

THE 210 kWe (gross) OPEN-CYCLE OCEAN THERMAL ENERGY CONVERSION (OTEC) EXPERIMENTAL FACILITY

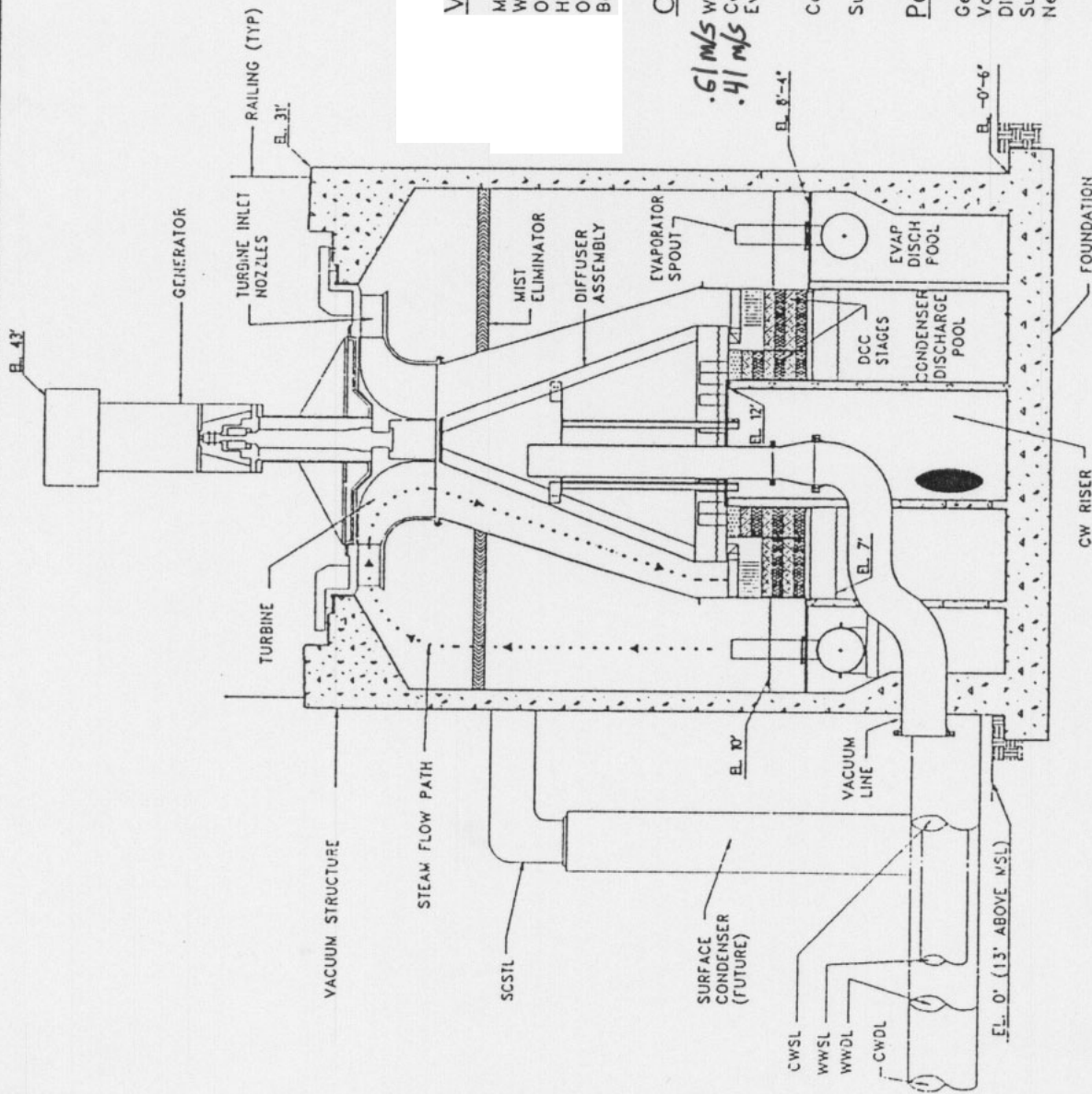
There are, basically, two approaches to the extraction of thermal energy from the oceans, one referred to as "closed-cycle" and the other as "open-cycle." In the closed-cycle, warm surface seawater and cold deep seawater are used to vaporize and condense a working fluid, such as ammonia, which drives a turbine-generator in a closed loop producing electricity. In the open-cycle, surface seawater is flash-evaporated in a vacuum chamber at pressures of approximately 3% atmospheric. The resulting low-pressure steam is used to drive a turbine-generator. Cold seawater is used to condense the steam after it has passed through the turbine. The open-cycle can, therefore, be configured to produce fresh water as well as electricity.

Several small proof-of-concept facilities have been operated for up to six months, but unfortunately, minimal operational data has been obtained. These projects demonstrated that both cycles are technically feasible and limited only by the large diameters required for the cold water pipes to sizes of no more than about 100 MW gross. In the case of the open-cycle, due to the low-pressure steam the turbine is presently limited to sizes of no more than 3 MW gross.

As the next step towards answering some of the questions related to the operation of OTEC plants, a small OC-OTEC land-based experimental facility has been installed and is operating at the Natural Energy Laboratory of Hawaii (NELH), Kailua-Kona, Hawaii. The offshore and inland seawater piping system (1 m cold water pipe) already installed at NELH is utilized. The power block is built around a single, vertical-axis, mixed-flow turbine supported by a concrete vacuum vessel, 7.6 m in diameter and 9.5 m high. The electrical generator is located above the turbine assembly and outside the vacuum enclosure. Steam is produced in an annular flash evaporator at the periphery of the vacuum vessel. The steam flows up from the evaporator and enters the turbine radially inward. The steam exits the turbine axially in the center of the vessel. A conical exhaust diffuser is used for pressure recovery. The condenser is a direct-contact, structured-packing condenser composed of two coaxial stages. The non-condensable gases liberated from the seawater streams, at pressures of 1% to 3% atmospheric, and a small amount of uncondensed steam are compressed and exhausted using a multiple-stage vacuum compression system. All subsystems have been instrumented to measure the parameters required to assess performance.

This experimental facility will demonstrate the feasibility of the low pressure open-cycle turbine and the high efficiency vacuum compression subsystems. Additionally, the production of net power will be demonstrated; therefore, the system is also referred to as the Net Power Producing Experiment, or NPPE. The turbine-generator nominal gross output is 210 kWe for a surface temperature of 26°C and a deep water temperature of 6°C. Given the infrastructure already available at NELH, only 40 to 50 kWe net will be obtained. As of March 1993, the highest surface temperature available was 25°C (the range at the site is from 24°C to 28°C) and 190 kWe (gross) has been produced. This is a world record for OTEC.

The design allows for a slipstream of the steam to be diverted to a surface condenser for the production of fresh water. The fresh water production subsystem is in the final construction phase and is expected to be "on line" by July 1993, producing 7000 gal/day.



SPECIFICATIONS

Vacuum Structure

Material: Reinforced & Post-Tensioned Concrete
 Wall Thk: 0.3 m (1 ft)
 Outside Dia: 7.6 m (25 ft)
 Height: 9.5 m (31 ft)
 Overall Ht: 13.1 m (43 ft)
 Base Elev: 4 m (13 ft) above MSL

OC-OTEC Process

Warm Seawater: 620 kg/s (9,600 gpm), 26° C (79° F) **36**
 Cold Seawater: 420 kg/s (6,500 gpm), 6° C (43° F) **24**
 Evaporator: 0.6 m (2 ft) dia manifold w/13 spouts
 3.5 kg/s steam (0.5% of WW Flow)
 2600 Pa (0.38 psia)
 Condenser: two-stage direct contact w/packing
 1300 Pa (0.19 psia)
 Surface Cond: 0.35 kg/s (5 gpm) fresh water production

Power Budget

Generator: 210 kW (synchronous, 1800 rpm)
 Vacuum Pump: 40 kW (five-stage train)
 Discharge Pumps: 80 kW (60 hp WW, 50 hp CW)
 Supply Pumps: 40 kW (not installed; 25 hp each)
 Net Power: 50 kW (on paper)

PROJECT TITLE:

210 kWe OC-OTEC NET POWER PRODUCING EXPERIMENT

SHEET TITLE:

VERTICAL SECTION

APPROVALS/INT

L. VEGA

DATE

7/10/82

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 Honolulu, Hawaii