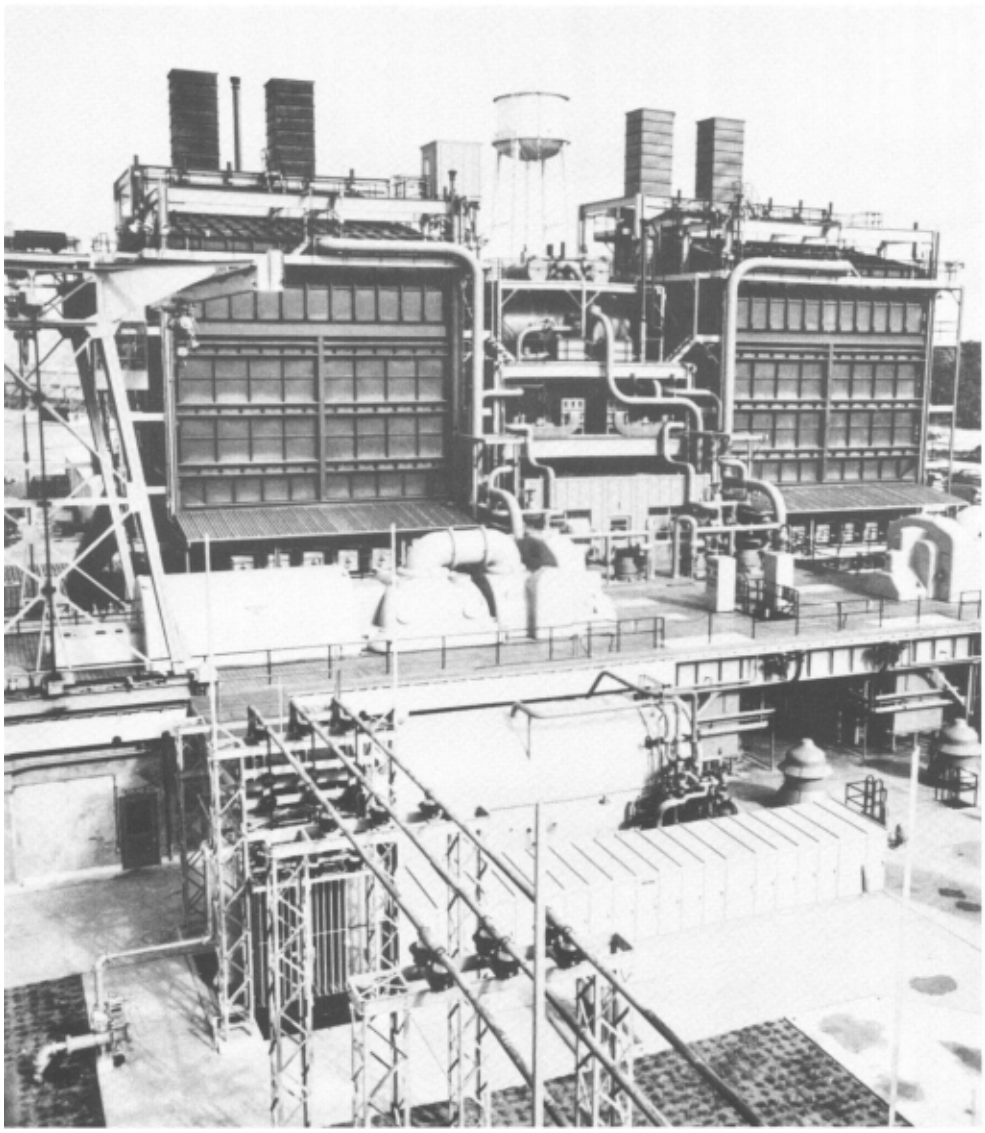


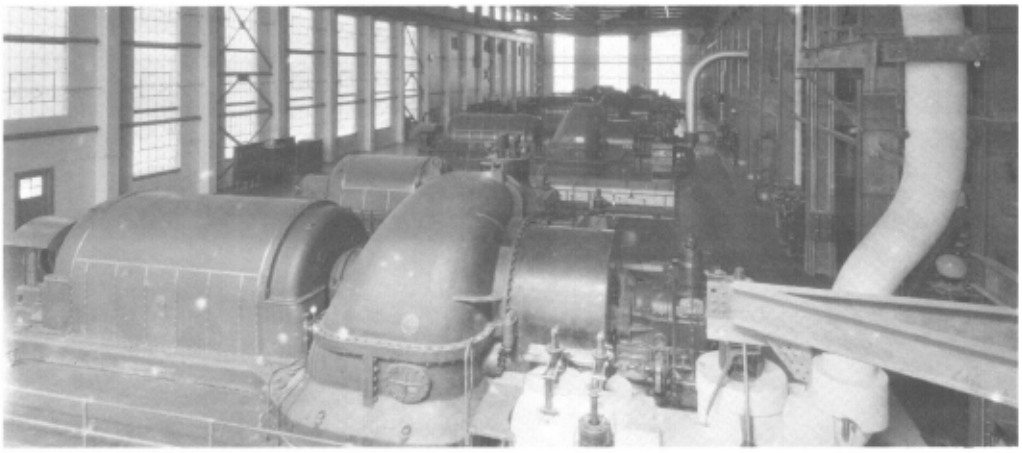
Greens Bayou No. 1,12070 HWY 90

Designation Ceremony
Greens Bayou No. 1
Houston Lighting & Power Company
First Outdoor Steam Turbine-Generator Plant
A National Historic Mechanical Engineering Landmark

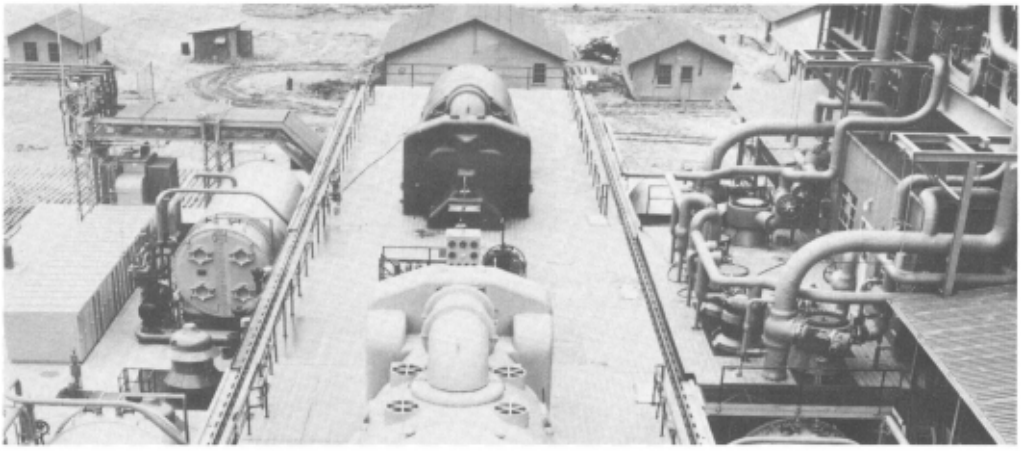
June 9, 1991

The American Society of
Mechanical Engineers

The ornate turbine hall, housing the turbine-generator at Houston Lighting & Power Company's Deepwater power plant, shows the typical power plant masonry construction of 1936.



The interior view of the Deepwater plant shows the protected work area and the turbine-generator installation inside the building.



In 1949, the Greens Bayou No. 1 turbine-generator (front, center), became the first fully outdoor unit to operate in the U.S.

Introduction

As surprising as it may seem, most turbine-generator facilities in electrical power plants were housed within large industrial structures known as turbine halls, until World War II. This was the accepted practice even in areas where the climate was relatively mild.

A major breakthrough in power plant design was achieved on April 21, 1949, when a completely outdoor turbine-generator was placed into commercial operation at the Greens Bayou electric power plant of Houston Lighting & Power Company. This outdoor design resulted in a significant reduction in the cost per KW to build the plant. Additionally, on-line lead time and maintenance was made easier and less expensive.

This 66 MW turbine-generator was one of the earliest "American Institute of Electrical Engineers and American Society of Mechanical Engineers (AIEE-ASME) Preferred Standard" units applied in the utility industry, and it was Westinghouse Electric Company's first outdoor preferred standard unit.

Greens Bayou No. 1 was placed in service only 21 months after the order date. This reduction in lead time was possible because of the available engineering on the "Preferred Standard" turbine-generators and due to outdoor design simplification.

Historical Significance

The Houston Lighting & Power Company Greens Bayou steam electric power plant was placed in service in 1949. It represented the culmination of a trend toward the construction of completely outdoor generating plants that probably started in 1933, when a power plant with outdoor components was placed in service in Schenectady, New York[1]. The Schenectady plant was built by the General Electric Company for the New York Power and Light Corporation. This plant was the first to operate on the Emmet mercury-vapor cycle where the mercury turbine and the mercury condenser-steam boiler were placed outside. Although a forerunner of the water-steam plants, it did not have the potential freezing problems of the water plants, because the freezing point of mercury prevents freezing in most of the country.

Significant savings in plant construction costs were anticipated from the change to outside construction. The early plants that followed placed the boiler outside, but not the turbine. Noteworthy examples, opened in 1936, were the plant of the Tucson Gas and Electric Company[2] and the Provo plant of the Utah Power and Light Company[3]. This type of construction produced demonstrated savings in material and other construction costs, as well as reduced construction time. However, in spite of the early start of outdoor plants in the northeastern United States, it was generally believed that this type of plant was suitable for the milder climates in more southern areas.

A semi-outdoor plant at Burbank, California, started operation on October 1, 1941. This plant did have an outdoor turbine with a light, weatherproof housing which could be removed by the gantry crane located on the turbine platform[4]. A similar plant was also placed in service at Glendale, California, at the same time[5].

Construction of a number of plants in which the turbine and boiler were protected by a light, weatherproof covering followed. Examples described in the trade press included the Harvey Couch Station of the Arkansas Power and Light Company[6], which went into service in October, 1943, and the West Junction Station of Houston Lighting & Power Company[7], also in 1943. In both of these plants, the turbine-generators were protected by a light, weatherproof covering.

The first water-steam plant to dispense with a removable, weatherproof cover was the Greens Bayou plant of Houston Lighting & Power Company[8]. This plant carried the outdoor concept to its logical conclusion by placing all plant components outdoors. The turbine and generator casings were weatherproof, and no removable housings were used.

The outdoor and semi-outdoor plants (the definition of the latter is variable, but indicates that some of the major components, such as the boiler or the turbine-generator, are located outdoors) have spread to the northern regions of the United States. One example is the Glenwood Station of the Long Island Lighting Company, which uses semi-outdoor boilers and outdoor turbine-generators and has a walk-in enclosure at the governor end of the turbine.

Outdoor power plants resulted in substantial construction-cost savings; these savings were estimated to be about $10 per kilowatt (1946 dollars)[9,10]. Interesting reviews of the financial and operating features have been published by Gourdon, Friend and Elliott9, by Hanson[10] and by Del'Homme[11]. In addition, the American Society of Mechanical Engineers held a "Symposium on Design for and Operating Experience with Outdoor Power Plants" at the 1953 Annual Meeting. This was published in the Society's Transactions[12], and included a useful map that located the outdoor and semi-outdoor plants that had been built in the United States.

Development of Outdoor Plant Design

The end of World War II unleashed pent-up consumer demand for more electricity, spurring a tremendous need for new utility power plants. In an effort to reduce costs and shorten the delivery times of turbine-generators, a committee of AIEE-ASME hastened to establish standards (including steam conditions) for eight ratings: 12.65 MW, 16.5 MW, 22 MW, 33 MW, 44 MW, 66 MW, 100 MW, and 150 MW.

One enthusiastic and involved young Westinghouse engineer, Walter Sinton, was assigned responsibility for the design of several of these ratings. He had finished the design of the 66 MW units before Westinghouse received the July, 1947, order for Greens Bayou Nos. 1 and 2. The order specified conventional units; however, an urgent request came from Houston Lighting & Power Company and Ebasco Services in February, 1948, to determine if it was feasible to modify the design and manufacture the units suitable for complete outdoor installation.

Sinton had a hectic week making the study and report. He reviewed solutions for access to components such as the governor, trip and test devices, gland control valves, gages, turning gear engagement, etc., if they were covered with form-fitting lagging. The report concluded that an outdoor unit was feasible, and Westinghouse notified Houston Lighting & Power Company's executive vice-president H.O. Clarke and chief mechanical engineer W. McDonald that the outdoor unit was a "go" on March 10, 1948.

The outdoor design gave the engineers an opportunity for several changes that significantly lowered plant construction costs. For example, the application of side-mounted condensers permitted lowering the floor of the plant from 26 feet to only 16 feet above grade. Additionally, the use of a gantry crane rolling on the turbine deck eliminated the main structural steel members required in turbine halls for crane support.

The outdoor lagging of the turbine-generator has proven its effectiveness over time. The unit has survived some of nature's worst storms, including Hurricane Carla. The reliability was such that lengthy periods between major inspections (up to five years) has become commonplace.

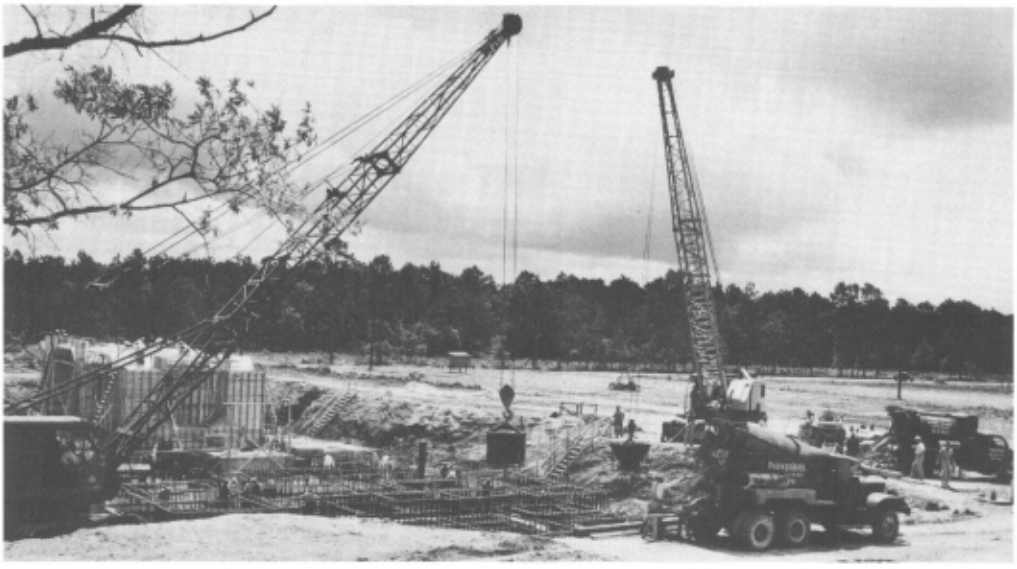
The outer lagging was designed for 70 pounds per-square-foot of wind load. A perimeter groove with grease fittings formed a seal between the seating plate and the turbine sliding feet. During construction, Sinton called the Westinghouse refrigeration division for neoprene door seals that served as gaskets for several access doors in the lagging.

General view of Greens Bayou No. 1 (right) & No. 2. with the 66 KV switchyard in the foreground and cooling towers in the background.

Greens Bayou Milestones

- Houston Lighting & Power Company placed the order for Greens Bayou Nos. 1 & 2 in July, 1947. Sinton completed the Design Specification on August 6, 1947, and ordered long lead items, the rotor forgings and blading.
- On March 16, 1948, the Design Specification was modified to cover changes to the completely outdoor operation.
- Shipment of turbine-generator parts began in December, 1948.
- Greens Bayou Unit No. 1–Westinghouse S/N 5-A-4530-1 (HP) and 5-A-4531-1 (LP)–went into commercial operation on April 21, 1949, only 21 months after the order date.
- Greens Bayou Unit No. 2–Westinghouse S/N 5-A-4530-2 (HP) and 5-A-45311-2 (LP)– went into commercial operation on September 5, 1949.

While Houston Lighting & Power Company's Greens Bayou No. 1 was one of the earliest and quite possibly the first, fully outdoor turbine-generator, its success led to the construction of many subsequent outdoor units located in the southwest and southern regions of the United States.



This 1948 photo shows the pouring of the concrete for the Greens Bayou No. 2 turbine-generator foundation.

Technical Background:

Evolution of Outdoor Plants at Houston Lighting & Power Company

The nation had been geared to supply the "war machine" in the 1940s. Consumer demand for electricity had grown and Houston Lighting & Power Company needed more generating capacity for the booming Texas/Gulf Coast area. Houston Lighting & Power Company had been going through the various stages of outdoor plant construction for over a decade.

Phase I

1939: The addition of a semi-outdoor boiler with an enclosure (a hood extending down from the roof to below the drum level) was a modest but successful start as part of an expansion of the Gable Street Station.

Phase II

1943: The turbine and boiler were semi-outdoor installations located at the West Junction facility. The turbine-generator had a metal enclosure with a sectional roof that was removable for access and major maintenance by the gantry crane. The success of this design led to construction of a second unit in 1946.

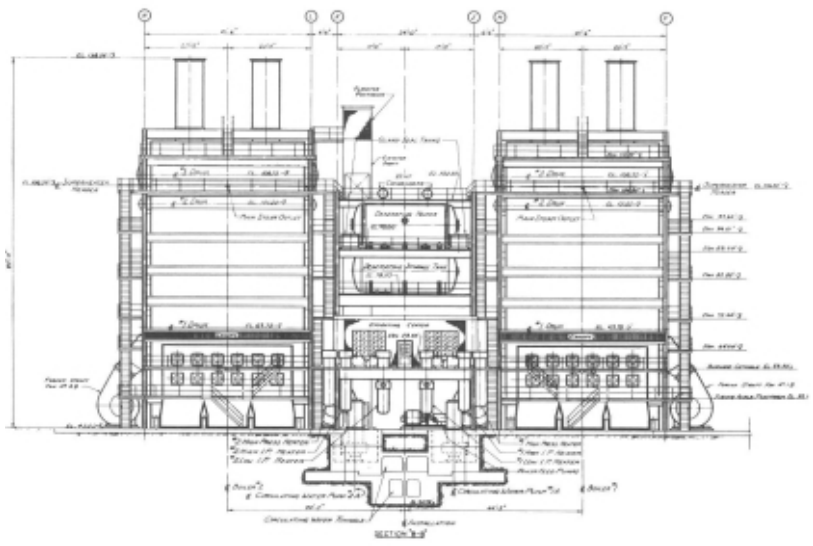
Phase III

1948: A third step placed a separate control room between the outdoor boilers, providing no housing for turbines and placing other auxiliaries outdoors for the Greens Bayou design. Building volume and floor area were reduced, with attendant savings in structural and reinforcing steel.

Description of Greens Bayou No. 1

As described by L.K. Del'Homme, a FELLOW of the AIEE, in his paper *Outdoor versus Indoor Steam-Electric Stations in the Houston Area* (AIEE paper 56-769)(11), these advances led to the construction of the Greens Bayou outdoor station. The plant consists of two 66 MW Preferred Standard units with a combined capacity of 145MW. All the auxiliaries, including the 480 and 2,300 volt switch gear, are located outdoors, except the boiler feed pumps. The feed pumps are protected by the control room located above them. The motors are of conventional splash-proof design, with the addition of extensions on the ventilation openings for shelter against driving rain. The turbines are protected from the weather by streamlined metal covers, while the generator casings are weatherproof.

Investment, or capital cost, is a major factor in deciding between an outdoor or conventional plant. Del'Homme showed that an outdoor station this size costs a little more than half the cost of the average indoor station, amounting to $17 per KW at that time. Del'Homme pointed out that the major savings resulted from elimination of the costly boiler and turbine buildings.



Greens Bayou elevation drawings show the exposed turbine-generators, the gantry crane and the split condensers–some of the major cost-saving features in a completely outdoor plant.

Mechanical Specifications

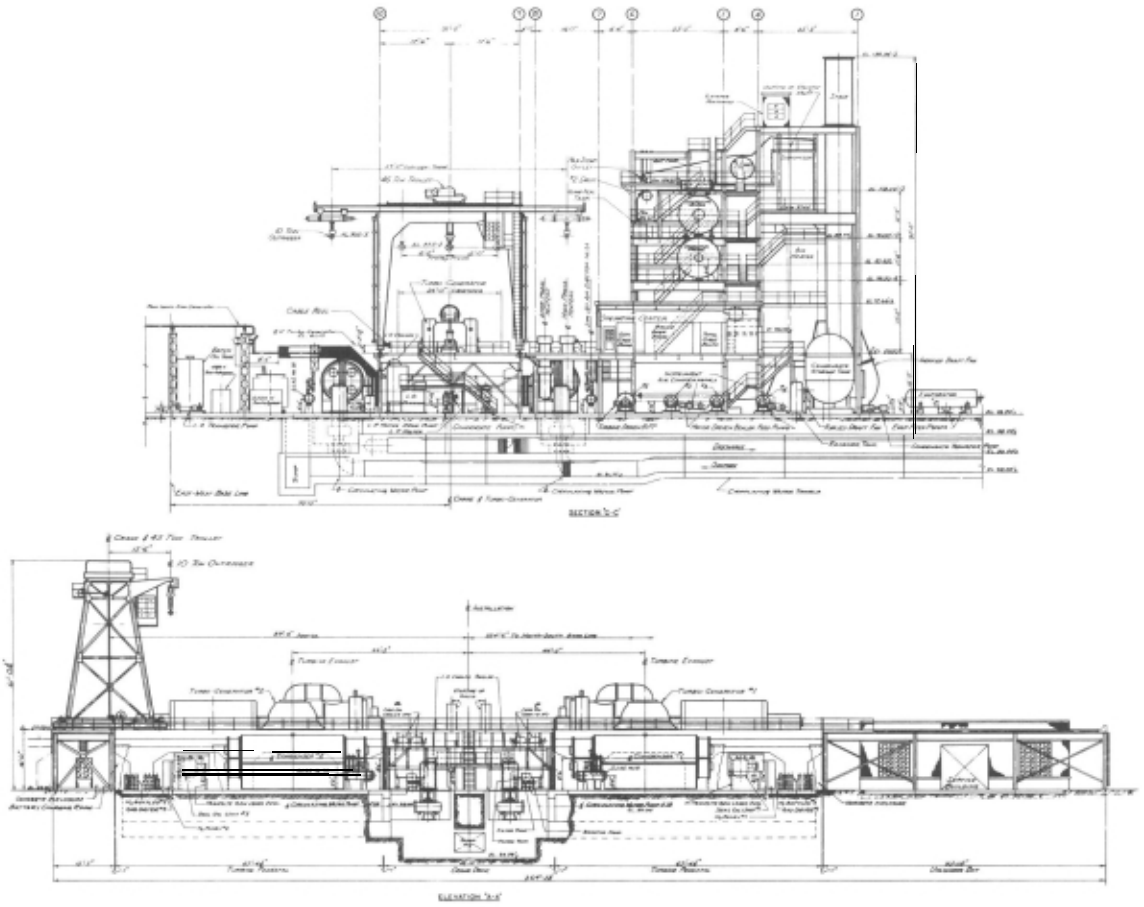
Greens Bayou No. 1 turbine-generator was an ASME-AIEE Preferred Standard Unit:

60 MW Rating
66 MW maximum power

Turbine: 3600 rpm
Steam Conditions: 858 psig
900 degrees FTT
1.5 In. Hg. A.

Generator: 70588 KVA
Power Factor: 85
Volts: 12,500
Hydrogen Cooled

Outdoor Lagging:
Design wind pressure load: 70 PSF



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Acknowledgements

The South Texas Section of the American Society of Mechanical Engineers acknowledges the efforts of all who contributed to the designation of the Houston Lighting & Power Company Greens Bayou No. 1 Outdoor Turbine-Generator as a National Historic Mechanical Engineering Landmark. Particular thanks are extended to Mr. Walter Sinton who submitted the nomination and provided much of the historical material and information, and to Mr. Bart Little of Houston Lighting & Power Company who confirmed data and located the technical papers that document the stages of the plant's development, and members of Houston Lighting & Power Company's Public Affairs Department, who helped plan and publish this brochure.

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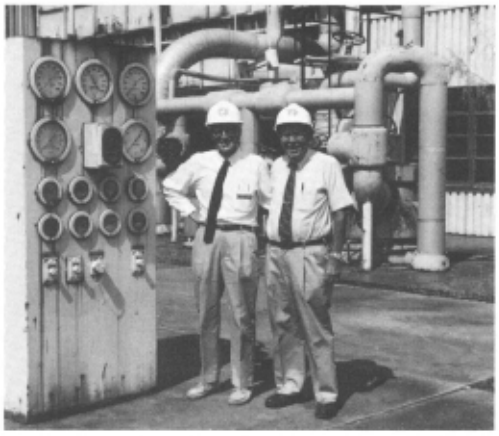


Pictured (left to right) are (A) South Texas Section History & Heritage Chairman, Sam Collier and Walter Sinton, and (B) Walter Sinton and ASME South Texas Section Chairman, Richard Boswell, touring the Greens Bayou turbine-generator plant in 1990.

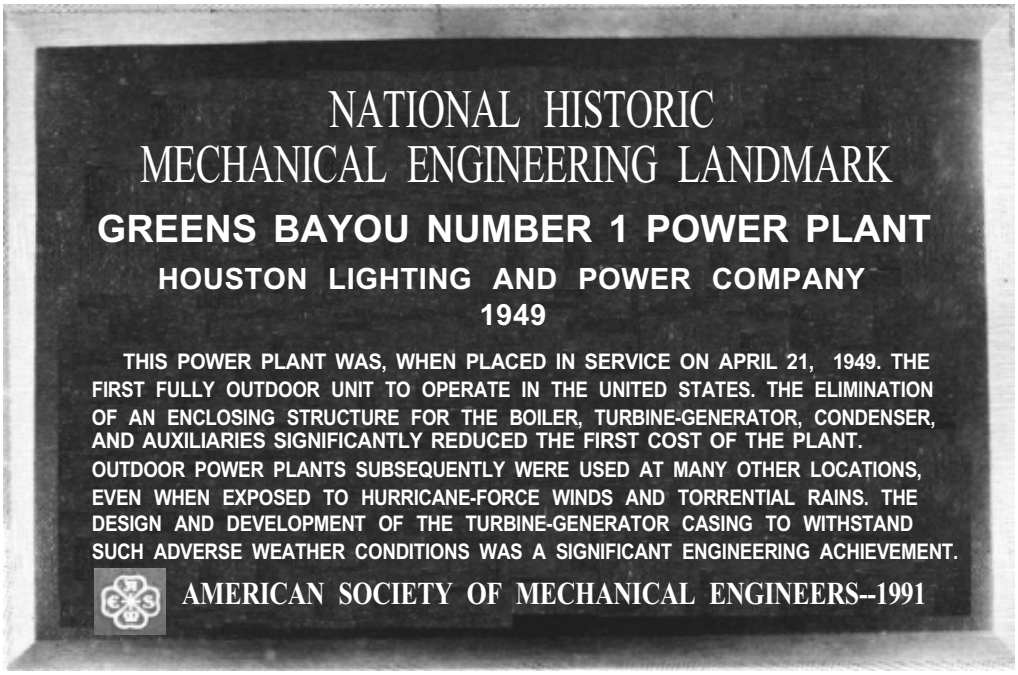
The ASME History and Heritage Program

The ASME History and Heritage Recognition Program began in September, 1971. To implement and achieve its goals, ASME formed a History and Heritage Committee, initially composed of mechanical engineers, historians of technology, and (ex officio) the curator of Mechanical Engineering at the Smithsonian Institution. The Committee provides a public service by examining, recording, and acknowledging mechanical engineering achievements of particular significance.

Houston Lighting & Power Company's Greens Bayou Outdoor Turbine-Generator is the 99th National Historic Mechanical Engineering Landmark to be designated. Since the ASME Historic Mechanical Engineering Recognition Program began in 1971, 143 Historic Mechanical Engineering Landmarks, five Mechanical Engineering Heritage Sites and two Mechanical Engineering Heritage Collections have been recognized. Each reflects its influence on society, either in its immediate locale, nationwide, or throughout the world.

An ASME Landmark represents a progressive step in the evolution of mechanical engineering. Site designations note an event or development of clear historic importance to mechanical engineers. Collections mark the contributions of a number of objects with special significance to the historical development of mechanical engineering.

The ASME Historic Mechanical Engineering Recognition Program illuminates our technological heritage and serves to encourage the preservation of the physical remains of historically important works. It provides an annotated roster for engineers, students, educators, historians, and travelers. It helps establish persistent reminders of where we have been and where we are going along the divergent path of discovery.


NATIONAL HISTORIC
MECHANICAL ENGINEERING LANDMARK
GREENS BAYOU NUMBER 1 POWER PLANT
HOUSTON LIGHTING AND POWER COMPANY
1949
THIS POWER PLANT WAS, WHEN PLACED IN SERVICE ON APRIL 21, 1949. THE FIRST FULLY OUTDOOR UNIT TO OPERATE IN THE UNITED STATES. THE ELIMINATION OF AN ENCLOSING STRUCTURE FOR THE BOILER, TURBINE-GENERATOR, CONDENSER, AND AUXILIARIES SIGNIFICANTLY REDUCED THE FIRST COST OF THE PLANT.
OUTDOOR POWER PLANTS SUBSEQUENTLY WERE USED AT MANY OTHER LOCATIONS, EVEN WHEN EXPOSED TO HURRICANE-FORCE WINDS AND TORRENTIAL RAINS. THE DESIGN AND DEVELOPMENT OF THE TURBINE-GENERATOR CASING TO WITHSTAND SUCH ADVERSE WEATHER CONDITIONS WAS A SIGNIFICANT ENGINEERING ACHIEVEMENT.
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