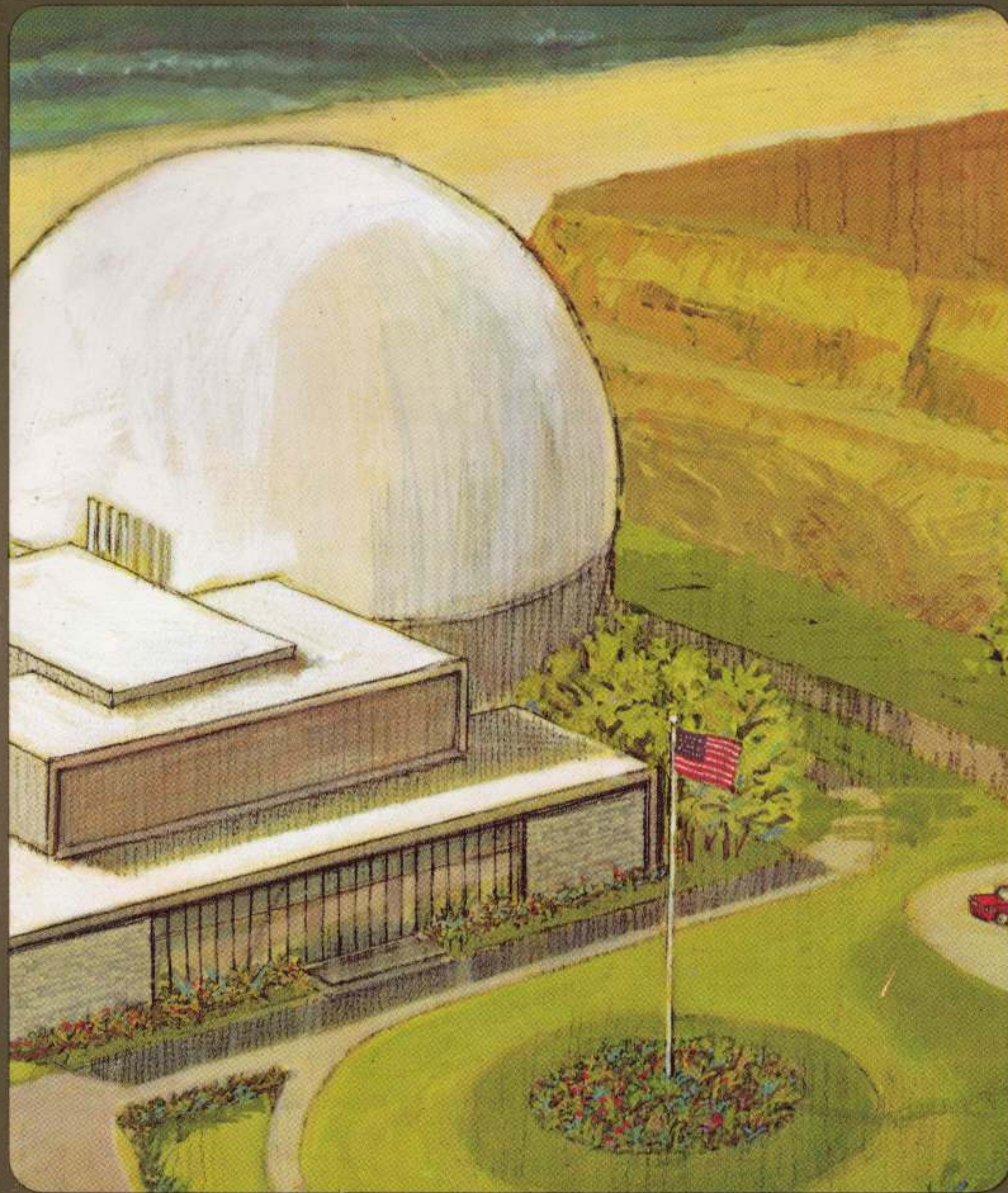
SAN ONOFRE NUCLEAR GENERATING STATION . . . TOMORROW'S POWER . . . TODAY!



WELCOME TO SAN ONOFRE NUCLEAR GENERATING STATION

San Onofre Nuclear Generating Station nestles in a man-made hollow carved into the cliff wall on the Pacific Coast four miles below San Clemente. It represents a significant step forward in man's progress to generate electricity from nuclear energy.

This is the story of the role nuclear energy will play in helping Southern California Edison and San Diego Gas & Electric to continue supplying you with low-cost, dependable, abundant electricity.

The station is expected to have an ultimate gross generating capacity from present equipment of 450,000 kilowatts, enough electricity for a city of more than half a million people. For the first time Southern and Central Californians will have a substantial portion of their electrical energy produced by nuclear power.

Southern California Edison Company performed the basic engineering for the plant. Westinghouse Electric Corporation and Bechtel Corporation are responsible for design engineering and construction. And the two utility companies share costs and output of the station . . . Edison, 80 per cent; SDG&E, 20 per cent. Because the station is located on the northwest corner of Camp Pendleton Marine Base, the land is leased from the United States Government.

This modern generating station stands as a tribute to the determination and ingenuity of the people of the investor-owned utility industry. The construction of this plant proves once again the soundness of the American tradition of free enterprise working for the public good.

HOW ELECTRICITY IS MANUFACTURED

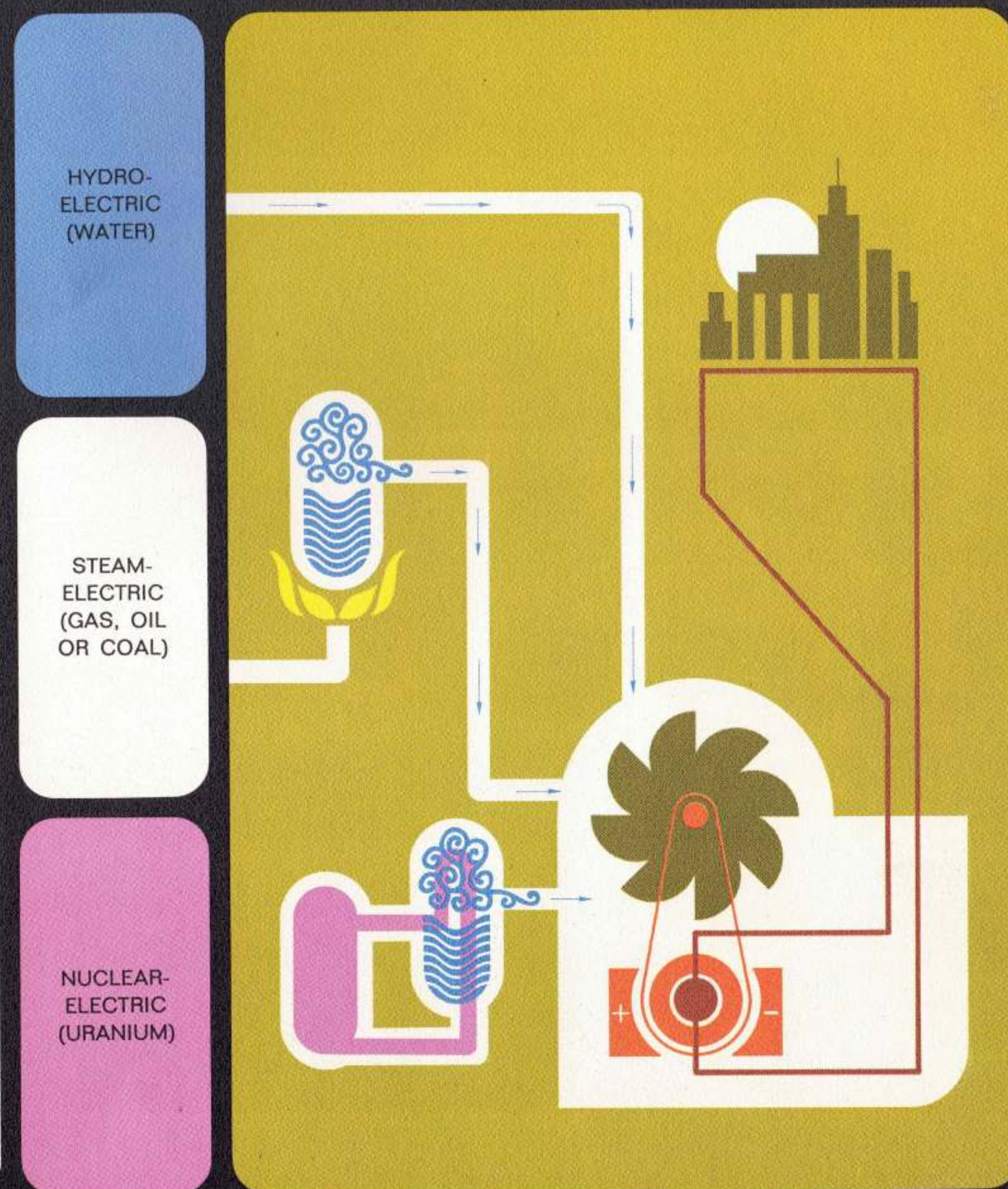
All electric power supplied to Southern and Central California is manufactured by huge turbine-generators. The differences in method are only in what power source is used to drive the turbines. There are two basic methods of doing this . . . hydroelectric and steam-electric.

The hydroelectric method utilizes the power of falling water. Water, stored in a reservoir, is released as needed and directed against turbine blades which spin a generator to produce electricity. At Edison's Big Creek-San Joaquin River Hydroelectric Project in the High Sierra, for example, melted snow and rain water are harnessed to drive generators at eight giant hydroelectric power stations, before being passed on for further use by the people of the San Joaquin Valley.

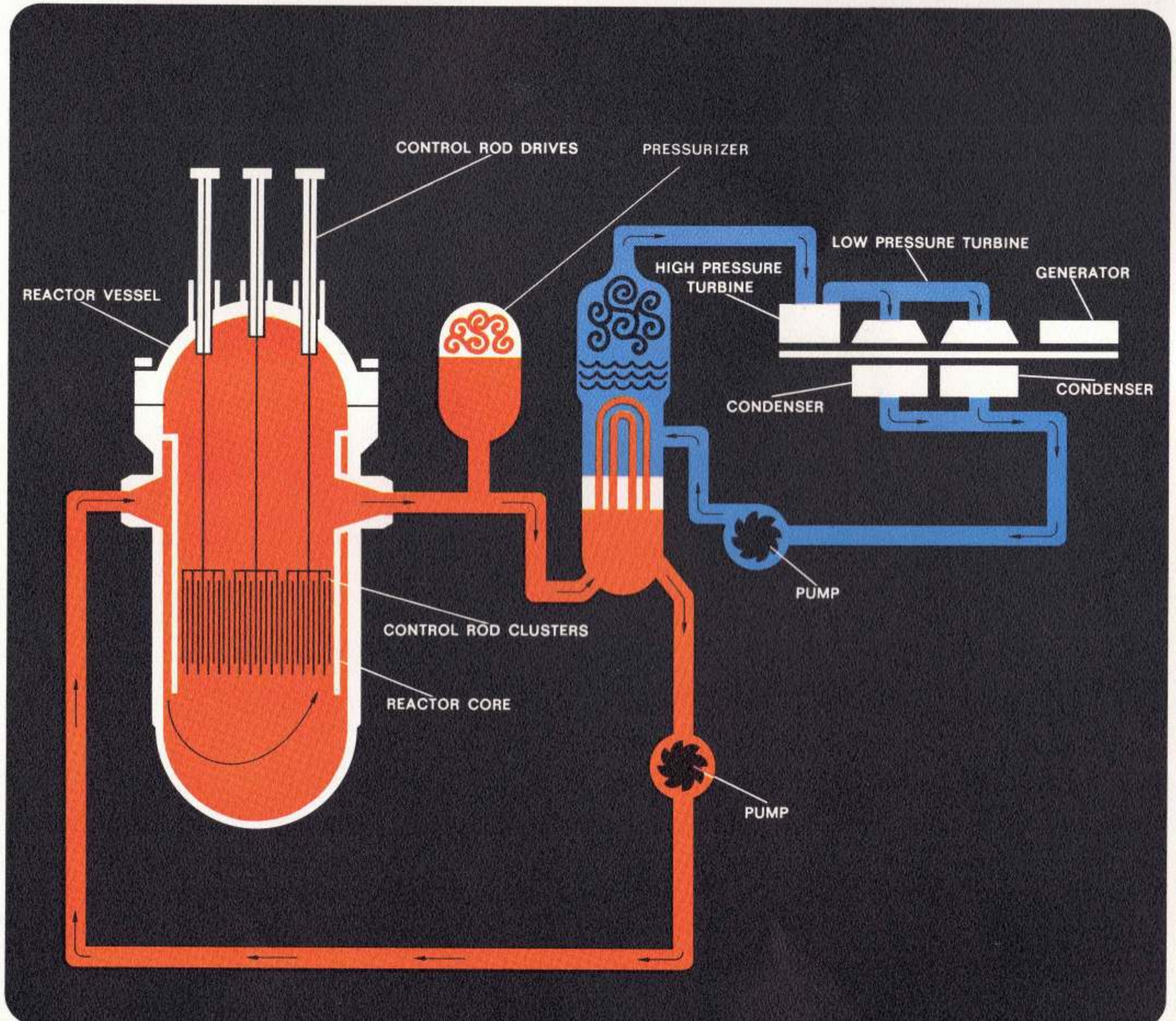
The second method, which is used to manufacture **most** electricity in Southern California, is steam-electric generation. In this system, water is heated to form high-pressure steam, which in turn provides the energy for the turbine that drives the generator. Steam-electric generation traditionally has utilized the heat from the combustion of fossil fuels (oil, gas or coal) to produce steam. However, new and economic methods and techniques of manufacturing electricity are constantly being developed and put to beneficial use.

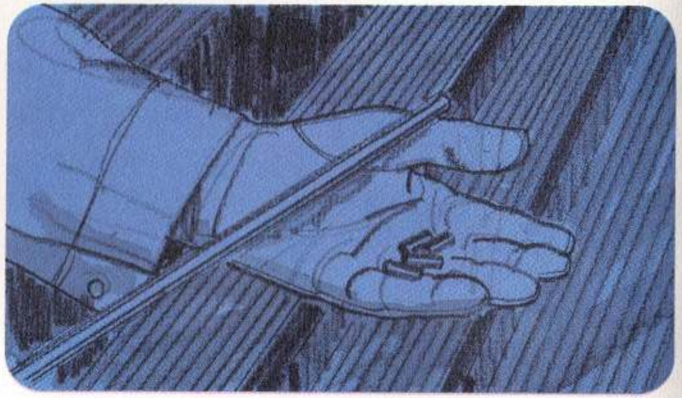
Nuclear generation is one of these new methods. In a nuclear power plant, a nuclear reactor supplies the heat to make the steam. Electric energy is then generated in the same manner as in conventional steam-electric plants.

Shown at right is a diagram illustrating these methods of generating electricity.



HOW NUCLEAR ENERGY IS USED TO GENERATE ELECTRICITY

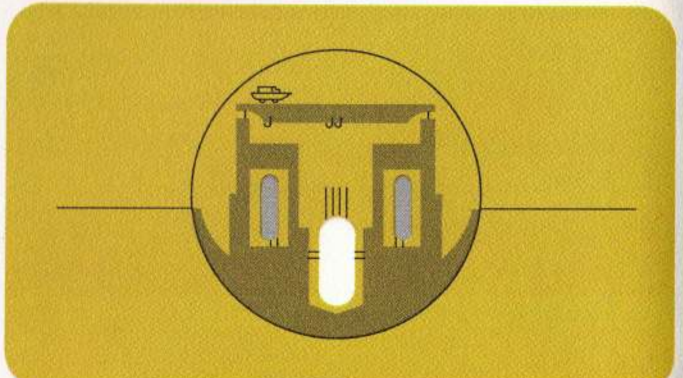




The illustration above shows the relative size of the fuel pellets (UO_2) and the stainless steel sealed tubes which hold them in relation to the size of a man's hand.

At left is shown a representational schematic of the use of reactor heat in manufacturing electricity.

Below you see the reactor vessel's location within the sphere.



NUCLEAR HEAT The basic difference between a nuclear electric generating plant and a conventional steam-electric generating plant is how heat is produced to form steam. The heart of a nuclear reactor is this heat-producing source shown at left . . . the reactor core.

Nuclear heat within the reactor is developed when atoms of uranium fuel are split apart . . . or **fissioned.** The atom splits into two fragments, each of which becomes an atom in its own right. **These two new atoms together weigh slightly less than the original uranium atom.** This slight difference in weight is the energy created by the fissioning of the atom, which energy produces the heat recovered from the reactor.

Each individual fission gives out only a minute quantity of heat. But since there are many million trillions of **controlled** fissions taking place within the reactor core every second while in operation, the **total** amount of heat developed is substantial and can be put to useful purposes.

CHAIN REACTION Another important aspect of the **controlled** atom-splitting process is that each atom, as it splits, releases two or three neutrons . . . fast-moving, uncharged particles of the atom which are capable of splitting additional atoms. Neutrons released by the splitting of the atoms speed through the reactor core until they strike and split other atoms. This sequence continues as long as the reactor is in operation and is referred to as a **chain reaction.**

FUEL The fuel used in San Onofre's reactor is composed of small cylindrical pellets of uranium dioxide (UO_2). There are nearly 6¾ million of these pellets fitted into 28,200 high-strength sealed stainless steel tubes. Bundled together, these tubes form the reactor core, which is ten feet high and nearly ten feet in diameter.

CONTROL Control rods are inserted through spaces in the reactor core to control the amount of heat being produced. These rods are neutron absorbers. When the control rods are completely **inserted,** the neutrons are absorbed; the chain reaction cannot take place, and the reactor is out of service. As the control rods are withdrawn from the core, fewer neutrons are absorbed by them, allowing the controlled chain reaction to begin.

MODERATION During reactor operation, water flows freely around and past each tube in the reactor core. The water serves two essential purposes. It removes the heat generated and also serves as a moderator to slow down the neutrons moving through the core. The heat is used to generate the steam required.

When an atom is split, the neutrons that are released would move too rapidly to trigger additional atom splitting unless the water slowed down their speed. The hydrogen atoms in water provide a cushion, which slows the speed of the neutrons. Without this slowing-down effect, or **moderation,** the chain reaction could not be maintained.

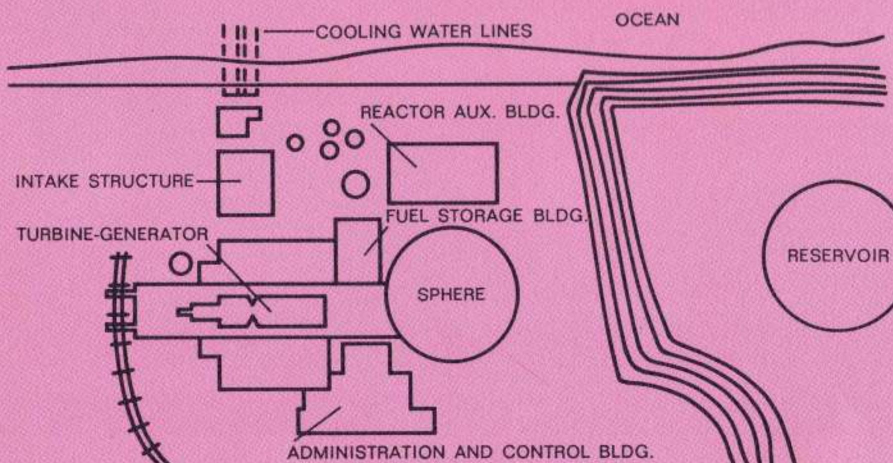
HEAT TRANSFER The heat from splitting atoms within the fuel pellets is conducted through the walls of their stainless steel tubular jacket. This heat is carried away by pressurized water circulating through the core. The water is pressurized to permit raising the temperature to approximately 600°F. without boiling . . . hence the name, **pressurized water reactor.**

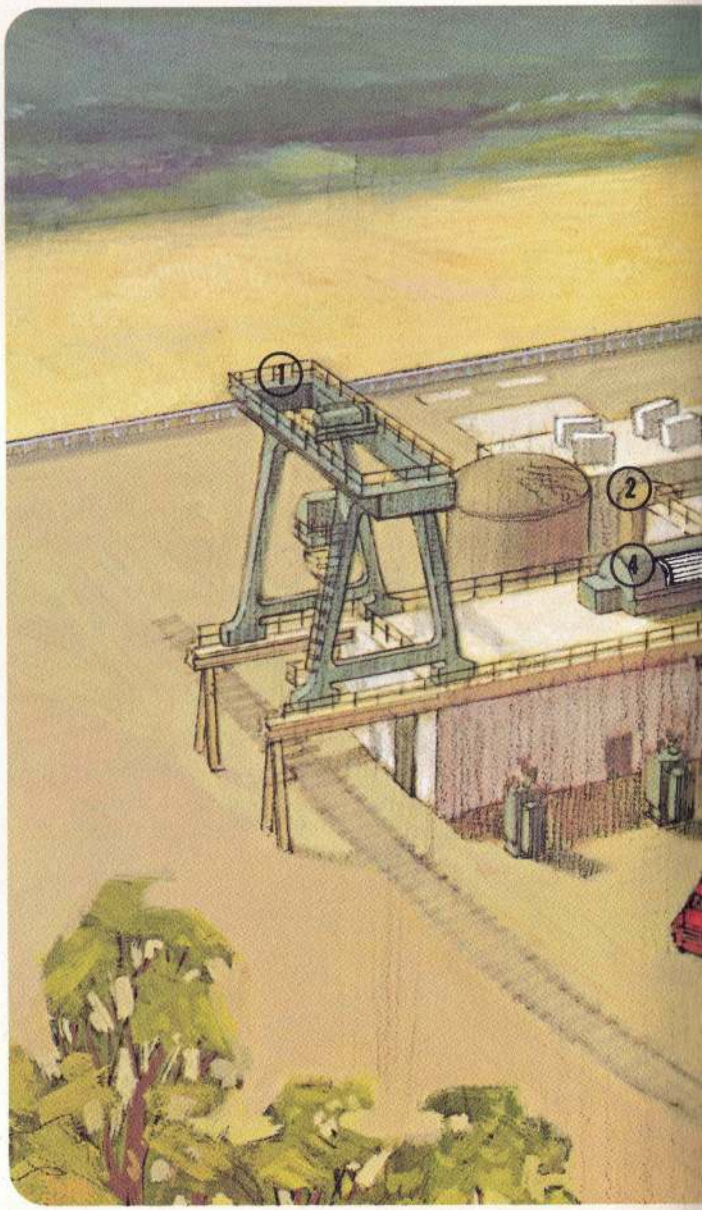
After leaving the reactor, the hot pressurized water passes through stainless steel tubes submerged in a boiler where it heats water in a separate system turning it to steam. The pressurized reactor water, having given up its heat in this process, returns to the reactor to be reheated, and the cycle is repeated.

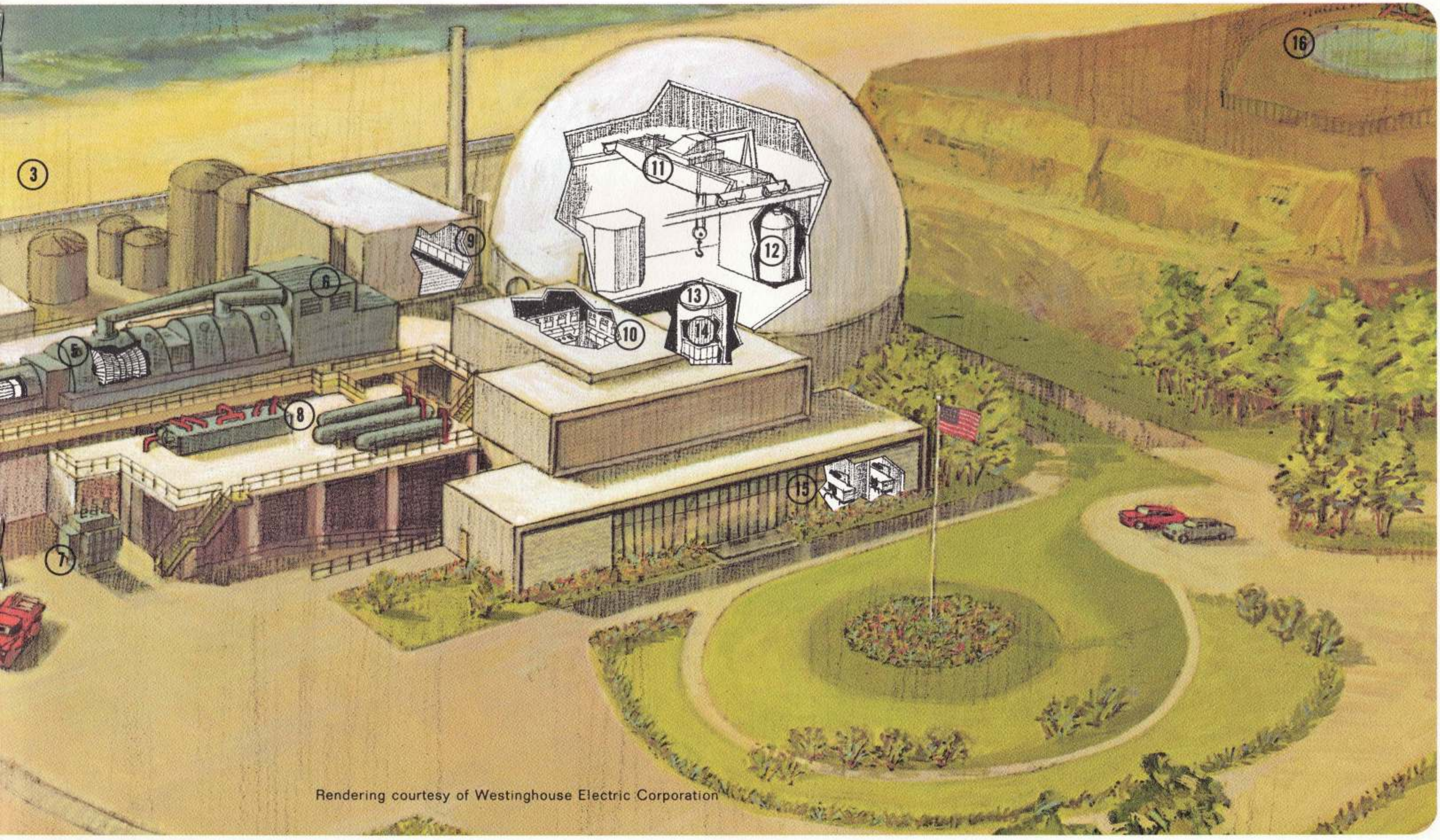
CONVENTIONAL STEAM SYSTEM From this point on, the San Onofre plant closely resembles any conventional steam-electric plant. The steam from the water in the boiler is used to spin a turbine which drives an electric generator. After passing through the turbine, the steam is condensed, and the resulting water is pumped back into the boiler to be reused.

CUTAWAY DRAWING OF SAN ONOFRE NUCLEAR GENERATING STATION

1 — Turbine Gantry Crane
2 — Circulating Water Intake Structure
3 — Seawall
4 — Generator
5, 6 — Turbines
7 — Main Transformer
8 — Flash Evaporator
9 — Fuel Storage Pit
10 — Control Room
11 — Reactor Service Crane
12 — Steam Generator
13 — Reactor Vessel
14 — Reactor Core
15 — Administration Building
16 — Water Storage Reservoir







Rendering courtesy of Westinghouse Electric Corporation

TECHNICAL DATA ABOUT SAN ONOFRE NUCLEAR GENERATING STATION

CONTAINMENT SPHERE

1. Houses reactor and other nuclear components.
2. Sphere diameter is 140′, volume 1,440,000 cu. ft. and surface area 61,600 sq. ft.
3. Sphere is designed for 46.4 psig internal pressure with a maximum shell thickness of 1 inch.

REACTOR VESSEL

1. Contains the nuclear fuel.
2. Vessel weight is 330 tons
3. Dimensions Height — 37 ft; inside diameter — 11′ 10″; wall thickness — 9¾″; stainless steel cladding thickness — 5/32″.

FUEL

1. First core will contain 72 tons of slightly enriched uranium dioxide valued at approximately $23,200,000 including fabrication cost.
2. Equivalent to 18,000,000 bbls. of fuel oil.
3. Spent fuel bundles will be moved and stored under water until returned to the AEC for reprocessing.

CONTROL ROOM

Centralized remote control of entire plant including reactor, turbine-generator, and 220kv and 138kv switchyards.

PLANT PARAMETERS

Power Output	Initial	Ultimate
Reactor thermal power, kw	1,187,000	1,347,000
Gross Electrical, kw	395,000	450,000
Net Electrical, kw	375,000	429,000

Primary Fluid Flow

Coolant flow, forced	78,000,000 lb/hr
Circulation inlet temperature	553° F
Circulation outlet temperature	597° F
Operating pressure	2100 psig

Core

Diameter	111 inches
Height	120 inches
Total UO_2 in core	143,600 lb
Subassemblies, total	157
Fuel rods in core, total	28,260
Flux — fast	2.0×10^{14} neutrons/cm²sec
Flux — slow	2.5×10^{13} neutrons/cm²sec
Stainless steel in core	22,000 lb
No. of fuel regions	3
Multiplication factor (K)	1.21

Fuel

Type	Compact, sintered UO_2 pellets
Density, UO_2	10.5 grams/cc
UO_2 Dimensions in fuel	0.383 x 120 inches
Average enrichment	~3.5%
Clad thickness (stainless steel)	0.0165 inches
Fuel rod spacing, center to center	0.556 inches

Water & Fuel Volume

Water	666,100 in³
Fuel	387,500 in³
Ratio — Water/Fuel (cold)	1.72

Neutron Control

Control rods	
No. of control rods	45
Composition	Silver — Indium — Cadmium
Soluble absorber	
Type	Boron (Boric Acid)
Maximum concentration	
For control (no rods) unpoisoned	2,500 ppm
For shutdown (no rods, K=0.97) cold	2,900 ppm

Heat Transfer

Average heat flux	143,350 Btu/hr ft²
Maximum heat flux	463,000 Btu/hr ft²
Ratio of max/avg	3.22
Power density per foot of rod	15 kw max.

EQUIPMENT DATA

Turbine

Type	Tandem-compound, 4-flow, 450,000 kw at 1.5″ Hg absolute, 1,800 rpm
Throttle conditions	
Pressure	680 psia
Temperature	Saturated (~500°F)
Flow	5,350,000 lb/hr
Turbine cycle heat rate	10,211 Btu/kwh at 450 mw

Reheaters

Pressure	115 psia
Temperature	453°F
Total flow	3,927,000 lb/hr
Number	4
Heat source	349,064 lb/hr main stream

Generator

Capacity	500,000 kva, 0.90 power factor, 18,000 volts, and H_2 cooled at 60 psig

Main Condensers

Type	Single pass, divided box
Size	150,000 ft² each
Number	2

Steam Generators

Type	Vertical U tube with integral steam separator
Capacity	1,900,000 lb/hr each with ¼% moisture at 710 psia
Number	3

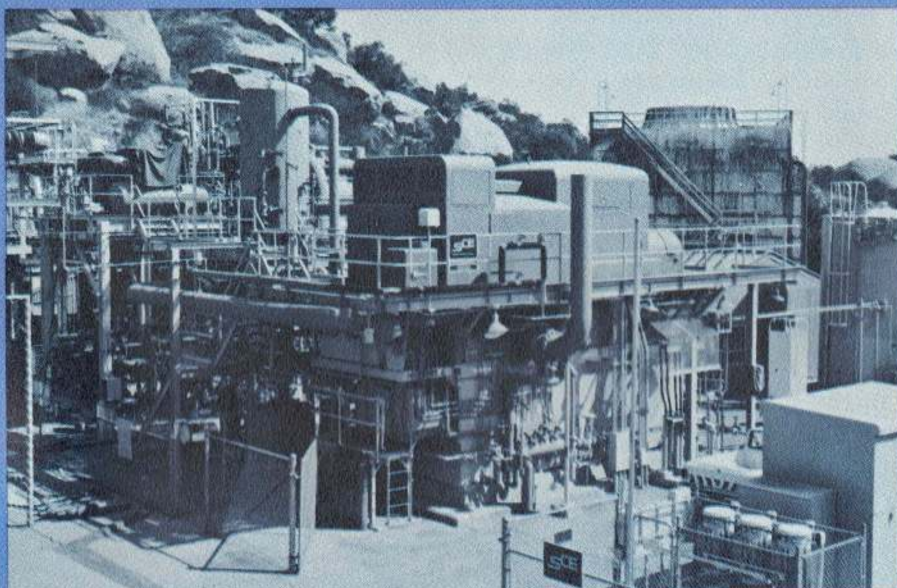
Feed-Water Heaters

2 Parallel paths	
Number	10 (5 per path)
Type	Horizontal U tube, double pass
Final feed-water temperature	417°F

Major Pumps

System	Number Required	Type Centrifugal	Capacity GPM	Rating HP
Circulating water	2	Vertical	173,000	1,500
Reactor coolant	3	Single stage	69,500	4,000
Condensate	4	Multi stage	2,900	700
Feed-water	2	Multi stage	7,000	3,500
Heater drain	2	Multi stage	2,300	600

SOUTHERN CALIFORNIA EDISON AND SAN DIEGO GAS & ELECTRIC HAVE PIONEERED THE PEACEFUL USE OF NUCLEAR ENERGY



Southern California Edison Company's nuclear powered experimental plant in the Santa Susana Mountains 30 miles northwest of Los Angeles was dedicated in 1957. The reactor at Santa Susana is owned by the Atomic Energy Commission and operated on an experimental basis by Atomics International, a division of North American Aviation, Inc.

In July of 1957 electricity produced at the plant was fed over Edison distribution lines into Southland homes and businesses. This marked the first time that a private utility company had commercially generated and distributed electricity using heat from a non-military nuclear energy reactor.

As charter members of High-Temperature Reactor Development Associates, both Edison and San Diego Gas & Electric share in a nuclear power research and development program being carried out by the General Atomic Division of General Dynamics. This association was responsible for the development of Peachbottom nuclear power station in Pennsylvania.

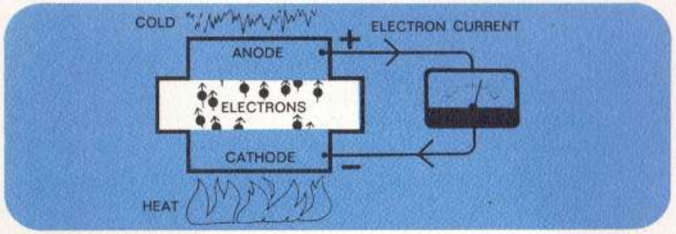
SDG&E is a member of Advanced Reactor Development Associates which co-sponsors, with General Atomic, research and development of a large, high-temperature, gas-cooled reactor capable of producing high-pressure, high-temperature steam conditions to utilize high-efficiency turbine generator equipment. The ARDA program is also working on the development of a prestressed concrete reactor vessel.

In addition, an extensive training program was undertaken to prepare Edison personnel for the design and operation of nuclear power plants . . . specifically San Onofre. Operating personnel received technical and practical experience at various nuclear installations; others were sent to special nuclear-oriented schools and courses. These included: a twelve-month course in reactor technology at Oak Ridge National Laboratory; a two-month program in San Onofre's plant systems at the Westinghouse Atomic Power Division; intensive nuclear engineering courses at the University of Michigan; a year-long seminar with the Los Angeles Department of Water and Power study team on Boiling Water Reactors; a 15-month special study at General Atomic studying High-Temperature Gas-Cooled Reactor systems; a one-year program at the University of California, which included three months of field work at the National Reactor Test Station in Idaho.

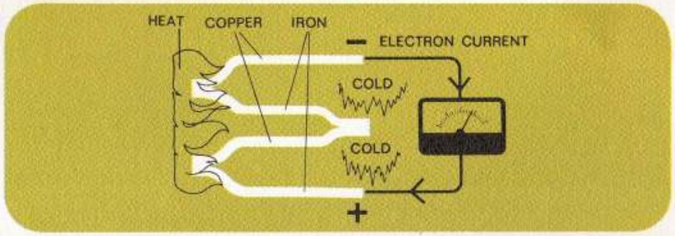
San Onofre Nuclear Generating Station is a monumental step forward in the application of nuclear fuel as a source of electric power for the future.

CONTINUING RESEARCH EXPLORES MORE POWER SOURCES FOR YOU

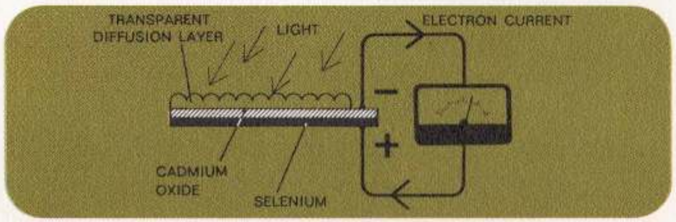
THERMIONIC



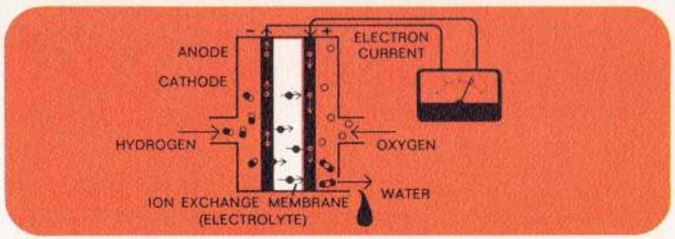
THERMOELECTRIC



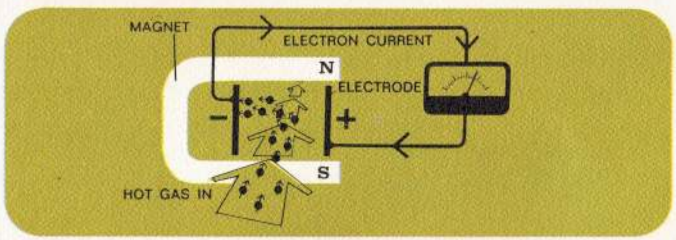
PHOTOELECTRIC



FUEL CELL



MAGNETO-HYDRODYNAMICS MHD



The investor-owned electric utility industry is looking beyond utilization of nuclear energy in power generation to even newer and more exotic methods of power production. Your electricity of tomorrow may be produced by the direct conversion of heat or chemical energy, such as the methods shown here.

1. THERMIONIC — A thermionic converter is a vacuum or gas-filled device with a hot electron emitter (cathode), and a cold collector (anode). The cathode discharges electrons to the anode. This electron exchange within a closed circuit is, of course, electricity.

2. THERMOELECTRIC — When two dissimilar metals are joined and heated at one junction, electrons begin to flow in the connected circuit. This is electricity. The materials which work best are poor conductors of heat but good conductors of electricity.

3. PHOTOELECTRIC — A photoelectric cell is constructed of two dissimilar materials treated so that one has an excess of electrons and the other has a deficiency of them. When light strikes the surface having an electron excess, the free electrons are dislodged and attracted by the second material which lacks electrons. The resulting electron movement in a closed circuit is electricity.

4. FUEL CELL — In the fuel cell, chemical energy is converted into electrical energy. Most fuel cells are continuously fed by oxygen and hydrogen. The hydrogen reacts with the electrolyte at the anode to give up its electrons and release a positively charged hydrogen ion. These ions combine with the oxygen at the cathode to form water (a by-product of this type of fuel cell) and the electrons flow through the closed circuit as electrical current.

5. MAGNETOHYDRODYNAMICS — Called MHD for short. When a moving conductor cuts through a magnetic field, current is induced in the conductor. In MHD the moving conductor is a heated gas or liquid metal moving at a high rate of speed. A powerful electromagnet provides the magnetic field, and the resulting flow of electricity travels through the circuit connected to collection plate electrodes at opposite sides of the moving gas or liquid metal.

A nation's strength is in large measure dependent upon its ability to produce abundant electric power . . . Power to give life to cities and farms . . . Power to move steel beams and build huge buildings . . . Power to run machines that build a million more machines . . . "Growth Power!"

This country, with only six per cent of the world's population, generates more than a third of the world's electricity. The United States has nearly as much electric generating capacity as the next five ranking countries combined.

This record of the investor-owned electric utility companies, which produce 80 per cent of America's power supply, provides your best assurance of abundant, low-cost power for all of America's needs today, tomorrow and in the future.

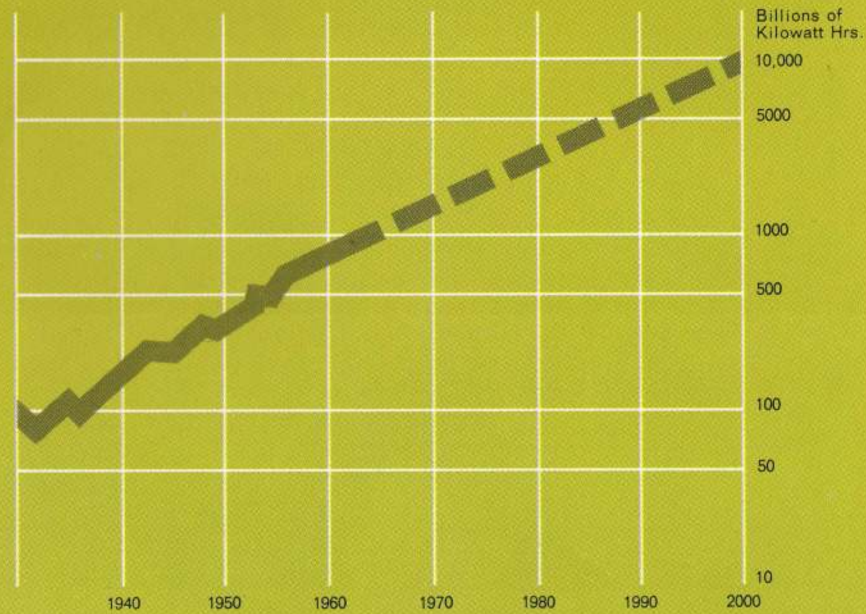
The graphic representation at right shows America's power production projected to the year 2000. It's an enormous growth picture. By 2000 the generating capacity of the United States will be 100 times as great as it was in 1930 . . . more than 10 times as great as it is today.

In 1930 the approximate amount of electric energy generated in the United States was 100 billion kilowatt hours. By 1965 this figure had soared to one trillion kilowatt hours.

The nation's growth depends upon an ever-increasing supply of economical electric power. The investor-owned electric utility industry is constantly conducting research and development to find new uses for and sources of electricity. Whatever the source, electric energy is limitless and your electric companies will continue to bring you an abundant supply at the lowest possible cost.

With the aid of the world's finest engineers and scientists, America's investor-owned electric utility companies stand ready and able to meet in full the future power needs of all Americans.

U.S. ELECTRIC ENERGY GENERATION



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