The First Electric Power Historical Museum Project in Japan

To commemorate the 50th anniversary of TEPCO's founding, the construction of the "Electric Power Historical Museum" has been decided. This museum is to open in autumn of 2001.

1 Objective and exhibition concepts

The exhibition concept of the museum is to keep what we call the "spirit of electricity production" alive. In other words, we wish to hand down to future generations the history of Japan's electricity production system, including information regarding the maintenance and operation of the system, as well as an accounting of the hardships that the pioneers of the Japanese electricity industry experienced in the Meiji era.

- We hope to show the significant role that electricity has played in the modernization of Japan, together with the history of TEPCO's corporate activities and its previous achievements. We plan to achieve this through showing the history of technological progress and the development of power resources as well as developments in the fields of electric power-related equipment and household electric appliances.
- In addition, we believe that it is necessary to show how important "the creation process" is in the electricity business by exhibiting equipment and appliances which were used in the past.
- One of our corporate features is "to be forever faithful to our customers and society", a commitment which has been fostered ever since the beginning of the history of electric power. In order to demonstrate our efforts to ensure a stable supply of electricity and to prove that we have put into practice the motto "electricity is the product of human effort", maintenance tools used in the past will be exhibited at the museum. One interesting example is "*kanjiki*", a type of snowshoe made of straws, which was used by linemen for walking in the snow when they checked the integrity of transmission lines.

In addition, we would like to present items that are suitable for depicting the history and significance of the construction of an electricity network and the importance of the system that integrates the generation, transmission and distribution of electricity in each region in Japan.

Moreover, because the museum will be located next to the TEPCO Research & Development Center, it will be designed to become "a center where visitors will find the answers to any question related to electricity". Therefore, there will be items on display to help deepen visitors' understanding of the basic theory of electricity, including the role of reactive power in the A.C. transmission and the process of the electron's movement in a conductor.

2 Exhibition Story

Introduction-First encounters with electricity -From Edo Era to Early Meiji Era (1700-1880)-

Japan first came into contact with European culture in the mid 16th century when Western science and technology were introduced. However, during the closing of the country (*sakoku*) in the Edo period, importation of things foreign was limited to the port of Nagasaki.

In the 1720s, Shogun Yoshimune the Eighth liberalised the importation of foreign books which began the accelerated learning of Western science mainly through the Dutch language. During this time, some ideas of electromagnetism were introduced around 1765, some 20 years after Benjamin Franklin conducted his famous experiment on electrostatic electricity. In this case, electricity was mainly used for the raputical treatment or entertainment using an electrostatic generator.

As soon as the government policy of *sakoku* was abolished near the end of the Edo period, Japan began to actively absorb knowledge from England, France, Germany and Russia. At that time, the voltaic battery was introduced from Germany.

Under the active policy of the Meiji government to promote industry, Kobu-ryo (later to become Kobu University) was started to educate young technicians. Later, these young people played an important role in promoting the electric industry in Japan including the starting of the electric power industry and the founding of the Institute of Electrical Engineers.

[The artifacts to exhibit]

- Dr. Ayrton's desk
- "*Erekiteru*"a power generator developed by Gennai Hiraga (replica)
- Early stage telegraph (replica)
- Du Posque's arc lamp (replica)

Group 1 Creation of an electrical power network with thermal power generation -Middle of the Meiji Era (1880-1910)-

[Technological developments]

With the invention of combustion engines and power generators, a new energy industry was born. Our daily life started to change with the introduction of a new form of lighting – the invention of the electric light bulb.

[Progress of individual technology]

- Electric lighting became practical with the inventions of the electric cell (for providing continuous electrical generation) and arc light.
- In 1879, Thomas Edison invented the incandescent light bulb which provided lighting for ordinary households. In 1882, Edison started commercial operation of the Pearl Street Power Plant in New York city in a central power station system.
- As early as 1882 when the Pearl Street Power Plant commenced operations, a group of leading private investors in Japan decided to set up the Tokyo Lighting Company. The group demonstrated electrical lighting with arc lamps in Ginza. The company was formed in the following year, 1883.
- After its founding, Tokyo Lighting Company provided arc lamps or candescent lamps in theatres, government buildings and railway stations. It started to supply electrical power using overhead power distribution lines and the 25kW Edison type No. 10 dynamos at the No. 2 Lighting Office in Minamikayaba-cho in Nihonbashi-ku in 1887 (Meiji 20). This was the beginning of the modern power supply.
- With the introduction of AC power generation, the advancement in power distribution technology and the increase in demand for electric light bulbs, the electric industry continued to develop. Lighting offices distributed throughout the city began to be replaced with central thermal power plants.

[The artifacts to exhibit]

- Early stage spool insulator for 3kV line and 3kV pin type insulator
- 15kVA, A-type transformer (made by GE, 1900)
- D.C. dynamo (made by Kobu University)
- Edison dynamo
- Brush D.C. dynamo
- Three-phase asynchronous generator (made by Ishikawajima Shipbuilding)
- Parsons turbine and generator
- Steam engine (4 cylinders)/ D.C. generator (made by Williams & Robinson)
- Steam engine (2 cylinders)/ generator (made by Westinghouse)

Group 2
Beginning of hydroelectric power generation and long-haul power transmission
-From the end of the Meiji Era to the beginning of the Taisho Era (1910-1925)-

[Technological developments]

As technical development continued on hydroelectric power generation, various types of hydroelectric power plants were constructed to promote the development of hydroelectric resources. Alternating-current high voltage technology was also developed to enable power transmission with little power loss from remote power plants. Meanwhile, the capacity of hydroelectric power plants continued to grow. The result is that Japan began to shift from thermal power generation to hydroelectric power generation which became the basis of electrification of Japan.

[Progress of individual technology]

- It is said that the history of hydroelectric power generation in Japan began at the Miyagi Boseki Miisawa Power Plant in 1888 (Meiji 21) in Miyagi Prefecture.
- Although the capacity of hydroelectric power generation was limited to only private use or transmitted to regions surrounding the plant, high-voltage long-haul transmission technology and further development of hydroelectric power generation was promoted. Increased demand for power by industries after the Russia-Japanese War and further development of electrical transmission technology backed up this promotion.
- The Komahashi Power Plant which started in 1907 (Meiji 40) transmitted 55kV of power from Katsuragawa in Yamanashi Prefecture to the Waseda Transformer Station in Tokyo, a distance of over 75 km. This was the beginning of large-scale hydroelectric power generation.
- In 1914 (Taisho 3), the Inawashiro No. 1 Power Plant transmitted power over 225 km to Tokyo. This was the first time for long-haul large capacity power transmission of 115kV from a remote hydroelectric power plant far away from a large city. (The Nikko No. 1 Power Plant was constructed at this time.)
- Together with the formation of a power transmission system with emphasis on hydroelectric power generation, a number of electrical enterprises were started bringing cut-throat competition to the electric industry.
- The Shinanogawa Power Plant, having the largest power generation capacity at that time in Asia, was a pre-war landmark of Japan as the “Kingdom of Hydraulic Power”.

[The artifacts to exhibit]

・3691kW, horizontal shaft, two runner, Francis turbine of Komahashi hydro power station (made by Escher Wyss, 1907)
・753kW, horizontal shaft, Francis turbine and generator of Nikko Daiichi hydro power station (made by Hitachi, 1917)
・ 39MW, vertical shaft, Francis turbine and generator of Shinanogawa hydro power station (made by Voith, 1939)
・ 50kW, hydro generation facilities of Kanaya Hotel (Francis turbine / 3 phase AC synchronous generator / switch board / power board etc.) (made by Siemens, 1908)
・ Speed governor handle for hydro power generator
・ 3.6kV, porcelain-clad, testing transformer of Inawashiro Daiichi hydro power station (made by Westinghouse, 1912)
・ Hard-dawn copper stranded conductors and twist joint and disk type suspension insulator for 110kV Inawasiro trunk line
・ Parts of steel tower for 110kV Inawasiro trunk line

Group 3
Formation of a wide-area power transmission network
-Early Showa Era (1925-1945)-

[Technological developments]

Due to the vigorous competition among smaller electrical companies, development of AC power transmission technology grew spurring on the development of power transmission networks transforming Japan into an "electrified" country.

[Progress of individual technology]

- Starting with the Komahashi Power Plant, transmission voltage gradually increased from 66kV (Shimotaki Power Plant), to 77kV (Shishidome Power Plant), 115kv (Inawashiro Power No. 1 Power Plant) and finally to 154kV, the mainstay of the power transmission system.
- The electric industry faced vigorous competition from the end of Taisho to the beginning of Showa when many power transmission networks were formed.
- Together with the expansion of electric power networks and their increase in complexity, electrical power generating systems became more sophisticated. First, there were individual power generating systems followed by connecting-line networks with power generation system separation points. Eventually, low-voltage inner ring linkage systems were developed. Also at this time, linkages between different power generation systems were started as evidenced by the hook-up between Tokyo Lighting Company (eastern Japan) and Daido Electric Company Ltd. (western Japan).

- Through the period of intensified competition where regulations were left to the companies, the electric industry began to edge toward national regulation. Regulations were put forward to unify electrical frequencies and distribution voltages and various electric power networks were either encouraged to unify or be abolished.

[The artifacts to exhibit]

- 22kV, cubicle with oil-filled circuit breaker (made by Metropolitan Vickers, 1924)
- Steel tower and pin type insulator for 44kV Tonosawa line (1908)
- "*Banzai*" steel tower for 60kV Kinugawa line (1910)

Group 4
Shift to large-capacity, higher efficiency power generation plants
-Post-war high economic growth period (1945-1970)-

[Technological developments]

Electrical technologies that had stagnated during World War II grew rapidly thereafter taking advantage of the introduction of overseas technologies. Construction of state-of-the-art thermal power generation plants shifted to large-capacity, highly efficient power generation. Large-scale hydroelectric power dams began to be constructed. These larger and more efficient power plants allowed for the rapidly growing demand for electricity.

[Progress of individual technology]

- With the reorganisation of the electric industry in 1951 (Showa 26), electrical power networks were changed to systems of consistent transmission and distribution according to region. In order to cope with the rapid increase in demand for electricity, large-scale power generation plants were constructed one after another. At the same time, the 275kV system was introduced, thus forming the ultra-high voltage outer link system.
- Large-scale thermal power generation plants of some hundreds of thousands of kilowatt power were constructed. For hydroelectric power generation, rivers were "redeveloped" and pumped storage power generation was developed while the capacity of hydroelectric power was increased.

[The artifacts to exhibit]

Group 4

- 1st unit plant facilities of Chiba thermal power station
  Turbine blades of HP, MP, and LP
  Generator rotors
  Generator hydrogen-cooled stator coils

Control panels of central operation room

- LP final stage blades
  600MW Kashima unit
  1000MW Sodegawura unit
- Turbine blades materials
- Pitot tube applied flow rate measuring instruments
- Electric power driven speed governor
- Magnet valve type speed governor
- Amplidyne type automatic voltage regulator
- Belt driven speed governor

Group 5a
Diversification of power sources and promotion of optimal mix of power generation
-Post-war steady-growth period (1970-2000)-

[Technological developments]
Various types of power generation sources were mixed to realise a secure supply of electrical power and to promote economic efficiency.

For thermal power generation plants, a new system using gas turbines was introduced. The use of nuclear power generation also increased. Pumped storage power stations gained significant importance to enable effective operation of power generating facilities among total given networks.

To effectively form a power generation network, ultra high voltage (UHV) transmission was introduced. The formation of a 500kV-mainstay or the development of UHV transmission technology were promoted.

At the same time, information transmission technology was actively introduced to facilitate a higher level of system operations that can flexibly accommodate changes in demands.

[Progress of individual technology]

- As Japan shifted from a high-growth period to a steady-growth period and as our daily lives and industries became more sophisticated, electric technologies had to tackle new technological challenges.
- In the filed of electrical power generation, power sources were diversified. Starting with the promotion of nuclear power generation technology and its eventual acceptance, the diversification

of thermal power generation fuels, the development of combined cycle power generation, large-capacity and large-height pumped storage power generation technologies were introduced one after another.

- In the field of electrical power transmission technology, transmission of 500kV was started followed by the development of UHV transmission technology. Expansion and duplication of 500kV outer link systems and development of compact units were also promoted.

[The artifacts to exhibit]

- Gas turbine combustor of Futtsu combined cycle thermal power station
- Burners for thermal power plants (coal / heavy oil / LNG)
- Test runner of Kazunogawa hydro power station
- Power transmission electrical wires and power transmission insulators and cables used from prewar days to postwar days
- Porcelain-clad circuit breaker
- SF_6 gas circuit breaker
- 66kV gas insulated switchgear
- Distributing transformer
- ASEA mercury-arc rectifier of Sakuma frequency conversion station
- Gate-turn-off thyristor for field test of Shin-shinano substation
- Early stage control panel of extra high voltage substation
- Multi-articulated shield driving machine (model)
- Pipe materials
- Insulation materials sample
- Fault section detection system

Group 5-b
Improvement of reliability (development of nuclear power generation)

[Technological developments]

Nuclear power generation technology was introduced to Japan from overseas. It has attained the highest level of safety and economic efficiency in the world after tackling the early problems and promoting and standardising the program of light water reactors (LWR). Japan also leads the world in its own nuclear power generation technologies such as ABWR and the improvement of anti-seismic design.

[Progress of individual technology]

- The improvement of nuclear power generation technology in Japan is shown in detail in terms of its reliability and economic efficiency.

- Development of nuclear power generation technology centred mainly on boiling water reactors (BWR).
- Exhibitions shall be held on the scientific knowledge required to understand nuclear power generation.

[The artifacts to exhibit]
- Chicago pile graphite moderator
- Remote control robot
- Actuator

Group 6
Toward the tomorrow of electric technology

With its limited energy resources and land, Japan has realised an optimal mix of power generation sources consisting of hydroelectric dams, fossil fuels and nuclear energy and an effective system configuration for transmitting electrical power in the 20th century.

The electric power industry in the 21st century will seek better mix of energy sources including new energy sources such as IPP or PPS while configuring a system that is considerate of resources, environmental and location problems. Thus, a higher level of electric power technologies will be required.

Electric power technology will continue to develop toward tomorrow.

Organisation of themes

Comparison of centralised power sources and distributed power sources
History and present status of development of small-scale distributed power sources and new energy sources
Development history of electrical storage technology and the latest technology
Utilisation of electric power technology and electrical power networks (utilisation of information communications technology and overseas deployment of electric power business)

3　Other museum Project in Engineering Field in Japan

Yokogawa Electric corporation is planning the first Measurement Technology Museum in Japan . Its concept is as follows.

Electric measuring apparatuses have been developing along with popularization of telegraph networks and arrangement of power sources while influencing each other. Among others, practical measuring instruments have greatly changed their characters from scientific tools at their first stage to innovative instruments appropriate for the industrial society and the electronics age.
Yokogawa Electric Corp. is proceeding with a "Measurement Technology Museum" project where visitors can track the history of measuring instruments from its dawn to today, and modality and development of technologies that have supported the entire period.
Up to now, we have gathered about 5000 actual materials including measuring instruments from U.S. and Europe and we are proceeding with preparation for exhibition by carefully repairing these and researching their backgrounds.
To contribute to the society, this museum shall feature,

1. Not to be limited to preservation and exhibition of technologies and products for each period,
2. Roles in, and impacts to the society of measuring instruments will be exhibited on a case study basis,
3. Exhibition related to daybreak of technology that allows present engineers to be inspired from superior ideas of pioneers, and
4. Learning corner for experiencing scientific technologies