Congress of the necessity to do so; thus far, Congress has been generally sympathetic while remaining skeptical of ambitious new programs in the area.

In the universities, it is difficult to gauge the extent to which antimilitary feeling has dissipated in the post-Vietnam climate. So far, DOD's gradualist approach and the kinds of research supported have not precipitated any serious backlash.

As for the legacy of the Mansfield Amendment, the Galt report noted that confusion still surrounds the relevance criterion. This is doubtless one reason for the Brown memo. DOD officials emphasize that they are interested only in sponsoring basic research which has genuine promise for solving defense problems. At the same time, there has been concern that the definition of relevance has been construed too narrowly. Relevance is always to some extent in the eye of the beholder, and in this case the law says the eye that counts is that of the Secretary of Defense.

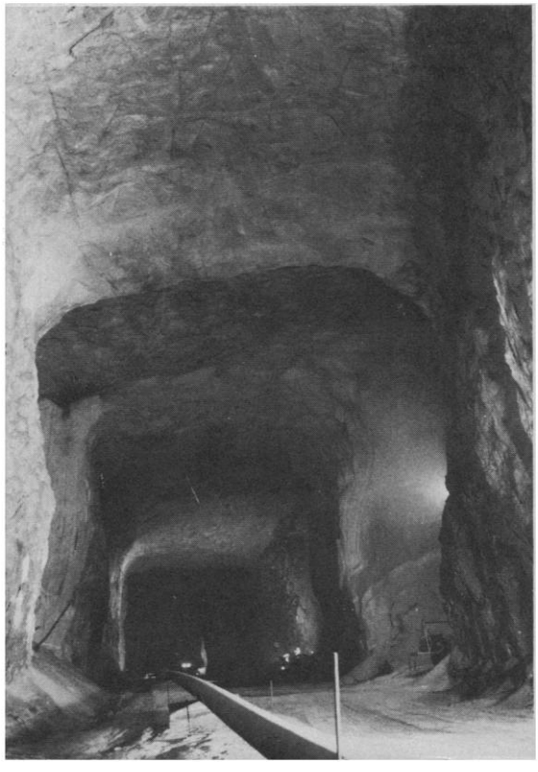
—JOHN WALSH

An Oil Insurance Policy That May Lapse

Strategic Petroleum Reserve plagued by early mismanagement, now beset by oil supply shortage, presidential commitments

As the Carter Administration and Congress push their search for a solution to the national energy problem, the long-troubled program to establish the Strategic Petroleum Reserve is receiving little high-level attention and continues to languish. Yet this reserve, which, if filled, will consist of at least 750 million barrels of crude oil stored in Gulf Coast salt domes (see box), would be the only buffer between the United States and an economic disaster in the event a large part of U.S. oil imports were cut off.

As insurance against such a calamity, Congress, acting at the urging of President Carter and President Ford, has appropriated nearly $7 billion for the reserve since early 1975. Some $1.4 billion of that amount will cover most of the development cost for the first 528 million barrels of storage capacity and the associated oil handling facilities; the remaining $5.6 billion will be a modest down-payment on the total cost of the oil needed to fill the reserve, now estimated by the Office of Management and Budget at $19 billion.



A tunnel in the Weeks Island salt mine. The mine will soon be sealed and declared ready to receive oil for the strategic reserve.

This is high-cost insurance, but the judgment at the White House and in Congress has been that it is worth the price. With a full reserve, the immediate response to a severe shortage would be to start moving crude from the salt dome storage facilities—at an initial rate, if need be, of as much as 4 to 5 million barrels a day—into the pipelines and fleets of coastal tankers that regularly deliver oil to most of the nation's refineries. The vital infusion of oil could be maintained for a half year or longer, thus giving the President a better chance to bring about a resumption of the flow of imports by careful diplomacy or other means.

But, while nearly everyone has agreed that the reserve is a great idea, there is less than 90 million barrels of oil in storage today and the flow of oil into the reserve has been drying up. Because of U.S. foreign policy commitments and the possible, if not probable, difficulty of filling the reserve without reducing supplies of petroleum products demanded by consumers, the reserve may go begging.

No oil has been purchased for the reserve since late last year when, with the mounting political crisis in Iran, the world market began to tighten. For the reserve to be filled to its planned capacity by the end of 1986, which is as early as anybody is now hoping for, officials at the Department of Energy (DOE) say that 250,000 barrels of oil a day must begin flowing into it by November, with this rate to be maintained day in and day out for the next 7 years.

President Carter's recent promise not to allow imports to exceed 8½ million barrels a day may mean that there can be no such steady flow of oil into the reserve, barring a prolonged recession. The import ceiling is 500,000 barrels a day above the current rate of imports, but 400,000 barrels below last fall's. To put 250,000 barrels a day into salt dome storage could put the reserve program in competition with consumers who want gasoline, home heating oil, and other petroleum products to remain in easy supply. With an election coming up, the President is unlikely to ask consumers to sacrifice for the sake of a reserve intended as a safeguard against severe supply disruptions that some people will perhaps regard as speculative and remote.

Buying oil for the reserve may be further constrained by commitments made in June at the Tokyo summit. President Carter and the leaders of other noncommunist industrial nations agreed not to buy oil for strategic storage when this would place "undue pressure" on prices. The tightening of the world oil market caused by the stoppage and subsequent curtailment of Iranian production already had led Secretary James R. Schlesinger, back in the early spring, to order DOE to suspend its efforts to buy oil for the strategic reserve, pending a softening of the market.

There has not, however, been a decision for the reserve program to be quietly dropped. Jay R. Brill, the retired Air Force general now directing the program, says there is no reason even to think that either the Carter Administra-

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tion or Congress feels that plans for the strategic reserve should be reduced in scale. "I've heard nothing that would indicate a deemphasis of the reserve," Brill told *Science* in an interview several days after President Carter promised, in his television address of Sunday 15 July, to curb the nation's appetite for imported oil.

It is up to the United States and the other oil-importing nations to depress the spot market by energy conservation, Brill says. In his view, this can and will happen. He predicts that by October DOE will be back trying to buy more oil.

But, despite such official optimism, prospects for filling the reserve appear doubtful, even allowing for the increases in production next year on the North Slope of Alaska and at the old Elk Hills naval petroleum reserve in California. That this should be so is ironic, to say the least.

In the reserve program's earlier years there was no scarcity of oil and the spot market was sagging. But at that time the reserve was not ready to receive a large, steady inflow of oil. Development of storage capacity and oil handling facilities—pumps, pipelines, surge tanks, and terminals—was a far larger and more complex undertaking than DOE had recognized. According to the fill schedule decided on in 1977, a total of 500 million barrels was to be in storage by the end of 1980, and half that amount was to be "in the ground" by late 1978. But plagued by technical mistakes and managerial incompetence, there was simply no chance of meeting this schedule which Brill thinks was unrealistic to begin with.

Now things are the other way round. The reserve is expected to be ready soon to receive oil in large and steady volume—storage capacity for a quarter of a billion barrels will be available by late fall and installation of another 280 million barrels of capacity will be well under way. But present market conditions for buying oil could hardly be worse.

In the hope that filling the reserve will be possible, Carlyle Hystad of DOE's policy evaluation office is preparing an options paper for Secretary Schlesinger, who will not be leaving DOE until fall. Hystad, who has been spending most of his time on more insistent problems such as the gasoline shortage, told *Science* in mid-July that he did not know when this task of policy formulation would be completed. However, Hystad and others have indicated that the strategy emerging is to have DOE's purchasing agent, the Defense Fuels Supply Center, seek to buy the oil needed for the reserve on long-term contracts, extending over 3 to

Oil in Salt Domes

Storing crude oil in man-made caverns in salt domes, rather than in steel tanks above ground, is attractive for several reasons.

The domes, of which there are nearly 500 along the Gulf Coast of Texas, Louisiana, and Mississippi, are immense columns of rock salt, generally 1 to 3 miles across and several miles from top to bottom. Rising from a mother layer of bedded salt, they have moved upward (probably because of their buoyancy) through the overlying sediments to within a few thousand feet of the surface of the earth and in some cases to the surface. Huge caverns can be leached out in these domes at relatively low cost by injecting large volumes of water into the domes—about 7 barrels for every barrel of storage capacity created—and then pumping out the brine.

Furthermore, the Gulf Coast is a convenient place to establish a strategic oil reserve. About 40 percent of all U.S. refining capacity is located there, and most refineries elsewhere can be easily supplied from a reserve in this region by either tanker or pipeline. Also, salt dome storage is a familiar technology, although never before has it been done on anything approaching the scale now being attempted. Over the two previous decades hundreds of caverns have been leached in Gulf Coast domes by private companies, in some cases to produce brine for use in petrochemical processes and in others to create storage space for hydrocarbon fuels, such as propane and butane. Although crude oil has not, until now, been stored in salt domes in the United States, it has been done effectively in Europe.

The strategy for establishing the U.S. petroleum reserve has been first to make use of 16 existing caverns, ranging in capacity from 5 to 22 million barrels, and the vast labyrinthine maze of chambers and tunnels of the old Morton salt mine at Weeks "Island," a topographic feature so named because an upthrusting salt dome has caused the land above it to rise 170 feet above the marshes and lowlands of the Louisiana coastal plain.

In the second phase of implementation, 32 new caverns with a capacity of 11 million barrels each are being created expressly for the reserve. It will be possible for oil to begin flowing into these caverns even as the leaching proceeds, because the leaching takes place in the lower part of the cavern and the oil floats on top of the brine thus created.

Viewed in perspective, the strategy for establishing the reserve storage facilities makes sense, but for a time its implementation was so beset by managerial and technical problems that it looked as though the Strategic Petroleum Reserve program might founder. For instance, brine disposal wells performed only about half as well as expected, and plans to lay brine disposal pipelines out into the Gulf of Mexico ran into environmental difficulties. Construction of the brine pipeline from the Bryan Mount salt dome south of Houston, Texas, was delayed 1½ years by permit procedures, and the pipeline finally had to be extended 14 miles offshore.

In addition, mistakes were made in assessing the size, shape, and structural integrity of a number of caverns. Some 87 million barrels of presumed existing capacity was ultimately found not to be there. New capacity, created through leaching, will have to be substituted at a cost of $217 million.

These and other problems seem to have deflated the extreme optimism that characterized the early days of the reserve program and have led to better management. Representative John D. Dingell (D–Mich.), chairman of a House energy subcommittee, is now persuaded that installation of storage facilities is progressing satisfactorily. The first phase of developing storage capacity will have been essentially completed this fall when the Weeks Island facility, which with its 75-million-barrel capacity is the reserve's largest single storage unit, is ready to receive oil.

Last winter, the reserve program was ridiculed in the press because there were no pumps for recovery of the oil already placed in storage. Yet the reserve managers' decision to make putting oil in the ground their first priority was not unreasonable. The pumps will soon be in place, but there is not much oil to recover should a crisis arise.—LUTHER J. CARTER

5 years or longer. The contracts would be with producing entities such as PEMEX in Mexico, ARAMCO in Saudi Arabia, and BP in the United Kingdom's North Sea province.

William Robinson of the Defense Fuels Supply Center is by no means confident that such producers will be willing to enter into long-term arrangements. The present tendency of producers, he says, is to sell on the spot market or to keep the oil for their own refinery needs. But Robinson, like Hystad, thinks an effort should be made to obtain such contracts, for they would offer substantial advantages.

One advantage is that the reserve would have an assured supply of crude, with the price being based primarily on the going OPEC rate at the time of delivery rather than at the much higher prices that would exist on the spot market under tight market conditions. Buying oil under long-term arrangements might offer the further advantage of putting less pressure on the world price than would repeated entries into the market to make spot purchases or to buy oil on short-term contracts.

Oil could be diverted to refineries even in times of noncritical shortages and thus used to increase supplies of gasoline and heating oil, but only at the risk of allowing the filling of the reserve to stretch out interminably.

In the event half of U.S. oil imports were cut off, severe shortages would be felt within 2 months, and—even with rationing, fuel switching, and other emergency measures—the present 90-million barrel reserve would be exhausted less than 1 month after the drawdown began. According to Edward N. Krapels, a petroleum economist and consultant to DOE, other industrial nations such as Japan, France, and Germany now have emergency reserves that would last about 45 days.

As of this writing, President Carter has not mentioned the strategic reserve in any of the energy policy statements he has made since his 10 days of brainstorming at Camp David in July. This does not mean the President now regards the reserve as unimportant; that would be a remarkable switch, for only last year it was at his initiative that the ultimate goal for total oil in storage was raised from 750 million barrels to a billion barrels (although no planning to that end has ever been done). But it does clearly mean that more politically pressing things are on his mind.

In sum, the future of the reserve program looks bad. The best chance that the reserve will be filled may lie in the gradual increase in the price of gasoline and other petroleum products resulting from the rising cost of imported oil and the phased decontrol of domestic crude oil prices.

If the price of gasoline went to $1.30 a gallon, say, it might help the reserve. But this is not likely soon to happen in the absence of the decontrol of gasoline prices, an option which President Carter has firmly rejected.—LUTHER J. CARTER

Thermidor at OTA

While the Administration was making high-level chops and changes, the congressional Office of Technology Assessment (OTA) had its own internal shake out. Jack Gibbons, who has been OTA director since 1 June, on 3 July fired 23 staff people, including several of the senior technology assessors. Gibbons has presented this as an economy move forced by the Congress. Skeptics abound among both fired and retained, which is why the firings have created a stir in the Washington science community.

Gibbons has explained that, unexpectedly, a shortfall of $1.8 million turned up in OTA's current budget of $11 million. To economize, Gibbons deferred $1.3 million in contracts to the next fiscal year, which begins 1 October; and another $500,000 was cut out of existing programs.

Included among those released is Joseph Coates, who headed OTA's exploratory office and was one of the initial proponents of the technology assessment concept. Coates was also the moving force behind the OTA-generated list of 50 research priorities, which caused much ill will in Congress last year. The office and its staff of five, including Coates, was eliminated.

Three lower-level staff have been dropped from OTA's office of administration, which is responsible for keeping tabs on the budget; one from the health and life sciences division; and 11 from the division of science, information, and transportation (mostly transportation). Three of the five persons in the press office were also terminated. The total amounts to 18 percent of OTA's staff of 130.

Gibbons says he released those that were least important to tasks specifically assigned by Congress. "I have no commitment to any individual here," he says, "but I do have a commitment to Congress to run OTA fairly and effectively. Coates' office did not have that much to do with what the Congress wants."

Skeptics on the OTA staff—past and present—say that most of those fired had the misfortune to cross swords at one time or another with Skip Johns, who directs OTA's energy division. No one in Johns' division was fired. Gibbons, before becoming director of OTA, worked with Johns on energy advisory panels. "Johns has gotten Gibbons to purge his enemies," is the way several of the wounded put it. Gibbons denies it. The candidates for firing came from all three division directors, he says, and the choices were made by him.

The skeptics also point out that a few weeks before the discovery of the OTA budget shortfall, Tom McGurn, the top OTA budget officer, was asking everyone to hurry up and spend more money. OTA had a surplus, he said, and would have to start some new studies swiftly or it would be left in the bureaucratically embarrassing circumstance of actually receiving more money than it used. Gibbons remembers the surplus projected then as $500,000; others remember a figure of $2 million. Whichever, it evaporated quickly as the initial weeks of Gibbons' tenure sped by.

Gibbons has told his congressional overseers that the discrepancy was caused by inattention to OTA's overall budget projections during the period just before he arrived—inattention particularly to spending projections. As it now stands, he says, "we have totally mortgaged next year's program with the contract deferrals from this year, unless we get a budget increase from Congress." In a typical maneuver, the House has already cut OTA's budget by $1.6 million; Gibbons is now pressing the Senate to assume its traditional role and boost it back up to the current level, or an even higher one, so that a compromise can be reached right in the middle. He is understood to have said he expects to do some hiring if the budget cuts are restored.—R. JEFFREY SMITH

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