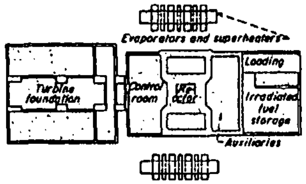
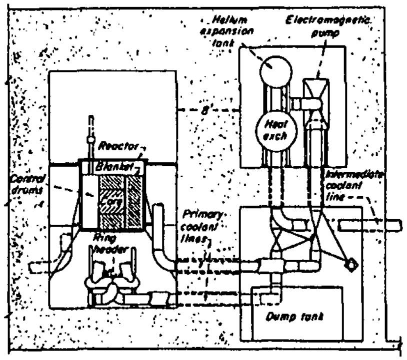
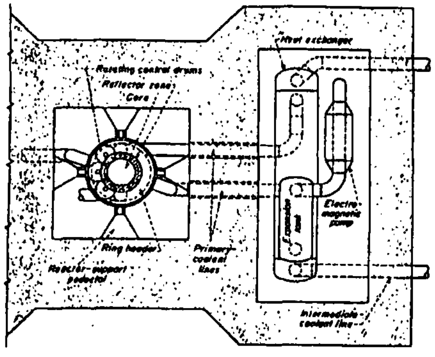






COMPACT SODIUM-COOLED REACTOR must be shielded and arranged for removing products and recharging at intervals

device releases the plates to let them fall into their sheaths.

A storage area holds new fuel assemblies. A separate storage tank holds irradiated fuel assemblies for the necessary time. The entire reactor charge must be replaced several times per year.

Reactor-plant operation needs 103 men, and power-plant 14 men, a total of 117. These do not include maintenance men. It was assumed that fuel-element fabrication and processing would be handled by central facilities.

Liquid-Metal-Cooled Fast Reactor. Table I gives details of the reactor, shown on page 100. A breeder blanket of depleted or natural uranium surrounds the reactor core

III — Power Cost, Sodium-Cooled Reactors

A: Dual-purpose reactor as currently conceived for power and plutonium
I: Dual-purpose reactor as currently conceived for power only
II: Dual-purpose reactor as currently conceived for power only after 5-year amortization
III: Future improved reactor built for power only
B: Conventional steam power plant

Item	A	I	II	III	B
		(Millions of dollars)			
Site and yard investment	2.8	2.8	2.8	1.1	0.5
Reactor-plant investment	33.1	33.1	33.1	16.6	—
Power-plant investment	15.1	15.1	15.1	12.1	13.5
Total investment	51.0	51.0	51.0	29.8	14.0
Site and yard fixed charges	0.36	0.36	—	0.15	—
Reactor-plant fixed charges	4.50	4.50	—	2.26	—
Power-plant fixed charges	2.05	2.05	—	1.65	—
Total fixed charges	6.91	6.91	—	4.06	1.90
(mills per kwhr net output)		(6.8)		(3.6)	(2.9)
Reactor annual operating cost	1.06	0.74	0.74	0.37	—
Power-plant annual oper cost	0.46	0.46	0.46	0.35	—
Total annual operating costs	1.52	1.20	1.20	0.72	0.40
(mills per kwhr net output)		(1.2)	(1.2)	(0.6)	(0.6)
Annual fuel, processing cost	10.38	4.60	2.50	1.50	1.67
(mills per kwhr net output)		(4.5)	(2.4)	(1.3)	(2.5)
Total annual costs	18.81	12.71	3.70	6.28	4.00
Net capacity, mw	145.0	145.0	145.0	160.0	100.0
Net an. output, 1000 mwhr	1020	1020	1020	1120	667
Average energy cost, mills per kwhr		(12.5)	(3.6)	(5.5)	(6.0)

of highly enriched material. An assembly of a large number of stainless-steel fuel elements make up the core. A reflector will probably envelop the core, decreasing the critical mass and limiting the heating outside the core. All these are in a cylindrical steel vessel, 8x8 ft. The vessel must be designed to circulate the liquid sodium, to refuel, and to accommodate control mechanisms.

Two electromagnetic pumps circulate the primary coolant to two intermediate heat exchangers at 900 F, returning to the reactor at 600 F, p. 99. The intermediate coolant (sodium) heats the two steam generators. The intermediate heat exchanger can be a single-tube design since sodium leakage from intermediate to primary circuits will not affect reactor operation.

Moving a reflector between core and blanket, or altering disposition of fertile and fissionable material can be used to control the reactor. Either method can use control drums, p. 100. Another possibility is a movable reflector outside the core, which can be raised or lowered to change reactivity.

Need for an inert atmosphere (helium), above the sodium at all times, complicates refueling. Complete refueling of the core and inner portion of the breeder blanket will be needed once a year. If the reactor runs as a converter, the U235 remaining in the core must be decontaminated and reprocessed. If the reactor runs as a breeder, a portion of the separated and decontaminated plutonium must be reprocessed to make up a future core.

The reactor is designed to run with an 80% annual capacity factor. One month is provided for scheduled maintenance and refueling.

The fast reactor cannot be considered equal to the water-cooled reactor on the basis of existing technology, time needed for design and construction, reliability of cost and performance estimates, or safeguards and degree of isolation now required.

Two more years will be needed to complete a fast reactor

installation, compared to a water-cooled thermal reactor. This could be reduced at the expense of additional and parallel development work.

Test results to date have not shown any limitations on temperature of liquid sodium. With further experience it may be possible to raise coolant temperatures to generate 1000-F steam for the turbine.

Economic Studies. Table II gives the estimated investment costs for the two types of dual-purpose reactors. All costs are based on June 1952 rates and prices. They are contractor's price, plus 10% for owner's overhead. AEC laboratory nuclear design and development entails considerable cost that was not included in these estimates. This was not considered chargeable to a specific project.

Table III shows the results of brief studies made to measure the economic feasibility of nuclear energy. These are based on 20-year amortization for power and fuel fabrication plants, private utility financing, 80% capacity factor.

Case I shows that an immediately feasible nuclear-power plant cannot compete with current steam-electric plants. The 3.6 mills per kwhr of Case II assumes capital costs of the plant have been amortized, and shows the plant would have substantial value as a power producer after retirement from plutonium production. Case III indicates that a future atomic plant might produce power on a competitive basis. This assumes reduced costs stemming from: improved technology, operating experience, construction of a large block of capacity (500 mw) at one site.

Certain improvements in thermal efficiency could be attained by refinements of design in the turbine-generator plant, resulting in plutonium-cost reductions. This becomes increasingly important as the economic life of the project is extended. Uncertainties with the initial plant, however, and the desire to minimize investment make it preferable not to use such refinements now.

When reactor operating conditions have been established in an actual design, detailed analysis should be made to evaluate cycle refinements. On a project for power only these would be of greater importance.

Conclusions. 1. Dual-purpose reactors are now technically feasible.

2. Construction and operating costs of the water-cooled thermal-type reactor can be predicted with fair degree of accuracy. Detailed design of such a reactor can be started promptly. Placing primary emphasis on plutonium production, at earliest possible date for a definite production period, will make this reactor very attractive.

3. The liquid-metal-cooled fast reactor conserves uranium and promises to be adaptable to high steam conditions. This makes it more attractive for power. Design and construction ought to be undertaken even though certain development work will be needed during the design period.

4. Though the liquid-fuel fast reactor seems to have greatest possibility of low-cost power production, the development still needed prevents design and construction in the near future.

5. It seems power sales from a dual-purpose reactor will not reduce the cost of plutonium production by a substantial amount. Under present plutonium demand and cost conditions, however, power sales more than justify the additional equipment in dual-purpose plants. After plutonium demand ceases and investment is recovered, the reactors may be economically valuable as power producers only.

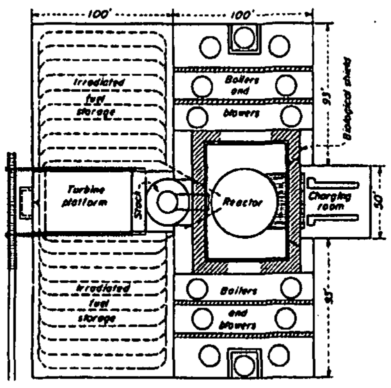
Commonwealth Edison — Public Service

This group believes heavy-water-moderated and cooled reactor has best economic possibilities. But they see the gas-cooled reactor as a substantial beginning in atomic power, one causing minimum interference with production reactors now under construction or contemplated

Two reactors were considered: (1) gas-cooled graphite-moderated (2) heavy-water-moderated and -cooled. The gas-cooled unit was chosen first, because more information was available on engineering, construction and operating experience. It seemed that less extrapolation of design data, less time and expense for research and development would be needed.

The heavy-water reactor was conceived essentially by the Argonne National Laboratory. The working group primarily helped in solving some of the electrical, mechanical and structural design problems, and prepared cost estimates.

Gas-Cooled Reactor. This 350-mw heat-output unit has



HELIUM-COOLED REACTOR: boilers in 60-ft-high building feed 350-psig 525-F steam to 60-mw turbine on open platform