battery).
1860	Antonio Pacinotti (Italy) produces a dynamo prototype known as Pacinotti's Ring
1865	James Maxwell (Scotland) establishes a comprehensive theory of electromagnetic waves, for which he succeeded in demonstrating the relation with light waves.
1866	Werner von Siemens (Germany) invents auto-excitation of the dynamo, under the term «dynamo-electric principle».
1867	Sir William Thomson (Lord Kelvin) invents the quadrant electrometer.
1869	Zénobe Gramme (Belgium) invents the dynamo that is named after him.
1873	Hippolyte Fontaine (France) produces the first electrical power transmission (applying the principle of reversibility of Gramme's dynamo) in Vienna.
1876	Alexander Graham Bell (USA) registers his patent for a "speaking telegraph" just before his compatriot Elisha Gray. Paul Jablochkoff (Russia) invents the "candle" that is named after him; his lighting system is installed the following year on Place de l'Opéra in Paris.

It is a fact that in the overall context of the second industrial revolution, in North America and in Europe, electricity was at the core of a new wave of innovation from the end of the 1870s. This has continued to the present day in the form of cycles, combining high and low currents, while its omnipresence and its very wide distribution have increased its apparent discretion, or even its "invisibility", in the industrial world.

In the late 19th Century, because of its numerous applications and the radical changes necessary for the organization of consumption and generation, electric energy was rapidly seen as the central element of a new technological system and a new industrial rationale. Thus it became the "fluid" of developed societies.

For the industrialist, electricity had a major competitive advantage in relation to steam: its transmissibility. In this form, energy could be transmitted and could supply an area that was separate from its place of generation. By combining innovations of products and of technical processes, electricity was also an effective factor of organizational and commercial innovations.

The initial expansion of direct current and the spread of the Edison system

Zénobe Gramme (Belgium) developed the industrial dynamo in 1869-1871 with his two first prototypes. But the future of the "Gramme Machine" would certainly have remained limited if Hippolyte Fontaine had not discovered in 1873 that it was reversible: that is, from being a generator of direct current, it could become an electric motor supplying mechanical energy, capable of replacing the steam machine in production workshops.

But the man who by the invention, innovation and industrial and commercial diffusion of a first complete system, created a spectacular expansion of the direct current technology on the international scale in the early 1980s, was Thomas Alva Edison (USA), nicknamed the "Wizard of Menlo Park".

TABLE 2: The formation of the electricity industry: a major cluster of innovations from 1878 to 1888

1878	First commercial use of Charles F. Brush's (USA) arc lamp in New York. Thomas A. Edison and Joseph Swan (UK) both separately invent the incandescent lamp.
1879	Werner von Siemens builds the first electric locomotive, which he presents at the Berlin Trade Fair, and he carries out experiments with the electric furnace.
1881 1882	First International Electricity Exhibition in Paris. First trolley electric tramways opened by Siemens in the area around Berlin. Nikola Tesla, born in present-day Croatia, discovers the rotating field phenomenon. Thomas Edison operates the first steam-powered central station: Pearl Street in New York.
1883	Thomas Edison registers a patent for his 3-wire distribution system.
1881-1884	Lucien Gaulard (France) and John Dixon Gibbs (UK) define the principle of the «secondary generator», called the electric transformer.
1886	Paul Héroult (France) develops the manufacture of aluminium by electrolysis. At the same time, American Charles M. Hall registers an identical patent. William Stanley applies the USA's first alternating current distribution system in Great Barrington, Massachusetts, while Sebastian Ziani of Ferranti builds Europe's first high voltage alternating current power plant in London. Franck-J. Sprague electrifies 13 miles of hippomobile rails in the area around Richmond, Virginia, USA.
1887	George Westinghouse (USA) obtains a patent for his transformer built on the same bases as that by Lucien Gaulard and John Gibbs. Heinrich Rudolf Hertz (Germany) demonstrates the existence of electromagnetic waves and illustrates Maxwell's theory of 1864-1865.
1888	Galileo Ferraris (Italy) and Nikola Tesla each separately produce an industrial alternating current induction motor. Tesla had registered a series of patents for the distribution of alternating electric current.

Thomas Edison was singled out firstly from the early 1870s as a specialist of telegraph systems, particularly for the Stock Market, with the development of "multiplex" telegraphy for sending several messages at the same time, and a teleprinter which immediately earned him a real fortune. In 1876, he chose to become an independent inventor and started to look for a place to set up an "invention factory". He chose Menlo Park, an isolated place suitable for reflection, between New York and Philadelphia. The buildings were gradually extended as his research took new directions and new innovation clusters developed. Thus, from 1878 to 1882, while Edison was concentrating on developing a complete, consistent electricity system, sheds were built for making incandescent lamps and carbon filaments. With the help of a remarkable team consisting of the best specialists, his fundamental originality and his basic competitive advantage were that he was a comprehensive inventor-entrepreneur who kept a very close watch simultaneously on questions of funding, publicity and, finally, market.

Thanks to his experience of the telegraph, Edison had become a general expert in electricity. From 1878, he addressed the issue of incandescence. He decided to use long, thin filaments supplied with low voltages in a vacuum. On 21 October 1879, a carbonised piece of Japanese bamboo was used for observing and admiring for the first time the basic element of a new world: the electric lamp. Other substances were later adopted: firstly vegetable materials, then metals. At the same time, on the other side of the Atlantic, the Englishman Joseph Swan continued to claim that he himself had invented the incandescent lamp. This claimed concomitance evidences a common process of international competition and confrontation which, until the present day, has characterised the history of science and technology, and particularly electricity and its industrial applications.

Figure 2 - Thomas Edison as a young man and later in his laboratory in the early 1920s

Edison immediately conducted a survey on the gas lighting system in the Wall Street neighbourhood to determine the characteristics of an artificial lighting market. In the autumn of 1878, with the help of a financial backer, he founded the Edison Electric Light Company, to which, for five years, he brought all his patents for electric lighting and motors. Other companies were quickly founded to create a coherent system: the Edison Electric Illuminating Company of New York founded in 1880 for the first "central power station", Edison Machine Works in 1881 for building generators, Edison Lamp Works (1880) and the Edison Electric Tube Company (1881) for underground distribution. One may say that, as from September 1882, a complete electricity distribution system had been conceived, patented and tested on a small scale in Menlo Park, before being extended in the next few months to New York (with the Pearl Street power plant in the Wall Street neighbourhood, originally with 400 lamps and 59 customers) and to the entire United States and then, within a few years, to the whole world. Thomas Edison continued his work as an inventor practically until his death in 1931, but virtually all his inventions in the innovation clusters in the electricity sector were earlier than 1882. In fact, in 1886, he left the sanctuary of Menlo Park and sold his shares in the capital of the electricity companies that he had founded. In 1892, Edison General Electric became the American and multinational giant, General Electric, which, on several occasions in the past and up to the present day, showed the world's greatest stock market capitalization.

The main commercial competitive advantage of Thomas Edison's company, represented by his motto "The System first", was that he had cleverly designed and marketed a complete direct current industrial system, from the generator to the most varied uses. It was indeed a comprehensive electrical innovation, combining innovations of products and of technical processes, but also – decisively – organizational and commercial innovations. Already before 1885, Thomas Edison had registered almost five hundred patents, but this pioneer of a new world led by the United States had to gradually give way to the emergence and expansion of the competing system, that of alternating current, and particularly three-phase alternating current.

The international buoyancy of the Westinghouse system and the triumph of alternating current

Thomas Edison's main competitor was the American inventor-entrepreneur George Westinghouse. The technical and industrial competition was international from the outset, beyond just the American market, which was after all the first electricity industry and the first electricity market on the world scale in the 1880s. George Westinghouse first started business in the 1870s, on the American scale, but very rapidly at an international level, in the strategic sector of safety technologies, in which he formed a first industrial empire. He invented and developed the first compressed air brakes, a series of automatic railway signals and a system for safely conveying natural gas. In 1884, however, understanding full well the considerable opportunities of this leading sector of the second industrial revolution, he decided to entirely devote his work to the innovation clusters relating to electrical energy. Westinghouse had watched with interest the developments in the generation of alternating current electricity in Europe.

Figure 3 - George Westinghouse 1906

In 1881-1884, Lucien Gaulard and John Dixon Gibbs demonstrated the advantages of the transformer, which allowed voltage to be modified. In 1885, George Westinghouse acquired the Gaulard-Gibbs patents for the United States and concentrated his efforts on improving their apparatus. In the following year, an alternating current distribution system including the use of transformers served one hundred and fifty incandescent lamps in a small town in Massachusetts. Hence as from 1886, the Westinghouse system started to compete strongly with the Edison system, which was entirely based on direct current. With their recent position of a virtual monopoly under threat, the advocates of direct current did not hesitate to launch a campaign in 1888 to discredit their competitor by trying to show that alternating current multiplied operation hazards and direct threats to human life. This campaign of negative propaganda, if not slander, related to major commercial and financial stakes, reached a new stage in the escalation of antagonisms when the State of New York decided to use electricity to carry out the death sentence from January 1889, thanks to the invention of the electric chair, which was supposed to bring instantaneous, almost painless death. The electric chair technique, of which the first official uses were both laborious and painful, was immediately associated with the Westinghouse system by its opponents.

At the same time, in a decisive move, George Westinghouse had recruited on his staff an engineer whose name was Nikola Tesla, born in present day Croatia, to perfect and produce alternating current motors and generators on a large scale. Tesla, who had emigrated to the United States in 1884, became famous in the international history of electrical innovation by developing the three-phase motor with immediate success. In the major patent registered for the transmission of alternating current, in a series of 112 patents that he registered in the United States alone, he established the following fundamental principle: *"By producing an alternating current each impulse of which involves a rise and fall of potential, the exact conditions of the generator are reproduced in the motor, and by such currents and the consequent production of resultant poles, the progression of the poles will be continuous and not intermittent."* Nicola Tesla worked for a short time with Edison, then left to join the major rival company, Westinghouse, which was developing a coherent, dynamic technological and commercial strategy aiming at the development and widespread use of alternating current. Within the Westinghouse Corporation, Tesla was one of the main players in charge of the setting up in 1895 of a large hydroelectric power plant at Niagara Falls, where his statue now stands. The opening of the Niagara Falls power station started the trend to locate generation facilities at a significant distance from the place of consumption, which was made possible with alternating current, due to its greater aptitude for conversion and transmission at higher voltages.

Figure 4 - Nikola Tesla 1893

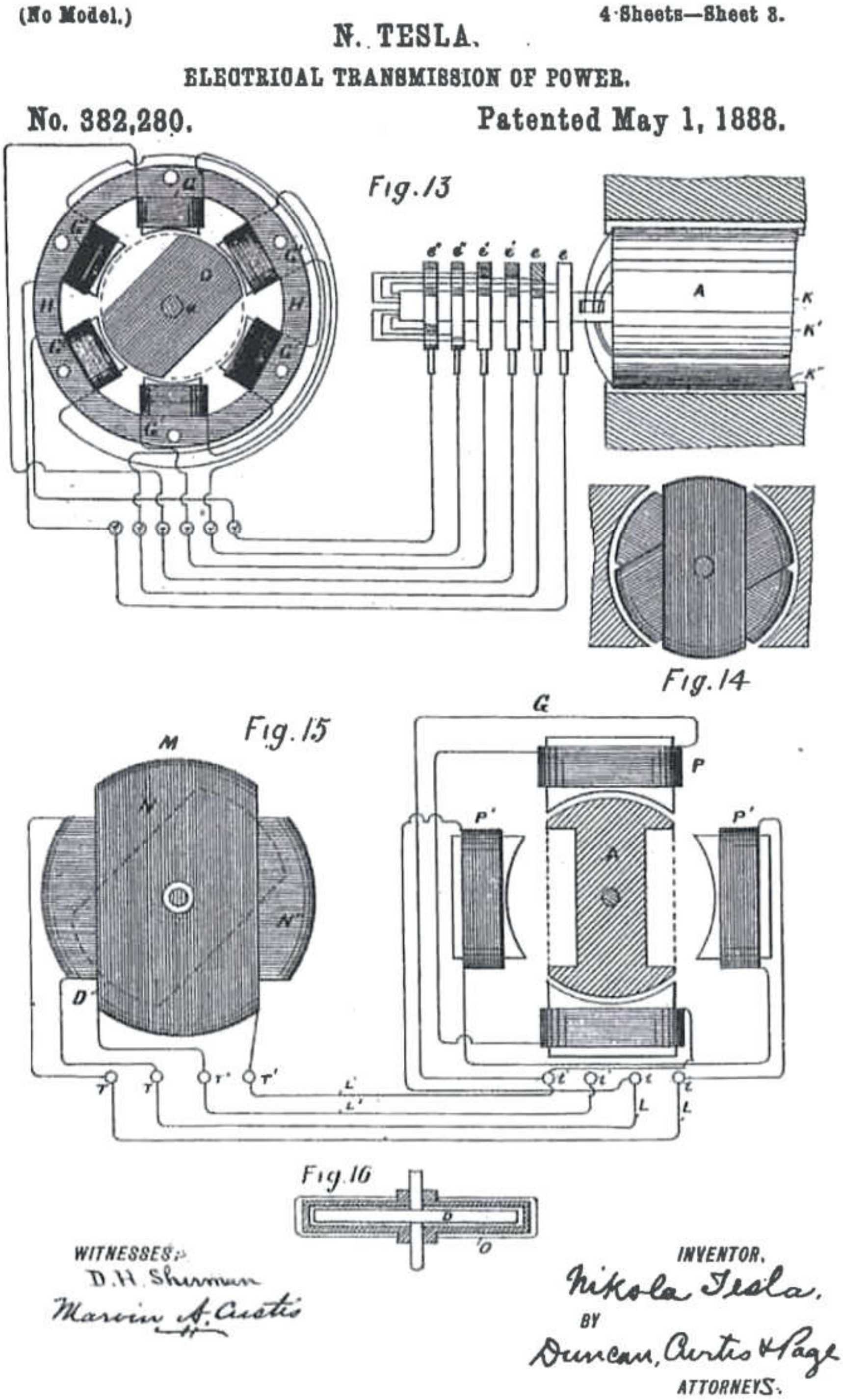

Figure 5 - Diagram N. Tesla's Model

At the very beginning of the 20^{th} Century, therefore, the three-phase motor and alternating current dominated the world of electrical engineering, even if there were many pockets of resistance where direct current survived and was very justifiably applied to specific uses. However, from the turning point of the two centuries, one may say that the era of inventors was replaced by that of the large multinational companies, marked by the power and influence of Westinghouse, of General Electric (created in 1892 by the merger of the Thomson-Houston Electric Company and the Edison General Electric Company), but also the Compagnie Generale d'Electricité, Brown Boveri & Co, Siemens and AEG.

The birth then development of electrification in North America and Europe from the 1880s extended very gradually to other parts of the world, although Japan, the British dominions, Latin America and Russia were a little faster. Only the large cities were able to really benefit from electricity before the First World War. The initial model for establishing and operating the electric system was generally based on the prolonged use of direct current in city centres and, on the other hand, on the dominance and rapid expansion of alternating current in outer city neighbourhoods, suburbs and outlying towns. Thus, in 1885-1886, Sebastian Ziani de Ferranti, the young chief engineer of the London Electric Supply Corporation, constructed and operated Europe's – or even the world's – first high voltage alternating current power plant in Deptford, a London neighbourhood. When it opened, the power plant generated current at 10,000 V and was already able to supply electricity to most of Greater London.

Germany undeniably played a leading role in Europe in this first industrial dynamics of electricity, with its major companies Siemens and AEG, ahead of the United Kingdom, France, Belgium and Italy. The development of the electric tram, first introduced in Berlin in 1879, was an early major illustration of this success.

The inception of long-distance transmission: from the beginnings to the development of three-phase system

At the Vienna International Electrical Exhibition in 1873, Hippolyte Fontaine realized the possibilities offered by long-distance transmission of electricity and the many advantages of reversibility, since electric energy could be transformed into mechanical energy and vice versa. Long-distance transmission was then perfected by the series of experiments, pioneering techniques and developments carried out by Marcel Deprez, who, with direct current, used higher and higher voltages to transmit large quantities of energy over long distances while limiting the cross-sectional areas of the conductors. The experiments took place between Vizille and Grenoble in 1883, then between Creil and Paris in 1884-1885. Marcel Deprez received the essential financial support of the Rothschilds, stakeholders of the *Compagnie des Chemins de Fer du Nord* railway company. Similarly to the telegraph, the role played by the railway industry in favour of this new form of energy was most significant on both sides of the Atlantic. Indeed, the historian

François Caron has shown on several occasions that electricity was for a long time a *"fille du chemin de fer"*[4], while, in the long term, the reciprocal effect of the electric system on the railway system was very decisive, as now illustrated by forty years of world history of high-speed trains.

TABLE 3: The inception of power transmission and the development of the electricity industry

1883	First industrial-scale transmission of electrical power by Frenchman Marcel Deprez between Vizille and Grenoble.
1884	Lucien Gaulard connects the Turin Exhibition to Lanzo railway station, which is lit by means of his transformers (37 km).
1885	Marcel Deprez transmits power 56 km between Creil and La Chapelle railway station in Paris (100 HP / 6,200 volts).
1891	As part of the Frankfurt Exhibition, Charles Brown and Michael Dolivo-Dobrowolsky transmit three-phase electricity over a distance of 177 km between Lauffen and Frankfurt.
1893	The Chicago Universal Exhibition, particularly with the installation of around 92,000 electric lamps, confirms the international development and world impact of the electricity industry. Aleksandr Popov (Russia) invents the radio-frequency antenna.
1895	Completion of the installation of the first Niagara Falls power plant (15,000 kW). Birth of wireless telegraphy or radio telegraphy thanks to discoveries by Maxwell, Hertz and Branly, concerning the propagation of electromagnetic waves; Guglielmo Marconi (Italy) becomes its true promoter.
1900	Electricity is crowned king of the 1900 Universal Exhibition in Paris, where the *Palais de l'Electricité* is a major attraction.
1906	First cross-border interconnection: the Campocologno power station in Switzerland is connected to the Lombardy Electric Power Distribution Company by a 55 kV line. René Thury from Switzerland creates a high voltage dc link between Moutiers and Lyon. A 13 kV ac underwater cable crosses Lake Garda.
1907	Lee de Forest (USA) registers the patent for the «three-electrode lamp»: birth of the age of electronics
1909	First high voltage (60,000 volts) line between Grenoble and Saint-Chamond.
1910	Thomas Edison develops the iron-nickel alkaline accumulator cell. Frenchman Georges Claude develops the neon discharge tube. V. Mitkevitch from Russia proposes using bundle wires for high voltage overhead lines.
1914	A 25 kV ac underwater cable connects Sweden and Denmark.

However, in these experiments with power transmission in the 1880s, despite all the efforts, firstly by Marcel Deprez, the efficiencies remained too low for

4 - Caron F., *"A propos de la dynamique des systèmes: pour une histoire des relations entre Electricité et Chemin de fer"*, *Electricité et electrification dans le monde*, Paris, P.U.F., 1992, pp. 477-486.

commercial purposes, with an excessively high proportion of energy losses. The use of the transformer – invented, as mentioned, by Gaulard and Gibbs in 1881-1884 – gave alternating current an essential advantage. The decisive leap, with the irreversibility of the innovation process, took place precisely in 1891. On the occasion of the Frankfurt Electrical Engineering Exhibition, 100 horse-power in the form of 30,000 volts three-phase alternating current, on a now large scale, was successfully transmitted between Lauffen and Frankfurt by Charles Brown and Michael Dolivo-Dobrowolsky, an AEG engineer. This confirmed that electricity could supply power almost instantaneously over a long distance, thereby establishing the superiority of three-phase alternating current which was rapidly validated scientifically and technically on the international scale. The process of regular increases in distances by associated increases in the transmitted voltages and capacities was therefore started, and has continued until the present day.

For generation, the largest consumers, which were industries in all fields of activity, had in fact mostly acquired stand-alone installations located in their own premises, from the early 1880s, before the "central stations" were gradually developed. These private generating plants – particularly those of tramway companies, underground railway companies, or electrometallurgy (aluminium) and electrochemicals (fertilisers, explosives, etc.) companies – only connected slowly and sometimes belatedly to the growing networks of central power stations in North America and in Europe. In any case, the United States were indeed the part of the world where the most impressive facilities were built; these were symbols of the technical and industrial predominance of the New World, which was spearheading a new industrialist, urban civilization.

Finally, with direct current, Edison had not made the right choice overall as to the best system, at least from the historian's comfortable position with the benefit of hindsight... We must stress the fact that it was precisely the transmission of electricity that made alternating current so successful. For it was easy to use this type of current to increase or decrease voltage, according to needs, by means of transformers, while direct current was not as convenient for voltage modulation. However, direct current resisted for a long time in certain areas. For example, in the Alps and Rhone areas of France, a 176 km long overhead line supplied Lyon's tram system for thirty years as from 1906. Also, direct current was used more widely for supplying electric-powered heavy traction systems – i.e., the railways, before the adoption of alternating current at industrial frequency in the 1950s, which was made possible by the invention of the thyristor – and for electrometallurgy. Naturally, direct current continued to be used in certain specific fields, such as the transmission of electricity by submarine cables, which is now showing a very fast development[5].

5 - See the work by CIGRE Committee 21, which became B1 in 2002, and the summary produced by its Chairman at the time, Bolza A., *Insulated cables and CIGRE Study Committee 21, a parallel story*, CIGRE, 2002, 6 pp.

From the impact of the International Exhibitions to the search for international scientific cooperation

In this spectacular process of the expansion of electric energy in industrial civilization, one must stress the decisive role of the International Exhibitions as a lever of communication and propagation of technological innovation. This lever was essential in the inception of the electricity system, at both national and international levels.

The general public first became acquainted with electricity at the Universal Exhibitions which were very popular in the 19th Century. The first Great Exhibition in London in 1851 was already the occasion for a telegraph conversation with the continent via submarine cable. At the Great Exhibition in Vienna in 1873, the transmission of direct current electricity over a distance of one kilometre and the reversibility of Gramme's dynamo, the basis of the electric motor, were highlighted by Hippolyte Fontaine. In Philadelphia in 1876, Alexander Graham Bell presented his major innovation, the telephone. At the turn of the 20th Century, a pavilion was always reserved for electricity at Universal Exhibitions. Its world recognition was evident from the Chicago Exhibition in 1893, a city of hyper-modernity, which confirmed the final establishment of alternating current, to that in Brussels in 1910. The 1900 Universal Exhibition in Paris showed the triumph of electric power with the simultaneous success of the *Palais de l'Electricité*, a major attraction, and the opening of the Paris subway. The climax event for electricity in the City of Light was the lighting of the Eiffel Tower, officially opened during the 1889 Universal Exhibition, where the original gas lighting system was changed to an electric system on the occasion of the 1900 Universal Exhibition.

At the same time, during the 1880-1890 period, very large-scale International Exhibitions were specifically devoted to electricity, very soon covering its entire sector and its widely diverse applications. They were originally held annually, and initially in Europe (Paris 1881, Munich 1882, Vienna 1883, Torino 1884, Paris 1885, etc.). They had the technical and financial support of the participating countries, particularly from the administrations of their Post and Telegraph companies. These lively meetings which had considerable media coverage aimed to spread scientific knowledge and to develop consumer demand. As forums highlighting the intense competition between companies and between innovators, they were the scenes for spectacular demonstrations that were both pioneering experiments and pioneering techniques. Thus, during the Munich Exhibition (1882), Marcel Deprez tried a direct current transmission from Miesbach. The Torino Exhibition (1884) was a triumph for Lucien Gaulard, who experimented with alternating current and the transformer on a line connecting the city to the Lanzo railway station. As mentioned above, three-phase alternating current became established precisely in 1891, at the Frankfurt Exhibition, when a line – the fruit of intense collaboration between Charles Brown (Oerlikon) and Michael Dolivo-Dobrowolsky (AEG) – connected Frankfurt to Lauffen.

Yet, the most decisive of all the international electricity exhibitions was the first, the Paris Exhibition, held from 11th August to 20th November 1881, a most significant, if not the most important date, in the historic celebration of the second industrial revolution. Among the 1,764 exhibitors, Siemens ran its electric tramway between Place de la Concorde and the Palais de l'Industrie in Paris, the *Société Générale des Téléphones* organised "theatre auditions by telephone", Deprez revealed his direct current distribution system, and Brush promoted his dynamos. But Edison was the man who achieved the greatest success, in lighting and much beyond, with the development of the first comprehensive design of an electricity system, from the electricity power plant to the consumer, including the distribution network and even its social and cultural applications. With more than 800,000 visitors, the 1881 Exhibition's popular success was enormous. The Scientific Congress organised in parallel brought together the greatest scientists of the time, who adopted the first international system of electrical units and started in-depth work to define the ohm, the volt, the ampere, the coulomb and the farad. The impact of these Paris events were the impetus for the constitution of a new professional community, marked by the foundation of the *Société Internationale des Électriciens* and an array of initiatives in Europe and North America.

Figure 6 - International Electricity Exhibition, Paris 1881 – General view

Hence, these very large scale events opened the way for creation of specific international bodies, and particularly, within the context of the history of CIGRE, the creation of the International Electrotechnical Commission (IEC) in 1906, and later the foundation of CIGRE (*Conférence Internationale des Grands Réseaux Electriques à Haute Tension*/ International Conference on Large High Voltage Electric Systems) in 1921, the World Energy Conference (WEC) in 1924, and the International Union of Producers and Distributors of Electrical Energy (UNIPEDE) in 1925.

In conjunction with the development of the International Exhibitions and the strong evidence of their influence, scientific and technical associations and societies had multiplied, firstly at national level, and then very gradually on an international scale. From the 1880s, the first national electrical engineering associations were formed, following the pioneer foundation of the Electrotechnical Department of the Russian Technical Society in 1879. In 1880 in London, the Society of Telegraph Engineers and Electricians was formed, confirming the joint heritage and relationship between telegraphy and electrical engineering and, more widely and more durably between low power and high power currents. In 1888, it became the Institution of Electrical Engineers (IEE). In 1883, the *Société Internationale des Electriciens* was founded in France[6], as well as *Elektrotechnischer Verein* in Vienna, for the Austro-Hungarian Empire. In the following year, the American Institute of Electrical Engineers was founded. The *Canadian Electricity Association* appeared in 1891, followed two years later by the *Verband Deutscher Elektrotechniker* in Germany, and in 1897 by the *Associazione Elettrotecnica Italiana* in Italy.

In the essential field of international uniformization of electrical vocabulary and pre-standardisation, or the inception of standardisation, the *British Association for the Advancement of Science* named a specialised committee in 1861, under the direction of Lord Kelvin, who was still called William Thomson at the time, to study the question of electrical units. Kelvin, the very first person to recognize the importance of these units, insisted that "*when you can measure what you are speaking about and express it in numbers, you know something about it.*" In the following year, in addition to recommending the use of the metric system, he stressed the need for a coherent series of electrical units. At the 1881 Paris Congress, despite the absence of precise definitions, the ampere, volt and ohm were, as mentioned, recommended as practical units. Kelvin's pioneering work at many international Congresses helped to establish a coherent doctrine for electrical units and standards and, until his death in 1907 his action was decisive in their widespread use on an international scale.

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6 - The *Société Internationale des Électriciens* became the *Société Française des Électriciens* in 1918.

Thus the cluster of innovations that led to the advent of the industrial era of alternating current from the 1890s, made it possible, mainly due to the ease of "power transport" (i.e., power transmission), to expand electricity use beyond the sole area of lighting and urban transport systems (tramways and underground urban railway systems). These innovations were a stimulus for the development of more and more diverse uses, both industrial and domestic, firstly in large cities, which became the symbols of the new industrial civilization and of modernity. Since the early 1890s, the three-phase system, which combined production, transmission and distribution within one single technological system, offered a comprehensive solution for industry and for public transport systems. At the turn of the 20th Century, with three-phase current, electricity became the main driving force of Western growth, as shown by the sector's Stock Market flotations on the eve of the Great War.

Overall, in the early 20th Century, a process started in the entire Western world which very gradually changed electricity from a luxury product to an everyday consumer commodity and much later, at an advanced if not ultimate stage, a product of mass consumption. Above and beyond the legal and technical obstacles, which must never be underestimated, the electricity markets in the 1900s and 1910s still remained limited because of the high cost of electricity for users, even in large cities. In Germany, the United States and Scandinavian countries, consumption in industrial and domestic markets developed rapidly at a sustained pace, and much more slowly in France and in the United Kingdom, particularly because of the fragmentation or insufficient concentration of the markets. In addition, the terms of the first electricity distribution concessions were often penalising and, for a long time, there was fierce competition with gas and to a lesser extent with steam, for motive power, and with the oil lamp for lighting. In fact, even within the Western world, national (and often regional) inequalities largely determined the initial step and first stages in the development of the power systems.

Thanks first and foremost to innovation in power transmission and to the development of a complete electricity system, from generation to consumers, electricity had already won over numerous areas, especially urban and suburban areas, on the eve of the Great War. In 1914, it had undeniably become both a subject and a major lever of the technological, economic, social and even cultural history of contemporary Western history (and gradually world history). At a more advanced stage of the spatial extension of electrification and the diversification and intensification of the uses of the new form of energy, the era of power systems now began, followed shortly by that of large electricity transmission and interconnection systems.

TABLE 4: Comparison of overall production of electrical power in the USA and in Western Europe in the early 20th Century

Electricity production in GWh

	USA	Germany	United Kingdom	France	Italy
1902	5.97	1.40	0.50	0.37	0.22
1907	14.12	3.20	1.43	0.67	0.70
1912	24.7	7.40	2.40	1.48	1.80
1917	43.40	12.00	4.70	2.40	3.43
1920	56.60	15.00	8.54	5.80	4.00

TABLE 5: Comparison of production of electrical power per head of population in the USA and in Western Europe in the early 20th Century

Electricity production in kWh per head of population (average for the 5-year period centred on the year in question)

	USA	Germany	United Kingdom	France	Italy	Norway	Switzerland
1902	81.2	27.9		10.3	8.5	35.7	81.3
1912	261.3	107.6	91	38.7	57.6	764.6	383.0
1922	577.3	264.1	195	152.9	140.6	1831.1	771.1

TABLE 6: Comparison of capacities of hydro-electric installations in the USA and in Western Europe in the early 20th Century

Capacity of dams in millions of cubic metres

	USA	Canada	Norway	Sweden	France	Italy	Switzerland
1910	2		0.550	0.550	0.600	0.510	0.380
1920	5.356	3.385	1.630	1.200	1.750	1.300	1.200

TABLE 7: Comparison of electrical power distribution in the USA and in Western Europe in the early 20th Century

Total power of electrical motors at distribution level (millions HP)

	USA	Germany	United Kingdom	France	Italy	Switzerland	Sweden
1906	4,098	935	1,560	549	493	477	77
1925	35,710	6,100	5,610	4,545	3,675	1,574	1,108

TABLE 8: Electric tramways operated in the USA and in Western Europe in the early 20th Century (1905)

Number of kilometres operated in 1905

	USA	Germany	United Kingdom	France
1905	48,270	3,899	3,606	2,003

Chapter II:

The catalysing role of the Great War and the dynamics of the first post-World War period

The dual influence of the First World War

The First World War ended in November 1918 with the terrible toll of a total war – a human tragedy first of all, but also material destruction. In the context of the activity which concerns us, it meant more than four years' disruption in the normal activity of electricity companies in Europe, for both those involved in electricity generation-transmission-distribution and for equipment manufacturers. Yet, the Great War undeniably played a catalysing role in the expansion of electric energy and its industrial applications, already including - to a certain extent - power transmission. The electricity economy largely proved to be a sheltered, counter-cyclical sector, as confirmed by the generation and consumption curves during the Great Depression of the 1930s and even during the Second World War.

This catalyst role of the First World War in 1914-1918 entailed the diversification of the uses of electricity, progress in electrical engineering, the persistence and soon the increasing buoyancy of electrical equipment manufacturers. It was also sustained by the inception of national industrial policies which were mainly aimed at preparing for the post-war period. Precisely in the electricity sector, it consisted in rationalising the generation and distribution system from 1917, applying the principle of interconnection of networks, with the first major national development projects. The role of the American model was essential in several ways, firstly through the impact of its electrical engineering knowhow, spurred on by the dynamic technological character of its manufacturers, with a high capacity for export and a strong multinational strategy, and also by the early impetus given to the development of networks on an already extensive regional scale, particularly in California.

However, nearly at the same time, the first example of a significant integrated system plan was developed in Soviet Russia by the GOELRO (the Government Commission for the Electrification of Russia) established in 1920.

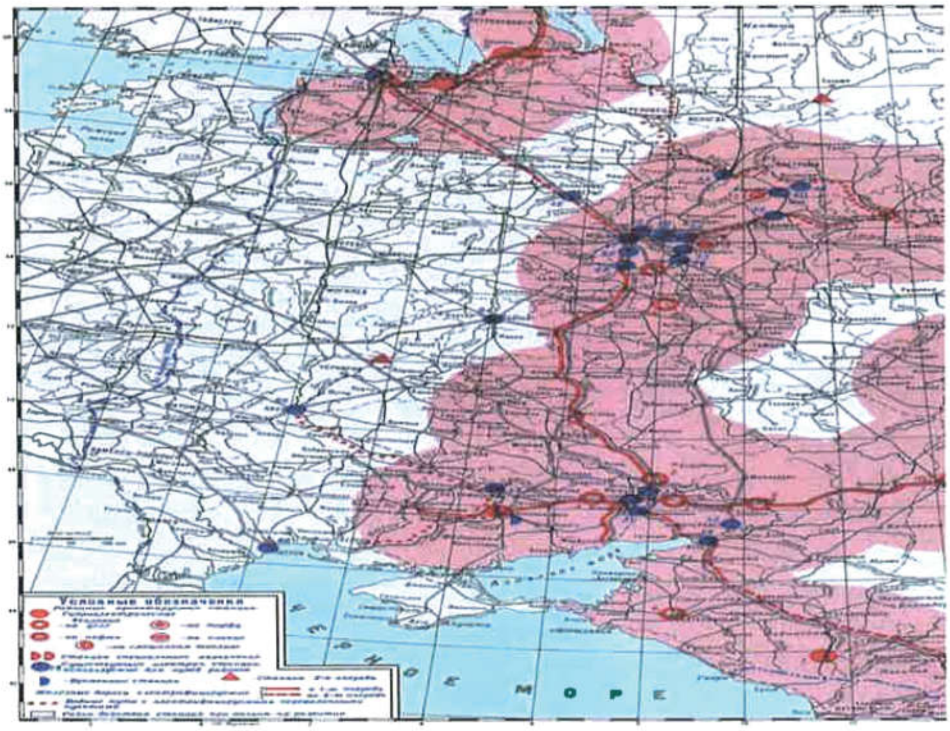

Figure 7 - The GOELRO Plan 1920

The first post-war period from 1918 to 1921, which was characterised in general history as a period of reconstruction and adaptation, was marked by great activity in the electricity sector, on both the national and international scales. In this context, with the emergence and development of the first truly regional power systems and the search for regional interconnection, new challenges had to be tackled. International cooperation was strengthened through the circulation of reliable scientific, technical and industrial information and by the application of a systematic comparative approach, which would be totally unbiased and independent of political pressure groups, or even interest groups. In the early 1920s, when the pacifist and internationalist spirit was at a climax as evidenced by the League of Nations, this was an essential lever. It should be noted that the spirit of the League of Nations had a strong technical dimension, considering that technical expertise – and firstly that of the international community of engineers – and international scientific and professional cooperation were the best guarantee to ensure that the Great War would be, according to the famous historical expression, "the war to end all wars".

In fact, in the early 1920s, within the prism of transformations to which it had given rise in the industrial world, electricity had already greatly contributed to the move towards internationalization of the economy, or even globalization, with the early multinational expansion of electrical engineering corporations, as characterized by the history of corporations such as General Electric, Westinghouse, Siemens, AEG and Brown Boveri. This process had accelerated during the Great War, when the United States' entry into the war alongside the Allies in April 1917 and their victory increased trade and technological exchanges between the two sides of the Atlantic. This was initially to the detriment of Germany's technological influence, which was weakened by its defeat in November 1918.

However, at the same time, this first post-war period was a decisive period of great organizational activity in the history of electrical engineering. It was marked by the multiplication of professional Organizations and national scientific societies at different levels, but which were closely complementary. Science, technology and industry formed a particularly inseparable trilogy for the electricity system and the electricity sector. In the early 1920s, as a result of the abundance of competent scientific and technical institutions in electrical engineering mainly at national levels, the need for cooperation on an international scale started to be particularly strongly felt throughout the whole Western world.

The search for international electrical standardisation: a new priority and the role model of the IEC.

Even if the units of electricity measurement were gradually standardised at the end of the 19th Century, as we have seen, the absence of standardisation of electrical apparatus had become a major concern on the world scale in the early 20th Century. With the development of economical generators, reliable switchgear and cables, the concessionary authorities and local distributors could choose for the first time between the advantages of different types of electrical equipment. However, without an approved classification system and recognized performance criteria, they often had to follow the advice of experienced consultants. If the manufacturers themselves were to achieve large-scale production and eventually mass production, it was essential to simplify processes and procedures. If simplified, they would simultaneously reduce costs for consumers, meet the competition from foreign manufacturers, and provide recognized guarantees.

The electrical engineers of the 1900s had felt the need for international collaboration encompassing internationally recognized terminology, tests, safety and specifications. This pooling and uniformization work would facilitate the consolidation and standardisation of the electricity system, after the intensive phase of electrical engineering innovations in the 1880-1890 period. The International Electricity Congresses – which were held one after the other since the first momentous Paris Congress in 1881 – only concerned electrical units themselves. Then, in the 1904 Congress held in Saint Louis (USA), priority was given to industrial and commercial development of the sector, and it was proposed to set up a permanent international commission to officially study the standardisation of electrical machines and apparatus.

Figure 8 - Saint Louis International Electricity Congress 1904

This International Electrical Congress in Saint Louis, Missouri, was concurrent with the Universal Exhibition held on the banks of the Mississippi to celebrate the 100-Year Anniversary of Louisiana being bought over from France by the United States, and also the 3rd Olympic Games of the modern era. In September 1904, the Congress, which was chaired by Professor Elihu Thomson, inventor-entrepreneur and founder of General Electric, hosted 16 companies and 719 scientists and engineers from fifteen countries[7].

On 15th September 1904, the delegates adopted a historic resolution, which launched the first official action leading to a permanent International Commission: "*steps must be taken to ensure cooperation between technical societies throughout the world, by forming a Representative Commission to examine the question of the standardisation of the nomenclature and classification of electrical machines and apparatus*".

Back in their respective technical companies, the delegates were to implement this resolution with the task of "*communicating the results of such actions to Colonel R.E.B. Crompton, representative of the U.K.'s Institution of Electrical Engineers (IEE), and to the President of the American Institute of Electrical Engineers (AIEE), in New York*".

Colonel Crompton was a key figure of British industry whose interests ranged from the bicycle and the automobile to road engineering and electric

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7 - See Ruppert L., *Brief history of the International Electrotechnical Commission*, IEC, 1956, 18 pp, in English and in French, and generally, the International Electrotechnical Commission (IEC), on the IEC website at *www.iec.ch*

lighting, including electricity generation and electrical facilities. He had been chosen by the Chamber of Delegates of the Saint Louis Congress because, at this Congress, he had given a brilliant talk on the subject of standardisation in electrical engineering. At the end of 1905, Colonel Crompton announced to the IEE Council, which was then chaired by Alexander Siemens, that he had conducted a first survey concerning the Commission and that he had received favourable responses from electrical engineering societies in nine countries, namely the *American Institute of Electrical Engineers*, the *Société Internationale des Electriciens* (France)[8], the *Associazione Elettrotecnica Italiana* (Italy), the *Association Canadienne de l'Electricité* (Canada), the *Verband Deutscher Elektrotechniker* (Germany) and the *Elektrotechnischer Verein* (Austria-Hungary).

Already aiming at maintaining a balance between the two sides of the Atlantic in the early stages of western cooperation in electrical engineering, the founding Congress was held in London in June 1906. Naturally, the British IEE was the organising institution. Alexander Siemens chaired its Executive Committee. The main operating rules were adopted during this founding Congress in London, with, it must be stressed, the following general principles which to a large extent served as a model at CIGRE's founding Congress:

- The Commission would be called the International Electrotechnical Commission, with the aim of standardising the nomenclature and classification of electrical machines and apparatus.

- Any sovereign country wishing to take part in the Commission should form a National Committee. These Committees had to be set up by the technical societies of each country, with one committee per country. In the case of countries counting no technical society, the government could appoint a Committee.

- Each Committee was required to send delegates to the Commission. Each country was entitled to only one vote, regardless of the number of delegates. Only the unanimous decisions of the International Electrotechnical Commission could be published. Any non-unanimous decision taken could only be published if the names of the countries which voted for and against it were specified.

- The head office of the Commission was established in London, in the premises of the Institution of Electrical Engineers. The means for carrying out the Commission's projects were placed in the hands of a Council comprising (a) the President of the Commission, (b) the Chairmen of National Committees,

8- Founded in 1883, its name was initially international, reflecting the immediate world field of the "new electric science", contained historically in its very inception. However, to ensure that its title would clearly show its national framework, it offically became the Société Française des Électriciens in 1918. See note 6 above.

(c) one delegate from each National Committee, and (d) the Honorary Secretary.

- The Commission's business would be conducted mainly by correspondence, but the President could call a meeting of the Council or the Commission in London, or in any other place decided by the majority of the Commission members. Each National Committee was to find the funds for its own expenses, and had to contribute an equal share of the expenses of the Central Office based in London.

The IEC's method of operation was now established, and all that remained was to appoint its directors. Due to his major role in setting up the Commission, Colonel Crompton very naturally became its first Secretary, while Lord Kelvin was appointed as its first President. In addition to his work on thermodynamics, Kelvin had been awarded the title of Lord for his major scientific contribution to the outstanding success of the laying of the first transatlantic submarine telegraph cable in 1865.

Although Kelvin and Crompton were the IEC's two founding fathers and directors, we should not forget the contribution of a third internationally-renowned pioneer, Professor Elihu Thomson, who was involved in many different activities, reflecting and confirming the powerful American influence. Since the early 1880s, Elihu Thomson had been a prominent player for many innovations in the field of electrical engineering. He had registered a very large number of patents, and the company he founded with Edwin. J. Houston merged in 1892 with Edison's company to form the General Electric Company, as mentioned above. On the eve of the Great War, Elihu Thomson – who had become the IEC's second President following Lord Kelvin's death at the age of 83 – declared the following in a letter to Colonel Crompton, looking back on the IEC's foundation and giving a first assessment of this new spirit of international cooperation:

"No task of such importance for the electricity industry has surpassed the work begun in these last years in the international exchange of ideas on electricity. Resolving these questions on an international level is a very arduous task. We must overcome jealousies and be careful to avoid offending all kinds of sensibilities; and we can be proud that no quarrel or dispute has yet occurred."

In 1914, the IEC had already formed four Technical Committees to deal with nomenclature, symbols, the classification of machines and of motors. The Commission had also published a first list of terms and definitions concerning electrical machines and apparatus, a list of international written symbols for units of measurement and abbreviations for the names of units, as well as an international specification for a tempered copper, a series of definitions concerning hydraulic turbines, and a number of definitions and recommendations for rotating machines and for transformers. The First World War suddenly interrupted the IEC's work, which was resumed in 1919, and the number of Technical Committees was increased to ten in 1923.

CONCLUSION

In conclusion, during this first historic phase, from the beginnings in the 1880s to the new dynamics in the 1920s, we have seen that power systems, which were considered as a radically new form of energy and more widely as an innovation in various forms, developed firstly on a local basis, around power plants and central power stations. However, very quickly, electricity was also seen as being able to provide long-distance transmission of energy, particularly thanks to increases in voltage, which were relatively inexpensive when associated with alternating current. As a result, during the Great War and in the decisive years 1918-1921, the concept of "large electric system" gradually developed. This concept was still very relative as it had to be superimposed on the networks that were responsible for the fine distribution of electricity in an area, which were now called distribution networks.

In the years after the First World War, which definitely played a catalyst role, electricity infrastructures were already undergoing such an expansion that people began to envisage their interconnection on the inter-regional, national and even international scales. Some pioneering techniques of cross-border connection were initiated at the beginning of the Century, particularly from Switzerland. The creation of an Organization which would officially coordinate the exchange of information between scientific societies in different countries, on a large scale and with complete technical, commercial and political neutrality, appeared to have then become a necessity. As we have seen in the above presentation of its inception, the International Electrotechnical Commission (IEC), founded in 1906, was already playing a substantial role within this perspective, but its work was limited to promoting the standardisation in the electricity sector. By the early 1920s, it had become clear that a further step in the structuring of the international community of electrical engineers was now called for.

PART TWO:

Inception of an International Organization to serve the development of power systems (from the early 1920s to the end of the 1950s)

In the years after the First World War, Europe and North America were particularly well suited for the strengthening of international technical exchanges, in the context of reconstruction and/or adaptation.

Following their entry into the war alongside the Allies in April 1917, the United States made a significant contribution to the final victory over the Central Empires. This contribution was also significant in the technological sphere, namely that of electrical engineering. In the early 1920s, USA's electrical technology, its companies and its new power systems exercised a multi-faceted influence on an already large regional scale. As opposed to this, Germany was viewed as the defeated industrial and technological power for quite a long time, despite guarantees of pacifism given by the new Weimar Republic. Walter Rathenau, director of AEG and son of its founder Emil, was actually Minister of Foreign Affairs in 1921-1922[9].

From the viewpoints both of contemporaries and of the historian, what were the determining factors that led to the meeting of the first *Conférence Internationale des Grands Réseaux Electriques à Haute Tension* - International Conference on Large High Voltage Electric Systems (CIGRE) in November 1921 and to the setting up of the corresponding Organization?

There were most certainly three factors which justified creating an Organization that was different from the International Electrotechnical Commission (IEC), with an area of expertise that was both sectorially more limited and functionally wider than the IEC, but at the same time largely complementary to it.

9 - However, Walter Rathenau was assassinated by the Nationalist extreme right wing in June 1922 as a symbol of the Weimar Republic's new pacifist and internationalist spirit.

The first factor was clearly related to the international context presented above. In some way, CIGRE was an organizational creation of the Allies, marked initially by the non-participation of Germany, despite its very high ranking position in world electrical science and industry. The foundation of CIGRE must be viewed within the context of the search for a new economic and technological governance on the international scale. It was founded in the general spirit of enthusiasm which characterised the early twenties, as evidenced by the League of Nations. Officially, however, on the political level, the United States preferred to stand back and did not ratify the Covenant of the League of Nations in 1920 and similarly did not join all the bodies that gradually gravitated around the League of Nations.

The second determining factor was the shortage of equipment and facilities, or even energy, in the post-war economic situation, when tension in the markets required a new dynamic of international cooperation. However, the most important factor was probably the necessity of a resolutely systemic approach to power systems, their technological development and their economy, in the original sense of the term[10].

As expressed directly by its official title, above and beyond the needs of the IEC, CIGRE provides both very interdependent dimensions of the electricity system and its central component, in terms of operation and territorial coverage, i.e. the network. CIGRE's creation was indeed embedded in a pioneering spirit, which really was a forerunner of the most contemporary debates on power transmission network boundaries and management status in the face of new regulations.

Thus, in 1921, people no longer wished to develop only an experienced and professional community pool on equipment and facilities; the aim was also to deal with networks and systems as a whole. The creation of CIGRE was thus well along the lines of the thinking of Thomas Edison, the American pioneer who, in the 1880s, as we have seen, was the first person to propose an overall, systemic vision of the electricity industry. As with Edison, it had to give priority to the combined study and perfecting of the global electricity system, with transmission systems at the strategic core of the industry. Within this perspective, it was to include industrial, entrepreneurial and economic aspects, as well as the socio-cultural repercussions of the expansion of electricity. Lastly, the international circulation of technical information on good practices for the construction and operation of electric power systems had to be placed under the sign of modern communication, using all channels, from the professional press to establishing trusting relations with both industrial corporations and national political leaders, large public administration bodies, and higher education and research institutions.

10 - The term "economy" is generic by definition and by etymology. It is fully relevant to electricity transmission systems, because it refers to the skill of good administration and good management, as well as the organization of the different elements of a complete system or assembly, that is, the interconnection of the parts of a system and their interrelationships.

Chapter III:

The creation of the Conférence Internationale des Grands Réseaux Electriques à Haute Tension [CIGRE] in 1921

Confirmation of an organizational need and creation of an international network of electrical engineering sector managers

The economic situation in the post-First World War period was still difficult for the electricity industry in 1920-1921, particularly, but not exclusively, in Europe. At the time, it was necessary to cope with the result of destruction and especially the lack of maintenance of power stations that had been built before the war. The development of energy transmission was seen as a way to reduce local shortages, since the construction of power lines required much less time than the construction of power stations. Furthermore, in Western Europe, the years 1920 and 1921 were exceptionally dry years, the supply from several hydraulic regions was severely affected, and the advantage of interconnections was seen all the more clearly. High voltage technology was already advanced enough to allow connections over quite long distances, with a technology that was progressing rapidly. A voltage of 120 kV was already quite developed in Europe, 132 kV and 150 kV were developed in America, and the switch to 220 kV was planned in California.

LES ENTREPRISES ET LA CRÉATION D'UN MARCHÉ

Carte n° 11 — Réseaux de transport d'énergie en France en 1923

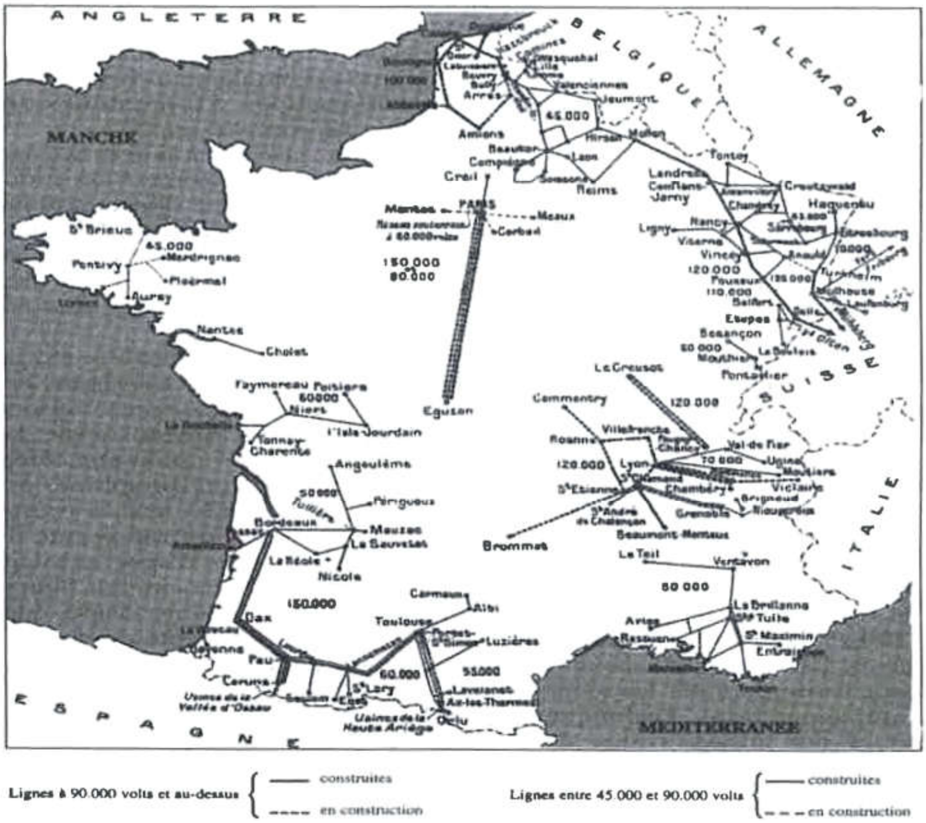

Figure 9 - Map of the French System in 1923

Therefore one could validly think of interconnecting several networks that were previously separate. However, there was some concern over the difficulties that could arise in the simultaneous operation of a large number of generators, and there was some doubt as to whether it would be possible to control the adjustment of very extensive interconnections. Not only were basic theories still insufficient to clearly shed light on these complex questions, but the Great War period had not been favourable to the development of publications on these theories, and lecturers were only just beginning to find the time to publish courses that were sufficiently updated. Concurrently in many countries, the need was felt for a high level of exchange and coordination on the construction and operation of networks at very high voltages. Therefore this widely felt impetus makes it rather difficult to yield to a natural inclination to definitively and exclusively associate one or more names with the creation of CIGRE.

Mr Bauer, Director of the *Société Suisse pour le Transport et la Distribution de l'Electricité* in Berne, started the movement by going to Paris late in the year 1920 to see R. Legouez, Chairman of the *Union des Syndicats de l'Electricité* (USE). R. Legouez was also of the opinion that interconnections would develop very rapidly with related technical problems arising which would require pooling of all experience. Successive International Congresses on electricity before the First World War covered much too wide a field to allow sufficiently in-depth studies and feedback of experience on very high voltages, considering the scope of the questions, both general and specific, to be addressed.

On the other hand, the International Electrotechnical Commission (IEC), – which, as we have seen, was founded in 1906 and chaired by Lord Kelvin followed by Elihu Thomson – had succeeded in setting up an international system of electrical units. For other units, the world was still divided into two entirely different systems. The IEC had also succeeded in standardising a number of items of electrical equipment. Lastly, in 1911, various bodies which had launched the first Congresses on the applications of electricity had asked the International Electrotechnical Commission to sponsor them in the future while rationalising the dates and places of meetings. It was therefore a natural move for M. Bauer and R. Legouez to turn to the IEC President, who, at the time, was Mr. C.O. Mailloux, from the United States.

Figure 10 - C.O. Mailloux

However, subsequent contacts showed that very high voltage transmission required an important and specific phase in technical research and experimentation, before there could be any real standardisation as performed by the IEC for voltage levels and equipment. Also, the problems to be tackled were not purely scientific such as the choice of fundamental electrical units. So, this obviously was not the appropriate role for the International Electrotechnical Commission itself. In any case, the technology of very high voltages needed to be addressed in detail and in depth by specialists, which excluded simply discussing it in general congresses on the applications of electricity. Therefore C.O. Mailloux, President of IEC, and Charles Le Maistre, its Secretary General, very clearly recommended the formation of a specialised body of a technical, scientific and applied technology character.

It was also felt that, like the IEC, the new body had to be open to teachers of electrical engineering and researchers, as well as to operators, manufacturers and entrepreneurs of networks. It had to have a somewhat private club character as it was not to directly question or challenge governments, nor spill over into the official area of regulations.

The contacts established in various countries confirmed these aims and led to the organization of the first conference in Paris in the Autumn of 1921. This meeting was considered as the inaugural conference of a new international electrical engineering Organization. R. Legouez entrusted Jean Tribot-Laspière, who was then Secretary General of the *Union des Syndicats de l'Electricité* (USE), with the practical organization of this first conference, and also, more generally, with the study and definition of the administrative structure that was to be associated with the Conference. He was assisted by the Delegate General of the *Syndicat des Producteurs Distributeurs d'Electricité*, Emile Brylinski, for his in-depth knowledge of technical issues.

Nevertheless, the historian must stress that the creation of CIGRE in 1920-1921 was undoubtedly international and collective, through the convergence and the combined efforts of other bodies (the IEC and USE) and of personalities, among whom J. Tribot-Laspière certainly played a leading role. This key role was officially recognized posthumously by an official decision of the Administrative Council some weeks after his death in 1963, which stipulated that any official document produced by CIGRE had to bear the mention "Jean Tribot-Laspière, founder". However, the United States undeniably played a major role along with France in the dynamics of CIGRE's foundation, and this essential contribution was sometimes overshadowed, a posteriori, by the praise of the French "demiurge" Creator, J. Tribot-Laspière...

In this history of a process of creation – which, as we have seen, revealed an international network of managers and therefore a human network of founders – Jean Tribot-Laspière's personal vision was slightly different. He considered he was the main founding father of the Association which was a perfectly human reaction considering the long time devoted to CIGRE and his responsibilities at the head of the Organization practically until his death in 1963. In this spirit he recalled the flash of inspiration which struck him at lightning speed and from which "his" International Organization had come to life.

"It was at 2:30 pm on 21st March 1921 that I had the idea of founding CIGRE, after a conversation with one of my friends who, as engineer-in-chief of a large company, complained of the difficulties that one faced from a technical view in country-to-country relations.

I immediately envisaged the means to make a reality of this idea, which appealed very much to me. Alone, I could do nothing. But, since I was Secretary General of the Union des Syndicats de l'Electricité and, in this respect, I had a number of friends abroad, I asked my Chairman for permission to approach some of them on the possibility of organising a congress. I obtained this authorization quite easily and I wrote to some societies or bodies in various countries. Since the replies received were unanimously favourable, I obtained the authorization to convene a congress in Paris, under the auspices of the Union des Syndicats de l'Electricité, at the end of November. This was how CIGRE started.

I was greatly assisted in my task by two very dear friends, Messrs Mailloux and Le Maistre, who were respectively President and Secretary General of the IEC, and who immediately understood the usefulness of a congress of free and fruitful discussions for technicians in general and for the IEC in particular. They trusted me and authorised me to write on their behalf and with their recommendation to the various electrical engineering committees, on the understanding, of course, that the future congresses would not in any case address standardisation, since this role was exclusively reserved for the IEC – a promise that was easy to make and to keep.[11]"

The birth of CIGRE - Paris International Congress in November 1921

The *Union des Syndicats de l'Electricité* (USE) of France took charge of organising this first Congress called *Conférence Internationale des Grands Réseaux Électriques à Haute Tension* - International Conference on Large High Voltage Electric Systems (CIGRE), under the impetus of its President René Legouez and its Secretary General Jean Tribot-Laspière. At the same time, it had the decisive support of the President C.O. Mailloux and the Secretary General Charles Le Maistre at the head of the International Electrotechnical Commission, the inception of which we have presented as dating back to 1904-1906 and its development up till the early 1920s. All these people fully grasped the strategic nature and the manifold advantages of a truly international technical forum for all players involved in electric systems and the industry throughout the world.

Therefore J. Tribot-Laspière was in charge of the practical organization of this First Congress, acting as Secretary General of the USE. It is noteworthy that all the

11 - Tribot-Laspiere J., "Petite histoire de la CIGRE", in *Electra*, No. 9, June 1951, p. 2

illustrious technicians of electric energy from the attending countries were present at the Paris Congress. They represented the "elite" of the world's electrical engineers, as shown by the historic photograph of the participants posing for posterity.

Thus 231 high voltage electrical engineers and technicians, 167 of whom were from France and 64 participants from eleven other countries (Belgium, Denmark, Spain, United States, United Kingdom, Italy, Japan, Norway, Netherlands, Sweden and Switzerland) met from 21st to 28th November 1921 at 7 Rue de Madrid, where the USE's headquarters were located at the time. The Conference delegates had been appointed mainly by the Electrotechnical Committees of the various countries. At the opening ceremony, C.O. Mailloux and A. Blondel (France) were appointed Honorary Presidents, while R. Legouez was appointed President and J. Tribot-Laspière Secretary General of the conference. Having been founded under the auspices of the IEC, CIGRE, like the IEC, adopted two languages from its creation: English and French. Such was the reason for the Organization's bilingual character from the outset.

There were no plans for this first International Conference on Large Electric Systems (CIGRE) to be followed by a further conference, but, considering the strategic nature of this meeting and the quality and interest of its discussions, its participants decided unanimously to meet again two years later, in Paris. Two major features of CIGRE were established from the outset:

- It would be organised as biennial Sessions, which were its fundamental *raison d'être* and its core activities; the Sessions were to always be held in the same city: Paris, the City of Light – a choice which, by its long-term constancy, was considered to have many logistic, financial and symbolic advantages.
- At the same time, the vital relations between CIGRE and the IEC were officially and precisely defined by the following resolution at the end of this founding Session in November 1921:

"CIGRE;

"Considering that its work is of a nature that provides very interesting and useful indications to the International Electrotechnical Commission (IEC) for its standardisation work and for facilitating this work...

"asks the Secretary General of the Conference to forward the result of its works to the IEC".

Therefore the major link with the IEC – which, to a large extent, orchestrated its foundation, as explained above – remained one of CIGRE's natural functions.

With this "club" of pioneers, CIGRE aimed to provide an international setting for the discussion and the study of technical questions concerning the generation, transmission and distribution of electric energy and to disseminate the progress made by experts from all over the world in these fields. Concretely, the Conference enabled renowned specialists to meet in order to address questions and problems in the following areas:

1. The manufacture of machines for the generation, transformation and interruption of electric current;

2. The design, construction and the maintenance of overhead and underground lines;

3. The operation, protection and interconnection of transmission systems.

Therefore, when it was founded, CIGRE brought together, on one hand, manufacturers of electrical machines and equipment and operators of power plants and transmission lines, and, on the other hand, electric energy producers, who were the natural customers of the latter, not to mention the professors, consultant engineers and engineers of major public administration bodies. Thus, manufacturers and entrepreneurs came to CIGRE's Sessions to find out about the latest directions and trends in technology, their customers' desires and the means for targeting their manufactured products. Energy producers and distributors could directly collect information on the latest progress made by manufacturers in all countries and on the new solutions to both urgent and long-term problems faced.

Furthermore, it should be noted that from one Session to the next, the three categories of conference attendees were always represented in the same proportions, although attendance showed a constant rise as given in the following Table for the period 1935-1950:

TABLE 9: Composition of conference attendance from 1935 to 1950 according to professional area

Sessions	Manufacturers & entrepreneurs %	Electricity producers & distributors (%)	Miscellaneous (%)
1935	36	44	20
1937	35	44	21
1939	35	42	23
1946	37	44	19
1948	37	45	18
1950	38	43	19

Although the Organization was originally founded in Europe, it very soon gained members in North America and in Asia. As we have seen, its very first meeting in 1921 was attended by 231 delegates from ten European countries as well as the United States and Japan. J. Tribot-Laspière liked to point out that *"from the beginning, there was a general spirit of happy trust and cordial simplicity among the congress delegates that became what was called the CIGRE spirit[12]"*.

The growing success of Sessions during the inter-war period and the institutionalization of CIGRE (the 1931 Statutes)

CIGRE's second Session was held from 26 November to 1 December 1923, with 394 participants from 20 countries – a number that confirmed the success of the first Session. It was also held in Rue de Madrid, Paris.

"Our 1921 Session, declared C.O. Mailloux at the closing ceremony, was an inaugural conference. This year's Session has been a conference of consecration. These [two Sessions] are the start of a series of Congresses of which none of us here will see the end".

At this second Session it was decided that, in the future, the Conference would be held in the Summer, Paris being confirmed as the permanent venue.

The third Session took place early in the Summer of 1925, from 16th to 25th June, with 530 participants from 27 countries. As the premises in Rue de Madrid were definitely too small to accommodate this number of people, the Session was held in the Fondation Rothschild, in Rue Berryer, Paris.

As the number of delegates continued to grow, the Fondation Rothschild premises, though very pleasant with the asset of a large park, were no longer suitable. The fourth Session in 1927, was held in the "Salles Hoche" premises, which continued to be used for the following five Sessions. A total of 544 Members from 28 countries attended the 1927 Session, during which it was decided to *"keep CIGRE's head office and the permanent Secretariat in Paris and to hold all its future meetings in this city"*. The fifth Session, from 6th to 15th June 1929, showed a major increase in numbers, with 703 participants.

The need for a permanent structure was soon felt. In 1931, the Conference became an independent Organization. That same year, the sixth biennial Session attracted 738 delegates from 36 countries, that is, three times more participants than for the first event.

Until then, CIGRE had no official headquarters or offices, nor even any specific staff. Until 1931, it was officially domiciled in the premises of the *Union des Syndicats de l'Electricité* (USE). The Secretary General of USE also had

12 - Ibid., p. 4.

these functions for CIGRE. As for staff CIGRE could rely on the assistance of adjoining groupings who also shared one Secretary General.

The opening Ceremony of each Session elected a Secretary General and some people who made up its Officers. All of the Officers were re-elected from one year's Session up till the next. They remained permanently in office and handled organization of the conferences. The financial structure was not at all well established. The expenditure of a Session was not always covered by the receipts, and the deficits were only compensated for by subsidies from some associations and societies in various countries. Such a situation could not be maintained permanently and, considering that people wanted CIGRE to be a permanent institution, it was necessary to give it a form of organization that would also be permanent.

Figure 11 - 1931 Session – Salle Hoche

On 18th June 1931, during the sixth Session, an international association was founded which had a legal existence governed by the French Law dated 1st July 1901, defining the rules governing non-profit, non-government associations or societies. The thirteen official co-founders of the new CIGRE association, who met on 18th June 1931, were all participants from the early stages: Messrs. Bakker, Barbagelata, Bauer, Brock, Drewnowski, Duquesne, List, Norberg-Schulz, Perrochet, Tribot-Laspière, Ulrich, Wilczek and Woodhouse. They were the first thirteen permanent Members of CIGRE, who were joined on the same day by Messrs. Attwood, Borgquist, Budeanu, Del Buono, Busila and Montanès. A President for the Association was elected unanimously: Marcel Ulrich (France), who had chaired the two preceding Sessions in 1927 and 1929 and who held these functions until his sudden death on 1st August 1933.

Figure 12 - President M. Ulrich 1927-1933

The Statutes of the Association adopted in 1931 corresponded well to an association of persons (individual persons and corporate/legal entities) and not to a federation of national groupings, and even less to a federation of countries. Therefore all political questions were excluded, and all members represented only themselves individually. They acted and took part in discussion meetings with total independence and in total freedom. Only their competence and their expertise were required. By definition, the Association was sovereignly directed by the General Assembly of all its Members, which met every two years and delegated its powers to an Administrative Council which performed its tasks through its President and its Delegate General. Therefore, as was conventionally the case, all powers were (and still are) concentrated in the Administrative Council. The latter is the Body which draws up the rules for Sessions and Study Committees; it also appoints Chairmen and Members of these Committees. The Administrative Council manages the Association's funds, and therefore, in accordance with French law and customs, its accounts are controlled by the General Assembly itself, which, for this purpose, appoints statutory auditors who are answerable to it.

The initial Statutes remained basically the same up till the 1960s. Two significant changes were the following:

in 1939 when CIGRE was termed a "Foreign" association by decree dated 12th April 1939, because more than one quarter of its membership was non-French; it however was still generally governed by the Act dated 1st July 1901 regarding non-profit associations. After the war and ever since, CIGRE's status has been that of an International Association governed by the 1st July 1901 Act.

The other modification , in 1948, concerned the categories of Members of the Association. There were three categories of Members: Personal (individuals) – Ordinary industrial or commercial companies – and Collective (associations, public administration bodies and other institutions, and public and corporate bodies). However, in practice, two categories seemed to be enough, and at the General Assembly of 28th June 1948 the category of "Ordinary" Members was dropped.

Membership fees, which in 1931 – year when the Association was founded – were FF75 for Individual Personal Members and FF250 for Collective Members, had to be raised several times to reach respectively FF100 and FF1000 in 1950.

The main aim of the status of the non-profit association was to provide it with the legal basis and subsidies to meet its needs as CIGRE had no other resources apart from its members' annual fees. At the same time, it was essential for CIGRE to enjoy a growth in membership, perfectly in accordance with the vital growth rationale for any Organization. The number of its permanent members – 500 in 1939 – gradually rose from 410 as at 31st December 1945 to 1 598 on 31st December 1950.

In 1931 CIGRE tried to put in place an ambitious journal, which aimed to be more than just the Association members' newsletter, as shown precisely by the editorial of its first issue in June 1931:

"Nearly three years ago, CIGRE's Board of Officers decided to create a journal which would be the official organ of the Conference, but unfortunately this was not possible, due to the fact that the Secretariat was overloaded with work. The work did not decrease, but when it was nearing time for the 6th biennial Session, the Conference considered that it was vitally essential to no longer defer publication of the journal, and the first issue is published today, on 15 June 1931, on the eve of the 6th Session.

During the opening discussion meeting, we will celebrate the 10th anniversary of the Conference's foundation, which is an important date in the history of international relations in electrical engineering. This anniversary will coincide with the publication of the first issue of the new journal, which will no doubt open a new period of activity for the Conference."[13]

The ambition of Electra was presented in Membership Application forms as a monthly journal devoted to the study of the generation, transmission and transformation of electrical energy, and therefore in a wide sense of the electricity industry which is not limited to power transmission systems. It was thus declared from the outset by the President, Marcel Ulrich:

13 - *Electra*, No. 1, June 1931, "To our readers"

"The aims of the Electra journal are the following:

1) First of all to secure the so desirable interconnection between members of the Conference, who are scattered all over the world and doubtless will be glad to receive monthly news from the Conference, and from their colleagues and friends whom they are accustomed to see every other year.

2) To outspread among attendants of the Conference the works of permanent studying committees between two consecutive sessions and the publishing of reports of different members of these committees will allow the knowledge of the facts and ideas which gradually arise from such works and will likewise enable members of the Conference to forward in good time to the presidents of the Committees their personal share of work in problems they are particularly interested in. "[14].

However, *Electra's* circulation aimed at a readership beyond the CIGRE community itself, widening CIGRE's international dynamic by making maximum use of the lever of bilingualism:

"In addition, the Electra Review, will endeavour to secure with the help of its hundreds of informants and friends, the most striking studies or reports; and in fact, everywhere one finds number of indefatigable searchers and clever minds who, during their slow laboratory task or their daily practice of networks or factories have come across an idea or invention which has caused a sudden improvement in the technical line.

Such men are found but the diffusion of their ideas can be rapid only if these ideas are published in world-spoken language. The knowledge of these works is slow, on the contrary, whenever they are written in an uncommon language. Therefore Electra will be honoured to translate into French and English the most important studies that will be published in one of these little-used languages, and to thereby open them very rapidly to the public opinion of the technical community".

The pacifist vision of the international role of electrification and of its systems as factors of peace and progress clearly inspired the President's conclusion:

"Lastly, the International Conference on Large Electric Systems does not forget that it is one of the greatest and most active international organizations as it is fully conscious of the many duties which it has to fulfil in view of the intellectual and technical closer connection of nations.

Therefore, the Review will publish whenever authorized and when possible, information about the works of other international associatioins, in order to cooperate in the necessary intercourse between all men of goodwill who fill the same profession and whose principal wish is to know, in the Electrotechnic line,all that is under preparation and discussion throughout the world."

14 - Idem and ibid below.

Unfortunately, this ambitious publication programme was very soon limited as regards the frequency and volume of issues and the nature or range of articles. Therefore this first series of *Electra* was short-lived. It gradually lost momentum, and it did not go beyond issue No. 16 in 1934[15]. Members had to wait until 1948 for the resumption of a second series of *Electra*, which has continued without interruption until the present day[16].

CIGRE's expansion and confirmed success on the eve of the Second World War.

In 1933, the leading French industrialist Ernest Mercier, Head of the Union d'Electricité corporation and one of the major artisans of the development of the French very high voltage system in the inter-war period, was elected to succeed to Marcel Ulrich as President of CIGRE. In office for 14 years, until 1948, he enabled CIGRE and its community to benefit from his powerful network of international relations, thereby helping to strengthen the CIGRE spirit, a resolutely supranational *"esprit de corps"* or team spirit.

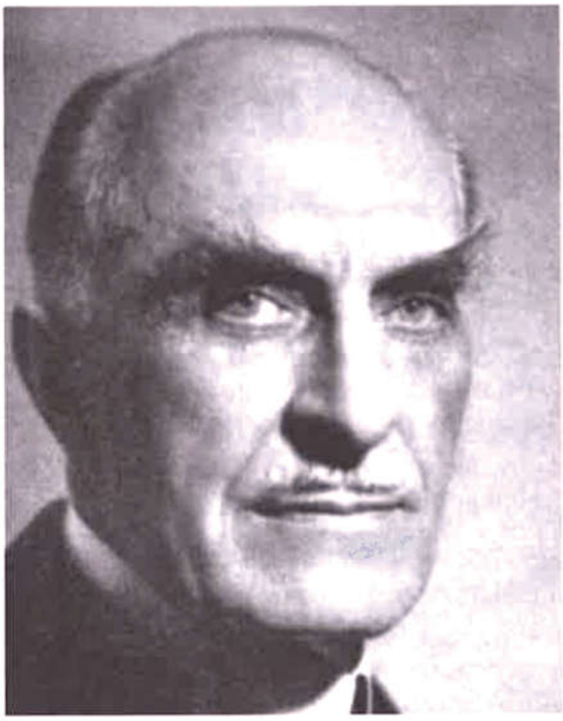

Figure 13 - President E. Mercier 1933-1948

This CIGRE spirit was subjected to the context of serious economic crises and development of international tensions which led to the Second World War.

15 - The last issues of this first series of *Electra* contained barely ten pages.

16 - See below, Chapter VI on the second and third series of *Electra*, starting respectively in 1948 and in 1967.

Germany and Austria, as powers defeated in the Great War, were originally excluded from the foundation of CIGRE, but joined the Association in 1932. Their integration took effect in June 1933 with the instatement of two Germans and one Austrian on CIGRE's Administrative Council[17]. It went hand-in-hand with difficult negotiations with their electrotechnical associations, focussed on the recognition of German as CIGRE's third official language. Thus, at the discussion meeting on 16th June 1933, Professor Rudenberg stressed that *"the major German associations have only agreed to take part in the Conference on the condition that the German language shall be treated as an equal with the other languages"*. After long in-depth and heated discussions, and despite the opposition – if not hostility – of the English-speaking members, the Administrative Council and the General Assembly adopted a compromise, by modifying Article 4 of the Association Statutes, as follows: *"the languages used at the Conference are the usual principal languages used in the technical field"*.

Such wording, expressing an essential political caution, did not solve the problem, since the proposed draft regulations for the use of languages, drawn up by a special Commission appointed by the Administrative Council, were never officially ratified. The draft regulations specified in particular that *"speakers must speak aloud, very clearly and very slowly, holding their head up straight. They will remember that most of the technicians can understand foreign languages if they are spoken slowly and clearly"*[18]. The practice of trilingualism – to the sharp discontent of many English speakers who saw it as the negation of the CIGRE's founding bilingualism, which had been presented as final – was partly introduced during the limited period from 1933 to 1939, at the peak time of international tensions. At the same time, by introducing German, this new trilingualism temporarily confirmed the French language's effective predominance until the final reestablishment of bilingualism in 1946. The continual progression of English until the present day has resulted in the pragmatic recognition of its predominance as an international language.

The 1935 and 1937 Sessions confirmed CIGRE's ever-growing success, with respectively 834 and 871 participants from all five continents. The number of reports – 176 in 1935 – reflected how much their authors valued CIGRE. However, this number became much too high in relation to the initial concept of CIGRE. It made the discussions too brief or impossible, and it involved considerable printing expenses which depleted the Association's budget. The 1935 peak number prompted the Administrative Council to decide to set a

17 - At the discussion meetings on 16 and 17 June 1933, new members were admitted to CIGRE's Administrative Council: Professors Rudenberg and Rachel from Germany, and Mr Brock from Austria, President of the newly-founded Austrian National Committee.

18 - Draft proposed regulations for the use of languages, Report of the Administrative Council Commission dated 14 April 1934. This Commission was composed of Messrs Rachel, Wedmore, Montanes, Barbagelata and Tribot-Laspière.

limitation to the number of reports, a decision which proved very difficult to enforce in practice.

The number of reports presented to CIGRE Sessions was almost continually growing, as shown in the following table:

TABLE 10: Number of reports presented at CIGRE Sessions from 1921 to 1950

1921	1923	1925	1927	1929	1931	1933	1935	1937	1939	1946	1948	1950
64	49	99	77	75	100	131	176	119	116	107	125	144

There was a second reaction by the Administrative Council after the 1950 Session where 144 reports were presented. The Administrative Council then wished to limit the number definitively to 100.

For the very first Sessions, since there were no rules, the authors took the greatest liberties in writing their reports and in observance of deadlines. On each occasion, a number of manuscripts, 18 out of 99 in 1925, were delivered at the Secretariat by authors on the day of arrival at the congress!

The delegates attending the 1923 and 1925 congresses justifiably commented on this casual attitude. In its 2nd Resolution, the 1925 Session instructed the Officers to draw up, without delay, Regulations *"which would be applied with complete stringency to prevent an excessively large number of authors from sending their reports with delays that make it impossible for the Secretariat to print and circulate them in due time"*. However, this was not of much use, and at the 1927 Session it was evident that *"despite the Conference's insistence, the authors send in their reports too late, after the set deadlines, and that this negligence needlessly complicates the organizational work"*. Thus, for 1929, it established some very simple but very firm recommendations, which, since then, formed the basis of the Reports Regulations. From that time, the Reports Regulations existed, but it took some time before they were fully applied. However, the situation improved gradually, and the proportion of reports that were sent in advance to the Session delegates – a proportion which was only 58% in 1933 – increased to 80% in 1939.

The organizational mechanism of the Sessions inevitably became more and more costly and complex, but at the same time more and more rigorous. From 1921, in order to allow the Chairpersons of discussion meetings to exercise their functions without constraints, a platform secretary relieved them of all practical concerns, and a Session secretary was appointed to draw up the proceedings of the discussions. The "Special Reporters" system was introduced a little later. It was requested in 1927, structured in 1929, and was finally adopted in 1931. It was perfected from one Session to the next, until Regulations were drawn up in 1946, defining the specific mission and their liaison with the person who chaired the discussion meeting in which Special Reporters took part. Since then, the Special Reporters have always prepared the discussions for meetings, and, in their Special Reports, they have stressed the issues for focus and on which they have raised precise questions for discussion.

As from the first Conference in 1921, the reports and discussions were divided into three Sections. Within these Sections, they were divided into a number of headings officially entitled "Groups". In 1946, the 3rd Section was split to create a 4th Section dealing with questions of very high voltages . The division of the subjects to be addressed and of the reports between these Sections remained for a long time the basis of the organization of CIGRE's Sessions. At the 1950 Session, out of a total of 25 headings, 7 concerned the 1st Section, 7 concerned the 2nd, 8 the 3rd and 3 the 4th. 17 CIGRE Study Committees corresponded precisely to 17 of these 25 headings.

In terms of regular attendance at Sessions, and thus loyalty to CIGRE, a first survey was conducted for the 1933 Session. It revealed that, out of the 751 people attending the congress, 73% had already come to one or more earlier Sessions, as shown in the following table:

TABLE 11: Number of participants in Sessions before the 1933 Session

Participation in previous sessions	Number of participants
None (first participation in 1933)	204
One previous session	130
Two previous sessions	118
Three previous sessions	107
Four previous Sessions	84
Five previous Sessions	69
The six previous Sessions since 1921	39
Total	**751**

Therefore CIGRE Sessions already included a major proportion of regular participants who wished to maintain their personal relations, who knew the Sessions' traditions and organization, and who took part in ongoing work and in a methodical, continual study of the same questions. This regularity was undeniably one of the reasons why the CIGRE Sessions were recognized for their efficiency and their great value.

For the 1939 Session, CIGRE met for the first time at the Fondation Berthelot, 28 bis, Rue Saint-Dominique, since the Salles Hoche premises had become too small for the growing number of people attending the congress. For the first time, this Session showed a slight drop in the number of participants: 814 as opposed to 871 at the previous Session – a drop due to the general world economic depression and the growing threat of war. The people attending the congress parted company on 8th July with an unconcealed feeling of anxiety, wondering whether the 1941 Session could take place and even if they would ever meet again. Less than two months later, the Second World War broke out, with its devastating and tragic consequences, putting CIGRE's international dynamics and its activities on hold for more than six years.

Chapter IV:
Structuring of the technological industry of large power systems: the contribution made by CIGRE

The creation and multiplication of National Committees: a CIGRE institutional network

As structuring and driving bodies of CIGRE, the National Committees were set up quite slowly, as opposed to the Study Committees. They were rendered official only in 1931, when the Statutes of the permanent Association were adopted and registered.

The name and the very principle of National Committees clearly came from the organizational model of the International Electrotechnical Commission[19]. A fundamental difference should however be noted. While the I.E.C. is a federation of countries represented by National Committees in the name of which the members of its international meetings act and speak, CIGRE is historically, legally and de facto, an association of persons in which all members speak only in their own name and only represent themselves.

In the I.E.C., the National Committees are themselves the members of the Association, while CIGRE's National Committees are administrative intermediaries between the members and the General Secretariat in Paris, and they are essential intermediaries. Their origin is in one of the resolutions of the second Session in 1923, which, feeling the need to progress in the organization of the Conference, expressed the wish that *"in every country, a Committee of some members would be created, with the aim of making the Conference known, having reports written, selecting only the most significant reports, and sending these reports to the General Secretariat so that they may be translated, printed and distributed before the opening of the Conference"*.

After this wish was expressed, three National Committees were created, respectively in the United Kingdom, the Netherlands and Italy. However, the creation of other Committees was delayed. The 1925 Session again recommended it in its resolution No. 2, and, returning to the question, the 1927 Session again expressed the wish that *"a National Committee would be formed in every country, in the same way as they have already been formed in several countries, with the aim of..."*.

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19 - See above, Chapter II on the IEC's organizational model

In 1931, the permanent Association envisaged, in Article 11 of its Statutes, the creation of National Committees for the purpose of *"participating in the preparation of the Sessions, having reports written and sending these reports within the set time limits, recruiting members of the Association and its Sessions, [and] making the Conference known"* – with almost exactly the same wording as the initial wording of the 1923 Session. Since then, a large number of National Committees were created, already reflecting CIGRE's profound worldwide diversity, with 32 National Committees operating in 1950.

Their role was indeed mainly administrative, as opposed to that of the Study Committees. The National Committee of a country was a very precious intermediary between CIGRE's General Secretariat in Paris and the permanent Members living in the relevant country. It significantly reduced the workload for the General Secretariat and facilitated contacts with its hundreds of members. For a long time, the National Committees' main tasks consisted in soliciting/collecting and studying the reports to be presented at Sessions, sending to CIGRE only those reports which had substantial value, ensuring that the Rules were observed by the authors (particularly for the physical presentation of reports), collecting and forwarding their members' annual fees, collecting and forwarding registrations for Sessions, recruiting new members, and putting forward their views in answer to Administrative Council consultations. Their action gradually diversified, which implied a growing workload and considerable dedication.

The creation and expansion of Study Committees: an international network of CIGRE technical experts

The rapid organization and rapid growth of CIGRE's Study Committees contrasted with the relatively slow formation of the institutional network of National Committees.

At the 1921 and 1923 Sessions, there was not as yet any official confirmation that further conferences would follow, and no permanent link was provided between them. However, as of 1925, CIGRE was finally taking shape and it was seen that it needed technical continuity from one Session to the next. This was the initial purpose of the Study Committees, whose role quickly increased in importance, simultaneously with the process of international recognition consequent to the rise of expertise in these Committees.

During the 1925 Session, chaired by T. Norberg Schulz, the first Study Committee, the Statistics Study Committee was created. It only lasted for a short time and was transferred to the new International Union of Producers and Distributors of Electrical Energy (UNIPEDE), which was itself founded in 1925. Three Committees were then introduced with the 1927 Session respectively for Oils, Cables and Switchgear. Four others were created at this same Session, but were only short-lived . The Insulators Committee and the Overvoltages Committee were created in 1929, the Overhead Lines and the Telephone Interference Committees in 1931, and the Towers and Foundations Committee in 1935. Later, a Committee was created for Reactive and Distorting Phenomena, and the Sub-Committee on Filler Materials for cable boxes.

At the time of creation of the Study Committees, CIGRE's Administrative Council only gave them very simple rules and the Regulations that it had drawn up were summarized in just six articles. All powers were given to the Chairmen of the Study Committees, who were free to direct the work of their Committee as they saw fit, to convene them when they considered it useful, and to apply any particular working method. Therefore the importance and value of a Committee's work depended mainly on the competence and the goodwill of its Chairman. The Chairmen generally showed great dedication in conducting their work, and ensuring the collective usefulness of their Committee for the CIGRE community. Moreover, each of them held a very important technical position in his respective country, which took by far the greater part of his time. Experience rapidly showed that a Study Committee not only had to have a good Chairman, but also a good Secretary: each Committee operated with a Chairman and a Secretary who formed a close-knit team and who were often from the same country.

From the outset, the two languages used in the Study Committees were French and English, as was generally the case in CIGRE. The discussions always took place in these two languages and all reports and documents were also bilingual. Therefore, within this perspective, as many members as possible of a Committee were sought among CIGRE members who spoke both languages.

English-French bilingualism was gradually integrated into all of CIGRE's bodies, meetings and documents. The aim was that no document would be published in only one of the two languages. The Study Committees' reports and documents, the reports presented at Sessions and published in the Session Proceedings also had to be printed in both languages. All correspondence was received or written in either of the two languages that suited the correspondents. During Sessions, a speaker was free to speak in English or in French and, by definition, the entire Secretariat also had to be bilingual.

Much long-term effort was required in order to attain this integral bilingualism. In 1921 and 1923 nearly all reports had been presented in French only and, in its resolutions, the 1923 Session had expressed the wish that "for the next Conferences, reports would be written in both English and French". The situation gradually improved and, from 1927, it was possible to publish the complete collection of all reports presented, in both languages.

On this strategic and sensitive question of language, during the Sessions themselves, simultaneous interpretation at the conference discussions was an important and difficult task. During the first two Sessions, it was only done by occasional willing interpreters. However, as of 1925, a man came to the forefront whom all CIGRE members particularly appreciated. For 20 years, R.A. McMahon, single-handedly took charge of interpreting all the conference discussions. For nine successive Sessions, with outstanding expertise recognized by everyone, he provided one of the hardest and most essential services of the Sessions. R.A. McMahon was undeniably one of the most significant contributors to CIGRE's growing success.

Fig. 1. — La tribune pendant une séance. De gauche à droite : MM. Mac Mahon (Angleterre), interprète-chef ; Pooc (Roumanie), secrétaire particulier de la 1re section ; Duquesne (Belgique), président de séance ; E. Roth (France), rapporteur général de la 1re section ; E. Hua, secrétaire permanent des séances ; J. Tribot-Laspière, délégué général de la Conférence.

Figure 14 - View of the platform with R.A. MacMahon at a discussion meeting during the 1931 Session.

From the first 1921 Session, the subjects dealt with in the reports and discussed in conferences covered virtually all the problems of the period related to energy transmission and its generation by power stations supplying transmission networks. For all of the inter-war period, they may be summarized as follows:

- Parallel operation of power plants and oscillation between machines;
- Problems in construction of large generators and transformers;

- Laws and electrical calculation of energy transmission, voltage adjustment and reactive power;
- Reliability of cables for high voltage;
- Insulation of lines, the nature and properties of insulators, and dielectric strength of insulation
- Earth connection of the neutral and extinction coils, and interference caused in telecommunication circuits.

In the process of interconnection of power systems, which was still in the development stage during the 1920s, one of the main technical problems was indeed the parallel operation of electrical machines. One of the seven Study Committees set up in 1927 – the year when the structure of the Study Committees was consolidated within CIGRE – was precisely concerned with this very difficult issue. The maximum transmission voltage was 150 kV, and then, at the turn of the decade, the change to the upper level of 220 kV was started. On the organizational level, the electricity sector was still characterised by the development of several regional companies, of very variable sizes, which were starting to consolidate their bases to increase their size, start a concentration process, and benefit from the rationale of economies of scale. In this process and this economic virtuous circle, parallel operation was technically fundamental.

Thus, in the inter-war period, particularly through the growing and multifaceted work of its Study Committees and the related impact of its Sessions, CIGRE largely contributed to the recognition of the strategic character of the industry of electricity transmission and interconnection. This was confirmed by the study of the first Preferential Subjects. It demonstrated the specific nature, within the electricity system and industry, of this technological and industrial sector, working particularly in-depth on the principles of interconnection.

As shown by the orientation of CIGRE studies at the end of the 1930s and the industrial concerns and aims of its members on the eve of the Second World War, the construction of power systems was an effective factor of regional modernization. At the same time urban electrification had largely progressed both in emerging countries and in the colonial world.

Chapter V:
A period of standstill during the Second World War and the new phase of CIGRE's expansion in the 1950s

The power systems crisis during the Second World War and the reorganization of the electricity sector in the post-war period: the introduction of a new integrated model.

During the Second World War, CIGRE activities naturally came to a halt. The Proceedings of the 1939 Session were drawn up as usual and published in early 1940, and then activity stopped almost completely. This period of war could have been fatal for CIGRE, had it not been for the watchful approach of the President who maintained a minimum level of activity. Thanks to the action of Ernest Mercier, who easily secured the assistance of French members, the latter provided the required subsidies every year for CIGRE to be able to keep a skeleton staff, and be ready to restart the organization's international work as soon as peace returned. It suffered no damage other than the destruction of a part of its archives in a bombardment, during which, unfortunately, one of the ladies on the Secretariat was injured.

In all fields of operation, and also in most countries that were at war and/or occupied, operation of electricity transmission and interconnection systems experienced an increasingly serious operation crisis. This crisis was marked by the destruction and shortage of facilities, the direct or indirect appropriation by the occupying powers, and the general disorganization, and then, in 1943-1945 in much of Europe, by the crumbling of the electricity economy. We must not forget that, as evidenced by the Allies' economic and technical archives, the electricity war was an effective weapon in the general war. In this electricity war, the electricity transmission systems were key targets, starting with transformers and control centres. These equipments were more frequently the target of attacks than were the hydro-electric power stations, which would take much more time and money to rebuild.

At the same time, the Second World War was conducive to the major development of State control of the electricity economy. This concerned both the coordination of the war effort and the rationalised management of shortages. Technocratic organizations flourished during this period and often continued after the war, with some minor adjustments. In the electricity sector, the principle of interconnection, in the national interest and public service of energy, which had gradually spread in the inter-war period, established itself as a dominant model, or even a paradigm. Hence, in the post-war period, in several major CIGRE countries such as the United Kingdom, France and Italy, an industrial model of national integration became the rule. This was also the case in communist countries, where the process of nationalization and State ownership was totally comprehensive by definition. This model, which could be organised around an integrated generation-transmission-distribution monopoly – of which EDF [the French national electricity company] became a prototype,– continued well up till the start of a new cycle of deregulation/reregulation which started in the 1980s. However, from 1945 to the 1980s, it was not predominant. At the time, the organization of the electricity sector was characterised by the division/opposition between countries with very free market economies, such as the United States where national integration of the electricity supply industry did not take place, and the communist countries, whose spatial extension reached a peak on the world scale in the 1970s.

Reactivation of CIGRE: the success of the 1946 Session and the new CIGRE spirit

CIGRE was able to start operating again from 1946. It was remarkably fast resuming its activities through the organization of a Session in Paris in June 1946 with more than one thousand delegates representing thirty different nationalities. In the post-war period there was a general enthusiasm for electrotechnics, above and beyond the urgency of reorganising power systems and restoring normal operating conditions, which was in many cases only achieved in the late 1940s.

From early June 1945, telegrams from the United States and the United Kingdom, followed by letters, had asked the President Ernest Mercier to put CIGRE back into action as quickly as possible. Responding to their strong and heartfelt plea, Ernest Mercier convened the Administrative Council as soon as international communications allowed and when accommodation became available in Paris. He suggested that, at the same time, a number of experts would be invited who could provide the Administrative Council with useful information relating to resuming studies. E. Mercier expected that only a few members of the Administrative Council would be present. Yet, fifteen members were there or were represented. Around ten experts were expected, and sixty-four were present ! The Administrative Council meetings were held on 14th & 16th November 1945 and the meeting of experts on 15th November. They took place at the "Cercle Interallié" and decisions were reached which made it possible to prepare, within a very short time, the 11th Session in June 1946. CIGRE was thus the first major International Association to resume its pre-war activities.

Figure 15 - 1946 Session

In accordance with the Administrative Council's decision, the 11th Session was held from 27th June to 6th July 1946 at the Fondation Berthelot, which had been the venue of the 1939 Session. Despite many practical difficulties faced by its Secretariat – of which the lack of paper was one of the most serious – and those facing the participants in connection with passports, visas and currency exchange, not to mention the transport difficulties and the general lack of facilities in Paris, the number of participants exceeded all expectations. 450 or 500 delegates were expected, and 877 were recorded, from 30 different countries.

Naturally, this post-war Session was of the highest interest for many countries which, for seven years, had been lacking technical information on the work carried out and the progress made elsewhere. This Session gave everyone a long-awaited opportunity to again meet colleagues from countries which had not experienced a period of occupation. It showed that CIGRE had not suffered any major damage in the extreme crisis of a total World War lasting six years. This was proof once again that it met a real need and a vital international necessity, going beyond an already very wide technological sphere.

At this essential Session in June 1946, the US National Committee's position was strengthened by the role played by the United States in war, and the influence of American technology. Its Chairman presented a well-argued proposal which led to the reorganization of CIGRE. This reorganization applied measures aimed at promoting the recruitment of permanent Members, establishing new annual subscription fees for each of the categories of members to fund the Organization, and extending the range of services provided for members between Sessions.

The American proposal led to the official establishment in 1948 of two categories of members, i.e. individual members (persons), and collective members, who could be any of the following:

- public or private industrial or commercial companies,
- Educational/Research Institutes[20],
- Governmental Organizations,
- Scientific or technical associations.

Another proposal from the US National Committee also set down as a permanent rule the use of French and English as the official working languages for the Sessions. Additionally, publication of the Session Proceedings would also be bilingual.

CIGRE's new international and organizational dynamics

The 1948 Session marked the full restoration of CIGRE's activity with a great increase in its attendance. Despite the persistence of difficulties concerning visas and currency exchange, the attendance at the Session clearly exceeded 1,000; 1,144 attendees were recorded as compared with 877 in 1946 – a spectacular 30% increase. In any case, the organization of a conference for 1,144 people, with 180 "accompanying ladies" (to quote the official expression) and other associated members, became more and more costly and complex. In 1948, some simultaneous meetings were attended by over 300 people. Accordingly, premises of higher capacity had to be found for the following Sessions.

During the 1948 Session, Ernest Mercier expressed his wish to leave his position as President of CIGRE which he had held for no less than fifteen years, since 1934. Despite his colleagues' great insistence, he did not agree to be renewed in his functions, a decision which the Administrative Council was compelled to accept but which was strongly regretted by all members. Until then, the Administrative Council had always been chaired by a Frenchman (R. Legouez 1921-1928, M. Ulrich 1928-1933, and E. Mercier 1933-1948). When the time came to choose a successor for E. Mercier, and upon the suggestion of the French delegates themselves, the Administrative Council thought it would be advisable that the presidency now be handed over to personalities of different nationalities. Thus a Swiss man from Lausanne, R. A. Schmidt, was elected by acclamation, while E. Mercier remained as member of the Administrative Council through his unanimous election as Honorary Chairman. R.A. Schmidt, President of Energie de

20 - In 1994, Educational Bodies were in a specific category with a lower membership fee, which gave them the right to 2 votes at the General Assembly (whereas Companies were entitled to 5 votes) .

l'Ouest-Switzerland, had chaired the *Union des Centrales Suisses* for fourteen years and, on the international scale, he had already been the President of the International Union of Producers and Distributors of Electrical Energy. He provided CIGRE not only with his technical expertise but also, like E. Mercier, with his extensive international network of contacts; he was President for nine years, until 1957.

Figure 16 - President R.A. Schmidt 1948-1957

The 13th Session in 1950 confirmed the continued pace of CIGRE's expansion, with 1,252 participants and 325 companions. It was now very far from the 231 attendees of the 1921 congress. With no less than 144 reports, concern was expressed over the dangers and possible negative drifts consequent to the growth of the Sessions and of the Organization in general. With a rise in numbers that some found excessive, wasn't there a risk that CIGRE might become a victim of its increasing success? Would it be able to cope with this multifaceted new dynamics ?

La séance d'ouverture.
M. Schmidt, président de la C. I. G. R. É., prononçant son discours.
A sa droite, et de *gauche à droite* : MM. Houbart, Gaspard et Tribot-Laspière.
A sa gauche, et de *gauche à droite* : MM. Louvel, Ministre de l'Industrie, Ernest Mercier, Attwood, Bardagelata et Ailleret.

Figure 17 - Opening Ceremony of the 1950 Session

The indicators of success were ambivalent and could be appraised with criticism regarding financial and organizational management of the Sessions. Considering the technical means available at the time, the size of the Sessions could be considered too large, or even excessive, by both external observers and the Governing Bodies of CIGRE.

However, in a determinedly positive approach, the new dynamics of CIGRE were driven by the creation of new Study Committees, which increased the technical – and perforce industrial and economic – spectrum of the international Organization's action. Thus, in the period after the Second World War, in order to better adapt to the development of technical systems and to the requests and demands of the CIGRE community, the following Committees were created:

Protection and Relays,

Energy Transmission by Very High Voltage Alternating Current,
Transmission by Direct Current,
Long-Distance Transmission,
Transformers,
Stability, and
Coordination of Insulation and Generators.

By 1950, there were 17 Study Committees.

Initially, all CIGRE members could join a Study Committee. However, it soon appeared that a number of members only joined a Committee to unilaterally retrieve information, but did not make any constructive contribution to the CIGRE community. In addition, a number of Committees counted 40 or 50 members, which made it practically impossible to do any efficient or even effective work. Therefore, by decision of CIGRE's Administrative Council dated 5th May 1947, which superseded that of 29th April 1938, the number of members on a Committee was limited in principle to 12, and these members were proposed by the National Committees for official selection by the Administrative Council. However, it was rapidly realized that this maximum of 12 was a little too low and, after a request by most of the Chairmen of the Study Committees, the Administrative Council raised it to 16 by a decision dated 20th June 1951.

Despite this relatively minor increase in the maximum number of official members allowed, a number of Study Committee Chairmen still criticized this restriction, complaining that they were thus compelled to do without the collaboration of some competent engineers whose contribution would have been useful if not essential. In order to meet their request, two measures were taken by the CIGRE Administrative Council:

- First of all, every Study Committee member was invited to form a Sub-Committee in his own country, chaired by himself, to which he would convene local peers he would select for their expertise. The members of these Sub-Committees, commonly known as *advisors*, continually improved the efficiency of the Study Committees. Started first in the United States, the participation of *Advisors* gradually extended to most countries counting a National Committee.

- In 1950, again for the purposes of widening the field of action of Study Committee Chairmen, the Administrative Council allowed each of them to invite a number of engineers, chosen for their expertise, to its Committee meetings, at the same time as its Official Members. The discussions could thus be widened and nurtured by new contributions. These people who formed *"Groupes d'Etudes"* [literally, "Study Groups"] were often advisors themselves. A first Study Group was created in 1951 by Mr. Margoulies, who chaired the Protection and Relays Committee.

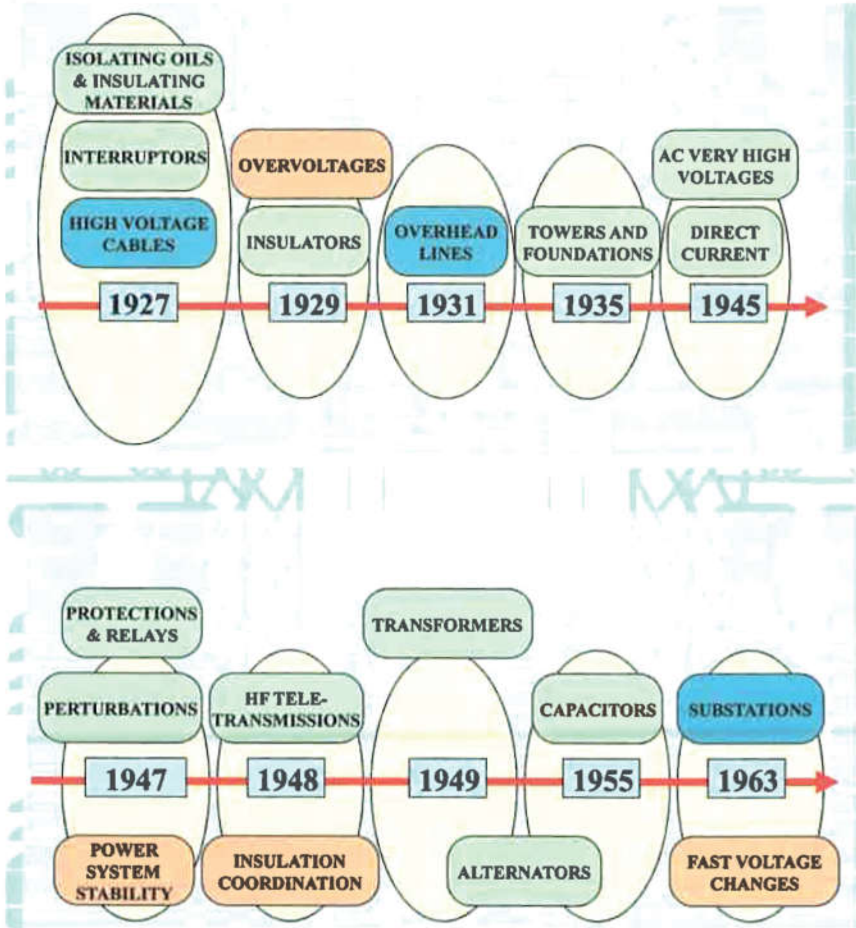
Originally, the purpose of the Study Committees was simply to enable CIGRE members who were interested in a subject to continue the exchange of views between two Sessions. However, experience showed that the Study Committee Chairmen could have a considerably greater role if each of them was asked to chair the "Group" of reports corresponding to their own Committee during one Session. Originally, the Chairmen of discussion meetings during a Session were appointed more on grounds of courtesy. Then, for Sessions after 1948, any person who chaired a Study Committee would - by right - chair the discussion meeting where the reports which referred to the person's Committee were presented and discussed.

This ensured continuity of CIGRE's work. Therefore, between two Sessions, each Study Committee could provide permanent liaison on a given subject.

Study Committee Chairmen were thus given due recognition for their essential role within CIGRE's organization. The Study Committee with a Chairman, a Secretary, often an appointed interpreter, and 16 Permanent Members, together with experts, advisors and its Study Group, now clearly was one of the fundamental units, if not the fundamental unit, on which CIGRE was definitively founded.

This fundamental unit of the Study Committee was consolidated by the strategic role of Special Reporter within each Session discussion meeting. A Special Reporter coordinating the work with the chairman of the respective discussion meeting was gradually recognized as essential. As a result, after 1948, the preparatory study of the reports to be discussed during a discussion meeting and the outline of the discussion were prepared in advance by both of them, in an indispensable close collaboration.

TABLE 12: CIGRE Study Committees from 1927 to 1963 [21]



21 - *An animated history of CIGRE Study Committees from 1921 to 2003*, CIGRE, 2003, document prepared by by Philippe Adam, Secretary of CIGRE's Technical Committee (See also Tables 14 and 15)

The complex economy of Sessions: simultaneous discussion meetings, strengthening of bilingualism, and regulation of reports

In the post-Second World War period, as from the 1946 Session, it was found that the single half-day allotted to each major subject was not enough for the development of discussions, and the need to have simultaneous discussion meetings became really urgent. Until 1946, there were never simultaneous discussion meetings, so that all congress delegates could attend all the discussions, if they so wished. This enabled them to have a complete view of the most recent technology in the enormous field of high voltages. This was the very aim of CIGRE's founders, and it was complied with very closely during the first eleven Sessions. However, to ensure that there was only one discussion meeting in progress at any time, it had become necessary to very tightly limit the speaking time devoted to each major subject, so that no discussion meeting would run over onto or overlap with the following one. Sometimes this could not be avoided. Considering the scope of the discussions and the number of subjects to be addressed, it became impossible, within CIGRE's post-Second World War dynamics, to devote only one half-day to each major issue. Therefore it was decided to allot a full day to each of them and, as the duration of a Session was to be maintained as ten days, it was absolutely necessary to run simultaneous discussion meetings.

So, in 1948 the initial principle of single discussion meetings was modified and, for the first time, some discussion meetings were scheduled to run simultaneously. However, this first test was tentative, since only two simultaneous discussion meetings were held on 26th June 1948, and two others on 1st July. Some congress delegates strongly regretted this move, and so, before making a final decision, CIGRE consulted with all its National Committees. Most of them answered favourably, though requesting that simultaneous discussion meetings be kept to a minimum. It was on this basis and in compliance with this general aim that the following Session was organised in 1950.

The experiment of simultaneous discussion meetings was therefore considerably extended at the 13th Session in 1950. In fact it could only be held at the Centre Berthelot, because six pairs of two simultaneous discussion meetings were planned. This made it possible to organise 20 discussion meetings instead of 16 in 1948 and 14 in 1946, and to have 70 hours of discussions instead of 46 in 1946 and 52 in 1948. Thus CIGRE was able to devote a whole day – and no longer only half a day as in previous Sessions – to the subjects of Stability, Transmission in alternating current at very high voltages, Switches and Overhead lines. As a direct consequence, half a day was devoted to issues which previously had to be covered in only half a discussion meeting period. This experiment was judged so positive that, as of 1952, almost the entire Sessions were planned with two discussion meetings being run at the same time.

Therefore much more time was devoted to discussions, which could be better delved into. At the same time, the discussion meetings were now chaired by the Chairmen of the Study Committees, who were by definition recognized experts in their field. They were happy to have the opportunity of Session discussion meetings to examine in a methodical way and with continuity the issues pertaining their Study Committee's field of activity. On the practical side at the time of the 1950 Session, the outside temperature was very high and although the ventilation in some of the Congress premises had been greatly improved, many congress delegates suffered considerably from the heat. They expressed the wish that the traditional date - last Thursday in June - should be brought forward to an earlier date. This request was implemented for the 1952 Session, which opened on Wednesday 28th May and ended on Saturday 7th June.

The organization of simultaneous discussion meetings, which had become inevitable, definitely improved the organization of Sessions. However, at the same time, it created great difficulties for CIGRE, in terms of bilingual personnel, who were quite difficult to recruit but whose number nevertheless needed to be increased, especially in the case of interpreters.

Thus, as we have seen, during the nine Sessions from 1925 to 1946, R.A. McMahon single-handedly carried out the arduous task of interpreting, but sometimes at the expense of his health. Naturally, his dedication had physical limits, and the 1946 Session showed that the task clearly exceeded the capacities of one single man, no matter how exceptional he was. Therefore CIGRE enlisted the services of other people, who took part in this difficult interpreting work as from the 1948 Session[22]. This enterprise, in all senses of the term, became all the more difficult as the number of simultaneous discussion meetings during a Session increased, thus requiring a larger number of interpreters. In the early 1950s, CIGRE was not sure that it could meet this major challenge. For the 1952 Session, because of the increasing number of simultaneous discussion meetings, no less than 12 interpreters were required.

The complete Proceedings of a Session which included the texts of the oral contributions, in three volumes, could only be published in both English and French as from the 1946 Session, because only from that year on was the number of subscriptions received for the English edition sufficient to cover the very high publication costs involved. However, ever since 1921, the subscriptions for the French edition had always been sufficient to enable this edition to be published regularly. For an international Organization such as CIGRE, full bilingualism was a major organizational, human and financial challenge, entailing both written translation and oral interpreting.

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22 - In 1948, to replace R.A. McMahon alone, no less than 9 different interpreters were required.

Overall, taking the 1950 Session as the historical reference, 144 reports were considered as overabundant material for presentation. It was certainly a good sign of CIGRE's prestige and usefulness that many authors sought the honour – or even a form of recognition – of presenting a report at its Sessions, but on the condition that reasonable limits be set. Such a large number of reports had two major disadvantages: the excessive printing costs that seriously drained a Session's budget, and also the lack of time for congress delegates to closely examine the reports in advance, even if they wished to concentrate only on those that were of special interest to them. To counter this problem, CIGRE's Administrative Council decided after the 1950 Session, to reduce the number of reports by 20% for the following Session in 1952, with the hope that the number could be further reduced in the future. However, the setting up of the Preferential Subjects System was the best approach, as we shall see below.

The printing and translation of reports and their distribution to congress delegates became one of CIGRE's greatest tasks. If we refer to the 1950 Session, it implied printing, translating and distributing 2,648 pages in French and as many in English, all abundantly illustrated, i.e., three volumes of 900 pages each, in less than six months.

In meeting this increasingly difficult challenge, the proportion of reports that were sent in advance to congress delegates reached 100% for the first time for the 1948 Session, after no less than 25 years of efforts. Thanks to the diligence and goodwill of the authors and the National Committees, all of the reports – which totalled 125 – were sent out on 20th May 1948, in both English and French, to all congress delegates who had registered by that date.

The 100% goal was also achieved in 1950, when all the 144 reports were sent on 15th May, in both English and French. This remarkable result, always obtained just in time, was due to the combined efforts of the National Committees in selecting the reports, and naturally the authors themselves, as well as the translators and printers, with the coordination of the Paris Office.

In terms of regular attendance at the Sessions, and thus dedication to CIGRE, a second survey was conducted at the 1948 Session, further to that of 1933. It was found that, out of 1,144 congress delegates, 68% had already attended one or more previous Sessions. In addition, by definition, the official programme of every Congress included technical tours of generation and transmission installations, as well as industrial research laboratories. It was followed by study trips which also included visits of tourist interest.

Figure 18 - Dinner-dance event - 30th May 1952 in the Cercle Interallié Gardens

The implementation of the Preferential Subjects system and the major fields of contribution by CIGRE members in the late 1950s and the early 1960s.

In 1955, as a direct consequence of this process of sustained growth from 1946 and therefore of these new overall CIGRE dynamics, CIGRE's Administrative Council established the coordinated system of Preferential Subjects to provide a means of selection, which was considered rational and transparent. Certainly, after the numerous tentative steps since the 1950 Session, the Preferential Subjects solution took a long time to develop and to become officially established, since the new system was only applied for the first time at the 1956 Session.

In 1956 the Preferential Subjects system was adopted. Each Study Committee decided on two or three major topics (referred to as Preferential Subjects) on which the papers to be presented and discussed at the next Session should focus. The list of these topics was issued as the "Call for Papers" and circulated to all National Committees. These Preferential Subjects reflected the topical issues of the time and as such they gave a good picture of the evolution of problems faced by the Power Supply Industry.

Transformers

Until the mid-1950s, the voltages in power systems reached 300 kV in successive leaps. However, during a period of fifteen years, from 1950 to the mid-1960s, there was an acceleration in the increase in voltage, which finally reached the level of 800 kV. The development of transformers and reactors for this high voltage led CIGRE, during this initial period of application of the Preferential Subjects system, to work on dimensioning and tests, as the increase in voltage developed with a significant growth in the power of equipment.

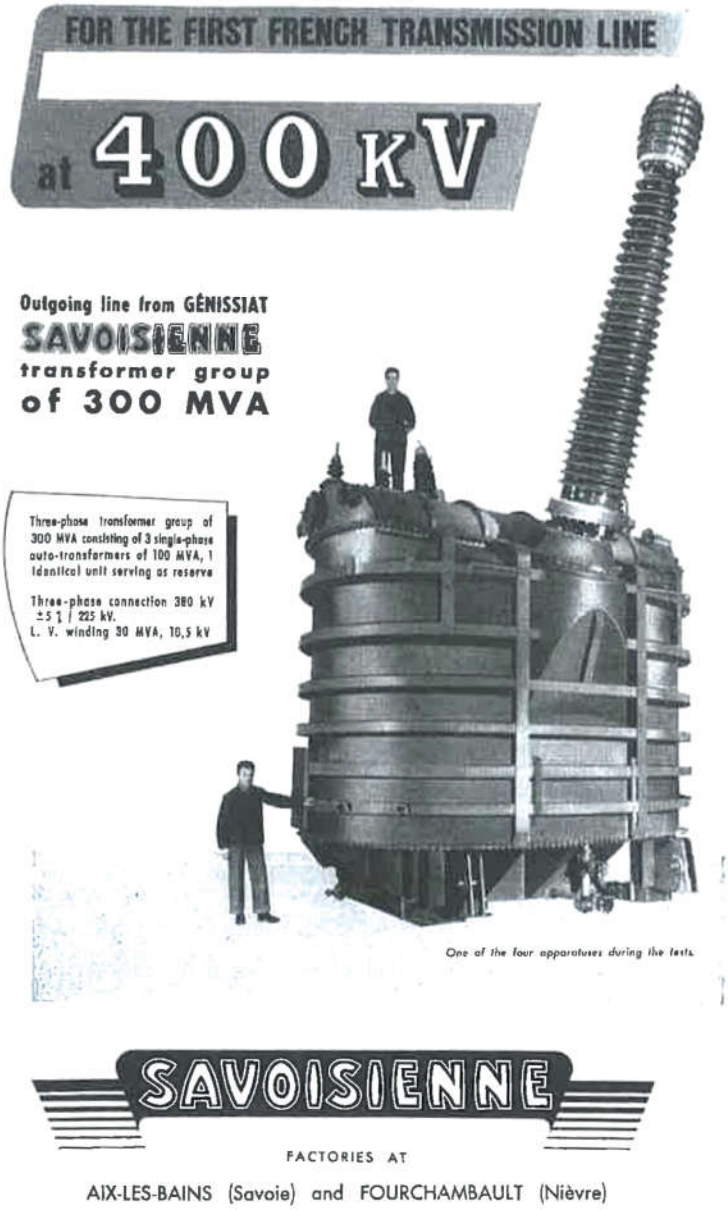

Figure 19 - Transformer-ELECTRA 28 - 1973

The specific subjects in the late 1950s and the early 1960s show that the withstand of transformers to lightning impulses was poorly known. The introduction of lightning arresters required additional studies to be performed so that lightning strike tests could be introduced with so-called "chopped" waves. The detection and locating of faults were also studied. The actual measurement of such voltages applied by means of a voltage divider already posed specific problems to specialists. The interconnection of the network led to the development of transformer tap-changers for automatic voltage regulation. The parallel operation of equipment was also studied at the time.

With the increase in the power of transformers, CIGRE addressed thermal problems and problems of short-circuit currents withstand. Laboratory test techniques and procedures were developed to characterise the effects of these severe constraints. In cases of short-circuit, windings are subjected to very strong mechanical strains, which deform the windings both axially and radially. These deformations can cause destruction of the windings' insulation, as well as loosening of the windings. The aim of CIGRE's work was to address the influence of the material used for the conductors, the stabilization of insulation materials in windings and the tightening of windings against the core.

Later CIGRE worked also on calculation tools for evaluating the strain on windings in service with strong currents, and on the thermal performance of these same windings. The increase in power also led the experts to examine the problem of transformer noise. During the same period, studies started on partial discharges and their detection and experts tried to use the signals of these discharges in order to locate them in the complex assembly of the windings.

The ageing of the insulation by oxidation led CIGRE to studies on the possibilities of slowing down the ageing of insulating oils. The presence of a separation between the oil and the ambient air reduces this ageing and thereby increases the lifetime of the facility or increases its operating temperature. This period over the late 1950s and early 1960s finally witnessed the introduction of auto-transformers that allowed savings to be made in materials, dimensions and losses, which were sources of substantial financial savings.

Overhead lines

In 1956, the fields corresponding to the Preferential Subjects devoted to overhead lines were in the second and fourth Sections of the Session and were divided among no less than four Study Committees for the general design dimensioning of lines: SC 22 for towers and foundation blocks, SC 23-24 for conductors, SC 25 for insulators, SC 40-42 for very high voltage lines (above 220 kV); and three "electrical" Study Committees: SC 33 for overvoltage and lightning, SC 35 for telephone and radio interference and SC 41 for "Insulation

Coordination". Regarding these Study Committees' scopes, a key technical achievement was realized in 1962 by the Volgograd-Donbass (USSR) DC Transmission line +/- 400kV. It was the largest DC Transmission line (473km) in the world for several years. Around the same time AC Transmission lines were put in operation: in the late 60s – 735kV in Canada, 750kV in the USSR and 765kV in the USA.

Until 1970, groups 22, 23-24, 25 and 33 alternated with groups 35, 41 and 40-42 and, as a result, the different fields related to overhead lines were discussed only every four years. The Preferential Subjects were then very specific to each of the components: insulators, foundations, conductor bundles, etc. At the 1960 Session, this very specific nature was clearly visible through the Subjects developed: insulators' thermal shock tests, withstand tests in a polluted atmosphere, heaving and corrosion of foundations, etc. Yet, in 1964, the Subjects became more general. People studied the lifetime of structures in relation to the effects of vibrations, weathering and the associated safety coefficients, conductor creep, etc. Lastly, at the 1966 Session, the reduction in the costs of towers was one of the priority subjects.

Insulated cables

From the creation of CIGRE in 1921, insulated cables were always discussed and were included on the agenda of the founding Session under the topic of "Construction of lines" and in the "Underground and submarine lines" group. The priority issues of this pioneering era concerned the limits of use of single-core and multi-core cables, the determination of electrical characteristics and post-installation tests. A pioneering overview report was presented by the French engineers Couffon, Geoffroy and Grosselin on "Very high voltage underground and submarine lines", which gave rise to an in-depth international comparison during the discussions. Almost 90 years later, these subjects are still central to the work of Study Committee B1. It was precisely in 1927 that the decision was taken to create a specific Study Committee SC 2, which was renamed SC 21 in 1966 and then became SC B1 in 2002 with the last reorganization of Study Committees. In fact, the date of 1927 for the creation of this Study Committee was very significant, in that this was when the first two OF (oil filled) underground lines operating at 132 kV were put into service in the United States, in both Chicago and New York. In this "Insulated Cables" Study Committee, the Dutch influence was very important, chairmanship being handled by several Dutch Chairmen consecutively with a Dutch Secretary, J.C. van Staveren, who assumed this task during the first thirty years (1927-1957); he was then appointed Chairman. A French period then started as the Secretary functions were held for many consecutive years by Frenchmen.

In 1956, the Insulated Cables Study Committee counted four Preferential Subjects: long-distance submarine cables, high voltage cables with synthetic insulation, the use of aluminium for conductors and sheaths, and the internal overvoltage withstand of very high voltage cables.

In 1958, the methods for installing and laying different types of cables were also entered on the list of Preferential Subjects, which still included direct current cables, long-distance submarine links and new plastic materials in the cables industry. No less than nine areas of interest were addressed at the 1960 and 1962 Sessions. In addition to the now traditional subjects of previous Sessions, new concerns were: feedback on the performance of very high voltage and aluminium sheath cables, the impacts of the thermal characteristics of soils on transmission capacity, and the possibilities of artificial cooling. Particular attention was paid to the performance of cables in short-circuits at the 1962 Session.

Protection, telecommunications and interference

In 1956 the fields corresponding to the three subjects: Protection-Telecommunications and Interference were included in the Session's third section, which was divided into three groups: group 31 for protection relays, 34 for communications, and 35A for telephone and radio interference. Until 1970, group 31 alternated with groups 34 and 35A. For Protection the proposed subjects concerned mainly the choice and performance of the various facilities and equipment, viz.: types of protection relays for lines, transformers, and reclosing principles. As from 1968, however, new problems emerged which were related to transients and particularly the performance of the complete assembly formed by the instrument transformer and the protection relays. Technological innovations were also discussed, with a subject on transistorised protection systems. Until 1974, in the field of telecommunications, Preferential Subjects concerning transmissions only concerned problems related to the use of powerline carriers (PLC). In interference, when group 35A started in 1958, the topics focussed on two types of «interferences» from power systems in relation to the following:

- telephone networks, following faults to earth in power systems and the means to be adopted to reduce the effects;

- radioelectric networks, mainly due to the corona effect on lines and the measures to be applied to reduce its impact.

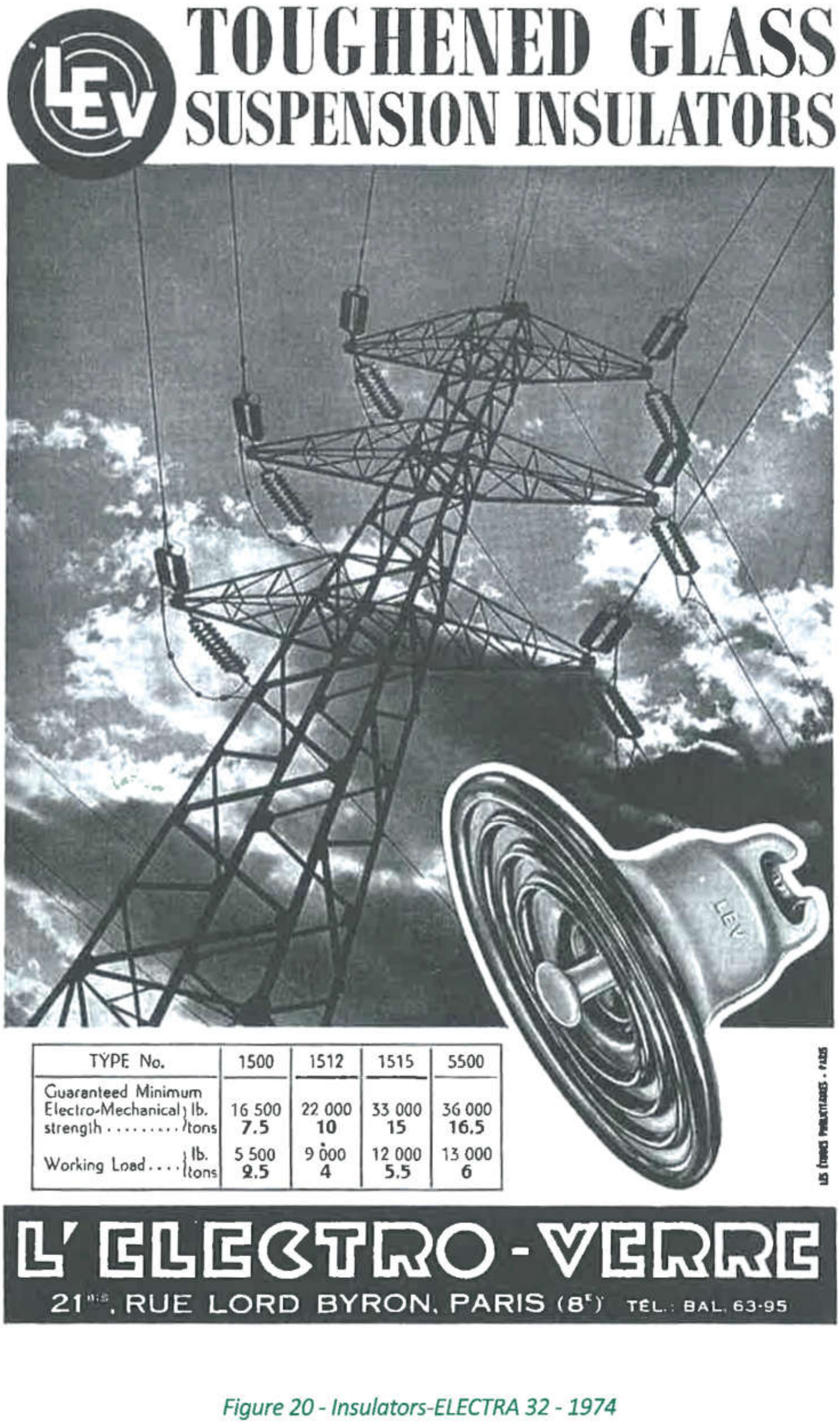

Figure 20 - Insulators-ELECTRA 32 - 1974

Up until 1966 there was no change, except for the added concern of television interference and the creation of SC 26, when the subject was added which concerned induced interference generally related to gas and oil pipelines, in vehicles and various structures. The topics no longer addressed impact on neighbouring equipment and concentrated on quality of supply, that is, sudden voltage variations (voltage dips) within the electricity transmission/distribution system.

Systems Preferential Subjects

During the period, the ways in which these subjects were to be handled within the Committees were thought out and reorganised several times. This reorganization process – in fact, a process of continual adaptation – is perfectly understandable since it is central to the mission of an "International Conference on Large Electric Systems". CIGRE operates in this very wide field of studies at the high end of all equipment, structures, automatic control systems and smart systems, all of which contribute to ensure the continuity of supply, but also at the interface with the world outside the realm of electrical engineering, that is, the world of the human communities for which engineers are working. This interface has had to constantly adapt to changes in electromechanical equipment, new control/ monitoring, information technologies, and changes in energy sources and their distribution, as well as in institutional and social paradigms.

In the late 1950s and early 1960s, the predominant context was that of an energy-hungry world. The consumption of power systems in developed countries doubled every ten years. CIGRE's main priorities for study were the increase in transmission capacities, mainly by a voltage increase, and the stability of power systems, which were becoming more and more interconnected. As part of the general reorganization of the Study Committees in 1962, both a specific Committee for "Lines of voltage greater than 220 kV" and a Committee on "Design and operation of power systems" were created. The increase in voltages caused new problems of "Insulation coordination" and of "Telephone and Radio Interference", which were to continue for a long time. They were experienced throughout the following decades, because they were a source of constraints that hindered an increase in voltage. Good insulation coordination was necessary to limit the cost of equipment. It depended more and more on internal overvoltages, particularly switching overvoltages, a recurrent topic as was corona radio interference, which made it necessary to oversize the conductors in relation to the size required for an economic utilization of their thermal capacities.

Of course, stability and operation of power systems were still studied, but with full awareness that the means of study were changing. From the 1960 Session onwards CIGRE worked on the comparison of analogue and digital analysers, expressed in 1962 in terms of "analogue and digital calculators". It should be noted that the first Preferential Subjects of the 1956 Session included both a comparison between direct current transmission and alternating current transmission and a subject on the use of series capacitors. These two subjects were closely linked to very long distance power transmission, which CIGRE studied at a very early stage, probably with the incentive of Scandinavian countries whose concern was how to best handle the considerable hydraulic resources of their remote northern areas.

Conclusion:

At the start of the 1950s, CIGRE could rely on a wealth of experience of three decades, a long experience shaped by hundreds of collaborations. In fact, nothing was left to chance. Full bilingualism, translations, interpreting, regulation of reports and discussion meetings, discussions, National Committees, Study Committees, expenditure and income were all activities that had to be gradually regulated through a collaborative effort of the founders of CIGRE, the Presidents and members of the Administrative Council, the Special Reporters, translators and interpreters, the members of the National Committees and the Study Committees, as well as the congress delegates themselves, who often came long distances and showed widely varied professional backgrounds.

The assessment in 1951 was really impressive: CIGRE had 1,600 permanent Members from 40 countries, 32 National Committees and 17 Study Committees; more than 3,000 engineers from all five continents had already taken part, at least once, in its Sessions, and it included the most eminent engineers in the area of high voltage electricity.

Thanks to its own organizational set-up CIGRE was assuming a further dimension if compared to other Congresses and, in conjunction with the IEC to whom CIGRE provided constant support, it stood as a very significant international technical organization that had become absolutely invaluable. Due to the fact that there was only a short interval of two years between Sessions (whereas most other Congresses were held every three years or more), it was able to follow very closely the rapid progress in high voltage technology.

As a direct consequence of its good organization, its Sessions were attended by a majority of regular participants[23]. This was because, above and beyond their personal relations and the correspondence exchanged, they were keen to meet regularly and to continue their discussions and research work with others. Between two Sessions, the Study Committees, who played a growingly important role, ensured the continuity of work, as the normal, logical development of previous Sessions. CIGRE's Sessions, each of which required one year of preparation and almost one year of subsequent processing, could in no way be

23 - The rate of regular attendance was estimated at 70%.

compared to the more commonplace events of the time focussed on prestigious encounters and socialising purposes. In a way, the Sessions formed an international hub of technical and professional networks, where technical problems were examined methodically and from where the progress achieved in this technology of large power systems was disseminated to all countries.

As pointed out by J. Tribot-Laspière in December 1951, "CIGRE has contributed, is contributing and will contribute greatly to the advancement and the dissemination of technical progress in the world, and it justifies what was said by a congress delegate in 1948: 'If it didn't exist, it would have to be created!'[24]"

In any case, in the 1950s, CIGRE could rightly claim that it was the oldest international Organization, after the International Electrotechnical Commission (IEC), to address technical questions in the very extensive field of power systems, with some 2000 members, individual and collective, on the world scale.

A posteriori, from the viewpoint of the history of energy and not only of power systems, CIGRE's missions and its natural area of expertise appear sufficiently clear and rational, based on unquestionable criteria and coherent logic, to establish its legitimacy and distinguish it from the other international bodies in the world of electricity and more generally of energy. Therefore, when other international associations were founded after CIGRE, it was relatively easy for CIGRE to keep to its own track and objectives. Other Organizations would emerge but with their own and clearly different fields of activity. In fact, CIGRE endeavoured – and managed – not to encroach on any other field of action. The deep-rooted stability of CIGRE's position, or even its world-wide dimension, continued until the advent of new paradigms of liberalization of energy markets in the early 1990s. These new paradigms undeniably created a new situation and a new environment of an essentially international character. This challenged the Organization but at the same time, provided a lever for dynamic repositioning and required partial reconfiguration.

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24 - J Tribot-Laspiere, *Electra*, No. 11, December 1951.

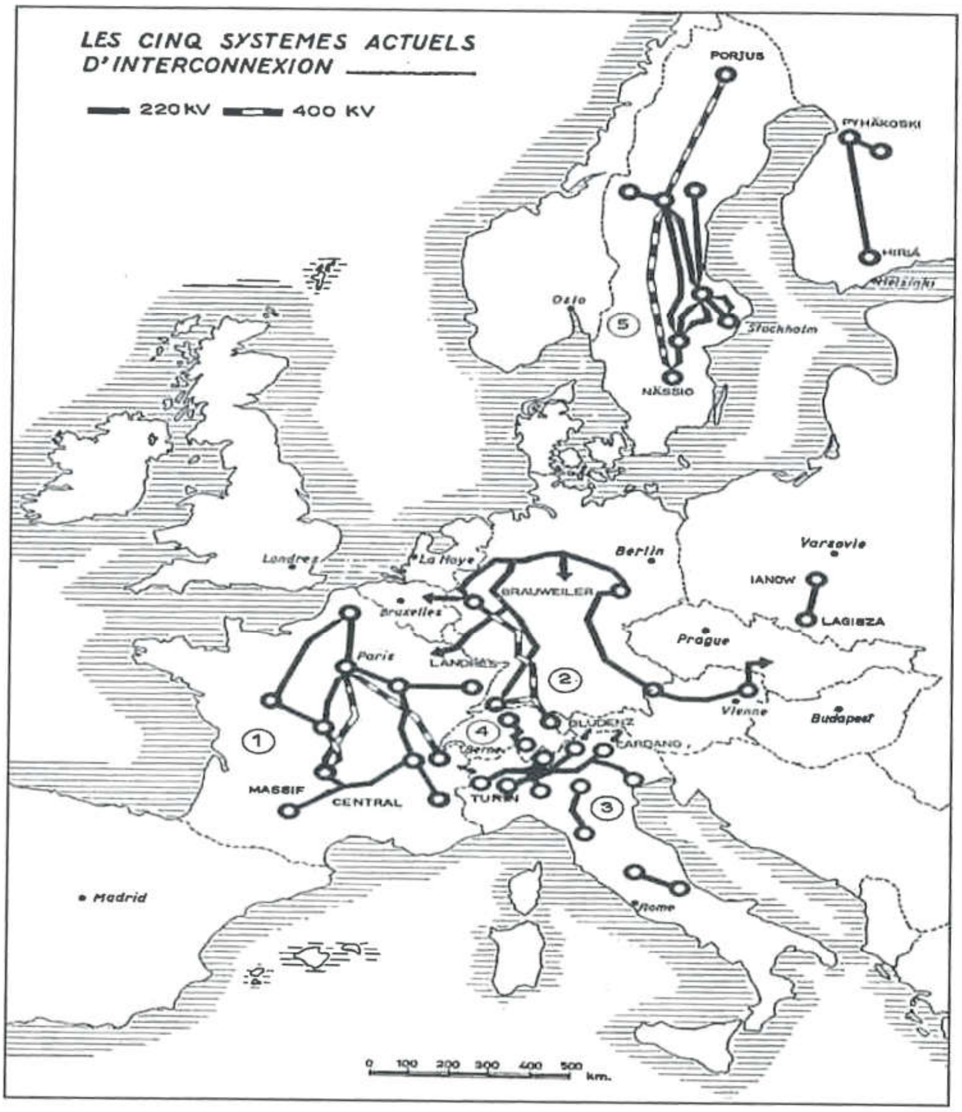

Figure 21 - Europe's Interconnection Systems in 1949

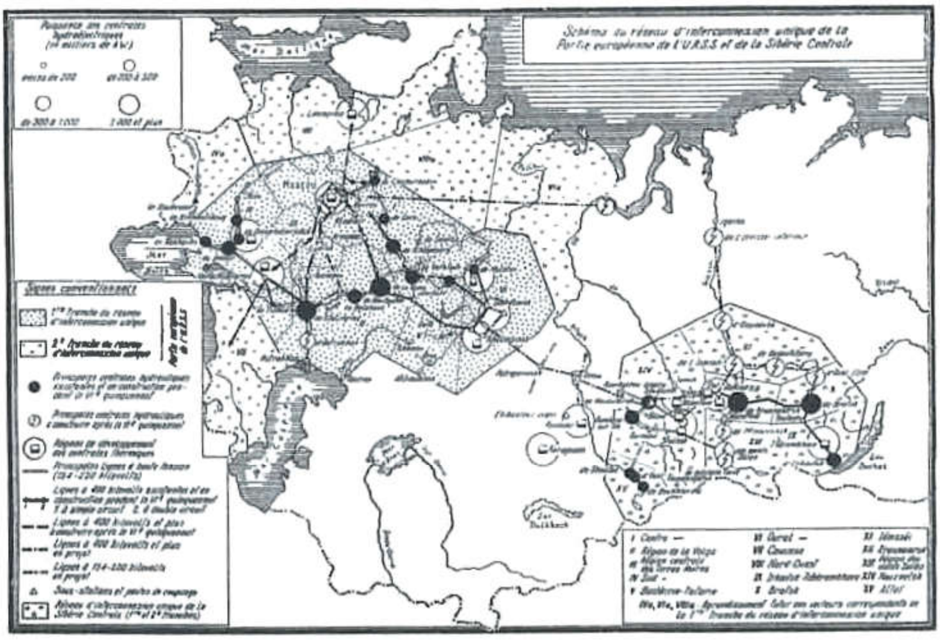

Figure 22 - The USSR Interconnection System in 1957

PART THREE:

CIGRE's maturity and the golden age of vertical integration

(from the early 1960s to the early 1990s)

The use of electricity developed very rapidly throughout the world during this major phase of expansion. Electric Power systems became widespread and increased the density of their grids in the developed countries with market economies (DCME) and, a little later, in European countries of the Soviet Bloc. They were gradually formed in developed countries (DC) at varying paces, with very different means and methods. Therefore the stakeholders in electricity had to mobilise massive sources of energy (hydraulic energy, coal, oil and then, from the 1960s, nuclear fission). Large power systems played a part in this rapid development by combining the following three functions which contribute to the optimization of the electricity system on a national scale, as a priority:

- long-distance (and often massive) transmission of energy from large sources,

- general interconnection, which allows major savings to be made in relation to the reserve facilities and equipment that would otherwise be necessary to deal with unforeseen events in generation and consumption,

- sub-transmission, which delivers energy to the consumers i.e. large users or distribution systems.

CIGRE took part in this rapid development of large power systems by offering a very vast forum for consultation and discussion.

Chapter VI:
Enhanced internationalization of CIGRE: from technical networks to human networks

As we have shown, CIGRE's creation in 1921 coincided with the trend of organization of the rapidly-growing electricity sector, in which it undeniably played a role in consultation, structuring or coordinating the work of the various players. The electricity sector, which was both a technological system and an industry, followed a path that led to a model which reached its peak half a Century later, in the early 1970s. In fact, this path was dual, and it had both technological and institutional aspects. In accordance with its mission, CIGRE was mainly involved in technological aspects. The list of Study Committees created throughout the years reflects these fields of technical interest, and the list of their members includes eminent personalities who contributed most significantly to the technical progress of electric power systems.

On the institutional level, the model of the electricity utility company was already well established by the time of CIGRE's foundation. An increasing number of local companies were then extending their activities on the regional scale, in a process that was interrupted by the Second World War, but which was resumed immediately after the situation returned to normal. As part of this process, in many European countries, companies – which were still varied and private-owned – became nationalised and were consolidated to form monopolies. This was how companies such as EDF (France), CEGB (United Kingdom) and ENEL (Italy) were formed. At this stage, the world of electricity was forming a model with quite clear lines. There were both public companies and private companies, but they were mainly characterised by vertical integration, with a tendency to operate jointly through interconnected pools. This tendency was particularly marked for power systems that were based on thermal installations since, thanks to economies of scale, the generating stations, whose capacities were continually increasing, became more and more economical. In certain countries where power systems were based mainly on hydroelectric power and could easily have sites that were suitable for large installations, for a relatively low price, such as Brazil and Canada, it was also appropriate to have extended power systems.

After the Second World War, considering the speed of economic expansion, these companies had to deal with a constantly increasing load. In the case of power systems based on thermal installations – an option chosen by most developed countries – the increase in efficiency of power stations and the stability (or even the reduction) of the price of fuels ensured that costs and prices continued to drop. The importance given to technological and engineering issues concerning the operation of the companies represented another major characteristic of this period of maturation. It applied both to the economy of large power systems, in the widest sense of the term, and in a synergy that was now natural, to its professional organization of international cooperation i.e. CIGRE. In the early 1960s, a new era of international development opened for the Association.

The end of the era of the pioneers: the death of the "founding father", Jean Tribot-Laspière

CIGRE's Vice-President and Delegate General, Jean Tribot-Laspière, died suddenly on 10th May 1963, having almost reached 81 years of age, just after participating actively in CIGRE's Administrative Council meeting which was held in Bellagio. He had appeared to be in great form, taking a very active part in the Council discussion, and also joining in the walk to Villa Monastero and to Villa Carlotta showing his usual stamina and enthusiasm.

Figure 23 - J. Tribot-Laspière 1954

Born on 21st June 1888 in Limoges, where he completed brilliant classical studies at the Lycée Gay-Lussac, he passed the competitive entrance examination of the *École Nationale Supérieure des Mines* Engineering School, from which he graduated with the title of Mining Civil Engineer. After the usual traditional work experience in a Coal mine, he started working in the financial studies department of the Crédit Lyonnais Bank in 1907. His career really started in 1909 as head of the Technical Department in the *Comité des Forges de France*, which had become the *Chambre Syndicale de la Sidérurgie Française* [French Union of Iron & Steel Companies]. He was also appointed as Secretary of the *Chambre Syndicale des Forces Hydrauliques*, of the Société Hydrotechnique de France and the *Chambre syndicale du Gros Matériel Électrique*, which were all based in the head office of the *Comité des Forges*.

In addition, in 1917, in the middle of the Great War, the Secretary General of the *Comité des Forges* requested that he set up anew the *Union des Syndicats de l'Electricité* [USE – Union of Electricity Companies], which had been dormant for some years, in order to seriously undertake the standardisation of electrical equipment, which was becoming an absolute necessity. He continued as Secretary General of USE until 1929, after creating 25 Commissions specialized in the standardisation of electrical equipment within the Union. This enabled the USE to be viewed on an equal footing with similar organizations in foreign countries.

During this crucial period from 1917 to 1929, he played a very active, if not decisive, role in the creation of new national unions of companies in the already very wide field of the electricity industry. These included the *Syndicat des Entrepreneurs de Réseaux et Centrales Electriques* [Union of Electricity Network and Power System Contractors], for which he was Secretary General until 1945, the *Syndicat des Fabricants de Matériels de Chauffage Electrique et des Appareils Electroménagers* [Union of Manufacturers of Electric Heating Equipment and Household Appliances], the *Syndicat des Installateurs Electriciens* [Electrical Installers Union], the *Association Corporative des Installateurs Electriciens* [Corporate Association of Electrical Installers] and the *Association Française de Normalisation* [French Standardisation Association], for which he remained one of the Administrators until his death.

However, at the core of this multifaceted activity, Jean Tribot-Laspière's work remains inextricably linked to the creation and development of CIGRE, of which he was in effect the main "founding father" and, for 42 years, the driving force in its many areas.

As we know, the pressing necessity, or even urgency, of establishing periodic contact between the stakeholders in electrical engineering from all over the world was the reason for the first Session in November 1921. The Session was organised with the help of the *Union des Syndicats de l'Electricité* and under the auspices of the International Electrotechnical Commission (IEC), of which C.O. Mailloux and

C. Le Maistre were respectively President and Secretary General. Thanks to the creative and organizational energy of Jean Tribot-Laspière, who was revered by his peers, CIGRE's biennial Sessions became the periodic meeting place of electrical engineers from over the world. He had achieved what he smilingly called his "1921 dream".

His in-depth expertise and his sense of diplomacy in resolving sometimes difficult questions, as required by the presence in CIGRE of so many delegates from different countries, enabled the international association to constantly increase its impact in the world of electrical engineering where Jean Tribot-Laspière had patiently built an enormous network of both expertise and friendly relations.

If, as the American philosopher R.W. Emerson said, *"any great institution is the projection of the shadow of a man"*, then this role was recognized in 1963 by the Administrative Council, which adopted a resolution according to which the words *"Founder, J. Tribot-Laspière"* now had to appear on CIGRE's official publications.

Figure 24 - President G. Silva 1957-1966

Revision of the Statutes and further stabilization of the Organization in 1966

In 1966, CIGRE's Statutes were significantly revised to reflect the maturity of a major International Organization, on the various organizational, functional and international levels. The preparation of new Statutes was the responsibility of an ad hoc Committee which included the elite of electrical industrialists of the time, like a sort of "Who's Who" for the large power systems profession. This ad hoc committee was chosen by the Administrative Council in June 1964. It was chaired by A. R. Cooper (UK), who became CIGRE's President from 1966 to 1972, succeeding to G.Silva's (Italy) term (1957-1966). The latter's motto was to maintain and develop *"the CIGRE spirit"*. This ad hoc Committee included P. Ailleret (France), G. Jancke (Sweden) and P. Sporn (USA) as well as F.Cahen (France) and R.A. McMahon (UK). For two years, from 1964 to 1966, it carried out patient, strategic work, requiring travels over several thousands of kilometres. In June 1964 they had agreed to jointly assume, on the basis of a "holding", the responsibilities that J. Tribot-Laspière had taken on before his death in May 1963. As P. Sporn said at the time, *"an Organization of this size could not continue to live with such an economy of means"*. H.C. Barnes (USA) and T. H. Thomas (UK) also attended all the meetings, providing their valuable assistance for collating considerable documentation. The 1966 CIGRE General Assembly ratified the new Statutes which were the result of this Committee's work.

Figure 25 - CIGRE's 1965 Ad Hoc Committee – Stockholm Meeting on 20/05/1965

The 1966 revision/modernization was the first really important reform of the Statutes and the Rules of Procedure since their establishment in 1931. The number and the fields of the Study Committees were radically reorganised, and their terms of reference were established. Limitation in terms of office were adopted for the President of the Association and for the Study Committee Chairmen. This last rule did not in any way imply criticism of the personalities, experts by definition, who, for many years, had occupied these positions with efficiency. It was designed to ensure that the repercussions of evolution and modernization would continually orient all CIGRE's activities. At the same time, the opportunity to fill positions of responsibility could be more easily given – gradually, of course – to younger people.

President Andrew R. Cooper spoke along these lines on the occasion of CIGRE's Jubilee in 1972, referring both to its first fifty years and to the recent reform of the Organization's Statutes, stressing the continued development of its internationalization:

"CIGRE is a collection of individuals rather than a collection of countries. It is true that the membership is drawn from some sixty countries and that more than half of these have their own National Committees, but this merely indicates that the activities of CIGRE are world-wide. It does not imply that nationalism, as we have come to know it, plays any controlling part in CIGRE's affairs. Cigreans are seekers after fundamental truths, who are happy to exchange information with their fellow members in those areas of specialized technology which are of common interest. Each man, in effect, represents himself. His country of origin, for all practical purposes is interesting but not significant"[25].

After the death of Jean Tribot-Laspière, François Cahen was asked to replace him in the strategic role of Delegate General (1963-1970). He was officially appointed by CIGRE's Administrative Council to implement the 1966 structural reform, which was designed to modernise working methods and to continually adapt them to the progress of technology[26].

Development of the Paris Office

In the history of the development of the Organization and CIGRE's multifaceted activities, the Central Office, which was set up statutorily in Paris, played an increasing role from the Association's official creation in 1931[27]. Until his death in 1963, the Central Office was placed under the direct responsibility of J. Tribot-Laspière, who, for more than forty years, coordinated the Organization as Vice-President and Delegate General. For administrative work, he was assisted efficiently at the head of the Central Office's Secretariat by Mlle Defrance, whose energy and professional commitment embodied the CIGRE spirit and significantly marked CIGRE's history. She only left CIGRE, with great regret, in 1968, when she was already well past retirement age. As we have seen, François Cahen held the position of Delegate General up till 1970. This position disappeared in that year with the first-ever nomination of a Secretary General, in the person of René Pélissier, who had had a fine career with EDF. A new phase of precisely three decades started in CIGRE's administrative management. From 1970 to 2000, EDF engineers succeeded each other as Secretary General, nominated by the French National Committee and officially confirmed by CIGRE's Administrative Council.

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25 - A.R. Cooper, "Introduction", *"La CIGRE, son passé, son futur"*, special issue of Electra, CIGRE, 1972, p. 2.

26 - See Cahen F., "La nouvelle structure et les objectifs de la CIGRE. The new structure and the objectives of CIGRE", *Revue Generale de l'Electricité*, February 1970, t. 79, No. 2, pp.151-156.

27 - This history of the Office was reconstituted with the help of the personal account by Liliane Ney, to whom we are very grateful.

Figure 26 - Mlle Defrance at the 1968 Session

For a long time, most of the Paris Office's work – both its daily work and its long-term work - was heavy and costly. It involved handling of membership files manually and translating of all Session papers and Session contributions for the Proceedings as full bilingualism was mandatory. In the 1980s, computers were introduced at the Central Office and work adapted to the new tools. The result was specialization of tasks and, at the same time, diversification of activities. The tasks and responsibilities were then divided among long-standing members of staff, on the basis of their specific expertise, their experience and their inclinations. The following fields were identified and still structure the work of the Office in Rue d'Artois:

- Assistance to the Secretary General, organization of meetings and of contacts with Governing Bodies
- "Membership", including contacts with the National Committees, following up fees and subscriptions and updating membership and Study Committee databases
- Publications, with all of the editorial process of the *Electra* journal, the publication of reports of the Sessions and Symposia (from 1983 on)
- Organization of Sessions, logistics, general services (supplies),
- Finance and accounting processes – covering events registrations and sale of publications circulation of which is essential for CIGRE's impact, beyond the simple financial aspect.

As expressed by the Secretary General René Pélissier in 1972 at the time of CIGRE's Jubilee:

"For the administrative framework of an association such as ours, there must be a perpetual search for the golden number or ideal proportion that allows the general lines of the continually-renewed collective work to develop freely. Just as a frame must not smother a work of art, so an administrative framework must not hinder the development of a technical work. I believe that CIGRE has clearly understood this, gradually putting in place an organization that meets the needs of the moment, but keeping a potential for changes that allow it to adapt flexibly to new needs as they develop"[28].

CIGRE's international community and methods: a multifaceted "club" effect

CIGRE was not in essence a scientific and technical research Organization, but one of its main aims was to discuss the advantages, disadvantages and risks of any new technology which was brought to its attention. This procedure made it possible to announce and disseminate promising innovations as far away and as quickly as possible, saving time in their transition to the industrialization stage.

Thus, at each change to a higher voltage level, only a very small number of countries climbed onboard at the same time and built one or two new lines, which implied taking risks. As the results obtained by the companies were reported and compared within the shortest possible time, the capital invested in the first stage of construction, as well as research and tests, could be limited. This allowed the less advanced countries to benefit from the technical progress earlier than would have been the case had it not been for CIGRE.

Therefore, to a certain extent, CIGRE assessed the advantages and the risks of any new technical idea or any new technical production. This method involved controversial discussions between the most qualified specialists, which proved to be a most vibrant and most efficient working method of CIGRE's Biennial Sessions. At the time of the transition to a voltage of over 220 kV, involving the necessity to deal with the corona effect for higher voltages, a very lively discussion took place in the General Session between the advocates of the bundle, either vertical or horizontal, and those who feared the risk of difficulties caused by wind, ice, short-circuits, etc.

CIGRE's success actually made it more and more difficult to conduct high level scientific discussions, in front of an audience that had become too large. This led to a reform of the role of the Study Committees, finalized in 1964-1966 by François Cahen as Delegate General. The Study Committees

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28 - R. Pélissier, "Evolution de l'organisation de la CIGRE", *La CIGRE, son passé, son futur*, special issue of *Electra*, CIGRE, 1972, p. 159.

were then organised so that the most critical and most detailed discussions could take place between specialists in the best possible conditions.

CIGRE's usefulness was not limited to debates between leading specialists. The outcome was the development of engineering knowledge, which was decidedly made available to all members through reports and meetings. It was also adopted by teachers of electrical engineering, who then disseminated these precepts while continually defining them.

Therefore CIGRE's biennial Sessions and the work of its Study Committees led to a unity of precepts in the technology of very high voltages – a unity that was far from being achieved in other technologies. The large number of collective experiences pooled within CIGRE in connection with the 220kV voltage, for example, led to the success of this voltage level, the most developed and best standardized in the world since the 1950s. CIGRE also without doubt reduced the time lag between the first experiments of a new technology and its industrial development. It not only announced new technologies, but it also provided assessments which reassured users more than if they had been informed via media of more commercial character, such as advertising. Thus, as we have pointed out, new countries could quite rapidly deploy new technologies the adequacy of which had been openly discussed by the CIGRE community. Not only did these new countries thereby save the expense of experimentation and development, but they could also apply these technologies with the amount of expertise and mobilization of human resources in terms of engineers available to them.

Even in developed countries CIGRE achieved universal consensus on a number of issues and innovations – a consensus which often meant that questioning of the value of some new technological developments was no longer necessary. For instance it cleared away the fear that extending parallel operation beyond a certain limit would be an impossibility. It also allayed with the concern over the use of higher and higher voltages.

From the beginning, it had been specified that CIGRE's objectives were mainly technical. This meant that, theoretically, CIGRE's field of action did not specifically include economic studies. Nevertheless, the comparison of technical processes inevitably involved economic evaluations and, for example, it was obvious that the optimal solution from a technical viewpoint was not totally irrelevant to the value of the interest rate. From Kelvin's laws of the economical cross-sectional area of conductors to the comparisons between direct current and alternating current transmission, technicians always had to use economic methods, and often in unforeseen conditions. At the same time, very clearly, CIGRE did not have to discuss economic theories in themselves, and it remained almost exclusively at the service of the international community of technicians, experts and industrialists.

Another major feature that CIGRE acquired gradually was its now well-established and internationally-recognized "club" aspect. R. Attwood, who was for a long time chairman of the US National Committee, and J. Tribot-Laspière valued particularly strongly this "club effect". Personal contacts developed between the specialists from various countries during Sessions and during meetings of Study Committees (at a time when journeys between continents were much slower and less frequent). The "club" aspect of CIGRE was also one of the reasons for creating the members' newsletter, which gradually developed until it reached the high technical standard that *Electra* attained in the late 1960s.

As we have seen, a first short-lived series of *Electra* had been issued in 1931 at the time of the Association's official creation, but it was not possible to meet its ambitious objectives and its publication stopped in 1934. The new CIGRE dynamics in the second post-war period – which started with the 11th Session in 1946 and was confirmed by the 12th Session in 1948, together with the buoyant support of members in five Continents – led to the revival of Electra. The first issue of this second series was published in September 1948, with both a French version and an English version. The declared aim was somewhat more cautious than in 1931: it was announced that *Electra* would be issued two or three times a year, and would be reserved for the Association's permanent members[29]. Thus fifty-eight issues were published from September 1948 to December 1966, while the pace of publication gradually increased and the newsletter became thicker as the years progressed. The culmination of this process of development and growth, which evidenced the Journal's maturity, was the 1967 launch of a new format for Electra, which, in a way, historically was the third series which has been continued, with regular improvements up to the present day. The President of CIGRE, Andrew R. Cooper, and the Delegate General, François Cahen, presented "the new Electra" as follows, in its issue No. 1 published in March 1967:

"Electra appears today for the first time in a new form. Its new format is that standardized by the ISO: 21 X 29.7 cm. The publication becomes bilingual and replaces the two former editions written respectively in the French language and the English language; the French and English texts are presented side by side, respectively in the two columns of a page, printed in different characters to facilitate their reading, and one column corresponding exactly to the other. The figures will be common to the two texts and provided with a legend in French and in English. Advertising will also be bilingual if our advertisers so wish. Electra now has a new, simple and modern cover which marks its transformation.

After long reflection, the decision was taken to proceed with this modernisation of our journal, whose form and presentation have not been changed since 1948.

29 - This second series of Electra, after the long interlude of 1934-1948, was simply entitled "Bulletin périodique publié par la CIGRE". Thus the overly ambitious aim of 1931 of being a "Monthly journal published by CIGRE and dedicated to the study of the production, transmission and transformation of electric energy", quickly came to a halt.

The part played by CIGRE in the electrical industry of the world amply justified moreover the improvement of this Association bulletin which allows keeping informed three thousand members from all countries, on the life of our Association, on the results of its Sessions and on the work of ever growing importance and technical value produced by its Study Committees.

The collective usefulness of Electra for the whole CIGRE community, its working bodies and its members was therefore enhanced and clearly defined within the full range of its functions and its different types of articles:

"The change of format will allow a progressive increase in the space available for technical communications. Our journal will no longer content itself with publishing the Study Committee Minutes, which generally set out the results in too condensed a form. But Electra will become the real means of expression of Study Committees, who will be able to publish in it reports setting out the most important results of their work without overloading excessively, as is often the case at present, the Reports of their work presented to the Sessions. Our publication will increase in interest accordingly, but above all we shall thus establish a closer and more regular contact between our Study Committees and all CIGRE members, who will have the advantage of the most up-to-date news on the research carried out by the best specialists in an international framework, even when they cannot take part in the Sessions, and even when their countries are not represented in the Study Committees".

This newly developed format and this new series of Electra clearly reflect the transition, as of 1967, from the status of internal newsletter (though by definition it was circulated internationally to the CIGRE community) to that of international technical journal, fully recognised by the international community of engineers and experts.

Chapter VII:
The continuing race for technical innovation: maturing of international cooperation

Growth and renewal of Study Committees and organization of Sessions stabilised

CIGRE's fundamental raison d'être has always been the development and dissemination of knowledge in the field of large power systems. Its daily work is based on the ongoing work of the Study Committees, composed of experts from all over the world. Especially from the 1940s, the Study Committees contributed continually to the advance of technology, favoured the emergence of solutions and disseminated the results of their research on a world scale.

The nine Committees in the 1930s gradually increased to reach a maximum of 19 in 1963. Over 1966-1968, CIGRE conducted a first major reorganization to take into account changes in technological fields and emergence of new issues and new priorities in the operation of power systems. The number of Study Committees was reduced to 15 in 1966, then to 14 in 1968. It remained stable in the 1970s and 1980s, but substitutions were made to better address strategic questions, such as the future of electricity transmission and the development, operation and control of power systems, at a sufficiently distant time in the future. Within the Study Committees, studies were gradually entrusted to Working Groups as real driving forces of the Study Committees.They produced reports that were authoritative within the international community of experts.

The reports presented at each Session for discussion had to be closely related to a number of Preferential Subjects set in advance (in principle, three per Group). As we have seen in presenting the founding of the Preferential Subjects system, it was first officially applied at the 1956 Session, to avoid scatter of the discussions and, inversely, to favour their concentration on a small number of topical subjects. The reports were printed and sent in advance to registered congress delegates in the language of their choice (French or English). A discussion meeting of one day for each Study Committee was entirely devoted to the discussion of the corresponding reports. They were neither read nor commented upon individually during discussion meetings, but the discussion had been prepared in advance by the Special Reporter, whose task was to draw up a Special Report which would give the gist of the reports and raise a number of questions for discussion. The Special Report was sent at the same time as the set of reports.

Initially, the Study Committees' main aim was to examine questions which, after being discussed at a Session, had not received a satisfactory answer during discussions. Then, as part of the general reform of CIGRE in 1966, their mission was widened and specified at two levels.

Firstly, each Study Committee now had to conduct all studies and research that it considered useful for the advancement of technology in its field of activity, particularly by examining the most current issues in the field. In this respect, it remained entirely in charge of its work programme, under the coordination of the Technical Committee set up in 1949 and officially confirmed in the new Statutes.

Secondly, it had to participate actively in the preparation of relevant Group discussion meetings for the biennial Sessions. It was the Study Committee which set the Preferential Subjects that had to be addressed directly by the reports presented at these Sessions. The Study Committee Chairman also appointed the Special Reporter(s), according to the nature of the chosen subjects. As specified above, the Chairman of the Committee had automatically become Chairman of the corresponding discussion meeting, for which meeting he was assisted by the appointed Special Reporter.

The 1966 reform confirmed and increased the major role played by the Study Committees both by their internal work and by their orientation of the Session work. They were able to approach a subject in their specific Study Committee, and could then initiate wide-ranging debates on its subject within an international framework. The Study Committees' working methods remained very flexible. The most commonly used method consisted in creating Working Groups with a small number of experts who conducted in-depth examination of clearly defined topics, and reported on their work at Study Committee meetings. This method was very beneficial, as it meant that the best international specialists could be in charge of a precise study or research in their specialised area and that their countries could benefit from the studies and research conducted in the Working Group.

In conjunction with their annual meeting, Study Committees could also organize conferences (Colloquia) devoted to topics specific to their field of activity. External experts were invited to these events.

Figure 27 - Meeting of Study Committee N°5 at the Central Electricity Research Laboratory on 9th May 1967

The Study Committees had undeniably increasing success with CIGRE members. Thus, in 1968, the 14 Study Committees counted a total of 291 Regular Members, representing 31 countries, and 52 Working Groups. In 1966, the maximum number of Members had been raised from 16 to 20 (not including the Chairman and the Secretary). Despite this membership extension, most of the Committees had full membership and, for many of them, the number of candidates exceeded the number of seats available.

As early as 1949 a need was felt for coordination by a Technical Committee. It was thus decided to set up a body which would consist of the Study Committee Chairmen. It would be chaired by the President of CIGRE or by the Delegate General.

This body met regularly up till 1966 when the official creation of the Technical Committee was incorporated in the new Statutes and its composition defined: three Administrative Council members, one of whom would Chair the Technical Committee, all Study Committee Chairmen and the Secretary General.

The reports presented at the Sessions were published under the one cover and referred to as the set of Session papers. After the Session, the complete texts of the discussions, the text of the Opening Address and the General Reports drawn up by the Special Reporters were issued as general Proceedings of the Session. The work was published as hard bound volumes in French and English. Table 13 illustrates the number of reports presented at the 1970 Session.

Figure 28 - 1966 Session at the Fondation Berthelot – Maison de la Chimie

TABLE 13 - Number of reports presented at the 1970 Session by each Study Committee for discussion in the Group Meetings

COMMITTEES	Number of reports presented at the 1970 Session
1st Section: Equipment	
11 – Rotating Machines	11
12 – Transformers	7
13 – Switching Equipment	15
14 – AC-DC Converting Plant	5
15 – Insulating Materials	6
2nd Section: Cables, Lines and Substations	
21 – High voltage Insulated Cables	7
22 – Overhead Lines	11
23 – Substations	6
3rd Section: Power Systems	
31 –Transmission Systems	9
32 – System Planning and Operation	17
33 – Overvoltages and Insulation Coordination	12
34 – Protection, Automation and Remote Control Devices	7
35 – Communication	4
36 – Interference	5
TOTAL	**122**

In addition, as we have seen, CIGRE published a quarterly Bulletin exclusively for its Members, the journal *Electra*. Then, in 1967, its circulation expanded with the development of its new format. It rapidly received greater scientific recognition and an enhanced reputation on the international scale within the community of experts, above and beyond the CIGRE community which was already very extensive[30]. This bilingual French-English publication contained, firstly, general information on the life of the Association, the Minutes of the General Assemblies, a comprehensive report on the Sessions, and secondly, very substantial technical articles from very diverse sources on very diverse fields of study:

- Annual Progress Reports of the Study Committees, drawn up by their respective Chairmen,
- Technical communications resulting from the work of Study Committees and their Working Groups,
- "General reports" presenting the results of the discussions of a conference.

Electra was thus a very efficient means of informing CIGRE Members in all parts of the world, but also strategic means for the Study Committees to publish their work when they considered useful to do so.

Overall, as expressed with appropriate hindsight by the Technical Committee Secretary Philippe Adam, the Study Committees gradually took on two essential, absolutely complementary roles: "In fact, the Study Committees have the dual role of preparing the discussions of Groups at Sessions and leading and supervising the work of their own respective Working Groups. These two activities, conducted in parallel, are nevertheless closely linked. Firstly, the Sessions feed back to the Study Committees the topics of interest for the community, which can justify further in-depth study by new Working Groups, and secondly, the work of Working Groups themselves lead the Study Committees, through the choices of Preferential Subjets, to stimulate the community's technical and scientific contributions to CIGRE. This approach, which is original in relation to conventional conferences – whose promoters do not always organize, in the long term, the use of the information produced by the conferences by Working Groups – is definitely one of the keys to CIGRE's lasting success."[31].

The dynamics of Preferential Subjects from the 1960s to the early 1990s

As mentioned earlier, the Call for Papers giving the Preferential Subjects was sent out to the National Committees for circulation to members and potential authors. Each National Committee was attributed a "paper allotment", allotments ranging from 1 to 10 papers. National Committees were required to choose the

30 - See CIGRE, *Electra 30 years*, 4 CDs containing the 190 first issues of *Electra* from 1967 to 2000, CIGRE, 2002.

31 - Interview with Philippe Adam, speaking as Secretary of the Technical Committee, 9 February 2010.

best papers to fill their allotment. Additionally, they could put forward papers under the "Additional Allotment". The latter allotment would also include papers by authors from countries where there was no CIGRE National Committee. Another existing paper allotment was the "International Allotment" for papers from authors from different countries. All Proposals were to be sent to the Central Office with a synopsis, for selection by the Technical Committee.

Transformers

During the period 1964-1992, covering almost three decades, certain research projects were conducted by CIGRE in continuation of their in-depth study. These were mainly questions of transformer noise, measurement of partial discharges, and the performance of windings in a short-circuit.

In the 1980s, as a consequence of the great increase in the power of apparatus, studies concerned the measurement of losses and temperature rises in large transformers. As regards the growth in size of the equipment, CIGRE reviewed all the problems posed by in situ installation, more especially with regard to the necessity to check the equipment's dielectric performance after installation with a significant amount of work on the specifications of dielectric tests for high voltage apparatus.

The 1966 Session examined for the first time the question of the drying and impregnation of windings as it had been observed that the stability of windings was strongly linked to their in-factory treatment, in which insulating materials were dried and compressed under heat and pressure. Studies then also started to take into account the accessories fitted on most transformers. The occurrence of faults during operational service led CIGRE to pursue development work in the field of short-circuit performance tests and in the measurement of partial discharges during dielectric tests. The aim of these latter tests was to detect the presence of any defects, before the transformer left the production premises.

A programme of studies was set up in the field of reactors in order to avoid failures during operation. These studies related to problems of design dimensioning and tests for taking operating conditions into account.

During this period were examined maintenance processes, measures to be taken to limit ageing problems, and also the need for coordination of the insulation system in order to meet the needs for voltage performance during tests and in service. The Study Committee continued to develop methods to regulate the voltage of large auto-transformers. The temperature rises in large apparatus and the temperature profile inside windings particularly led to examination of factory tests, design dimensioning rules and conditions for use. Similar work was done on short-circuit performance, firstly taking into account the requirements of the power system. The calculation of stresses and their consequence for design dimensioning and construction led to studies being conducted on reduced-scale models. The comparison between tests on apparatus and on reduced-scale models was the subject of numerous contributions, as was the study of test conditions to reflect the requirements of the power system.

The increase in test voltages required numerous studies in high voltage tests. Feedback was used for analysing problems met in all types of apparatus, including those installed in High Voltage Direct Current (HVDC) systems, by applying statistics and probability techniques. New test procedures for testing at service frequency, with lightning strokes and with switching overvoltages were developed for introduction into IEC Standard 60076 – part 3. These new requirements led to revision of the dimensioning and production methods, while taking into account the experience in service.

It was only from the 1976 Session that interest was shown in study of the performance of the insulation system of transformers in service. These studies concerned the methods of analysis and the criteria to be adopted for proper operation of apparatus, while taking into account the manufacturing parameters and the properties of solid and liquid insulating materials. Diagnostic techniques were constantly improved, which made it possible at the same time to improve preventive maintenance procedures.

During this period, studies systematically analyzed the possibility of using new materials in the construction of all types of apparatus, including reactors and very high voltage (EHV) transformers. Transformers used for special applications (furnaces, rectifiers, etc) and problems raised by bushings and other types of connections were also studied.

The problems related to overvoltages due to transients and the effects of resonance led to numerous studies, both in Working Groups and in Sessions. These problems appear to be particularly complex, as they were difficult to characterize due to the limited means of measurement at the time.

Studies examined transformer losses and their effects on performance in service, on the design dimensioning of bushings and on other construction parameters. The influence of current and voltage harmonics were also studied, as well as the validity of loss measurements during factory tests in relation to the real in-service losses.

The effect of transformers and reactors on the environment led CIGRE Study Committee 12 to address this major subject in reports during Sessions, as well as within Working Groups and during conferences. The noise from apparatus under load and cooling devices, with methods of measurement and attenuation of the noise level, was one of the key subjects during this period. The recovery of heat losses from transformers as a means of heating was the subject of some contributions. The risk of major incidents, such as the tank explosion, with and without fire, was also systematically taken into consideration.

With the increase in the power of apparatus, it was necessary to examine problems of transportation and installation in situ. The specific conditions of use of large units, especially in overload, resulted in studies on thermal aspects, particularly the occurrence of hot points, using direct means of measurement during in-factory tests or operational tests. It was also necessary to study the maximum permissible temperatures of these hot points, taking into account the problems of reliability, availability and maintenance related to these critical cases of use.

At the 1992 Session, for the first time, discussions were initiated on the means of continual monitoring and diagnostic for assessing the condition of equipment in order to plan the replacement of apparatus, to extend its lifetime or to improve equipment reliability. One then observed the impact on specifications of the new test resources in partial discharges, lightning impact tests and noise tests.

The modelling of transformers in the HF field was introduced to check the performance of windings for rapid transients, as well as during the energising of the apparatus or the interactions with the operation of circuit-breakers. As regards the effect of static electricity created by the circulation of oil through windings, it was dealt with in collaboration with the Study Committee in charge of insulating materials.

Overhead Lines

The reorganization of Study Committees in 1966 led to a new configuration of the field of overhead lines, with Study Committee 22, officially named «Overhead lines», Study Committees 33 for insulation coordination, and 36 for interference. Unquestionably, in 1970, the new configuration of Study Committee 22 made it possible to combine within a single Study Committee all the issues concerning design dimensioning of structures: foundations, towers, multiple conductors in bundles and insulators.

The increase in power system voltage was a priority in the early 1970s in order to allow an increase in transfer capacities and to reduce transmission costs. From the early 1960s to the early 1980s, overhead transmission lines at 735, 750 and 765 kV were mastered in Canada, USSR, USA, Brazil. Thermal and electrodynamic problems also arose after the increase in levels of transmitted power (effects of nominal, exceptional current intensities and of short-circuit currents).

For the first time in 1974, consideration of the environment in the design of overhead lines, and therefore their acceptability, was chosen as a Preferential Subject. The topic was to be long-lived and in the 1990s the aesthetics of towers design was a major area of the CIGRE community's work. Tubular towers, architectural towers and compact towers were the subject of very interesting presentations and discussions.

In the late 1970s, the development of information technology resources became a vital tool in the development of power systems: programmes for optimization of structures (optimization of towers and optimization of conductors) also appeared, and they gave rise to regular discussions. The development of PCs led to the development of very efficient software applications, which are now standards in their respective fields. The progress in information technology also made it possible to perform dynamic loading calculations and resulted in the drawing up of less restrictive and more realistic design rules.

Probabilistic approaches were discussed in 1988: probabilities of maximum currents, of maximum ambient temperatures, of low wind speeds, etc. At the same time optic fibres also appeared as one of the Preferential Subjects. This was somewhat the starting point of the rapid development in the incorporation of these new telecommunication links in the networks, in spite of the additional constraints they induce on the design and the operation of the lines.

In 1990, since the oldest EHV (Extra High Voltage) lines had then been in operation for 60 years or more, lifetime of structures started to be a concern for operators. It remained one of the recurring subjects of the Sessions, with priority issue feedback on operation and maintenance methods, considering the strategic stakes attached to those topics. In 1994 for the first time live line work, aimed to improve the availability of structures, was tackled.

Insulated Cables

In insulated cables, four major topics of interest were identified. They were discussed at all Sessions from 1964 to 1976: synthetic insulation materials which were being introduced for high voltage, direct current cables, thermal performance and transmission capacity of cables and, lastly, problems related to protection against corrosion. Under slightly different headings, three Preferential Subjects were at the core of the Session discussions from 1978 to 1982: direct current cables and the mechanical aspects of submarine cables, cables with extruded synthetic insulation and their accessories, underground installations for high power transmission based on traditional and new technologies.

The 1984 and 1986 Sessions addressed, the reliability of submarine power cable links combined the design, manufacture, installation and maintenance of cables with synthetic insulation, and the new generation of very high voltage cables.

By the end of the 1980s the discussions focussed particularly on permissible stresses in synthetic insulation materials, design criteria for sheaths, transition between cables of different types and tests after installation of high voltage cables with synthetic insulation.

Figure 29 - 400 kV cable section

Equipment for Substations

In the very wide field of equipment for substations, CIGRE's Preferential Subjects from the 1960s went hand-in-hand with a major development of engineering sciences in the study of transients. Major difficulties for substation equipment have always been design conditions, switching operations, and the consequences for equipment adjacent to switchgear. The vocabulary of the Preferential Subjects is particularly indicative of this transformation.

Thus, until the mid-1960s, people spoke of natural frequency and amplitude factor, or, at best, of the 4-parameter method for switchgear (circuit-breakers). Engineers and researchers associated this vocabulary with Fourier series, or with analogue simulation models (with a transient analyser), or, at best, with field recordings on grounds that were very difficult to perform.

From the 1970s, new terms appeared, such as transient voltage, in make and break, and zero passage in synthetic tests. These terms cover another method to approach transients, based more on impulse responses and numerical simulation by finite differentiation analysis or modified Bergeron methods. Engineers immediately switched from purely analogue models to digital models, which required the most powerful calculation resources of the time. They very quickly pooled their resources in order to move forward, as each team was too small to make sufficient progress by itself. CIGRE provided a fundamental forum for exchange concerning all transient digital models, and it was used in most fields, such as: circuit-breakers in all situations (energization of lines and of cables, interruption of inductive and capacitive currents, and overvoltages), propagation of these overvoltages and lightning strokes on lines, electrical characteristics of lines, protection against transients, insulation coordination, transformer dielectric withstand, surge arresters, spark-gaps, etc.

In the 1970s and 1980s, one of CIGRE's outstanding contributions to these methods was the validation of models by round robin tests. These involved parallel processing of reference cases provided in Working Groups, all validating a new model in order to draw the right operational conclusions, to everyone's benefit. This inter-comparison – of both the results and the means to achieve them – gradually led to the discard of methods that were too cumbersome or complex for the precision sought by the engineers.

CIGRE selected and oriented the spectrum of research not by dealing directly with basic research subjects, but by very closely following those that were being developed. A good example of a fruitful contribution is the history of the "Current Zero Club", a scientific forum where researchers exchanged their knowledge on arc plasma in circuit-breakers. Many engineers who took part in CIGRE also took part in this more fundamental research body, and in it they compared theoretical results.

Another crucial issue concerning substation equipment which was chosen as a Preferential Subject from the 1970s was equipment reliability. In fact, up until the early 1990s these recurrent Subjects covered different states of knowledge, as evidenced by the evolution in the terms used and even more so by the gradually more specific character of the issue. Initially, data collecting was the priority task. This was a major effort and especially a "politically" courageous act on the part of operators and manufacturers, because it provided public access to data that many considered commercially strategic. Subsequently, each location of apparatus was gradually considered in order to closely assess performance and reliability in the different locations. Care was taken to define specific means for checking the reliability progress (for example, capacitive interruption for circuit-breakers).

In the end, one of the main reasons for the success of these CIGRE exchanges of work related to Preferential Subjects was that none of the techniques were singled out or advocated by comparison with others. Definitions and functional requirements with the appropriate means of verification (often including tests and measurements) were published with full transparency. Thanks to CIGRE, all technologies could be put forward and discussed, the only judgement criterion being that functional requirements be met with the guarantee of compliance through means approved by all (for example, performance in real-life tests). The advantage of this process and this CIGRE method was clearly demonstrated by the Subjects of the Substations Study Committee in 1980, because it included a practically exhaustive synthesis on the reliability expected and obtained for all equipment.

Protections, telecommunications and interference

The interaction between the power system protection systems and the generation units was a strategic concern from 1970, not only for normal operation, but also for abnormal conditions due to incidents. One of the recurrent Preferential Subjects was the protection of large turbine generators plants. The development of EDF's electronuclear programme from 1970 up until at least 1994 was probably one reason why this issue was explored in depth.

From 1976 on, with the introduction of static then digital protection relays, the reliability of and the methods for analysing failures during operation of protection and control equipment was an issue that was raised several times, as was the collecting of information concerning service feedback on the performance of this equipment. The advantage of analogue then digital simulation was addressed in the 1980s, not only as a tool for evaluating the performance of protection systems and instrument transformers during major incidents in power systems, but also for developing and evaluating new protection relays. At the end of the 1970s, there were memorable power black-outs in several countries, such as the black-out in France on 19th December 1978. Therefore the philosophy and strategy of protection against incidents in large power systems, particularly the search for protection systems able to detect very rapidly (in less than 5 seconds) the transition between a stable state and an unstable or disturbed state were addressed in 1980. The emphasis was placed on reviewing measures for reducing the spread of faults, such as splitting of the power systems. Procedures for restoration of service were also discussed.

As regards equipment, the dominant issue was the evaluation of the performance of protection and automatic control systems, not only at the design stage but also in operation, particularly to verify settings. Adaptive real-time setting was even addressed in 1984. Staff training was also a subject for discussion.

In telecommunications, the subject of telecommunications media other than powerline carriers was not introduced until 1976. This subject concerned systems, leased links and even optic fibres, which were at their very beginning.

At the 1976 Session, quality and reliability of the transmission of operational data for remote monitoring, remote control and telephone communications were Preferential Subjects together with powerline carriers. From 1978, SCADA systems and teleprotections became a recurrent subject, combining factors of precision, response time, security and reliability. This topic became more and more important in the Sessions. As regards telecommmunications media, radio links were studied from 1978, while the planning of telecommunication networks for power transmission systems became a recurrent subject as from the 1982 Session.

On the subject of interference, from 1970, the usual topics of interference in telephone and radiotelephone networks were addressed, as well as the problems of corrosion of underground pipes near electricity lines. At the 1978 Session a subject was raised for the first time which gradually proved to be of major concern for the CIGRE community and all stakeholders involved in the electricity economy: «*the electric and magnetic fields (both alternating and direct currents) in substations and under overhead lines and in adjacent areas, as well as their effects on living organisms (including human beings) and also directly on sensitive equipment (in laboratories, hospitals, etc.). Measurements, calculation methods and possible remedial action.*» The discussions on this issue have not been concluded to this day.

In 1982, apart from the usual topics already mentioned above, interference in the electricity system such as harmonics, rapid variations in voltage (voltage dips and flicker) and voltage dissymmetry were discussed. The origins and also the consequences on equipment installed on the power system and in the premises of customers using sensitive electronic equipment were examined. With the introduction of electronics in substations and power stations, transients in high voltage circuits caused destructive overvoltages in the wiring, and, at the 1986 Session, the discussion focussed specifically on the instructions for installations in order to limit the consequences.

Systems Preferential Subjects

The 1990s were an important transition period for the "Systems" Preferential Subjects. Of course, they remained marked by the changes in the three previous decades:

- the emergence of concepts of "planning and development of power systems";
- the consideration of the specific problems of developing countries, whose quantitative needs were equivalent to those of the 1920s in developed

countries but could – or should – benefit from new technologies of the late 20th Century, mastered and exported by Western countries;
- in 1978 introduction of the strategic question of the preservation of energy resources, with its consequences on the expansion and the economy of electricity uses;
- the development of the use of computers for operation, planning and control of power systems; and lastly, the increasing use of direct current.

An important prospective inside view on the achievements of CIGRE Sessions was particularly well captured and, to some extent, synthesized at the 27th Session in 1978 by the Round Table on "Electricity Transmission at the turn of the 21st Century", with the participation of experts from Great Britain (P.Govard), USSR (V.Popkov), USA (L.Bartold), France (A.Dejou), Federal Republic of Germany (R.Leber), Sweden (T.Lindström), Italy (L.Paris) and India (S.Murti).

Against the background of continuity, pioneering and spearheading issues and topics emerged:

- "competition or coordination?" and their impact on the development and planning of the generation-transmission system;
- the acceptability of power systems for society and the environment; the integration of the energy supply system through to the distribution stage;
- the development of organizational structures in the control of power systems with data interchange requirements;
- operator training, etc.

CONCLUSION

Participation in CIGRE showed a steady growth over a long period. In 1972, after 50 years of existence, the Association recorded 2,239 participants at the Session, 56 countries being represented. They could justifiably celebrate the Jubilee of their International Organization.

As pointed out in 1972 by its Secretary General R. Pélissier, in terms that are still very topical today, the essential keys to CIGRE's international success during the prosperous period from the early 1960s to the early 1990s were the combination of two factors, two decisive levers:

"Firstly, despite all the external constraints to which it is subjected, CIGRE's continually growing success is based on a dynamism that is partly due to the way it has managed to focus sufficiently on a continually developing technology, and also partly due to the fact that its members, whose authority comes only from themselves, feel free to work within a community of welcoming friends.

Secondly, CIGRE's continual development, while giving the Biennial Sessions their due importance as irreplaceable places for meeting and exchanging ideas, has been based more and more on the Study Committees, international research teams that have become indispensable not only for the IEC, but in fact also as a support for a leading-edge technology that must at all times take risks on the international scale.

These multiple goals, which are closely interlinked, can only be achieved if CIGRE's organization maintains the balance between the rules required for the efficiency of work and what Giovanni Silva and Jean Tribot-Laspière called "the club aspect", which ensured a friendly welcome for all people of goodwill, no matter where they came from in the world"[32].

To account for this unquestionable success of CIGRE through the continual evidence of its efficiency and its usefulness for the CIGRE community, Pierre Ailleret provided the following additional comments in 1972:

"First of all, CIGRE is a meeting of specialists. Mathematical terminology and language protect it against being hindered by the laymen.

Secondly, its technology covers a more uniform field than in most other industries because electrical engineering still plays an important role in it, even in overhead lines. Therefore the participants are themselves more uniform in their knowledge, and the exchanges of ideas between them are easier. For example, if one compares this with the steam generator industry, which is economically more important than the large power systems industry, this field of thermal engineering does not have the same uniformity as is found in electrical engineering in CIGRE. Turbines, boilers and water chemistry are technologies that are more different and that require more distinct specific training than is the case for transformers, generators, circuit-breakers or even cables and lines.

This uniformity of the engineers is also one of the reasons for the very good cross-boundary and cross-national relations between technicians – in brief, the "club" aspect of CIGRE, which facilitates members concentrating the most interesting information on new technology in CIGRE. CIGRE's members appreciate these biennial meetings which refresh their training in the latest electricity transmission innovations and which widen their horizons, particularly by showing them, through a worldwide view of technologies, that some of the habits and customs of their countries are perhaps not as necessary as local tradition would lead them to believe"[33].

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32 - R. Pélissier, "Evolution de l'organization de la CIGRE", *La CIGRE, son passé, son futur,* special issue of Electra, CIGRE, 1972, p. 162.

33 - P. Ailleret, "La CIGRE et le développement des grands réseaux de transport d'énergie électrique", *La CIGRE, son passé, son futur,* special issue of Electra, CIGRE, 1972, p. 15.

In any case, the impact of CIGRE and the multifaceted activity of its members flourished worldwide during the 1970s and 1980s.

Figure 30 - CIGRE Presidents from 1966 to 1990 : A. R. Cooper (1966-1972), W.S.White (1984-1990), R. Guck (1978-1984) and G. Jancke (1972-1978).

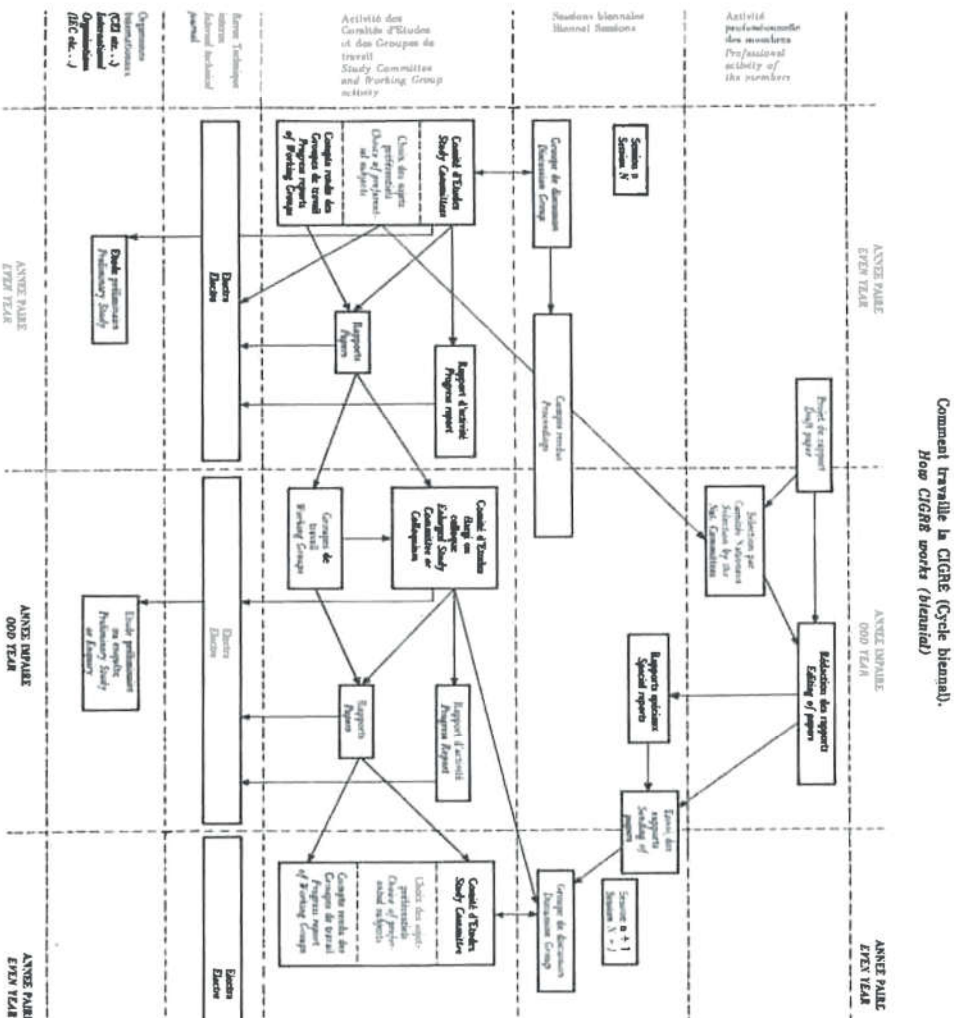
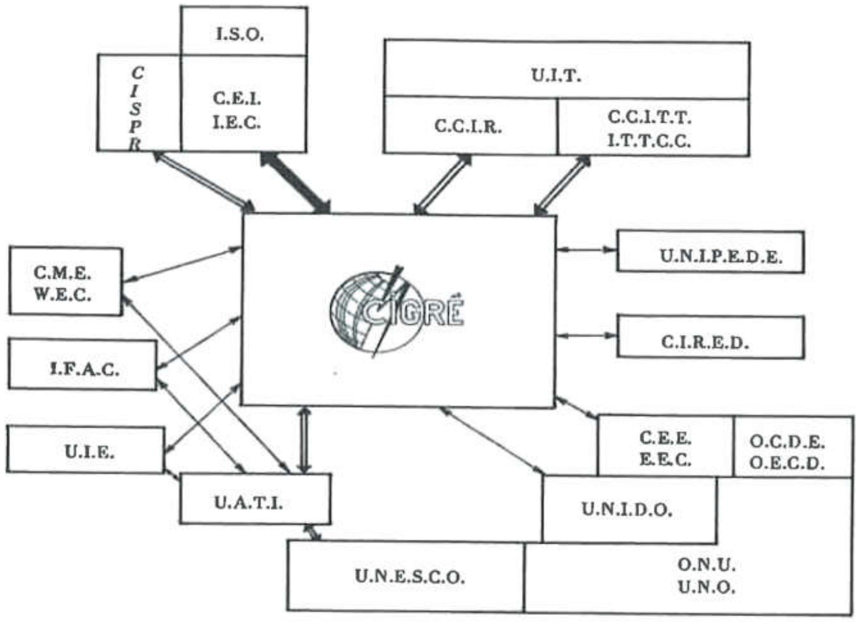


Figure 31 - How CIGRE works (over a 2-year period) in the 1970s

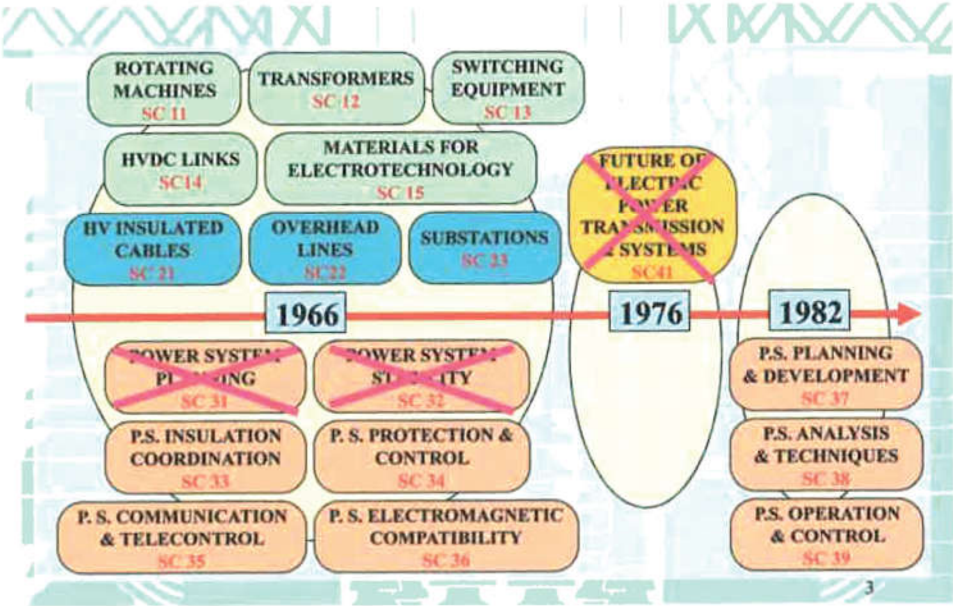
La CIGRE et son environnement international actuel.
CIGRE and its present international surroundings.



C.E.I.	Commission Electrotechnique Internationale.
I.E.C.	*International Electrotechnical Commission.*
C.I.S.P.R.	Comité International Spécial des Perturbations Radioélectriques. *International Special Committee on Radio Interference.*
I.S.O.	Organisation Internationale de Normalisation. *International Organisation for Standardisation.*
U.I.T.	Union Internationale des Télécommunications. *International Telecommunication Union.*
C.C.I.R.	Comité Consultatif International des Radiocommunications. *International Radio Consultative Committee.*
C.C.I.T.T.	Comité Consultatif International Télégraphique et Téléphonique. *International Telegraph and Telephone Consultative Committee.*
U.N.I.P.E.D.E.	Union Internationale des Producteurs et Distributeurs d'Energie Electrique. *International Union of Producers and Distributors of Electrical Energy.*
C.I.R.E.D.	Congrès International des Réseaux Electriques de Distribution. *International Conference on Electricity Distribution.*
C.E.E.	Commission Economique pour l'Europe. *Economic Commission for Europe.*
O.C.D.E.	Organisation de Coopération et de Développement Economiques.
O.E.C.D.	*Organisation for Economic Co-operation and Development.*
U.N.I.D.O.	Organisation des Nations-Unies pour le Développement Industriel. *United Nations Industrial Development Organisation.*
O.N.U.	Organisation des Nations-Unies.
U.N.O.	*United Nations Organisation.*
U.N.E.S.C.O.	Organisation des Nations-Unies pour l'Education, la Science et la Culture. *United Nations Educational, Scientific and Cultural Organisation.*
U.A.T.I.	Union des Associations Techniques Internationales. *Union of International Engineering Associations.*
U.I.E.	Union Internationale d'Electrothermie. *International Union for Electroheat.*
I.F.A.C.	Fédération Internationale de l'Automatique. *International Federation of Automatic Control.*
C.M.E.	Conférence Mondiale d'Energie.
W.E.C.	*World Energy Conference.*

Figure 32 - CIGRE and its environment in the 1970s

TABLE 14: CIGRE Study Committees from 1966 to 1982



PART FOUR:

CIGRE faced with the challenges of new regulations and sustainable development since the 1990s

For the last twenty years, electric power systems – and therefore CIGRE – have had to face major challenges, which, with sufficient hindsight, undeniably constituted a strategic and historic turning-point. Symbolically, this turning-point encompassed both the end of the 20th Century and the start of a third millennium. At the same time, the new paradigms evidenced the world as both more simple and more complex. It was simplified by the success of market economy in the 1990s and the process of globalization; and it was made more complex by the approaches of deregulation/re-regulation and the new world order, with the rise of emerging powers, led by China and India. The new regulations of the electricity business have had major repercussions on the economy of power systems. At the same time, the vital and politically essential rise of sustainable development issues implied a change in the management of power systems. This arose as a consequence of the variety of energy production means involved (wind energy, solar energy, etc.) and thus the varied conditions of connections to systems, with the related changes in operation.

Clearly, CIGRE has had to anticipate, monitor and study these change factors and constantly adapt to the changing world.

Chapter VIII:

The CIGRE international community faced with the introduction of new regulations in the 1990s

In most developed countries the 1990s were characterized at a varying pace by a fundamental evolution, or should we say "revolution", of the principles of regulation, both in investment and in operation. The means of regulation of the electricity system changed from centralized planning – either by public institutions or by a cartel and, in general, by each country individually – to implementation of a regulation ideal through competition in production. This new paradigm led to major changes in the design and operation of power systems. Therefore it had important repercussions on the recent history of CIGRE.

The advent of a new paradigm of the electricity economy: from deregulation to the search for a new form of regulation.

In the early 1990s, the electricity supply industry was undergoing profound changes with the emergence of liberalisation of the electricity market. It was clear that CIGRE had to adapt to the new concept. The question was perfectly well put into perspective by J. Lepecki, who on the occasion of CIGRE's 75th Anniversary, delivered an address for the opening of the 36th Session. The address was entitled: "The 75 years of CIGRE" and read as follows:

"Nevertheless, at this time it is proper to question whether CIGRE should again carry out some major modifications. This is because the environment in which it operates – the environment of electric energy utilities – has been undergoing important changes, in some cases quite radical.

These changes came into being as a result of earlier trends involving technology, economics, and social and political aspects. Some of these trends appeared mainly in developed countries while some others were more universal.

First of all, the utility cost. During decades they were due to technological improvements, economies of scale and low fuel costs. This phenomenon was fairly universal but was more pronounced in developed countries where electric generation is mostly thermal and accounted in part for the continuous increase in electricity consumption. Eventually the law of diminishing returns set in and the costs stopped to decline and even began to rise. Among the causes we can list *the difficulty of further large improvements in thermal efficiency of steam plants and increase in the cost of money which made unattractive large outlays for bigger plants....*

Another trend was the change in demand from a steady growth to decreasing rates and erratic behaviour. Especially in developed countries, this was due not only to transient economic conditions but to conservation measures and to a degree of saturation of the markets.

From a technological standpoint there was the emergence of inexpensive gas turbines with ever more efficient and more ecologically friendly cycles. Information and communication technologies also contributed to more efficient management techniques. This contrasted with utilities wish sunk costs in large and expensive steam plants and heavy administration expenses.

All these factors made it possible for a non-utility producer as a large consumer or even an independent producer to bypass the utility structure and generate power in smaller units and more cheaply than a utility itself.

The social and political climate in many industrialized countries was becoming conservative and the idea that government should be less pervasive and that more competition in business, including the regulated activities, such as telecommunication, airline industry and, more recently the electric power industry, is salutary, was taking in many political circles, especially in the UK and US.

All these factors together started the changes in electric industry that we all know about. Fundamentally, these changes introduce competition through privatization where appropriate, deregulation and restructuring (mainly unbundling the once integrated functions). The competition is introduced in the generation sector by deregulation and introduction of Independent Power Producers. The transmission system is still considered a natural monopoly, while the situation of distribution companies is less clear. According to some ideas they also are monopolies and have a franchised territory. On the other hand, in some more radical changes, it is supposed that all customers can have a choice of their own supplier.

Again, the kind of changes we are talking about vary from very radical countries to almost nonexistent in others. It is difficult to foresee at this time what models will eventually stem from the present conditions, on a worldwide basis.

It seems reasonable to expect that no uniform solution would appear and that each country or each region would provide individual responses to its own problems. For example, it is probable that, in developing countries, electricity companies that are centralised and even, most often, owned by the State, shall remain confronted with the necessity to satisfy a demand for rapid growth as soon as possible. Nevertheless, one may observe certain common tendencies which present the following main features: increasing competition, deregulation *and decentralization in the electricity provision sector. The scenarios may vary from one totally deregulated and competitive sector, in which the structure of companies differs greatly from that of present electricity companies, to a scenario where the companies keep many or most of their present characteristics. Nevertheless, they operate in a different environment, they will be in competition with each other, even on the international scale, and they will have to do business with the independent power producers, energy brokers, electricity transmission systems with open access, customers that can no longer be taken for granted, and so on. In any case, the entities that supply energy must keep their costs to a minimum, while trying to keep a competitive advantage by providing more and numerous services of the best quality"*[34].

Figure 33 - Presidents J. Lepecki (1990-1996) et M. Chamia (1996-2000)

CIGRE's new thinking and reorientation.

All these major changes could only greatly influence CIGRE's history and its policies, with important repercussions on both its key activities and its members. Modifications in the electricity companies' activities, introduction of independent electricity producers, smaller power plants and open access to the network affected transmission systems in different ways and the Study Committees definitely had to take this into account. At the same time, there was a risk that the administrative and institutional changes in the electricity companies' environment –particularly the pre-eminence of financial aspects as well as, perhaps, a new inclination to underestimate purely technical questions - which were nevertheless its central purpose – would have a negative influence on the structure of CIGRE and its core technical mission.

34 - *Ibid, p.4.*

The Study Committees quite quickly assessed the importance of these new problems and gradually incorporated the technical dimensions of the new issues into their activities. However, from the end of the 1980s, CIGRE's Governing Bodies felt the need to have an overview of the internal and external transformations in progress, which could possibly lead to a complete diagnosis and new recommendations.

For this purpose, in January 1990, the *CIGRE 2000* Group was officially created, chaired by Professor Hans Glavitsch (Switzerland), with Karl-Heinz Schneider (Germany), Chairman of the Technical Committee from 1984 to 1990, Lionel O. Barthold (U.S.A.), Jacques Cladé (France), Lev G. Mamikoniants (U.S.S.R.), Eduardo Nery (Brazil), and Yasuji Sekine (Japan), as well as CIGRE's Secretary General, Gérard Leroy[35]. The group held 4 meetings and, after a year of work, *CIGRE 2000* concluded its work with orientation proposals for CIGRE's future work.

The Administrative Council then decided that another Ad Hoc group should be set up, whose assignment would be to study in greater depth the changes observed in the electricity companies' environment and to translate the result of its studies into recommendations for a better governance of CIGRE as a whole.

This was how the Advisory Group on Public Affairs (AGPA) was formed under the responsibility of John Banks (UK), CIGRE's Treasurer from 1990 to 1996, and including several members of the Executive Committee. The AGPA group carried out several studies and collaborated closely in the Technical Committee's work, constituting a reference and also providing a second opinion concerning the strategic planning of technical activities. The Technical Committee's Strategic Plan, eventually published in 1998, was also an innovation, which took into account the necessity to better assess the external conditions in preparing the Study Committees' activities. In 1995, the ad hoc group had fulfilled its mission and on the initiative of its convener, John Banks, it was disbanded.

Nevertheless, in 1995, Executive Committee members then considered that the studies on more general subjects should continue, even if they were conducted in a less structured way. They also decided that, even without a formal new group, Executive Committee members should suggest subjects of interest for CIGRE, work on them and present the results of their work at Executive Committee meetings for discussion in plenary Sessions. The first subject addressed within this new framework was *"How can we interest present and new members in a competitive environment"*, following preliminary work by Harold Scherer and Michel Chamia, who was the Technical Committee Chairman (1990 to 1996) before becoming CIGRE President from 1996 to 2000. It was also based on contributions from Y. Sekine, N. Haase, P. Caseau and D. Croft, future CIGRE President (2000 to 2004). As part of these strategic and forward planning activities,

35 - Gérard Leroy was Secretary General of CIGRE from 1981 to 1991.

Executive Committee members discussed questions related to the influence of the transformations of the environment both on CIGRE and on the work of electricity companies. These questions were then presented to a wide audience, in a Panel discussion at the 1996 Session.

The potentially negative impact of deep transformations of the environment on CIGRE as an Organization, in terms of growth in membership, activities and resources, proved in fact to be relatively limited. Apart from a few fluctuations, with a worrying drop over 1989-1991, which also coincided with major geopolitical upheavals (collapse of the Soviet Bloc), the number of CIGRE members – both collective and individual – continued to show a slight rise during the 1980s and 1990s. Objectively, the number certainly increased at a less sustained pace than during the previous decades. Thus, in 1995, CIGRE counted 818 Collective Members and 3176 Individual members, i.e., 7% more than the 1980 figure. While not spectacular, this result was still satisfactory, especially considering the maturity of the Organization and the turbulence that had shaken many member Companies and Companies counting individual members of CIGRE.

In brief, during the 1990s, CIGRE never departed from its fundamental mission, which was to observe trends and to create specific mechanisms for identifying situations that required more drastic adjustments. However, there was an urgent need which at the turn of the 21st Century required a specific action plan. This was to make the international Organization better known outside its present audience of rather small technical circles.

In the final analysis, over the two previous decades (the 1990s and 2000s), the development of the market for electricity required a greater amount of transmission and interconnection. One would therefore tend towards perfect interconnection, which is commonly called a "copper plate". Yet, the physical development of the network which is a guarantee of reliability and an essential lever for optimising operation, is accepted with more and more difficulty by civil society and is particularly costly. The operator, i.e., usually the manager of the power transmission system, is then tempted to overcome these bottlenecks by pushing both the infrastructure and the system to the limits of their use – a process which must be very well mastered and controlled so that major incidents are avoided.

One major difference when compared with other large infrastructure systems (Large Technical Systems) is that electric power systems do not allow any traceability of the kWh they supply physically. The producers are the people who collectively supply the consumers as a collective body. By definition, the instantaneous operation of power generating stations and of the network that interconnects them are very closely related. In order to manage the electricity system adequately while aiming to ensure continuity of service, the power system operator must see to it that the rules set by the regulator are followed.

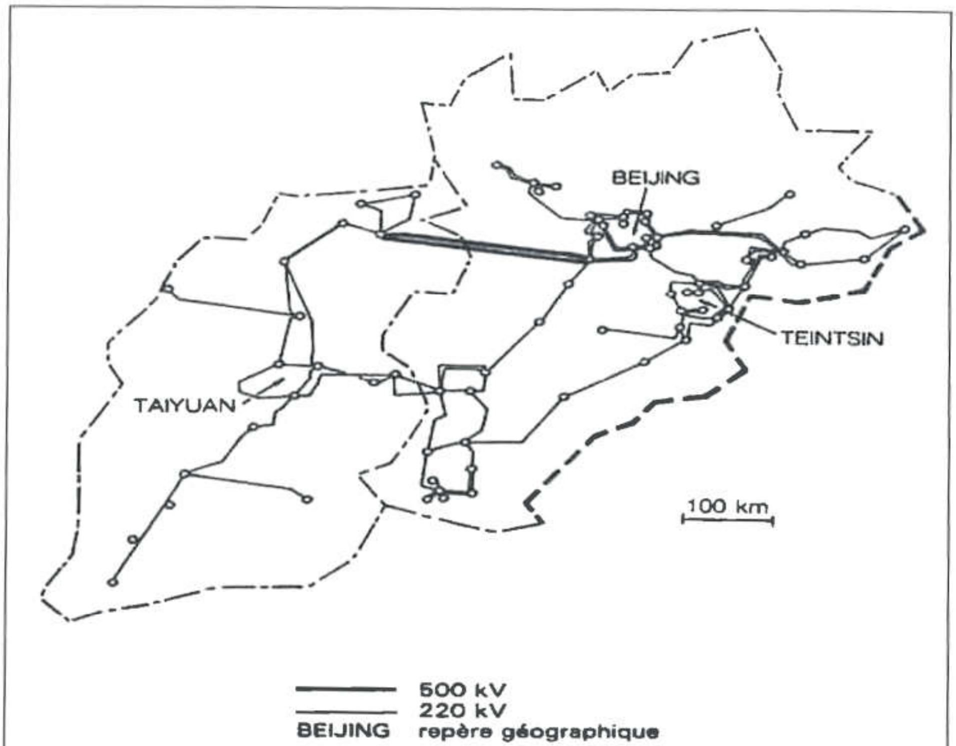


Fig. 8. — Réseaux 500 kV et 220 kV du nord de la Chine, en 1984.

Figure 34 - Northern China's Interconnection Systems in 1984

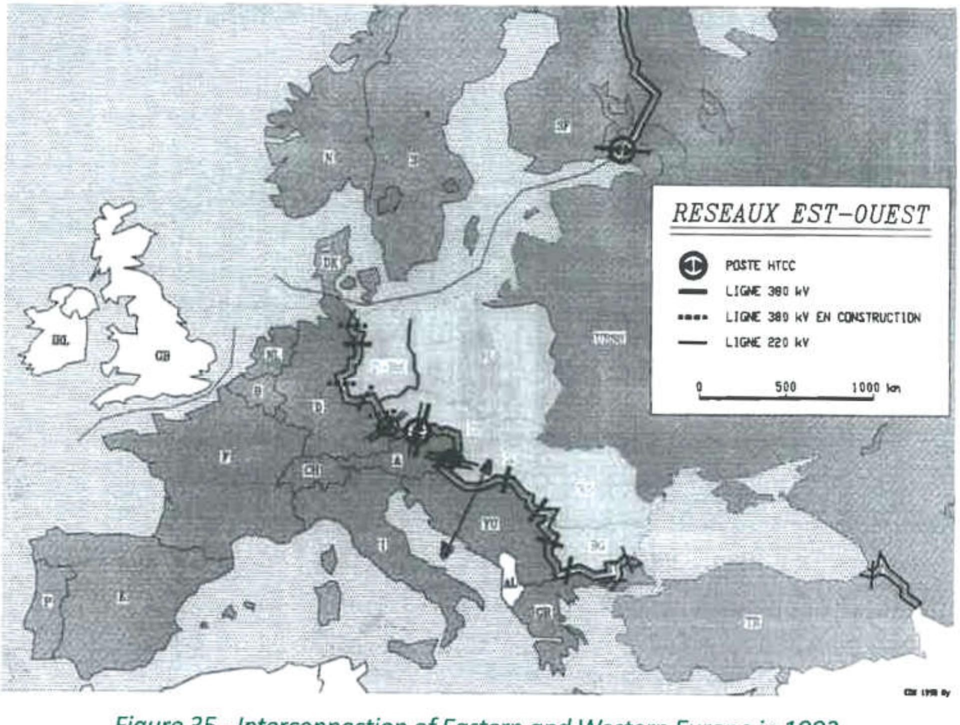


Figure 35 - Interconnection of Eastern and Western Europe in 1992

Chapter IX:
A new CIGRE approach for a new economy[36] of power systems

At the end of the 1990s, following on from the previous reflection, CIGRE's Governing Bodies started a process of in-depth reform and modernization of the Organization. The starting point was the MasterPlan, which was carefully drawn up following a very precise procedure and detailed information throughout 1999 and a large part of 2000, before being finally approved by the Administrative Council in 2000. This inventory and this objective assessment identified warning signals, with conclusions which were provisional, but sometimes severe. In particular, they resulted in a consistent set of proposals, to create a new dynamic and greater impact for CIGRE, whose objective was to maintain its leadership position in the new world picture of the electricity supply industry.

The setting up of the 1999 MasterPlan: necessary adaptation to the in-depth transformations of the electricity industry and electricity systems

The initial observation of the MasterPlan was naturally based on the dramatic change in CIGRE's working environment in an industrial and institutional context undergoing a great change if not an upheaval.

This observation was summarized as follows:

"Whether under the effect of institutional constraints (European Union Directive on the liberalization of the internal electricity market, the United States Energy Policy Act...) or affected by the trend towards a market economy, the electricity sector is currently undergoing profound changes that may be characterized as follows:

- *With developing competition on a national and international level Companies are growing more attentive to certain aspects of industrial property and technological heritage. Confidentiality regarding information is becoming automatic and circulation of technical, statistical or financial data is deliberately controlled and limited.*

36 - The term "economy" is used here in its double generic meaning, derived directly from its Greek etymology. It refers to the skill of good administration and good management, as well as the organization of the different elements of a complete whole, that is, the interconnection of the parts of a system.

- *Pressure on costs which results from competition, a concern to reduce staff, the essential need for gains in productivity, all lead companies to cutting their financial contribution to the work of scientific organizations, more especially by reducing the participation of high level experts in joint activities.*

Internationalisation of Companies is already in place and can only continue to spread. We note the setting up of bilateral, and sometimes even multilateral joint projects giving all partners the opportunity to discover the electricity scenario on a world-scale. Following this trend, International Organizations will gradually lose the exclusive character they have acquired and maintained over decades in this area"[37].

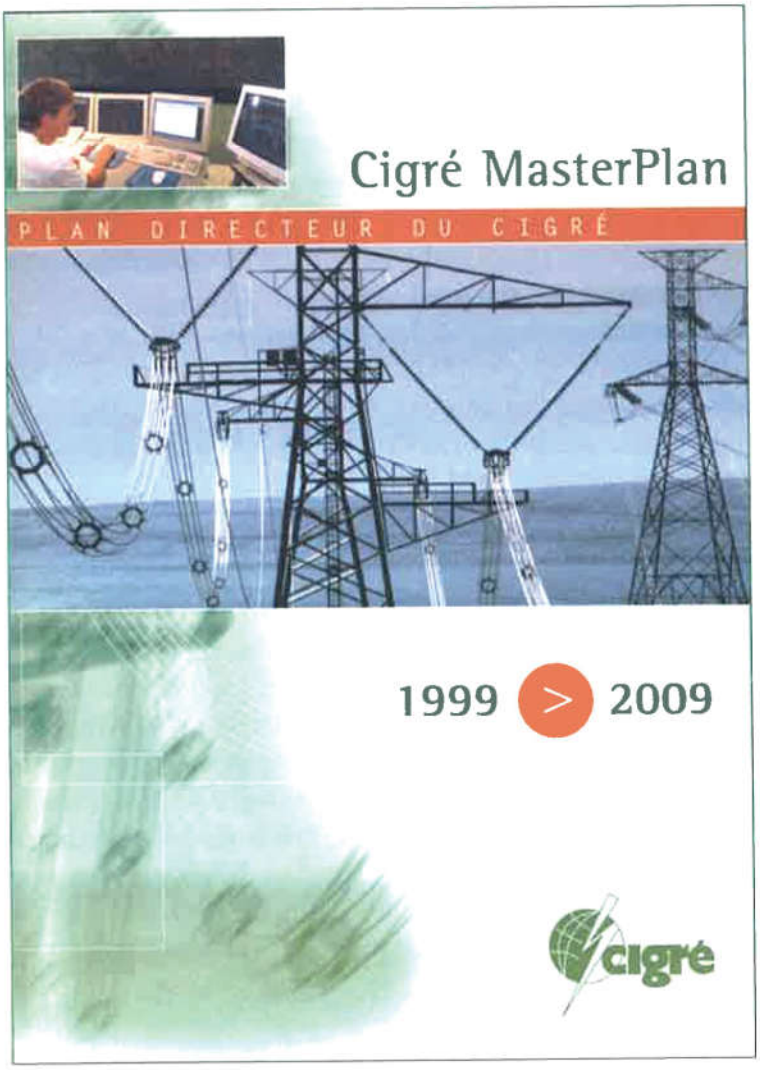


Figure 36 - CIGRE Master Plan

37 - CIGRE, *CIGRE MasterPlan - Plan Directeur du CIGRE 1999-2009*, Paris, CIGRE, October 2000, p. 3.

This new situation was a matter of great concern for international scientific Organizations, with CIGRE in the forefront, and it inevitably led to a re-thinking of strategic and vital questions and, in a way, to going back to fundamentals:

- To what extent were these Organizations really and directly useful for electrical engineers, for electricity companies and for equipment manufacturers?

- Should the Organizations define (or redefine) their respective field of activity in order to avoid duplication of their work and the resulting undue expenditure?

- Should one identify a priority field where the exchange of ideas was of essential importance and which could really be of added value for electricity companies and equipment manufacturers?

- How could CIGRE be sure to meet the expectations of the new players in the electricity market, particularly new owners and decision-makers, whose main concern was more related to profitability and return on investments than to technical considerations and security of supply ?

CIGRE was not protected from the new challenges mentioned above. At the turn of the third millennium, it undeniably showed many assets. CIGRE had a relatively well identified technical field, a unique character as a permanent forum for equipment manufacturers and electricity companies, with members who in 2000 represented no less than 833 companies (Collective members) and 3760 individual members - in 80 different countries; this was an enormous, continually-increasing technical heritage that was made available to all. Despite these undeniable assets and advantages, the situation had to be reviewed in order to preserve, or even strengthen, CIGRE's position as the first international technical association in the field of HV and EHV power systems.

Taking CIGRE's Mission as its starting point – as defined in the Statutes, which had not been changed significantly since 1966 – an analysis of the Association's strong points and especially its weak points led to the identification of the fields where changes and innovations were required. This approach made it possible to define a Vision for CIGRE for the next ten years, i.e. 1999-2009. The means for concretely defining this Vision in the medium term, in all non-technical fields, required the definition of a clear policy for the Association's internal and external communication. The development of links with universities, strengthening the role of National Committees, which entailed a more active participation of developing countries and recently developed countries, and the examination of the method of selection of experts for Study Committees, were to form the essential levers of the MasterPlan.

Mission, Vision and Strategy were thus to form the three pillars of CIGRE's MasterPlan, a trilogy that started the new dynamics of the international Organization.

First of all, in terms of its Mission, the objectives of CIGRE were still classically defined by Article 2 of its Statutes: *to facilitate and develop exchanges of technical knowledge and information between all countries in the general field of electricity generation and transmission at high voltages*. By definition, its activities included the following:

- purely electrical aspects of electricity generation;

- the construction and operation of substations as well as the associated equipment;

- the construction and operation of high voltage transmission lines;

- the interconnection of power systems and the operation and protection of interconnected systems.

In terms of the methods for achieving these objectives, CIGRE traditionally organises conferences known as Biennial Sessions, Symposia in years when there is no Session, and Regional Meetings. It carries out international studies performed continually by Study Committees between Sessions. It encourages and maintains friendly relations between associations, administration bodies, engineers, university staff, researchers and industrialists from all countries, who are competent in the subjects associated with high voltage and extra high voltage. At the same time, it cooperates with other international Organizations sharing common subjects of interest; it encourages and facilitates the organization of surveys and international research. CIGRE publishes the proceedings of Sessions and Symposia and a bilingual periodical journal called Electra, as well as other technical brochures, theses related to its own activities, and particularly the work of its Study Committees. Its publication database, which already included 4,000 items in 2000, is accessible to all members. Also, CIGRE issues a Membership Directory which is both a link and a powerful tool to facilitate contacts between members.[38]

In the MasterPlan Inventory, the Association's Governing Bodies decided to start their assessment with an identification of the weak points. In fact, they stressed from the outset "that warning signs had appeared, indicating that urgent radical measures were needed to avoid the Organization's collapse, or even, in the longer term, its outright disappearance..."[39]

Among the most immediate indicators and the easiest to analyse was firstly the variation in the number of the Association's members (see Appendix 1). From this viewpoint, the figures since 1980, both for collective members (companies and educational bodies) and for individual members, showed a gradual growth with peaks at the end of the 1980s, then a further strong increase in 1994 and 1996, with 1998 showing a record number of equivalent members. It is recalled that in CIGRE General Assembly voting as well as in CIGRE statistics one Collective (Company) Member is counted as equivalent to five Individual Members; one Collective

38 - This Directory is available in CD format : see the 8th edition of the Association Members Directory; cf website www.cigre.org

39 - CIGRE, *CIGRE Masterplan - Plan Directeur du CIGRE 1999-2009*, op. cit., p. 5.

(Educational Body) Member is counted as equivalent to two Individual Members.

Then the evolution of National Committees was also encouraging as their number showed a constant rise. With three new National Committees officially recognized by the Administrative Council in 1996, one in 1997 (Libya) and one in 1998 (Ivory Coast), CIGRE counted a network of 52 National Committees in 1998. At the same time, the number of countries that counted CIGRE members also grew regularly, reaching 88 in 1998.

On the other hand, the indicator of the participation in CIGRE Sessions was much more a cause for concern. Despite the fact that more countries were represented (78 in 1998), the number of congress delegates had reduced since 1990. A closer examination of the participation of each country showed that the number of participants from industrialised countries showed a continuing decline. Inversely, there was an increase in the participation from countries of Central and Eastern Europe – a direct consequence of the collapse of the Eastern Soviet Bloc – and from several newly-developed and developing countries.

Certainly, on the basis of the attentive examination of all these indicators, the Governing Bodies could safely state in the early 21st Century that there was no sign of an eroding interest in CIGRE on the part of experts in large power systems. However, they identified an evident geopolitical and geo-economic reshuffle where attitudes towards the Association were changing; a receding interest from industrialised countries and increased interest in newly-developed and developing countries.

Nevertheless, the complete diagnosis had revealed a series of weaknesses in the international Organization, which had already been detected and were therefore a matter for concern. These points are presented below in an order of decreasing importance:

- Firstly, the borders of its field of action appeared unclear at the turn of the third millennium, mainly at the natural boundaries with generation and distribution. While technical questions concerning HV and EHV were the very core of CIGRE's studies, the development of power systems now inevitably involved the study of both institutional and structural aspects, economic and social problems, concerning both power systems (for example, the supply of the energy produced) and components (for example, overhead lines and the environment). Therefore the Association felt that it was legitimately authorized to consider that these questions were becoming part of its area of expertise.

In addition, due to its long technical tradition, CIGRE did not have a clear recruiting strategy for members outside the circle of experts who took part in its work. It became absolutely necessary to open CIGRE membership to heads of companies and decision-makers because if its activities were confined to the traditional technical field, then this would lead to stagnation and, in the longer term, to the loss of interest on the part of management people in the power systems industry at the highest level.

At the same time, because of the nature of the subjects then addressed, and despite the aim to extend its area of expertise to various non-technical questions, the Association might not seem to be sufficiently open when it engaged in strategic studies. Consequently, company heads and decision-makers in large corporations could become sceptical about CIGRE's efficiency and its capacity to analyse problems and propose solutions. Therefore, in OECD countries where the electricity sector was being reorganised with return as a priority concern, there might be an inclination to cut down on experts' participation to the work of Study Committees, all the more so as the work for CIGRE was being performed on a voluntary basis. [40]

This situation could have had serious consequences as, at the time, the Association had no clearly expressed policy on the way to recruit young engineers. No special rate had yet been put in place to enable them to attend technical meetings, and there was no "Young Member" status. Lack of such encouragement in the long term would clearly run counter the ambition of maintaining, let alone increasing the number of members. In addition, CIGRE was perhaps not sufficiently in tune with the needs of universities, whereas, in most countries, these were the places of training for CIGRE's potential members. Its links with universities required strengthening in order to avoid the risk that scientists, teachers and researchers would lose interest in CIGRE. The only practical link which existed at the time was the sending out of *Electra* copies free of charge to a number of students selected by the National Committees. This facility was started in 1994 and maintained ever since.

Within another perspective that was just as strategic, in 2000, the Organization was not sufficiently involved in "Innovative Technologies", that is, technologies which might require two or three decades before they fully materialised, but which could then have a strong influence on the power systems of the future. The world technical community should be better informed on CIGRE's work and on CIGRE's continual assessment of the state of the art in these fields as well as their possible effects on the future of the electricity supply industry. Due to its specific technical nature, CIGRE seemed not to be sufficiently involved with electrotechnology circles. In a "private club" approach, with full confidence that its membership would be renewed by co-optation and would be long-lasting, CIGRE made no systematic effort to make itself better known according to a coherent action plan. In these circumstances, there was a risk that, due to a lack of information and

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40 - Rather than deliberate company policy, this reduction of the participation rate of the western companies could be due quite simply to the aging of experts, their retirement and non-replacement by the management.

communication, or even a lack of discernment, many heads of companies would turn to other, apparently better known Organizations, such as the World Energy Council or Eurelectric (formerly UNIPEDE), which they could consider as of higher repute or as presenting a greater strategic interest for them.

Lastly, a regrettable fact was bravely acknowledged: despite repeated efforts and numerous earlier statements, CIGRE's Governing Bodies and even its Study Committees were not fully "international", since objectively, with the historian's hindsight, the Association's general technical, administrative and strategic choices and guidelines always finally reflected the viewpoints of representatives from OECD countries. At the same time, these representatives also made the largest financial contribution to the Association. The long-term risk, which should not be underestimated, was that parallel competing Organizations would emerge which could be more in tune with the problems of developing or newly-developed countries. In the early 21st Century, there was great awareness of the fact that CIGRE had to strive to best meet the expectations of countries where consumption was increasing at a much faster pace than would be possible in North America or in Europe.

However, in this MasterPlan dated October 2000, the Association's Governing Bodies did not forget to highlight CIGRE's strong points, and they considered them as a "core business" on which new activities should now be based for building new opportunities in the service of the CIGRE community.

Firstly, CIGRE's highly structured organization undoubtedly included the world's top experts, belonging to very different technical fields and from widely diverse geographical areas. These experts who, together, within Study Committees and Working Groups, worked on a voluntary basis to resolve problems related to high and very high voltage systems in order to find solutions that were made available to all, were definitely CIGRE's greatest asset.

This advantage could be particularly useful for developing or newly-developed countries, who were keen to take advantage of the expertise and the technical experience of the most technically advanced countries. It was also extremely useful for them to be able to share their experience during the renovation or extension of their power systems or interconnections. In their long-term planning, the developed countries would also need to share their experience in order to devise the most efficient and most economical strategies and technologies.

In addition, CIGRE technical meetings were unique, circulating knowledge and information on international, regional or national levels (in plenary Sessions, Symposia, Regional Meetings, Conferences, and joint meetings with other Organizations). They embodied the continuity of the international Organization's work and the appropriateness of subjects for the current topical issues (interconnections, direct current, etc.) and for the specific problems faced in the field (planning in developing countries, interconnection, etc.). This resulted in the high quality of the technical reports presented in *Electra* and in Technical Brochures. Therefore the reports drawn up for its technical meetings made CIGRE one of the very first associations for setting references in the area of high voltage and extra high voltage. Its Technical Library, with over 4,000 references and 7,500 authors in 2000, and with new additions every year, is a mine of information accessible to everyone.

As regards the Technical Strategic Plan covering the period 1999-2009, which was drawn up by the Technical Committee, it proved CIGRE's ability to adjust to change and its approach as a unique and essential Users' Club, with no equivalent in a very unstable context. This Plan enabled members of the Study Committees to monitor, adapt to and deal with changes, identifying the new problems and implementing the solutions, which resulted from the technological changes required by structural modifications that affect power systems.

Among the Association's greatest strengths was also the justified feeling that CIGRE's members from all over the world formed a very united international community, particularly due to its relatively small membership. CIGRE's technical, social and friendly "network" of people responded very rapidly to its members' requests. Personal contacts played an important role in the definition and resolution of problems while avoiding excessively formal procedures. In addition, the continuity of the actions taken and the relative stability of the "body of technical experts" within the Study Committees greatly facilitated contacts. Extending the concepts and statements of its founder J. Tribot-Laspière on this human network, President Ernest Mercier already stated the following in 1948, at the time when he left his post:

"CIGRE is not only a frame of mind. It is also a state of mind – a spirit that has often been called the CIGRE spirit".

At the same time, the status of non-government Organization and non-profit association meant that it was relatively inexpensive to become a member, considering the quality and the range of services provided, compared to other similar bodies. The same advantages applied to the participation in technical events.

Another major asset for CIGRE's development was the existence of a real "secondary" network of 52 National Committees in 2000. These Committees form simple, efficient relays between the Central Office and existing and potential members. Within this perspective, the hosting of Symposia in their countries, the organization of Regional Meetings (for which Central Office provided assistance) provided a powerful means for enabling National Committees to circulate technical information and to make the Association and its spirit of cooperation better known locally.

Lastly, *Electra*, the Association's periodical journal, has played the role of an essential link between the members. With a circulation of 6,000 in the early 21st Century, its high-quality articles supply information on the results of the Study Committees' work and form the basis of CIGRE's technical heritage. The opening of its columns to external articles on questions other than purely technical is an additional asset. In acting as a link with its members, *Electra* also contains general information on the life of the Association.

The MasterPlan's main objectives at the turn of the 21st Century

After the diagnosis, remedial measures were recommended by CIGRE's Governing Bodies in a systematic action plan, called the MasterPlan.

The clearly-identified priority objective was to increase the number of members by counting on the international Organization's strong points, with its major ambition expressed as follows:

"Anyone who is closely involved in HV, EHV and UHV systems and who is not now a CIGRE member, either due to a lack of information concerning our services, or because they doubt our Organization's capacity to resolve their problems, must be convinced that CIGRE is the world reference Organization that is best placed to provide solutions or to at least clarify a certain number of points to enable them to make the right decisions"[41].

CIGRE's MasterPlan for the 1999-2009 period had to meet the combination of four basic requirements.

Firstly, it had to meet the expectations of high voltage system managers and operators and to thereby enable equipment manufacturers to produce equipment, techniques and systems appropriate for all types of power systems, whether they operated in developing countries or in developed countries with market economies. In searching for an optimum, the aim was to obtain the best possible technical conditions for the development of the electricity sector in terms of efficiency and reliability, but also the lowest possible cost for the consumer.

The MasterPlan then had to express CIGRE's strong willingness to be a reference international Organization for all issues related to power systems, including the impact of non-technical issues, to encourage the interest of decision-makers at the highest level in electricity companies, among equipment manufacturers, within regulation and control authorities and in the new structures that were then appearing everywhere in the world.

Thirdly, the MasterPlan had to extend CIGRE's field of action to neighbouring technical fields (economic and environment aspects, impact of organizational and regulatory aspects, dispersed generation).

41 - Ibid., p. 10.

Lastly, it had to take the measures required for increasing the representation of strongly-developing regions in CIGRE's essential bodies, i.e. the Executive Committee, the Administrative Council and the Study Committees.

Generally, this MasterPlan drew up an overall CIGRE strategy for the first time. As a priority, its field of activity had to be redefined at the beginning of the 21st Century. In effect, beyond the field of power systems, a notion that some people mistakenly considered to be rather obsolete at the time, CIGRE had to consider the electric system as a whole, that is, all interconnected components the role of which is the transformation of sources of primary energy into electricity, as well as the transmission and distribution of electricity.

Upstream, issues related to primary energy sources were obviously a matter for the World Energy Council (WEC). If the expansion of CIGRE's field implied overlapping with the WEC's field of action, then these issues should not be handled directly.

Downstream, the questions related to low and medium voltages were normally addressed by the International Congress on Electricity Distribution (CIRED). However, it was undeniable that dispersed generation, with such a strong impact on planning and operation of electric systems, was the type of subject which was quite within CIGRE's field of interest.

Already, through decisions of its Administrative Council dated 28th September 1993, 27th August 1994 and 2nd September 1999, CIGRE had written Rule of Procedure No. 2 to try to delimit the Association's Aim as precisely as possible:

"The questions addressed by CIGRE are, in accordance with Article 2 of the Statutes, those that concern the technology of high voltage equipment forming the electrical part of power stations or of high voltage lines and transformers, as well as those concerning the operation and development of high voltage transmission and interconnection systems as a whole, including systems and apparatus for control, monitoring, testing, measurement, protection and telecommunication required for the proper operation of this equipment and these systems.

All these questions are easily distinguished from technological questions of distribution systems supplied by high voltage transformers. However, it does not appear to be possible to define the border between the two fields in a simple way, in the form of a determined voltage value, because the types of equipment considered can be used at different voltages and the limit between transmission and distribution changes differently with time in different countries"[42].

The October 2000 MasterPlan then restated CIGRE's mission as follows:

42 - CIGRE, Rules of Procedure, April 2000, Rule 2, p. 3. This paragraph is no longer included in the Rules of Procedure, of which the complete text is available on the CIGRE website at www.cigre.org together with all of the Association's organizational texts.

"CIGRE aims to:

- Facilitate and develop the exchange of engineering knowledge and information between engineering personnel and technical specialists

- Add value to the knowledge and information exchanged by synthesizing state-of-the-art and world practices

- Make managers, decision-makers, regulators and Academia aware of the synthesis of CIGRE's work, in the area of electric power.

More specifically, issues related to the planning and operation of electric power systems, as well as the design, construction, maintenance and disposal of equipment and plants are at the core of CIGRE's Mission.

As from 2000, the term "electric power system" covered a wider range of topics and issues that could be possibly addressed by CIGRE, and at the same time a new series of studies were spurred on as follows:

- industrial, strategic and prospective studies, which, for both 2010 and 2020, anticipated a technological "revolution", new technical hazards, the emergence of a single supplier of equipment or a decrease in research investments;

- new dynamics of studies related to the institutional change in power systems (even if these subjects were already addressed by Study Committees);

- studies concerning tariffs charged for transmission and interconnection;

- studies related to public opinion issues concerning the development of power systems, beyond the environmental aspects, concentrating on the question of the vulnerability of importing countries (technical and political risks).

While CIGRE's Mission consisted in being able to answer questions from management on all levels and in all fields of power systems, its Vision was defined in the MasterPlan, as follows:

"CIGRE shall be recognized as the leading worldwide Organization in Electric Power Systems, covering their technical, economic and environmental aspects, and taking into account the impact of organizational and regulatory aspects"[43].

The Organization was to be present in all countries that had high voltage systems. In 2000, the target number was set at the threshold of 10,000 'equivalent' members to be reached by 2009.

In order to meet these challenges by 2009, three priority objectives were defined by the MasterPlan finalised in October 2000, which all contributed to widening CIGRE's audience: to increase its influence on the international scene, to continually develop the Organization in order to match CIGRE's Mission and ambitions, and to strengthen ties with other international Organizations in the electric energy sector.

43 - Ibid., p. 10.

To achieve the first objective in terms of influence and impact, CIGRE had still not taken full advantage of its "Worldwide" character. In 1998, 70% of its members still belonged to OECD countries. However, developing meant taking on new experts, particularly from new countries, which would enhance competence in Study Committees, and at the same time prepare the way for new generations to take over.

In the new strategy for development of the Organization set forth in the MasterPlan, the National Committees had undoubtedly an essential role to play in recruiting new members . Their task consisted in making both potential members and new members aware of the value of CIGRE membership. The new members necessarily had to include electricity generation companies, transmission system operators (TSO), regulatory authorities, and so on.

At the same time, a clear strategy was defined for recruiting younger members. CIGRE had to carefully ensure that the number of its members increased continually, starting with students. Unfortunately, at the time it was noted that the number of technical experts was decreasing, the reason being that electrical engineering attracted fewer students who were more inclined to go into the commercial sector.

In 2000, as a key element in the new approach to communication the MasterPlan suggested that the *Conférence Internationale des Grands Réseaux Electriques à Haute Tension* should become the *Conseil International des Grands Réseaux Electriques* – that is, it changed from a "Conference" to a "Council". The main aim of this change of name and this new official title, ratified by the General Assembly in August 2000, was to reflect the real image of CIGRE, which is definitely much more than just a conference.

The second priority objective of the MasterPlan consisted in continually developing the Organization to coordinate its mission and its ambitions.

The area covered by CIGRE's field of action was first redefined in 2000. It now covered not only conventional technical expertise, which was always considered to be its main area of competence, but also fully included economic and environmental aspects, and took into account the impact of aspects related to organization and to regulations. This extensive coverage enabled CIGRE to better respond to changes affecting the structures of the energy market, while providing reactive and precise information on new questions (such as the repercussions of new forms of organization of power systems, the impact of the development of dispersed generation, independent generation, or the integration of oil and gas in the electricity sector).

The third aspect of the MasterPlan aimed to strengthen CIGRE's links with the other international Organizations of the electric energy sector.

Thus a new policy was defined in 2000 for exploring synergies between CIGRE and other Organizations. The aim was to identify fields in which

Organizations wished to share the work in a specific sector or, on the contrary, to concentrate the work within a single Organization, in order to avoid inefficient overlapping and duplication. Many international Organizations were working in the energy sector, and this was no doubt a threat, since budgets are perforce limited, as is the availability of expertise. Duplication means waste of time and money. This new orientation of the MasterPlan simultaneously developed a more worldwide vision of energy and clarified CIGRE's role in relation to the positioning of international Organizations as a whole.

CIGRE had to rapidly determine which Organizations really represented opportunities for cooperation. This classification is still now relevant with respect to these synergies and the policy of CIGRE's opening out. Four Organizations belong to this first category based on a proven or potential partnership:

- first of all, naturally, the International Electrotechnical Commission (IEC), since CIGRE had played the role of pre-standardisation Organization for a long time, and since this role is constantly renewed and is now strengthened. They had been closely associated since CIGRE's beginning, which, as we have seen, the IEC had partly promoted, and this institutionalised cooperation is evidenced by the fact that the IEC President is a permanent guest member on CIGRE's Administrative Council .

- WEC (the World Energy Council), with which there is no overlapping as this Organization's scope covers all forms of energy. It therefore draws members from regulatory authorities, company top management and decision-makers.

- IEEE-PES (the Institute of Electrical and Electronics Engineers - Power Engineering Society), with which a cooperation policy has been set up in 1993, but which now needs to be further strengthened.

- CIRED (the International Congress on Electricity Distribution Systems), with which collaboration should focus on the development of decentralised or dispersed generation, with regard to increasing generation of intermittent energy.

An in-depth reform of CIGRE at the turn of the 21st Century: the symbolic advent of the International Council on Large Electric Systems

In accordance with this MasterPlan, the Organization was reformed in-depth and modernized from 2000 to 2002. As we have seen, these changes went much further than just the symbolic or even strategic change in the Association's name. In the early 21st Century, CIGRE changed from a periodic "Conference" to a permanent "Council", and to a determinedly widened area of expertise. However, the CIGRE acronym remained unchanged[44]. A three-fold action which concerned respectively the activities of the Study Committees, the governance of CIGRE and its publication policy was undertaken.

The first reform was carried out by the Technical Committee headed by André Merlin from 1996 to 2002. In his Address at the 2002 Session, aptly entitled "*Future activities of CIGRE*" he said [45].

In September 2000, the Administrative Council asked me to propose a new organization to adapt CIGRE technical activities to the evolutions of the Electrical Power Industry. This request was the logical consequence of the publication of CIGRE Master Plan approved in 1999, and resulted from a strong will of a better service to its members and to welcome new actors interested in Power Systems (regulators, energy traders, independent power producers, investors, financing institutions, distributors, ...)

The principles governing the present organization of CIGRE works were defined in 1966. A slight adaptation was made in 1982, with the creation of Study Committees 37, 38 and 39 to cover the aspects of development, analysis and operation of Power Systems.

Meanwhile, the operating environment of power systems has changed : the power markets have been liberalized, the activities unbundled, and regulation was introduced ; environmental concerns have taken a growing importance and, last but not least, new technologies have strongly developed: information technology, microelectronics, optic fibres, new materials, ...

Until now all these changes were taken into consideration through a dynamic coordination of the activities of the Study Committees. This coordination has mainly consisted in creating transverse Working Groups, in planning joint sessions of several Study Committees or in organizing panels and workshops with both transverse and prospective purposes.

I have asked Kjell PETTERSSON, Chairman of Study Committee 23, to convene an ad hoc group in charge of analysing the present situation and proposing evolutions to better suit the needs of the clients of CIGRE.

In the Spring 2001 it was then possible to discuss within the Technical Committee a first project, when we met in China in a splendid place near the Three Gorges Project, and I have presented the main lines of the new organization to the Administrative Council in the Autumn."[46]

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44 - The MasterPlan 1999-2009 was approved by the Administrative Counccil in August 2000 and the change of name was ratified by the Extraordinary General Assembly on 28 August 2000.

45 - In the editorial of Electra in February 2002, André Merlin had already drawn up a first report on the progress of reform work that he was leading in the Technical Committee, naturally with the support and approval of CIGRE's Council. As the proposed actions were completed by year 2005, a new MasterPlan 2006-2011 was issued in 2006.

46 - Merlin A., "Future activities of CIGRE, address by André Merlin, Chairman of the Technical Committee, 39th Paris Session, 26th August 2002.

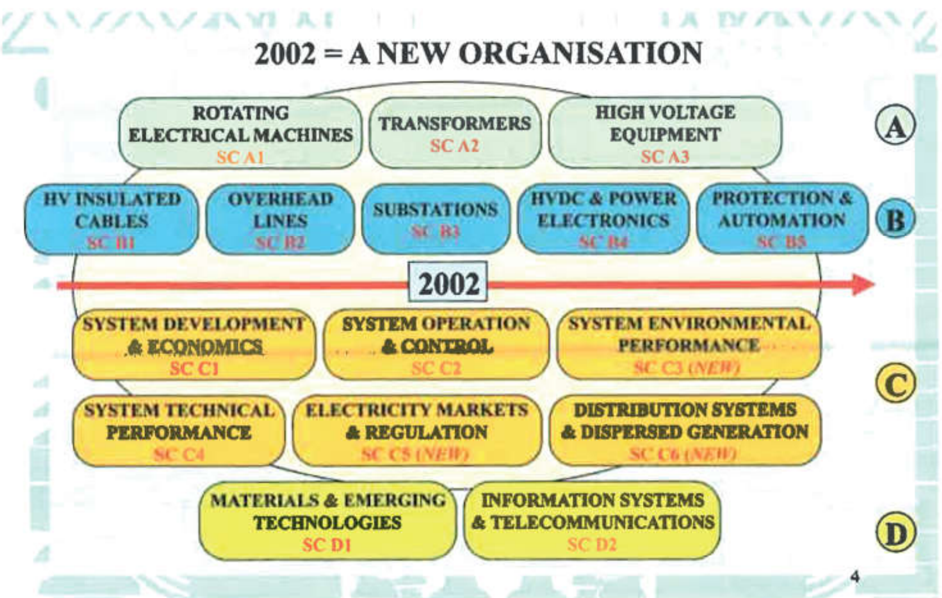
In this new form of organization, the major change is the broadening of the area covered by CIGRE, beyond the technical and economic aspects of the development, operation and maintenance of large electric systems, which remain fundamental. This widening opened CIGRE to new "customers", who were much more focussed on the environmental and institutional context of electricity systems.

In order to keep a reasonable number of Study Committees and thereby avoid the danger of the inflation of CIGRE bodies, the new configuration suggested new groupings of subjects which were previously addressed by several Study Committees. In addition, a number of Study Committees were given an official role of providing support for other Study Committees.

Finally, the new form of Organization in 2002 maintained ten of the previous Study Committees in their former configuration, with some minor changes. At the same time, it created six new Study Committees, which resulted either from the grouping of "traditional" activities or from the extension of the areas covered and therefore the introduction of new subjects which had to be addressed by CIGRE. Since 2002, the Study Committees were divided up as follows:

- 3 A Equipment Committees
- 5 B Sub-Systems Committees
- 6 C Electricity System and the Energy Market Committees
- 2 D Information Technology and "New" Technology Committees

Table 15 - Study Committees in 2002



This reorganization, with the Working Groups and Task Forces reassigned to the new Committees – a complex redistribution when they were common to several Study Committees – was launched in 2002 and was monitored by the Technical Committee thereafter.

An important change was introduced in the content and running of the Biennial Conference. The first full day of the Session week was devoted to discussions on strategic interdisciplinary issues and, on the following four days, 4 simultaneous Group meetings were run each day, covering the full scope of the CIGRE Study Committees. This set-up is still in force today.

The new Chairman of the Technical Committee, Aldo Bolza (2002-2006), completed the implementation of this major reorganization of the Study Committees, which has now resulted in a networked system of over 200 CIGRE working bodies, each with a specified mission for a determined period[47]. Aldo Bolza presented the principles of his action as follows in the December 2002 issue of Electra:

"All the players involved in the reorganization of CIGRE's technical activities are well aware that the process in which they are involved is not change for the sake of change, but rather the search for adaptation to changes in the environment within a framework of continuity"[48].

The suitable deployment of reorganization went hand-in-hand with the renewed efforts to enhance CIGRE's efficiency through a significant improvement of the Study Committees' mode of operation, while raising their standards, and therefore, in the long run, their technical excellence. It was a matter of *"better meeting the present and future needs of continually developing groups that it serves, while preserving the technical know-how that has contributed to making it what it is today... and while, in President David Croft's words, perpetuating the CIGRE 'success story' "*.

In July 2003, on the basis of the work of the Technical Committee which met in Rio de Janeiro in April 2003, its Chairman Aldo Bolza drew up a Reference Model for Study Committees. This was ratified by CIGRE's Governing Bodies and gradually applied aiming to improve the rules of operation of Study Committees[49]. This Reference Model stressed the need for the proactive character of the Study Committees, which had to absolutely avoid gradually becoming artificially expanded and self-sustaining technostructures with organization and running costs far exceeding their actual technical output. With a view to best efficiency, the seven headings of the text stressed the requirement for Study Commiittee

47 - Their respective work programmes, with their corresponding schedules, normally remain set for a period of three years.

48 - See "Message from the Chairman of the CIGRE Technical Committee", Electra, No. 205, December 2002, p. 4, to be read as related to his message assessing his work two years later in Electra, No. 217, December 2004, p. 4.

49 - Aldo Bolza, Reference model for CIGRE Study Committees, Milan, July 2003, 4 p.

Chairmen to show strong leadership and sense of coordination and the need for Chairmen to be assisted by an efficient Secretary. Advisory Bodies should be separate and complementary, and should not encroach upon the Chairman's management. The Working Groups had clearly specified technical objectives and a set duration, generally three years. They represented – in Aldo Bolza's words – "the 'driving forces' of the technical production of the Study Committees and, in the end, of the CIGRE as a whole". The priority objective, "to improve our response times, in accordance with the requirements of our 'market'", was clearly to enhance the activities of these Working Groups requesting faster delivery times for their studies, conclusions, and resulting publications.

The new organization of Study Committees with their improved consistency and transparency, was most satisfactory and, with the necessary hindsight, CIGRE's President Yves Filion (2004-2008) could justifiably celebrate the success of this ambitious modernization programme in his August 2008 speech, when wishing success to his successor, André Merlin, as CIGRE President.

Governance of CIGRE revisited

As part of the general reform of CIGRE governance initiated in 1999 by the MasterPlan, the system of recruitment and appointment of the Secretary General and his/her position within this new governance were specified and redefined. In 1998, an Ad Hoc group from the CIGRE Executive Committee, referred to as AHGOM (Ad Hoc Group on Organizational Matters), chaired by David Croft, future CIGRE President (2000-2004) was formed. Its objective was to improve the international Organization's management, by adapting it better to the new context of liberalization and deregulation of markets and to reflect on a further opening out of the Association to non-Western countries. The latter should be given more weight in the Organization[50].

Figure 37 - Presidents D. Croft (2000-2004), Y. Filion (2004-2008) et A. Merlin (2008-)

50 - See CIGRE, *Ad Hoc Group on Organizational Matters (AHGOM), Minutes of the Meetings*, London (3 June 1998) & Sydney (19 May 1999). AHGOM was composed of D. Croft (Chairman, Australia), J. Dürr (CH), H. Scherer (US), Y. Sekine (JP) and F. Taher (EG).

Regarding this last geopolitical issue, the aim was to encourage geographical zones, distant from Western Europe and North America which were playing a central role in CIGRE activities, to take greater part in the work of CIGRE. Promoting CIGRE through circulation of information and initiating activities within these countries and in so doing maintaining/increasing CIGRE membership (and possibly avoiding the formation of parallel local organizations no longer linked with the central CIGRE dynamics), were the key objectives addressed by AHGOM.

Within the CIGRE Statutes of 2000 Article 17 was introduced, on "Regions". The Article provided for National Committees from a group of countries to be able to set up a Region, which would then be officially recognised by the Administrative Council. Regions are not recognised unless there are at least five National Committees involved. In general, Regions were to be set up to make CIGRE better known and further its interest in particular broad geographic areas. The functions which Regions could perform would combine organising Regional Meetings, encouraging the activities of Study Committees in addressing regional issues, coordinating actions with industry organizations within the Region, encouraging and nurturing new National Committees[51]. This new Article provided for formal recognition of the concept of Regions as part of the organizational structure of CIGRE. While not Governing Bodies, Regions when formed were to give a more focussed priority to the issues specific to a geographic area.

Following the new regional dynamics, the first Regional Council was created in Asia and Oceania in May 2000: the AORC-CIGRE (Asia-Oceania Regional Council) founders were the National Committees of Australia, China, India, Japan, Malaysia, South Korea and Thailand. The second regional structure of CIGRE was established in Scandinavia in March 2002 and consisted of Denmark, Finland, Norway and Sweden. Later the Baltic countries were included in this Region. The name chosen for this Region was the "Nordic Regional Council of CIGRE" (NRCC). In Latin America the third one, RIAC (Iberoamerican Region of CIGRE), included 14 countries of South and Central America, with the addition of Spain and Portugal.

Thus the concept of 'Regions' was thought out and defined in 2000 to highlight and support vigorous and creative CIGRE activities in areas distant from Europe and North America. It actually provided innovative multiregional dynamics, associated with a stronger and fruitful diversity of CIGRE Regions. By year 2010, 3 Regions are in operation and no doubt contribute to developing technologies more particularly relevant to local needs in their geographical zones. Other projects for creation of new Regions are being considered.

AHGOM's priority mission was to examine the governance of CIGRE, better define the role of the Secretary General and his link with the Governing Bodies,

51 - According to Rule 14 of the Rules of Procedure, a Chairman for the Region, from one of the member National Committees, should be elected, for a two-year term, renewable once. For instance, Y. Sekine was elected as the first chairman of AORC. Annually, each Region should forward a report to the Administrative Council, outlining activities over the previous year and plans for the future.

and to recommend specific terms of office for CIGRE Officers. Coincidentally, at the same time EDF decided from 2000 to no longer directly subsidize a number of non-governmental Organizations, including CIGRE. It had done so since 1970 through payment of part of the Secretary General's emoluments. Therefore the AHGOM group proposed a major change in the recruitment procedure for the Secretary General. Selection criteria were defined and a Position Description was drawn up. The Secretary General would no longer be systematically from EDF. On the basis of the clearly defined criteria a call for candidacies would be launched with the National Committees to choose the best profile in accordance with a transparent and stringent process. An International recruitment firm was appointed to handle the process and screen the candidates. Jean Kowal, who was appointed at the end of 2000, was the first Secretary General recruited according to the new rules.

ACOPPE and *Electra 2000*

Among the CIGRE actions being reconsidered was the journal *Electra*. An ad hoc group from the Administrative Council, ACOPPE (Advisory Committee on Publication Policy of *Electra*), was entrusted with the task of examining the object, contents and presentation of this journal. A survey was launched to closely study readership. A new format – "*Electra 2000*" – was suggested and supported by the Administrative Council in August 2000 and the first issue was published in October the same year. The new format took into account the evolution of the communication means in CIGRE, with the website and the online Bookstore "e-cigre". From then on the CIGRE Technical Brochures could be ordered on-line and downloaded. Consequently, it appeared that the texts of the brochures no longer needed to be published in extenso in *Electra*. Also, the Study Committees could use the website to post information on the progress of their activities. So Electra 2000 changed its orientation from a specialist to a more general character journal.

As regarded the contents of Electra, the technical reports were condensed as an executive summary introducing full papers. Members interested could retrieve these from the web. More space was devoted to the life of the Association, where National Committees could report on local events. New columns were opened for "Invited Papers" put forward by members. At the same time the general appearance of Electra was modernised and changed from black and white to colour.

Generally, the Organization's multifaceted modernization in the early 2000s and CIGRE's symbolic name change to Council correspond to the perfecting of the CIGRE "mechanism", according to the very expression of Jean Kowal, with operative words such as neutrality, expertise, transparency and democracy. Nowadays, CIGRE's governance corresponds more and more to a fruitful combination of geographic approach, linked to the international network of 57 National Committees, and an interdisciplinary technological approach, driven by the dynamics of the Study Committees. At the same time, it is a successful blend of an institutional and administrative system, organized around the usual Association set-up consisting of the General Assembly, the Administrative Council, the Steering Committee and a scientific and technological system coordinated by the Technical Committee, for which the Study Committees form the basis of activity and expertise.

Figure 38 - ELECTRA issues over several decades

Chapter X:
The search for a new optimum for managing power systems: widening of the fields of study by CIGRE

The dynamics of Preferential Subjects from the 1990s to 2010

We must now complete the historical trilogy of the study of CIGRE's Preferential Subjects since 1956 and of the changes in their organization, their orientations and their contents, by presenting their dynamics throughout the last two decades.

Transformers

The period 1992-2010 is characterised by a growing interest in the possible repair and rehabilitation of equipment, especially in the context of developing on-site work. Cleaning methods for eliminating sludge, inspection of the active part for identifying any weak points and assessing their criticality, dielectric tests after repair or other works on site have been the subject of numerous contributions. Special attention was paid to reliability of repaired units; impact of particles in oil and the means for eliminating them have been the subject of studies, taking into account the increasingly critical quality requirements.

The increasing number of HVDC installations has led to tackling the subject of converter transformers which call for specific technology to take into account the constraints and requirements in service.

The spurious operation and lack of reliability of accessories – such as Buchholz relays, pressure relief valves, bushings, on-load tap changers and cooling systems – led CIGRE to look into these equipments which are found in practically all transformers. A Group meeting at a Session was partly devoted to conventional and unconventional instrument transformers, for dealing with problems of reliability, maintenance, tests and design dimensioning. During this very recent period, CIGRE worked on failures of power transformers and reactances, while assessing new technologies and new concepts.

Numerous studies on short-circuits were carried out to evaluate new load calculation methods of the related stresses, the impact of repetition of these events, test procedures, economic aspects, and the influence of design and service conditions. The influence of the type of network and the earthing conditions were also considered. Experts were given the opportunity to present their visions of the future of materials, components and the use of apparatus. Asset management, reliability of transformers and strategic, technical and economic aspects remained important subjects of discussion, with exchange of experience, as was the case for new types of on-load tap changers and for the impact of transients from the network. These were the topics of two workshops at Sessions.

In 2006, for the first time, Study Committee A2 (formerly 12) opened the discussion on phase-shift transformers, which are in growing use in modern systems.

As new liquid insulating materials were used in very special cases service information was collected based on feedback, particularly concerning maintenance, deterioration and diagnostic tools, as well as thermal and dielectric performance. This allowed the updating of IEC standards 60076-13, which concern hybrid insulation systems. The introduction of these new liquids on the market was to be carefully monitored because, in the future, they were to play a major role in personal safety and in protection of the environment. Recently, failures of large transformers were observed that were caused by the poor performance of certain insulating oils, and therefore intensive work was carried out which enabled the IEC to very rapidly produce recommendations for a more appropriate specification of these fluids.

Reactors were again at the centre of discussions, in order to consider service feedback information and to enable the relevant standards to be updated, especially as regards noise in service, vibrations, acceptance tests and performance in service.

The problem of fires in transformers and their prevention has been tackled. As these are often related to an explosion of the tank, it is necessary to review the simulation tools that can be used to better identify the performance of this important element. A Working Group was set up to better identify the needs and accumulated experience in power systems with very different legacy practices. The use of gas-insulated apparatus was part of this work.

CIGRE also examined the benefits provided by its publications concerning specifications and design studies. In order to generally relate to an economic framework, concepts of life cycle costs were discussed, including maintenance, continuous monitoring with expert systems, condition assessment through diagnostic methods, asset management and supply/procurement policies.

Overhead Lines

In the 2000s studies and discussions in the area of overhead lines focussed on the increase in transmission capacities and on the ageing of structures: increases in voltage, taking into account in real-time weather conditions, development of new types of conductors (composite conductors with metal or glass fibre core).

The storms observed around year 2000 throughout the world led to renewed discussions on the dimensioning of structures based on methods combining static and dynamic loads in a probabilistic approach.

The considerable progression, in terms of general innovation, and of Geographic Information Systems (GIS) was acknowledged in 2006. It was confirmed that they were applied to all phases of the life cycle of a line: planning, design, construction, operation, management and control of vegetation, forest fires, inspection, maintenance, rehabilitation, dismantling, etc.

To increase the transmission capacities different solutions were discussed: real-time management of certain structures became possible as a result of the development of sensors indicating the real sag at the most sensitive point and notable gains in transit capacities could then be envisaged, but this required specific organization of the control actions. In some configurations, the transformation of alternating current overhead lines into direct current overhead lines could increase transit capacities by more than 100%, but with costly conversion stations, etc.

Lifetime assessment and lifetime extension, precise knowledge on the equipment condition, diagnostic methods, environmental and societal acceptability of overhead lines were other topics in recent Group meetings.

Insulated Cables

In the early 1990s Session was focussed on installation techniques, stressing the economic dimension of these techniques, for both underground and submarine cables. The criteria for the design of cables with extruded insulation and their accessories were still on the agenda, and new subjects appeared including the monitoring and maintenance of cables in service, diagnostic in service, the detection of hot points, availability and reliability, which are still central twenty years later.

Evolutions in accessories, the first experiments with fluidless terminations, the introduction of prefabrication, and computer-aided design techniques followed. High AC or DC transmission was a new challenge, and the integration of optic fibres into cables aroused great interest, particularly for monitoring cables in service, or the transfer of data. However, a major part was still devoted to new studies and experience feedback on high voltage cables with synthetic insulation. The role of waterproof sheaths for extruded cables was seen as of priority concern for the future of these cables and their move towards higher and higher voltages and was the object of special attention.

In 1996 and at following Sessions, CIGRE started to compare solutions proposed for high voltage transmission via underground cables, overhead lines and, later, gas insulated lines (GIL). The use of synthetic extruded insulation for DC power cables, superconductor cables and GILs were touched upon.

In addition to the periodic discussion of new products, the impact of the changing context of operation of the power systems and the general question of asset management – testing, maintenance, condition monitoring, life assessment and extension – have to be singled out as topics dealt with during the period.

Finally, it is important to underline the emphasis given over the period to high voltage submarine power cables, for which CIGRE recommendations remain to date the only internationally recognized de facto standards.

Figure 39 - Laying of submarine cable

Substation Equipment

As regards substations and relevant equipment, in the 1990s, the question of maintenance became established as one of the main issues. The reduction in labour costs, extension of lifespans, and the dispersed nature of installations and their volume, made it necessary to share the acquired expertise and methods for maintenance of equipment. Not only were maintenance costs, methods and scheduled operation intervals discussed, but there was also a move towards continuous monitoring and auto-checking. The real-time transmission of equipment information to control centres or, better still, to the protection system, brought intelligence in the management of assets a step closer to the smart grid.

Knowledge of materials and components was always required for mastering technologies, and was continually monitored by CIGRE from the beginning, including solid insulating materials, insulating oils and gases such as SF6. The development of switchgear - circuit-breakers - which are among the strategic and sensitive components of power systems, remained gradual, without any sudden radical technological change. Technologies with compressed air, then with low volumes of oil, and, for almost two decades, technologies with SF6 are present in power systems with satisfactory service experience today. The optimization of interruption chambers and the use of mechanical operating mechanisms have kept these products reliable and compact while reducing their investment and maintenance costs. However, all these technologies use the principle of mechanical movement of contact fingers with arc puff and, in accordance with the increasing safety requirements (concerning potential explosion caused by an internal defect), composite envelopes are gradually replacing the traditional porcelain envelopes.

For static interruption systems, manufacturers are examining new concepts that include power electronics. The advantage with these would be controlled interruption phases, with extremely short interruption times. However, the industrial application of such systems faces major difficulties, such as the capacity of semiconductors to withstand overvoltages, their protection, series connection of a large number of modules to withstand the dielectric stresses, the maximum current bearable by power electronics components, etc. At least ten to fifteen years are required for the development and implementation of these technologies which could be subjects for future discussions.

The impacts of the environment with respect to substation equipment were also taken into account in the Preferential Subjects. However, more importantly the topics related to asset management, maintenance, life assessment, rehabilitation, and replacement. CIGRE studies are becoming more and more attuned to economy and management of resources, above and beyond the fundamental consideration of the development of technologies, which for over eighty years now has been the traditional basis of CIGRE's work.

Protection, Telecommunications

After the introduction of the first digital protection systems in the 1970s, the architecture of substation automation systems, their digitization and the standardisation of protocols for communication inside substations were recurrent subjects throughout the 1990s and 2000s. The use of unconventional transformers raised the problem of their interface with the substation secondary equipment, and the replacement of the conventional CTs and TTs.

Economic questions first appeared in the 1980s and became a vital factor from the 1990s, when the problems of the renewal of secondary equipment of substations had to be examined.

Deregulation/re-regulation resulted in new conditions of operation of the power systems, where the notion of risk started to be taken into account in decision-making. This risk, which was previously much less explicit, led to reduced security margins in the system operation. The impact of deregulation on practices for protection and control, operation and management was first discussed in 1998 and was to remain long on CIGRE's agenda.

The effects of deregulation of the telecommunications sector on the electricity industry were examined as early as in 1996. The question of return on investment had been raised already by system operators, not only for their operation functions, but also for their external needs, that is, communication with customers and market players. For instance, one of the subjects on the agenda of the 1996 Session concerned the telecommunications systems to be implemented in order to cope with a natural disaster and to help restoring operation afterwards.

In 2004, in addition to the now classic field of telecommunications was that of information systems. It concerned real-time information systems, which were required to meet increased requirements of speed of access to information, which determined the speed of restoration of service. In any case, deregulation and competition were much more present in the Session, whether with respect to the impact on control centres or the availability of value-added services (Internet, low-voltage powerline carriers and Wi-Fi) by electricity utilities.

Fifty years after starting in 1956 with the study of powerline carriers, the telecommunications topics changed after 2000 to satellite links, thereby keeping pace with the numerous technological innovations that have affected and promoted telecommunications.

Systems Preferential Subjects

The "Systems" issues, which were by definition the CIGRE community's core business, went through very considerable and even strategic changes during the last two decades of CIGRE's very recent history, and may continue to do so in its immediate and long-term future. These changes featured major external transformations which to a great extent affected the work of system electrical engineers, with the change of institutional paradigm affecting almost all developed countries and a very significant emergence of environmental problems. Faced with these in-depth transformations of the electricity supply industry, CIGRE showed – and continues to show – its ability to adapt as efficiently as possible to the requirements and constraints of a rapidly changing external world. Thus the new Committees which, since 2002, had continued and adapted the tasks of the former Committees were to address wide Preferential Subjects as follows:

- the resilience of power systems[52] in relation to faults, a question very closely related to the increase in the trend to take risks, which resulted from the opening of electricity supply to competition;

- the consequences for the design and operation of power systems, including electricity distribution systems, of an energy policy aimed at reducing emissions of CO2 by using renewable sources, whether or not dispersed;

- the search for an increase in the transmission capacity of corridors;

- the new operation of the electricity markets with its inter-related conse -quences and the new issues concerning ancillary services.

During the 1990s, electrical engineers and the players involved in the economy of power systems, and therefore, by definition, all CIGRE members had to resolve particularly complex questions. Furthermore, at the same time, the power systems in developing countries faced challenges that were very far from the more and more sophisticated new devices called for by the policy of opening electricity supply to competition.

Faced with these issues, CIGRE's response could only be in the mainstream of its initial missions: to spur on discussions between engineers in very different political, social, industrial and technical/technological environments. Furthering an in-depth dialogue in a context of diversity was certainly in line with the raison d'être of this International Organization and of the CIGRE community at large.

52 - The term resilience was originally used in the science of Mechanics to denote the mechanical characteristic that defines the impact resistance of materials; when energy is absorbed by the impact failure of a material, this unit directly measures impact resistance. This term gradually established itself in electricity systems to characterise the capacity of the systems to resist after exceptional events.

Chapter XI – CIGRE in 2010

CIGRE's status and organization: brief run-up till 2010

CIGRE, is governed by its Statutes which are broadly along the lines of the 1966 text, the major revision dating back to 1999 when the concept of Regions was introduced and the governance was revised and closely defined.

There are now four main Governing Bodies: the General Assembly, the Administrative Council, the Steering (formerly Executive) Committee, and the Technical Committee.

The General Assembly meets every two years and appoints the members of the Administrative Council, which, from among its members, elects the CIGRE President, the Treasurer and the Chairman of the Technical Committee as well as the members of the Steering Committee. These elections take place every two years.

In 2006 it was decided that each National Committee should hold a seat on the Administrative Council, with weighted voting right (ranging from 1 to 3 votes) depending on the number of their respective members and no vote in the case where a National Committee does not meet minimum membership statutory requirement. The President, Treasurer, TC Chairman, past Presidents and President of the International Electrotechnical Commission are members by right but do not vote.

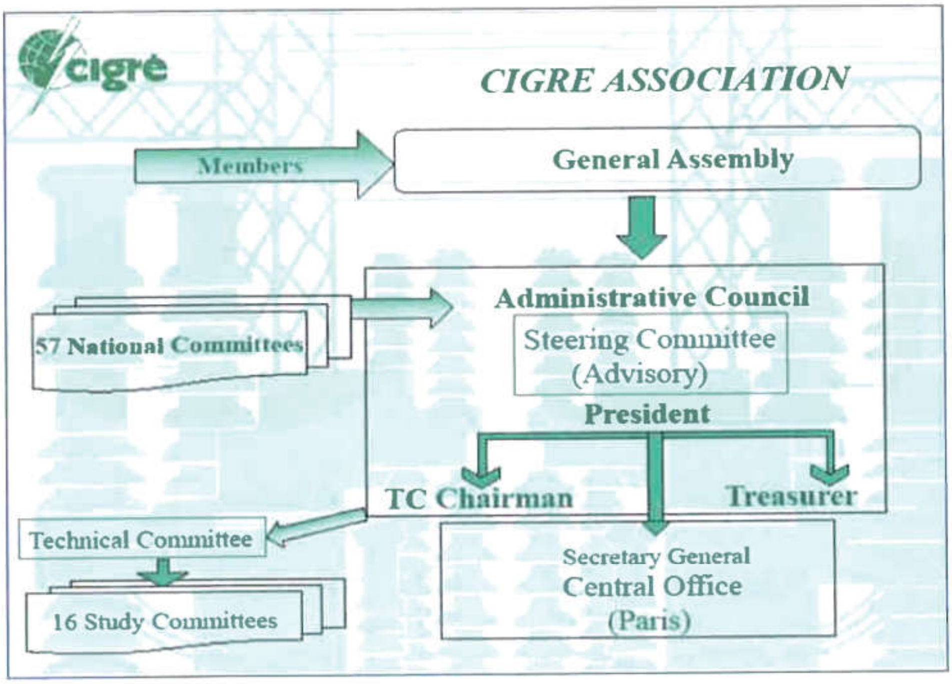
The Steering Committee also according to the Statutes is made up of fifteen members of the Administrative Council: in addition to the three Officers – CIGRE's President, its Treasurer, and the Chairman of the Technical Committee – it counts 12 members whose appointment is based on a nomination procedure which considers the membership ranking of the National Committees as well as a balanced representation of the four geographic zones as identified in CIGRE's statistics, that is, Europe, the Americas, Africa/Middle East, and Asia/Pacific. Additionally, the rules also provide for three members to be appointed by direct election, irrespective of membership or geography. Whereas the General Assembly and the Administrative Council have executive powers, the Steering Committee is an advisory body which prepares the work of the Administrative Council, carrying out studies, making recommendations. (In 2006 the name "Executive" was changed to become "Steering" to reflect more accurately the advisory character of its functions.)

The Technical Committee is made up of a Chairman appointed by the Administrative Council, assisted by a Secretary, the Chairmen of the Study Committees, two members of the Administrative Council and the Secretary General. In charge of the technical activities of CIGRE, it coordinates the Study Committees' activities and ensures that the issues of interest for the international community are properly taken into consideration.

The above Governing Bodies hold regular meetings and their organization directly reflects the Association's international character. In even-number years, all meet in Paris at the time of the biennial Session the venue of which since 1988 is the Palais des Congrès premises. The Session is the climax of the International Organization's activity and its major showcase in terms of communication and impact. In odd-number years, the Governing Bodies and Study Committees meet in a different country every time, to ensure satisfactory rotation of host countries in different parts of the world.

Figure 40 - The Administrative Council in 2010

TABLE 16: CIGRE organizational chart in 2010



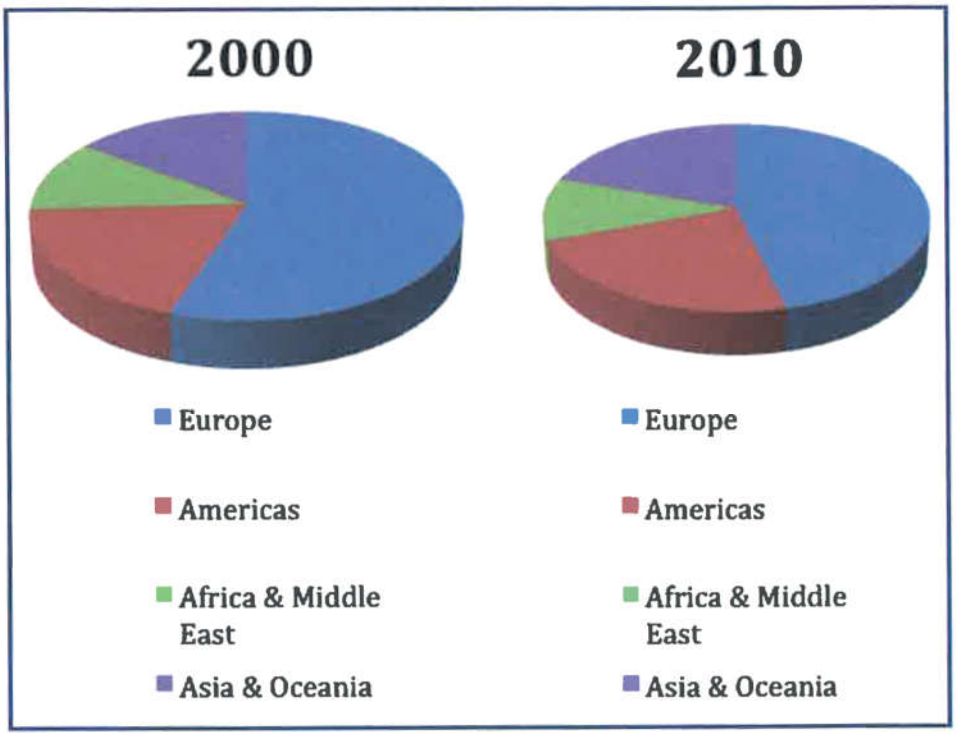
CIGRE Membership – National Committees

Members of CIGRE are either individual members – persons only – or collective members i.e. companies (collective Members I) and educational bodies (collective members II). Representation of the two categories is differentiated in General Assembly decisions to reflect the greater financial contribution of collective members. Collective I have 5 votes, Collective II have 2 votes. Individual members make up the larger part of the CIGRE community – around 85%. The proportion increased further when in 2004 with a view to recruit members among young engineers a "Young Member" category was introduced: a temporary status – 2 years – for engineering students and young engineers aged under 35. For these "Young Members" the membership fee is halved.

In 2010 CIGRE membership is as follows: 3 categories of individual members: Individual I, Individual II (young members) and Honorary Members; 2 categories of collective members: Companies (I), Educational Bodies (II).

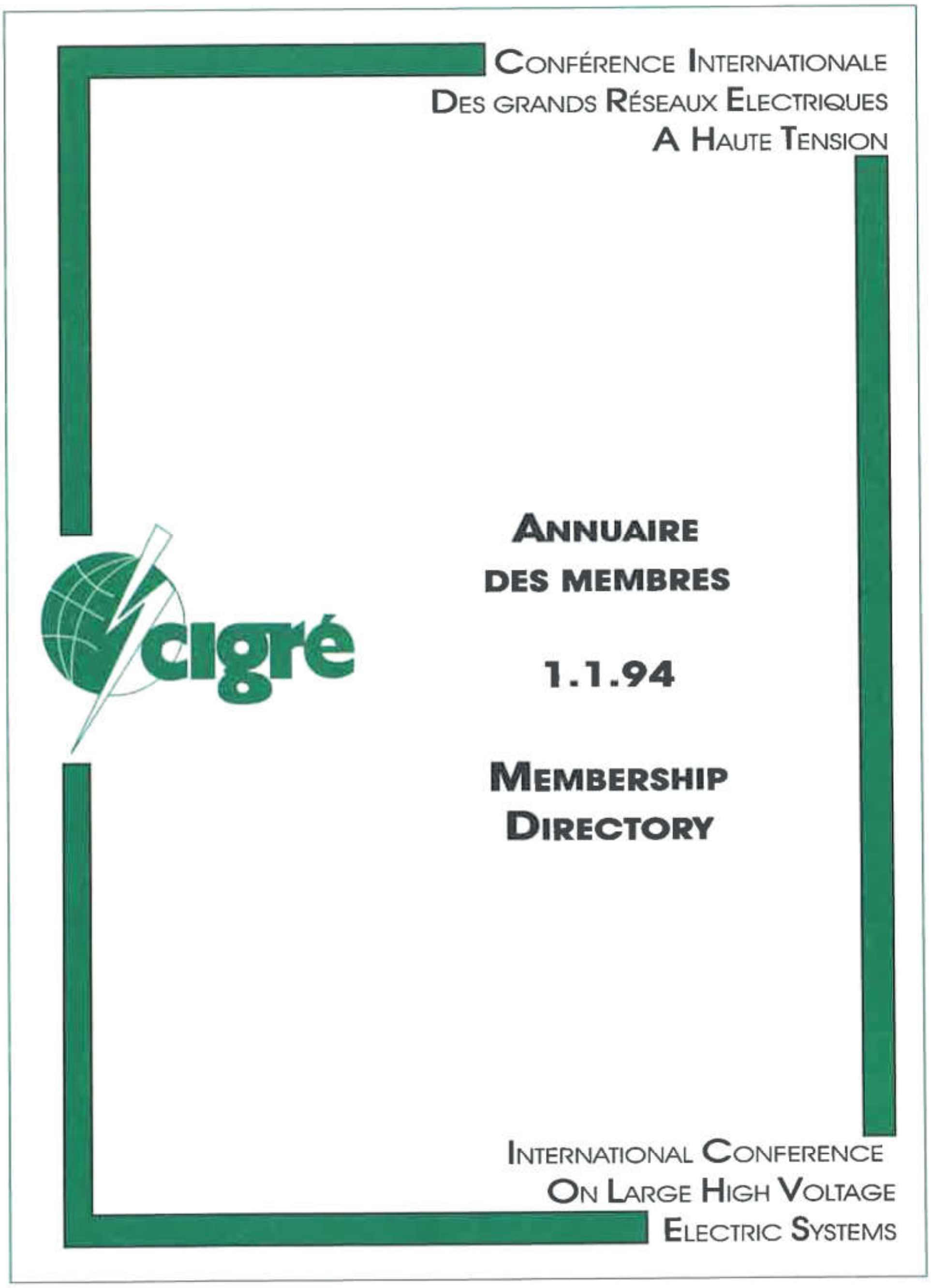
When recording membership numbers, the same rule as for General Assembly votes is applied: one collective member(I) is regarded as equivalent to five individual members, one collective member (II) is equivalent to two individual members. In 2010 the total equivalent membership figure was: 11 565, as follows: 6367 individual members, 976 collective (I) members and 159 collective (II) members. The equivalent membership figure for 2001 was 7817.

TABLE 17: Variations in CIGRE membership growth (expressed in numbers of Equivalent Members) in 2000 and 2010 and breakdown by continent.



National Committees are important players in the organization of CIGRE. Created as far back as 1923, their role consists in promoting and pursuing CIGRE's activities in the respective countries. Their duties involve collecting membership applications on behalf of the Central Office, encouraging the presentation of papers at Sessions, organising technical events, on their own, or jointly with Study Committees. National Committees appoint representatives on the Study Committees and Working Groups. These representattives thus have the opportunity to raise technical issues of concern for their country and to bring home the teachings drawn from the collective experience of CIGRE. In 2010 National Committees numbered 57 and CIGRE counted members in 82 different countries.

Networking is an important feature of an international Association. To facilitate contacts between members, the CIGRE Membership Directory is issued every other year in the form of a CD-Rom. The first such Directory was issued in 1994.


CONFÉRENCE INTERNATIONALE
DES GRANDS RÉSEAUX ELECTRIQUES
A HAUTE TENSION

cigré

ANNUAIRE
DES MEMBRES

1.1.94

MEMBERSHIP
DIRECTORY

INTERNATIONAL CONFERENCE
ON LARGE HIGH VOLTAGE
ELECTRIC SYSTEMS

Figure 41 - Cover page of "Membership Directory" 1994

CIGRE Awards

As most major scientific Associations CIGRE recognises the contributions of its members.

The CIGRE Award system was introduced some years back to reward a number of experts singled out for their contribution to the work and hence to the development of CIGRE. The Award system combines scientific and technical recognition with CIGRE's high renown and its international character within the framework of CIGRE. One of these awards recognizes very long-standing membership in addition to contribution at the national level. The highest award is the CIGRE Medal introduced in 2008.

Up until 2008, there were three types of Awards:

- The title of Honorary Member was introduced as from the beginnings of CIGRE and the only nominees were the former CIGRE Presidents. In 1996 the award which was granted every two years (Session years) was extended to office bearers "who have fulfilled their task with distinction". The candidates could be outgoing Study Committee Chairmen, outgoing Steering Committee members and possibly one or two members of the Administrative Council singled out for their exceptional contribution to the Association.

- In 1993, the Technical Committee Award was introduced. This award is under the responsibility of the Technical Committee Chairman. Proposals are put forward by Study Committee Chairmen who may each put forward one or at the most two names every year for this award.

- In 1996 the "Distinguished Member" award was introduced to reward both seniority (minimum 10 years' membership) and contribution (administrative and/or technical). National Committees put forward proposals every two years and thus reward their best members. Candidacies must be approved by the President of CIGRE.

Overall, during the 2000s, this system of CIGRE distinctions reached an average of 150 recipients every two years, which was considered to be too high. Indeed, it was felt that the status of the awards was not up to the level of CIGRE's reputation and its ambitions of universal international recognition. So, in 2008 the award system was revised by the Steering Committee and the relevant recommendation was approved by the Administrative Council. The three existing awards were maintained but selection of candidates was to be more stringent: "Distinguished Member" candidacies were not to exceed 1% of total National Committee membership, as opposed to 5% earlier.

With the new system an additional Award – the CIGRE Medal - was introduced as the highest of all CIGRE distinctions, reserved for people whose outstanding contribution to the work of CIGRE had also had a significant impact outside CIGRE circles. Only one or at the most two CIGRE Medals would be granted every two years. In order to enhance attribution of this award, handing out of the CIGRE Medal was to take place at the time of the Session, as part of the Opening Ceremony. The new system provides for candidates selected to be assessed by the Administrative Council acting as a Nomination Committee. The candidates are then chosen by a Selection Committee composed of CIGRE's President, the former President, the Treasurer, the Chairman of the Technical Committee, the immediate past TC Chairman, and the Secretary General. This Selection Committee is also responsible for the appointment of Honorary Members.

The first two CIGRE Medals were granted to Aldo Bolza (Italy) and to Joao Batista Guimaraes Ferreira Da Silva (Brazil), at the 2008 Session Opening Ceremony, on 24th August 2008, at the Palais des Congrès, in Paris.

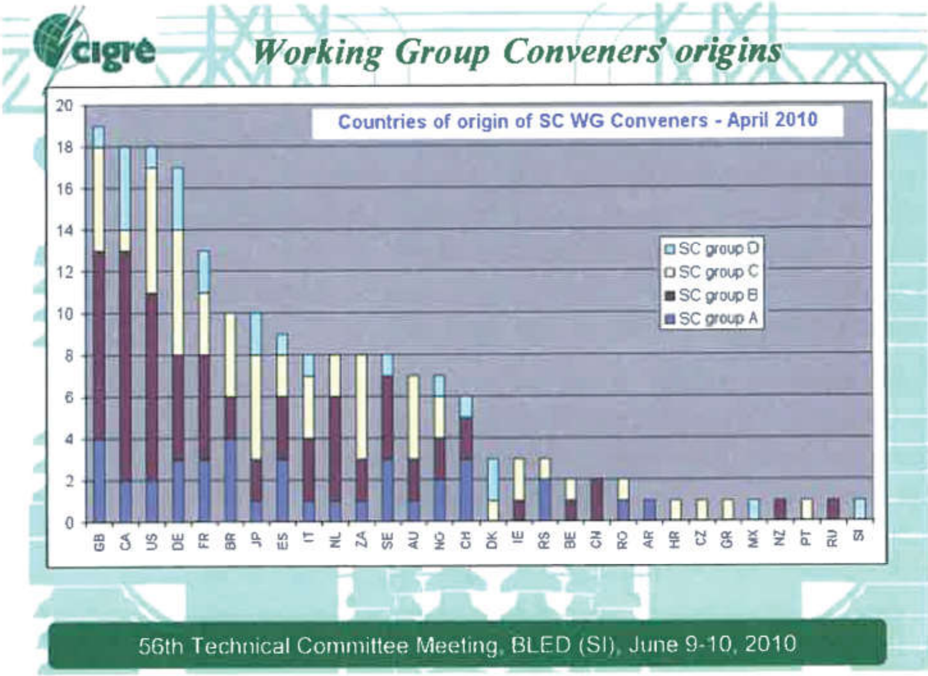
Figure 42 - 2008 CIGRE Medal recipients :
Aldo Bolza (top) and Joao B.G.F. Da Silva (bottom)

The Technical Committee and the Study Committees

In 1949 the need for a coordination of the Study Committees was recognised and a Technical Committee (TC) was set up, made up of the Study Committee Chairmen and chaired by a CIGRE Officer, the President or the Delegate General. In 1966 the Statutes confirmed the structure and specified that the Committee would include three members of the Administrative Council, the TC Chairman being one of these, and the Secretary General. The composition is still the same today.

The TC has responsibility over the technical activities of CIGRE, the technical contents of the conferences and the work of the Study Committees. It draws up the Strategic Plan which outlines the main axes to be followed by the Study Committees in the definition of their activities, and an Action Plan. The very first Strategic Plan was issued in 1998 and updated in 2004. In 2010 a new Plan was finalised, which constitutes the roadmap of the Study Committees' activities for the next decade. Further to orienting the work of these Committees, it supervises their activities, approves the launching of new studies and monitors their progress. Last but not least it plays an important part in the choice of Study Committee members and Chairmen.

Study Committees and the corresponding Working Groups carry out technical studies. Since the 2002 reorganization the responsibilities and fields of activity of the 16 Study Committees have remained the same (See Table in Appendix), with the exception of Study Committee D1: "Materials and Emerging Technologies" , the title of which was subsequently changed to "Materials and Emerging Test Techniques". The Working Groups are the engines of CIGRE. They consist of international experts and their production reflects the buoyancy of CIGRE. In 2010 over 210 Working Groups are operating, bringing together a total of 2400 experts, as shown in the following graphs.



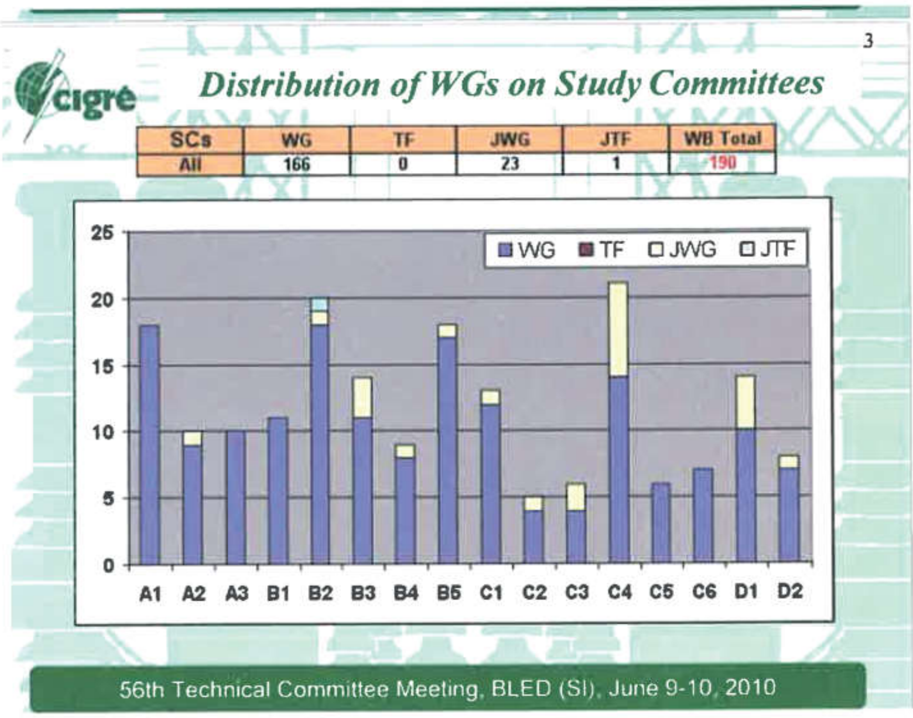


Figure 43 - Working Group figures

CIGRE events and services to members

Organising biennial Sessions was in 1921 the "raison d'être" of CIGRE and it was the only one as per the Statutes of 1931. In 1966 the new Statutes provided for an extension of the Study Committees' work. CIGRE's regular growth in membership and need to expand its area of influence implied diversifying the means for circulating knowledge and the latest information on subjects of topical interest. Under the new Statutes the object of CIGRE was "to facilitate and promote the interchange of technical knowledge and information... in the field of generation and transmission at high voltages".

Sessions are still the major spearhead event for CIGRE. Participation has increased steadily to reach over 3000 delegates in 2010. Since 1994 this prestigious event has been complemented with a Technical Exhibition held in the same premises. Sessions are now held over one week at the end of August, and always in Paris. The general format of the conference, apart from the changes which resulted from the 2002 reorganisation has remained unchanged.

Figure 44 - 2010 CIGRE Session

In 1980 the idea of organising – in non-Session years - events in a location other than Paris and focussed on one subject of topical interest was raised and discussed in the Administrative Council. The decision to hold Symposia regularly was made and a first test event was organised in 1981 in Stockholm. Two Symposia were to be held in uneven-number years. Projects for Symposia were proposed by the Technical Committee upon suggestion from the Study Committees and were approved by the Administrative Council. The venue was upon invitation by a National Committee. The procedure is still the same today. Some Study Committees take the opportunity of Symposia to schedule their annual meeting in conjunction with these events. Since the 1980s Symposia have addressed a number of strategic issues such as: the integration of power transmission equipment and facilities into the environment, power systems in developing countries, the reliability of installations, deregulation and dispersed production.

Dissemination of technical information is an important part of CIGRE services and material produced is available to both members and non members. Through the journal *Electra* members are informed on new publications through an executive summary. The contents of the journal include information on the life of the Association, announcements on upcoming events, reports on National Committee events, Regional Meetings. CIGRE articles and technical brochures are also posted on the CIGRE website which was started in 2000 and is now the major information and promotion tool for CIGRE.

Today, the widest distribution of technical information is through the on-line Technical Library and Bookstore. Some 7000 items are listed which cover the Session papers, Symposia Proceedings, *Electra* articles, and Technical Brochures. CIGRE members can download any publication on the list, free of charge. Non members cannot download material but they may place an order and receive the selected material against payment.

The CIGRE Central Office

CIGRE's headquarters have changed location several times. Up till 1996 the Central Office premises had always been rented. In 1990 the offices were on Boulevard Haussmann, the lease had ended and would not be renewed. New, spacious premises were found in the heart of town, though not in the business area. In the early 90s, the Secretary General, Yves Porcheron, considered that the Central Office should have a permanent address and not be subject to ending leases. He considered that purchasing premises should be envisaged as real estate prices were at a low ebb and CIGRE reserves allowed this. This was a big move for CIGRE and the question whether or not the Association should purchase property was discussed at length and finally supported by the Administrative Council. Once the decision was made the Secretary General started searching for the most appropriate location and premises. The offices located on rue d'Artois, in a business and residential area were the best option. The deed was signed by the President, Jerzy Lepecki in 1996.

Figure 45 - Jerzy Lepecki and Yves Porcheron in 1996 on the occasion of the move into the Rue d'Artois offices following purchase of the premises.

The Central Office plays a strategic and a vital role in building and expanding the CIGRE dynamics. The Central Office, under the leadership of a Secretary General handles the day-to-day management of an International Organization. With a staff of less than 10 people, the Central Office carries out the following tasks:

- preparation of the meetings of the Governing Bodies
- handling and follow-up of the Association membership
- handling process for Study Committee membership
- Edition of Electra and Technical Brochures
- Processing of Session and Symposia papers
- Practical organization of Sessions and communication function
- An accounting/finance function in connection with the above activities.

Figure 46 - Rue d'Artois building

As provided for in the Statutes, the Secretary General, backed by a small team, coordinates the short- and long-term aspects of CIGRE's missions, represents the Organization and confirms its international character. The Secretary General liaises with the National and Regional Committees. In addition, he/she supervises preparation of the Study Committee papers and the issue of all CIGRE Publications. The Secretary General also handles relations with other International technical Organizations.

Improving services to members is a constant objective and paying personal attention to requests and queries from members has always been an important unwritten rule for the CIGRE Central Office. This approach is in keeping with the major role played by human relations within CIGRE. These contribute to the "club effect" and to the social construction of an international professional community, cultivating the values of technical unity and international culture within the Organization.

Figure 47 - 2010 Session

CONCLUSION

CIGRE managed the fundamental changes over the period 1990-2010 by basing itself on significant recognition of its usefulness, as shown by the large number of results published and their worldwide use.

Viewed as part of a long-term process since the foundation of CIGRE in 1921, these changes were much less technological than geopolitical and economic, but they were just as difficult to incorporate appropriately into the international organization's activity. The arrival of new players, the divisions between roles related to the new market regulations and to the emergence and development of new electricity powers were taken into consideration by its authorities and incorporated in its organizational dynamics. The main response to these changes was the major reform in the early 2000s of the Study Committee technical set-up. This made it possible to collaborate with the world community of electrical engineers in addressing all the new questions raised by these changes in the framework of its activities.

At the same time, CIGRE has constantly strengthened its support for international research by collaborating actively with other groups of experts. In particular, its work still provides a basis for standards defined by the International Electrotechnical Commission (IEC), and it has sought to better define its place and its role in relation to other international organizations, mainly the IEC, WEC, IEEE and CIRED.

The new CIGRE dynamics, opening into the second decade of the 21st Century, had to take several major challenges into consideration. The first challenge was related to the development of a new cycle of technological innovation, which combined technological systems for controlling the operation of power systems. This included information systems, microelectronics, optic fibre and new materials. The second challenge was the increase in environmental concerns, which was a priori irreversible and was characterised by the increasing requirements of sustainable development. The third involved the establishment of new devices, arrangements and configurations for power systems, marked by the progression of renewable energies and their repercussions on the control and planning of power systems (particularly wind energy). Within this perspective, the debates on their optimum size and the development of decentralized or dispersed systems are among the strong features of CIGRE's vision for the 2010s.

EPILOGUE:
CIGRE Roadmap for the 2010s:
The Power Systems of Tomorrow

The vision of the technical directions of CIGRE activities for the 2010s is outlined in the 2010-2020 Technical Committee Strategic Plan, drawn up under the guidance of Klaus Fröhlich, Technical Committee Chairman. The contents of the Strategic Plan were put forward to the Administrative Council and were approved at the meeting of 23rd August 2010.

This Strategic Plan analyses the facts shaping the future of the power systems and defines the main axis of the activities of the Study Committees for the coming decade.

An evergrowing demand

The need to serve an evergrowing demand for electricity, diversified in space, time and quality: nearly 2 billion people still without electricity, impact of standards of living, varying growth rate between developed countries and emerging economies, quality requirements of the digital society, new uses of electricity or electricity replacing other forms of energy in areas such as transportation, industrial processes, increasing impact of demand side management and deregulation.

Facing the issue of climate change

The environmental challenges concern over climate change and impact of human activities have resulted in a thrust in the development of "non carbon generation", either dispersed or lumped in large generation farms. These non carbon generations are typically wind mills, solar generation, which are intermittent and not easily predictable, but also hydro or even nuclear, for which there is renewed interest today though it shows limited flexibility.

Scarcity and costs of conventional energies call for energy savings and search for new sources, especially renewable.

Acceptability of infrastructures

Power system infrastructures are less and less accepted, especially in the case of high voltage transmission, either from fear of the hypothetic health effect of EMF(electromagnetic fields), or because of the negative impact on real estate value. There is need to better use the existing corridors or to find acceptable techniques such as underground cables. At the same time, as a side effect of the climate change the earth is undergoing extreme weather conditions, which call for stronger, more massive infrastructures, hence more visible if not eyesores.

Efficient use of existing infrastructures

A significant proportion of the existing infrastructures are nearing the end of their useful life. Hence, condition assessment, maintenance, rehabilitation, and uprating are of growing concern for companies.

The enablers

New technologies are being developed in various fields. Insulating materials, ITC technologies, power electronics and high voltage current offer potential application opportunities in power systems and should help to find answers to the challenges of the future. But they will first have to be adequately studied and validated by CIGRE experts.

Prepare the power system of the future

This power system will have to wheel bulk power from remote generation sites – hydro, nuclear, large farms of renewable generation – to the load sites; it will have an interconnection function, which is necessary to compensate fluctuations of the generation from renewables, or their unavailability due to their geographical or temporal variability. The future power system will comprise a strong and extensive transmission and interconnection network and will call, when appropriate, for techniques such as ultra high voltage (UHV), direct current transmission, power electronics, and wide area supervisory and protection systems.

As a result of the search for all available sources of green electricity, the power system of the future will also be able to collect millions of small dispersed generation units. Tomorrow, wind turbines, photo voltaic devices, small cogeneration devices, plug-in hybrid electric vehicles (PHEV) will be connected to low or medium voltage network and these "local energy systems", or microgrids, made up of the generation units, the storage devices, the loads, and the demand side management all interacting intelligently, will have to interact as well with the high voltage system. Both concepts, the strong transmission and interconnection system and the local energy systems are the components of the power system of the future.

Make better use of the existing assets, using efficiently the equipment and exploiting the built-in capability of the power system

A number of subjects are involved as, for instance, on the component side: condition assessment of equipment, on-line monitoring, maintenance optimisation, extension of equipment life, and on the system side: development of advanced protection and control tools, and real time assessment of equipment capability.

Preserve the environment

In addition to being able to efficiently integrate renewable energy, power systems of the future must cater to environment concerns as regards equipment and systems: develop environment-friendly equipment, more acceptable infrastructures – underground cables or gas insulated lines – , more efficient use of space.

Facilitate access to knowledge

The objective must be not only to develop the appropriate technical response to the challenges of the industry, but also to achieve a good understanding of the challenges and issues of the Power Supply Industry, which will help overcoming some of its acceptability problems.

In 2010 the Study Committees have started to adjust their action plans according to these directions and, furthermore, a specific coordination structure was set up to monitor the progress of the activities, under the banner "Technical Committee Project", all of which evidence the determination of CIGRE to tackle the challenges of tomorrow's power system.

In any case, in 2010, even more than in 1921, CIGRE remains a social network, that of an international professional community combining extremely varied forms of expertise and very different spatial rationales. The CIGRE spirit identified by J. Tribot-Laspière in the inter-war period represents an advanced form of technical culture, whose operative words are neutrality, comparatism, technical progress and, in the end, the pacifism of power systems, which act as life-lines.

Generally, one must stress the importance of maintaining, disseminating and renewing a technical culture worthy of this name within the CIGRE community, particularly for its young members, but also for players outside of the electricity sector. At the risk of being reduced to a strictly technical role that minimises economic and societal or even cultural stakes, this technical culture of people involved in power systems must remain sufficiently general, or even universal, while including and stressing the vital importance of electricity in the global society. The industrial and now post-industrial civilization of power systems has been led by CIGRE on the international scale for almost a Century. It only acquires its full meaning, particularly to meet the challenges of the coming decade, when engineering sciences and economic sciences also meet and dialogue with the humanities and social sciences.

Figure 48 - Fernand Léger - Le transport des forces (transmission of forces), Palais de la Découverte, Paris, 1937

GENERAL CONCLUSION

CIGRE's coming to life stemmed from a world mobilization to face three major challenges: respond to the exponential growth in demand, provide electricity transmission over always longer distances, and develop the interconnection of systems. The process of innovation combining the consideration of these three challenges led to the use of higher and higher voltages and intensities. This escalation in voltages and size of systems created its own technical difficulties involving the planning, design, construction and operation of power systems. Therefore CIGRE had to work, especially from the 1950s, on the reliability and stability of power systems, which were becoming more and more interconnected, and whose vulnerability increased with the multiplication of exchanges.

CIGRE gradually asserted itself worldwide as a main technical forum for the stakeholders of the power systems. An essential key to its success, which has now lasted for almost 90 years, is that it has always managed to adapt to the extreme diversity of its members, both by their professional position and their geographic origin, and that it has made this diversity a source of individual and collective betterment.

Since 1921, CIGRE's priority role and "added value" has always been to facilitate mutual exchanges between all its components: network operators, manufacturers, universities and laboratories. It has continually led to the search for a good balance between the handling of daily problems encountered by its members in doing their jobs and the reflections on the future changes of power systems and their equipment. Its role in exchanging information, synthesising state of the art, and serving members and industry has been constantly met by CIGRE throughout events and through publications resulting from the work of its Study Committees.

Above all, CIGRE allowed dialogue between the various electric energy professions, starting with network operators and manufacturers, generally facilitating the improved mastery of the innovation-development processes which were particularly difficult to implement in electricity networks. For a network is an assembly of components, with power and intelligence functions, whose design and manufacture require extremely varied expertise. All these components are complementary and interact, so that introduction of a new element could affect the whole, potentially jeopardizing security of supply.

The organizations that have been set up pragmatically by electric energy professions have always taken into account the difficult balance between experience and innovation that is one of the marks of their activity. CIGRE's irreplaceable role consists in providing all power system professionals with a discussion forum, helping all of them to orient changes in their field according to the good general balance of resilience versus performance.

CIGRE was founded in 1921 with this aim and this vision, and throughout its long history, CIGRE has organised itself and its work in a spirit of cooperation between all the professions making up the electricity sector.

Being a CIGRE member really means belonging to a fundamentally cooperation oriented community, a community which has faith in human progress and betterment of life through good mastery of electrical technologies. These are based on the lever of development of power systems and on their many different benefits, which go largely beyond just the professional community of electrical engineers and are applied to all contemporary societies supplied with electricity.

Finally, in the long term, CIGRE has successfully taken up the manifold challenges, by combining the stakes and solutions:

- Keeping focussed on engineering professions, combining the best expertise in their various technical forms (from the largest electro-mechanical equipment to the finest information and communication technologies), but also thematic forms (technical-economic affairs, development, engineering, tests, and operation),

- Keeping a good balance between the resolution of operation problems and a reflection on the technical changes and the needs of the future,

- Setting up an efficient organization based on Study Committees composed of national representatives, who express wide-ranging viewpoints, each Committee working continually within its field under the coordination of the Technical Committee,

- Disseminating knowledge to the community of electrical engineers through conferences and publications.

Hence, the world of electricity has constantly supported CIGRE and many top management people were personally involved in defining its objectives and methods of operation, emphasising regularly the benefits accruing to the electric utility industry from CIGRE. From then on, a virtuous circle was created between the industry of large power systems and CIGRE, which explains the moral authority of an organization which, throughout its history has always been a key player in the field of large power systems.

In fact, CIGRE mirrors the complex growth interaction of the contemporary world, sustained by electrification and its technological, economic, social and cultural dynamics. The exemplary evolution of CIGRE is related to the fact that electrification is considered to be the most radical innovation in modern history.

CIGRE is proud to have played an important part in the international dynamics of power systems and is ready to tackle the challenges of the 21st Century.

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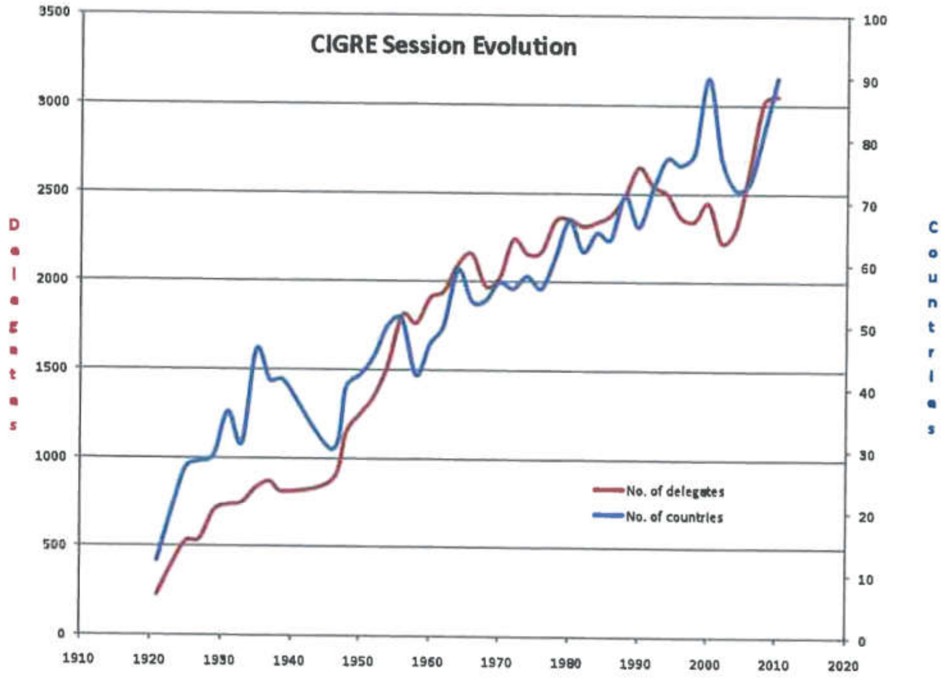
APPENDICES

APPENDIX 1: Participation in CIGRE Biennial Sessions from 1921 to 2010



APPENDIX 2: CIGRE Study Committees from 1927 to 2002

1 Insulating Oils and Insulating Materials **1927-1966**
2 High Voltage Cables **1927-1966**
3 Interruptors **1927-1966**
4 Protection and Relays **1947-1966**
5 Insulators **1929-1968**
6 Overhead Lines **1931-1966**
7 Towers and Foundations **1935-1968**
8 Overvoltages **1929-1967**
9 AC Very High Voltage **1945-1968**
10 Direct Current **1945-1966**
Ex 11 Interference **1947-1966**
11 Rotating Machines **1966-2002**
12 Transformers **1949-2002**
Ex13 System Stability **1947-1966**
13 Switching Equipment **1966-2002**
Ex 14 HF Remote Transmissions **1948-1966**
14 DC Links and AC Power Electronics Equipment **1966-2002**
Ex 15 Coordination of Insulation **1948-1966**
15 Materials for Electrotechnology **1966-2002**
16 Transformers and Substations **1963-1971**
17 Generators **1949-1966**
18 Condensers **1955-1968**
19 Sudden Variations in Voltage **1963-1968**
21 High Voltage Insulated Cables **1966-2002**
22 Overhead Lines **1966-2002**
23 Transformers **1966-2002**
31 System Planning **1966-1982**
32 System Stability **1966-1982**
33 Insulation Coordination in Systems **1966-2002**
34 Protection of Power Systems and Local Control **1966-2002**
35 Telecommunications and Remote Control of Power Distribution Systems **1966-2002**
36 Electromagnetic Compatibility of Power Distribution Systems **1966-2002**
37 Planning and Development of Systems **1982-2002**
38 Analysis and Technology of Systems **1982-2002**
39 System Operation and Control *1982-2002*
41 The Future of Transmission and of Power Distribution Systems **1976-1982**

APPENDIX 3: Fields of activities of the CIGRE Study Committees (since the 2002 reform)

A_1	**Rotating Electrical Machines** Economics, design, construction, test, performance and materials for turbine generators, hydrogenerators, high-power motors and non-conventional machines.
A_2	**Transformers** Design, construction, manufacture and operation for all types of power transformers, including industrial power transformers, DC converters and phase-shift transformers, and and for all types of reactors and transformer components (bushings, tap-changers, etc.)
A_3	**High voltage equipment** Theory, design, construction and operation of devices for switching, interrupting and limitation of currents, lightning arrestors, capacitors, insulators of busbars or switchgear, and instrument transformers.
B_1	**Insulated cables** Theory, design, applications, manufacture, installation, tests, operation, maintenance and diagnostic techniques for land and submarine AC and DC insulated cable systems.
B_2	**Overhead lines** Design, study of electrical and mechanical characteristics and performance, route selection, construction, operation, management of service life, refurbishment, uprating and upgrading of overhead lines and their component parts, including: conductors, earth wires, insulators, pylons, foundations and earthing systems.
B_3	**Substations** Design, construction, maintenance and ongoing management of substations and of electrical installations in power stations, excluding generators.
B_4	**HVDC and Power Electronics** Economics, application, planning, design, protection, control, construction and testing of HVDC links and associated equipment. Power Electronics for AC systems and Power Quality Improvement and Advanced Power Electronics.
B_5	**Protection and Automation** Principles, design, application and management of power system protection, substation control, automation, monitoring and recording, – including associated internal and external communications, substation metering systems and interfacing for remote control and monitoring.

C_1	**System Development and Economics** Economics and system analysis methods for the development of power systems: methods and tools for static and dynamic analysis, system change issues and study methods in various contexts, and asset management strategies.
C_2	**System Operation and Control** Technical and human resource aspects of operation: methods and tools for frequency, voltage and equipment control, operational planning and real-time security assessment, fault and restoration management, performance evaluation, control centre functionalities and operator training.
C_3	**System Environmental Performance** Identification and assessment of the environmental impacts of electric power systems and methods used for assessing and managing the environmental impact of system equipment.
C_4	**System Technical performance** Methods and tools for power system analysis in the following fields: power quality performance, electromagnetic compatibility, lightning characteristics and system interaction, insulation coordination, analytical assessment of system security.
C_5	**Electricity Markets and Regulation** Analysis of different approaches in the organization of the Electric Supply Industry: different market structures and products, related techniques and tools, regulations aspects.
C_6	**Distribution Systems and Dispersed Generation** Assessment of technical impact and requirements which new distribution features impose on the structure and operation of the system: widespread development of dispersed generation, application of energy storage devices, demand side management. Rural electrification.
D_1	**Materials and Emerging Test Techniques** Monitoring and evaluation of new and existing materials for electrotechnology, diagnostic techniques and related knowledge rules and emerging technologies with expected impact on the system in medium to long term.
D_2	**Information systems and Telecommunications** Principles, economics, design, engineering, performance, operation and maintenance of telecommunication and information networks and services for Electric Power Industry ; monitoring of related technologies.

APPENDIX 4: CIGRE Presidents, Technical Committee Chairmen, Treasurers and Secretary Generals

CIGRE Presidents since 1921

1921-1928 R. LEGOUEZ (France)

1928-1933 M. ULRICH (France)

1933-1948 E. MERCIER (France)

1948-1957 M. SCHMIDT (Switzerland)

1957-1966 G. SILVA (Italy)

1966-1972 A.R. COOPER (United Kingdom)

1972-1978 G. JANCKE (Sweden)

1978-1984 R. GUCK (Germany)

1984-1990 W.S. WHITE Jr. (United States)

1990-1996 J. LEPECKI (Brazil)

1996-2000 M. CHAMIA (Sweden)

2000-2004 D.CROFT (Australia)

2004-2008 Y.FILION (Canada)

2008- A. MERLIN (France)

Technical Committee Chairmen since 1949

1949 M. SCHMIDT President of CIGRE (Switzerland)

1950 J. TRIBOT-LASPIERE Vice-President of CIGRE (France)

1952 M. SCHMIDT President of CIGRE (Switzerland)

1958-1966 G. SILVA President of CIGRE (Italy)

1967-1972 O. S. JOHANSEN (Norway)

1973-1978 M. H. MEYER (Switzerland)

1978-1984 L. PARIS (Italy)

1984-1990 K-H. SCHNEIDER (Germany)

1990-1996 M. CHAMIA (Sweden)

1996-2002 A.MERLIN (France)

2002-2006 A. BOLZA (Italy)

2006- K. FRÖHLICH (Switzerland)

Treasurers since 1966

1966-1968 C. KNELLER (Germany)

1968-1974 P. SPORN (USA)

1974-1980 O. S. JOHANSEN (Norway)

1980-1984 W. P. WILLIAMS (UK)

1984-1990 L. ERHART (Switzerland)

1990-1996 J. BANKS (UK)

1996-2000 Y. SEKINE (Japan)

2000-2004 P.De PAUW (Belgium)

2004-2008 P.TYREE (Australia)

2008- P. ESMERALDO (Brazil)

Secretary Generals since 1921

1921-1963 J. TRIBOT-LASPIERE Delegate General

1963- 1970 F. CAHEN Delegate General

1970-1980 R. PELISSIER

1981-1991 G. LEROY

1991-1995 Y. PORCHERON

1995-1998 Y. THOMAS

1998-2000 M. HEROUARD

2001-2010 J. KOWAL

Since August 2010 F. MESLIER

APPENDIX 5: CIGRE Membership figures and corresponding countries from 1923 to 2008

	1923	1937	1946	1970	1976	1982	1998	2002	2005	2008
ALGERIA					10	11	2	40	40	40
ANDEAN National Committee										146
ARGENTINA		3	2	6	1	9	105	65	136	228
AUSTRALIA				11	21	15	281	343	341	415
AUSTRIA		12		29	29	25	136	129	141	144
BELGIUM	26	76	108	115	98	79	138	136	90	103
BOLIVIA									10	
BOSNIA							54	25	40	37
BRAZIL			1	16	28	77	366	626	760	891
BULGARIA		2		4	1	1		7	6	1
CANADA	1	4	2	42	52	55	153	258	264	343
CHILE					1		7	11	61	55
CHINA		1				13	44	73	74	319
COLOMBIA						1	11	15	18	
CROATIA							61	68	72	84
CYPRUS							5			56
CUBA				2						3
CZECHOSLOVAKIA / CZECH & SLOVAK REPUBLICS	6	60	21	21	11	12	89	87	95	112
DENMARK	3	3	5	41	46	59	119	79	72	83
ECUADOR							1	5		
EGYPT		3	3	5	10	12	265	306	306	300
ESTONIA		1						2	47	43
FINLAND		1	4	28	41	37	89	117	104	127
FRANCE	217	325	397	483	498	494	611	522	558	583
GABON							5		5	
GDR (EAST GERMANY)					1	13				
GERMANY		60		170	192	190	432	365	376	401
GHANA					2	2	2		2	
GREECE		3		6	13	14	152	186	142	104
GULF STATES National Ctee							205	185	204	214
HONG KONG							10			
HUNGARY	1	10		8	13	9	42	52	48	37
ICELAND							8	50	26	45
INDIA			1	2	8	18	214	194	226	268
INDONESIA					1	3	7	9	3	71
IRAN			1	2	6	6	41	47	68	86
IRELAND		3		15	13	23	92	105	83	94
ISRAEL						1	42	39	40	44
ITALY	18	34	18	105	106	105	182	170	169	201
IVORY COAST				2	5	12	45		5	5
JAPAN	4	8		29	38	60	268	292	313	407
JORDAN					1	2	40	39	37	52
KOREA						10	34	115	128	214
KUWAIT										
LATVIA		1					5	8	8	
LIBYA						3	50	51	52	
LITHUANIA								2	7	7
LUXEMBURG		2	1	3	4	2	6	1	1	
	1923	1937	1946	1970	1976	1982	1998	2002	2005	2008

MACEDONIA							40	43	40	44
MALAYSIA				4	4	3	82	84	63	83
MOROCCO				10	7	3		5	5	
NETHERLANDS	9	9	13	67	82	71	124	109	134	125
NEW ZEALAND				1	2	33	26	49	152	
MONTENEGRO										
NIGER						1	5			40
NIGERIA				4	9	5	1	2	4	1
NORWAY	2	4	1	55	79	114	178	181	168	165
International Organizations			21	17	19	10				
PAKISTAN				6	5	24	6	1	1	
PARAGUAY						1	55	45		85
PERU								1	7	
POLAND	2	19	14	6	7	5	156	122	124	139
PORTUGAL		1	6	35	16	20	68	79	82	102
ROMANIA		11	2	5	3	2	69	127	156	131
RUSSIA (U.S.S.R.)	7	19	4	9	13	11	368	369	364	364
SERBIA-MONTENEGRO								51	46	40
SINGAPORE						1	2	5	2	
SLOVENIA							62	74	83	94
SOUTH AFRICA	1	2		5	11	19	115	90	83	51
SPAIN	8	5	1	69	79	89	210	265	303	376
SWEDEN	3	6	17	68	83	120	267	267	262	284
SWITZERLAND	11	58	28	160	137	122	227	256	253	318
TAIWAN							8	8	9	11
THAILAND				2	4	3	34	28	26	30
TUNISIA			3		5	4	1	1	1	5
TURKEY	2		1	3	4		1	2	10	9
UKRAINE							17	20	55	63
UNITED ARAB EMIRATES							205	185	204	214
UNITED KINGDOM	13	88	117	197	171	162	253	238	365	616
UNITED STATES	11	22	17	79	107	100	614	403	355	519
URUGUAY		1			2	1	8	7	6	13
VENEZUELA				4	15	12	53	52	35	52
VIETNAM								31	9	
YUGOSLAVIA		6		46	46	36	70			
OVERALL TOTAL	**345**	**838**	**810**	**1990**	**2170**	**2314**	**7667**	**7957**	**8446**	**10494**

APPENDIX 6: Study Committee Chairmen since 1927

Study Committees 1, 15 & D1

- DRENONOWSKI (Germany) 1927-1934
- SCHERING (Germany) 1934-1946
- WEISS H. (France) 1946-1966
- LEARDINI T. (Italy) 1966-1974
- FALLOU B. (France) 1974-1980
- PARKMAN N. (United Kingdom) 1980-1986
- PRAEHAUSER T. (Switzerland) 1986-1992
- REED C. (USA) 1992-1998
- SMIT J. (Netherlands) 1998-2004
- GOCKENBACH E. 2004- 2010

Study Committees 2, 21 & B1

- BELLAAR SPRUYT M. (Netherlands) 1927-1929
- BAKKER G.J.T (Netherlands) 1930-1955
- LABORDE M. (France) 1955-1957
- Van STAVEREN (Netherlands) 1957-1962
- GOOSSENS (Netherlands) 1962-1970
- BROOKES (USA) 1970-1974
- GAZZANA PRIAROGGIA P. (Italy) 1980-1986
- PESCHKE E.F. (Germany) 1986-1992
- BJORLOW-LARSEN K. (Norway) 1992-1998
- BOLZA A.(Italy) 1998-2002
- SCHROTH R. (Germany) 2002-2006
- RÜTER F. (Sweden) 2006-2010

Study Committees 3, 13 & A3
- PERROCHET (Switzerland) 1927-1934
- JUILLARD (Switzerland) 1934-1950
- SCHILLER (Switzerland) 1950-1963
- MEYER H. (Switzerland) 1963-1971
- CATENACCI G. (Italy) 1971-1978
- SLAMECKA E. (Germany) 1978-1984
- RUOSS E. (Switzerland) 1984-1990
- SCHRAMM H.H. (Germany) 1990-1996
- BRUNKE J. (USA) 1996-2002
- FRÖHLICH K. (Switzerland) 2002-2006
- WALDRON M. (United Kingdom) 2006-2010

Study Committees 4, 34 & B5
- MARGOULIES S. (Belgium) 1947-1955
- HUSKIN (Belgium) 1955-1960
- DIETSCH (France) 1960-1966
- BRATEN J.L. (Norway) 1966-1974
- DIENNE G. (Belgium) 1974-1980
- HOROWITZ S. (USA) 1980-1986
- CHAMIA M. (Sweden) 1986-1990
- CHEETHAM W.J.(United Kingdom) 1990-1996
- ZIEGLER G. (Germany) 1996-2002
- De MESMAEKER I. (Switzerland) 2002-2008
- AMANTEGUI J. (Spain) 2008

Study Committee 5
- Van CAUWENBERGLE (Belgium) 1929-1938
- ALLIBONE T.E. (United Kingdom) 1938-1947
- GILLAN (United Kingdom) 1947-1968

Study Committee 7
- LAVANCHY (Belgium) 1935-1946
- JOBIN (Switzerland) 1947-1955
- PASCHOUD (Switzerland) 1955-1968

Study Committees 6, 22 & B2

- LIST (Czechoslovakia) 1931-1939
- JACOBSEN (Norway) 1939-1946
- SILVA (Italy) 1946-1957
- BETTERHOLIM (Sweden) 1957-1962
- SMEDSFELT (Sweden) 1962-1968
- A.B. WOOD (United Kingdom) 1968-1976
- BOURGSDORF V.V. (USSR) 1976-1982
- PORCHERON Y. (France) 1982-1988
- SCHJETNE K. (Norway) 1988-1994
- MEYERE P. (Canada) 1994-2000
- STEPHEN R. (Australia) 2000-2004
- DALLE B. (France) 2004-2010

Study Committee 8

- de VINUESA M. (Spain) 1929-1939
- WEDMORE E.B. (United Kingdom) 1939-1946
- BERGER K. (Switzerland) 1947-1958
- BAATZ H. (Germany) 1958-1967

Study Committee 9

- SPORN P. (USA) 1945-1968

Study Committees 10, 14 & B4

- BORGQUIST N. (Sweden) 1945-1954
- RATHSMAN B. (Sweden) 1954-1956
- LANE M. (Sweden) 1956-1965
- SMEDSFELT S. (Sweden) 1966-1976
- BATEMAN L.A. (Canada) 1976-1982
- CALVERLEY T.E. (UK) 1982-1988
- HINGORANI N.G. (USA) 1988-1996
- POVH D. (Germany) 1996-2002
- SZECHTMAN M. (Brazil) 2002-2008
- ANDERSEN B. (UK) 2008-

Study Committees 11 & 36

- MARSHALL M.(UK) 1947-1954
- GOSLAND L. (UK) 1954-1967
- PAIMBOEUF M. (France) 1967-1976
- PESONEN A.J. (Finland) 1976-1984
- SFORZINI M. (Italy) 1984-1990
- MARUVADA P.S. (Canada) 1990-1998
- ROBERT A. (Belgium) 1998-2002

Study Committees 12 & A2

- NORRIS (UK) 1949-1968
- LUTZ (Switzerland) 1968-1974
- SOLLERGREN G. (Sweden) 1974-1980
- DIETRICH W. (Germany) 1980-1986
- ALLAN D.J. (UK) 1986-1994
- BAEHR R. (Germany) 1994-2000
- GUUINIC P. (France) 2000-2004
- BOSS P. (France) 2004-2010

Study Committees 13 & 32

- CRARY S.B. (USA) 1947-1960
- CONCORDIA C. (USA) 1960-1970
- MAGNIEN M. (France) 1970-1974
- VALTORTA M. (Italy) 1974-1976
- GLAVITSCH H. (Switzerland) 1976-1982

Study Committees 14, 35 & D2

- POMA (Belgium) 1948-1957
- RICHARD (Belgium) 1957-1966
- PODSZECK (Germany) 1966-1968
- BORREMANS (Belgium) 1968-1974
- CARROTHERS M.J. (Ireland) 1974-1980
- JORANSSON T. (Sweden) 1980-1986
- KOSKINEN R.K. (Finland) 1986-1992
- VINCENT G. (Australia) 1992-2000
- GONZALO F. (Spain) 2000-2006
- de MONTRAVEL G. (France) 2006-2010

Study Committees 15 & 33
- HERLITZ (Sweden) 1948-1958
- BAATZ (Germany) 1958-1966
- PALVA V. (Finland) 1966-1976
- K.H. SCHNEIDER (Germany) 1976-1984
- CARRARA G. (Italy) 1984-1990
- ERIKSSON A.J. (Switzerland) 1990-1996
- THIONE L. (Italy) 1996-2002

Study Committees 16, 23 & B3
- STAUCH B. (Germany) 1963-1972
- MULLER H.G. (Germany) 1972-1976
- DAVENPORT F. (UK) 1976-1984
- YKEMA T. (Netherlands) 1984-1990
- DUBANTON C. (France) 1990-1996
- PETTERSSON K. (Switzerland) 1996-2002
- WIERSMA A. (Netherlands) 2002-2008
- BESOLD F. (Switzerland) 2008-

Study Committees 17, 11 & A1
- BELFILS M. (France) 1949-1958
- GLEBOV M. (USSR) 1958-1968
- RUELLE G. (France) 1976-1984
- DACIER J. (Belgium) 1984-1990
- HODGE J.M. (UK) 1990-1994
- HEROUARD M. (France) 1994-1998
- WALLIS D. (UK) 1998-2004
- COETZEE G.J. (South Africa)2004-2008
- FERREIRA FIGUEIREDO E. (Brazil) 2008-

Study Committee 18
- ROSER H. (Germany) 1955-1960
- LEHMHAUS F. (Germany) 1960-1963
- ELSNER M.H. (Switzerland) 1963-1968

Study Committee 19
- D'ARBELLA (Italy) 1960-1963
- BALERIAUX M.(Belgium) 1963-1968

Study Committee 31
- BARNES H.C. (USA) 1968-1976
- VALTORTA M. (Italy) 1976-1982

Study Committee 37 & C1
- NAGEL T. (US) 1982-1984
- CLADE J. (France) 1984-1990
- MANZONI G. (Italy) 1990-1996
- MESLIER F. (France) 1996-2000
- RAY C. (UK) 2000-2008
- SOUTHWELL P. (Australia) 2008-

Study Committee 38 & C4
- ELLIS E. (UK) 1982-1986
- GENS R.S. (USA) 1986-1992
- FALCK CHRISTENSEN J. (Denmark) 1992-1998
- VIEIRA FILHO X. (Brazil) 1998-2002
- KUNDUR P. (Canada) 2002-2006
- NUCCI C.A. (Italy) 2006-

Study Committee 39 & C2
- SVOEN J. (Norway) 1982-1988
- MERLIN A. (France) 1988-1994
- WAHA J.P. (Belgium) 1994-2000
- LARSSON S. (Sweden) 2000-2006
- ARMSTRONG M. (Canada) 2006-2010

Study Committee 41
- BARTHOLD L.O. (USA) 1976-1982

Study Committee C3
- NASCIMENTO BAPTISTA J. (Portugal) 2002-2006
- NEGRI A. (Italy) 2006-

Study Committee C5
- LAUGHLIN K.W. (USA) 2002-2008
- FOSSO O. (Norway) 2008-

Study Committee C6

- INVERNIZZI A. (Italy) 2002-2008
- HATZIARGYRIOU N. (Greece) 2008-

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