HISTORY OF ELECTRIC ENERGY SYSTEMS AND NEW EVOLUTION

Yanoush B. Danilevich
Division for Basic Researches in Electrical Power Engineering, Department of Physical and Technical Problems of Energetics, Russian Academy of Sciences, Russia

B. E. Kirichenko
Division for Basic Researches in Electric Power Engineering, Russian Academy of Sciences (RAS), St.-Petersburg, Russia

N. N. Tikhodeev
High Voltage Technology Department, HVDC Power Transmission Research Institute, St. Petersburg, Russia

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Summary

During the XX century modern power systems with all necessary equipment have been created and the problems of power transmission were solved.

Further trends in power transmission development are connected with the necessity to have lower annual peak load to ensure highly reliable electric power supply. It is also necessary to bring the costs of energy to as low as possible. According to the prevailing global trends the latter can be achieved by introducing energy conservation systems, to create easily maneuverable power systems through wide application of uncontrolled and thyristor-controlled series compensation and double-fed power sets. Under certain

conditions high voltage direct current facilities, whether power transmission lines or back-to-backs, are a more economical interconnection alternative, particularly when asynchronous operation is desirable, permitting an independent management of operating conditions in each system while assuring the capability to control the transfer capacity of the tie line. Interconnection of power systems involves considerable investment in additional tie lines, improvement of existing transmission lines, emergency control and protection systems etc.

Pooling of large electric power stations into a power system and uniting of power systems into a national or international interconnected power grid is prompted, primarily, by economic advantages to be enjoyed by all or next to all electric energy users involved, making it possible to lower the total annual peak load and warranting a much higher reliability of electric power supply. Tie lines used to interconnect power systems for synchronous parallel operation are generally extra-high or ultra-high voltage alternating current transmission lines of sufficient power transfer capability. Under certain conditions high voltage direct current facilities, whether power transmission lines or back-to-backs, are a more economical interconnection alternative, particularly when asynchronous operation is desirable, permitting an independent management of operating conditions in each system while assuring the capability to control the transfer capacity of the tie line. Interconnection of power systems involves considerable investment in additional tie lines, improvement of existing transmission lines, emergency control and protection systems etc.

1. Introduction: Electrical Energy

When we push buttons and switch on electric lights in our apartments, we seldom think of what electricity is. The electrical energy now is everywhere but only approximately 100 years ago the first electrical transmission took place. It happened during Frankfurt am Main International Electrotechnical Exposition in 1891. It was the a scale transmission of power from hydro-electric plant of Lauffen am Neckar over a distance of 175 km to the Exposition at Frankfurt. The transmission was the first three-phase line. The electrical energy was supplied from a synchronous generator rated 210 kW, 95 V, 40 Hz, speed of rotation 150 rpm.

It was only the beginnings of the Synchronous Machine but before this event many other developments took place. They were due to contributions by such prominent persons as Nicola Tesla, Galileo Ferraris, Charles Bradley, and Fridrich Haselwander and they all were based on Michael Faraday's experiments due to which the electromagnetic induction phenomena were discovered. According to Faraday's views confirmed by experimental results, the space is not empty but there was an intricate field which by its inter-connections transmitted the prime mover mechanical energy into electric energy which can be further transmitted via transmission lines to the electrical energy customers.

100 years ago the first electric power station with rating of hundreds of kilowatt was used for lighting purposes then for electric power supply for central parts of the cities, industrial plants and these were created by electrification company leaders such as AEG in Germany, GE in USA etc. During the first decade of the XX century the capacity of

the largest electric power station reached values of 10 MW, during the 1930s – already 200-300 MW, and during the 1960s – 1 GW. The increase in the capacity was stimulated by economical considerations – the larger rated stations were characterized by larger efficiency, and less costs of installation. Around the middle of the 20th century it became evident that electrical energy is the most comfortable kind of energy very easily transformed into every other kind.

Nowadays approximately 60% of primary energy is transferred into electric energy and then used in diverse applications. The electric energy production is concentrated in power stations both of large and medium ratings, mostly on thermal (about 70% of summary power), hydraulic (about 20%), and nuclear (about 10%) systems.

The "heart" of every power station is the synchronous generator (see *Electrical power generation*).

At the beginning all electrical power stations were operated separately, supplying electrical energy only to their own customers. But very soon the engineers realized that the integration individual power stations into a electric power system gives many advantages, technical (increase power supply reliability)and economical (decrease costs of energy), and integration of systems became very rapid. It was based on the progress in electric power transmission technology and parallel operation of several power stations. For successful power system transmission it was very important to increase the transmission voltage in gradual steps to a high value which now is at 750 kV and more. This made transcontinental power systems and long transmission lines possible.

So, now electrical energy is produced by converting the mechanical energy of the prime mover into electricity and integrating separate sources of energy into power stations and systems to distribute the electrical energy among the customers and to use it in many applications.

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Biographical Sketches

Yanush B. Danilevich, is full member (academician) of the Russian Academy of Sciences (1997), dr. sc. (eng.) (1974), professor (1976), full member of Academy of electrotechnical sciences (1993), the full member of the International Power Academy (1995), President of Association of Engineers - Electricians, a member of the Bureau of Branch of Physicotechnical Problems of Power of the Russian Academy of Science and so forth, and author of more than 400 publications.
Academician Danilevich was born on December, 06, 1931 in city of Vilnius. In 1955 he graduated with distinction from the Leningrad Polytechnical Institute, during 1955-61 he was laboratory chief of Institute of Electromechanics Academy of Sciences, in 1961 he received his PhD (eng.) degree. During 1961-92 he worked in Russian Research Institute for Electric Machinery as the head of a department, the main designer. Since 1992 he is the director of the Division (Institute) for Basic Researches in Electric Power Engineering of Russian Academy of Sciences (OEEP RAS). It is awarded with an award of the Labor Red Banner (1981), and an award of Friendship (1999).

Boris E. Kirichenko was born in St.-Petersburg in 1950. He graduated from State Marine Academy, St.-Petersburg in 1972. He joined RAS in 1995. Now he serves as scientific secretary of the Division for Basic Researches in Electric Power Engineering and is the laboratory chief "Unconventional Energy Sources and Ecology" in the same division.

Nikolay N. Tikhodeev, was born in Russia in 1927, received the Electrical Engineer, the Candidate of Technical Sciences and the Doctor of Technical Sciences degrees in 1952, 1955, and 1966, respectively, from the Leningrad Polytechnic Institute; at present he lectures there as Professor. In 1979 he was elected a Corresponding Member of the USSR (now Russian) Academy of Sciences where he became an Academician (Full Member) in 1992. Within CIGRE he is a member of SC33 "Overvoltages and Insulation Coordination" and now a Distinguished CIGRE Member. He became an IEEE Senior Member in 1990. In 1980 he was awarded the National Prize for his contribution to development of 750 kV AC power transmission lines and in 1997, the Russian Academy of Sciences Yablochkov Prize for a series of papers published in 1991-1997. Since 1955 Prof. Tikhodeev has been with High Voltage Technology Department of HVDC Power Transmission Research Institute in St. Petersburg. He directed the Department from 1958 to 1996; since 1997 he is Scientific Director of the Department. He does research in many fields of high voltage engineering, including theory of bundle conductors with large numbers of subconductors; large-scale studies of air gaps and line insulation in the megavolt range of voltages and overvoltages; development of statistical methods of calculation and coordination of insulation; experimental and theoretical studies of various facilities for reducing environmental effects of overhead lines, etc., but the area of his major interest is EHV and UHV AC and DC power transmission. Prof. Tikhodeev was directly involved in research efforts relating to development and implementation of 525, 750 and 1200 kV AC power transmission lines, as well as to planning of 1500 kV DC transmission in the USSR. He authored eight books and some 240 technical papers.