in funds for building the very large array (VLA) telescope was requested, even though last year Congress lopped a similar $10 million request for the VLA in half. Science policy, technology assessment, and such activities are also receiving increases, including the Science and Technology Policy Office, which was set up last year to aid Stever as science adviser.

Apart from these increments, other NSF program budgets will be struggling to keep up with inflation. The four national research centers are proposed to receive only minor increases. The National Center for Atmospheric Research will receive only $1 million more—although even that amount may signal NSF's renewed confidence in that recently troubled establishment.

There are casualties too. The Experimental Research and Development Incentives Program was virtually exterminated with a cut from $12.3 million to $1 million. RANN's fire research is to transfer to the Department of Commerce. Institutional Grants for Science, which received $7 million in obligations last year, was cut out altogether. The Science Education Improvement Program dropped by $6 million to $61 million. The latter two programs are popular on Capitol Hill and Congress will probably try to restore these funds.

If the Congress approves anything like this proposed budget, the NSF could find itself in fiscal 1975 with a new mix of activities, emphasizing energy, and bolstering basic research and science policy. However, the mood in Congress during the last year or so has been to fiddle, sometimes drastically, with the Administration's NSF budget proposals. Last year, both the authorization and appropriation reports included various floors and ceilings on NSF's spending, forcing several programs to change their plans. A recently launched General Accounting Office investigation of RANN, requested by one of RANN's chief backers, Senator Edward M. Kennedy (D–Mass.), may also indicate skepticism.

Finally, by the time this budget undergoes congressional scrutiny, it will be spring, and the crisis atmosphere of the winter's energy shortage, in which this budget was prepared, may be giving way to more sober reflection on these new trends.—DEBORAH SHAPLEY

Synthetic Fuels: Will Government Lend the Oil Industry a Hand?

For half a century now, the American petroleum industry has kept a covetous eye on the nation's immense deposits of coal and oil shale, secure in the knowledge that it would someday be practicable to make synthetic oil and gas from these vast hydrocarbon reserves. Until recently the prospect of a synthetic fuel industry remained a tantalizing mirage, shimmering just beyond the grasp of profitability, but now that vision is fast approaching reality.

The combined effects of government and industry research, and the exploding prices of conventional petroleum, have brought synthetic oil and gas* well within a comfortable profit margin. The federal government has begun leasing large tracts of rich Western shale lands, and even before the Organization of Petroleum Exporting Countries (OPEC) succeeded in doubling the world market price of oil, private industry was pressing ahead with plans to build at least one shale oil plant on private land and two commercial coal gasification units in the West.

Notwithstanding this swift progress in the fortunes of synthetic fuels, the White House, urged on by a number of federal energy officials and the oil and gas industries, appears to have concluded that the government ought to be doing even more than it already is to accelerate the birth of a new industry in the interest of national self-sufficiency. The clearest indication of this tilt toward synthetic fuels, but by no means the only sign, appeared in a little noticed section of President Nixon's energy message to Congress on 23 January. Urging a rapid increase in domestic energy supplies, he called for "maximizing the production of our oil, gas, coal, and shale reserves by using existing technology. . . ." Later in the message, under the heading "Stimulation of synthetic fuel production," Nixon asked federal energy chief William E. Simon to evaluate possible "financial or economic incentives or regulatory changes" that may be needed to overcome present constraints on a "major increase in the commercial production . . . of synthetic fuels."

Well before the January message there were scattered signs that the Administration was gradually moving toward a commitment both to share the financial risks inherent in the first commercial shale and coal-conversion plants and to help industry raise billions of dollars in capital to build such plants. No formal proposals have emerged yet and no money is changing hands. But there is a ground swell of opinion in the Administration that it ought to.

"One of the major presidential priorities is to get these pioneer plants online with existing technology," an official of the Office of Management and Budget (OMB) remarked in late November. By early December a clutch of "task forces" under the Atomic Energy Commission's national security affairs chief, Major General Edward B. Giller, was exploring the incentives problem in conversations with oil and gas industry representatives. Among the incentives then (and still) under discussion in the AEC, the Interior Department, and the OMB were low-interest loans to industry; guaranteed loans, in which the government would take the loss if a synthetic fuel venture failed; accelerated tax write-offs for first-generation plants; oil import tariffs or government purchase contracts that would put a floor under prices, and thus profits, on synthetic fuels; an easing of patent restrictions; and, to expedite construction, special dispensations from environmental laws for pioneer plants.

"There is no consensus [in the Administration] as to what should be done to promote synthetic fuels," an AEC official close to these discussions said

* The term "synthetic fuel" is widely used to describe any burnable gas or liquid derived from oil shale or coal.

in mid-January. But, he added emphatically, "There is a consensus that *something* should be done."

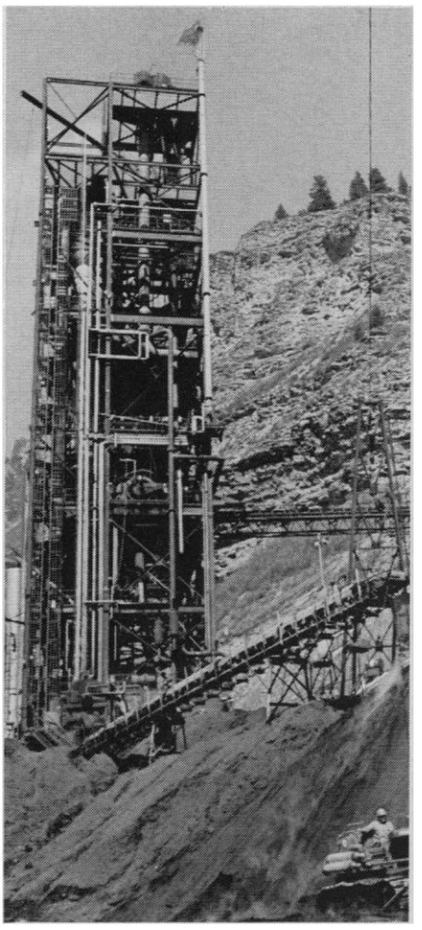
What all of this adds up to is that the Nixon Administration has arrived, or believes it has, at roughly the same juncture the government reached with respect to nuclear energy in the late 1950's. Then, as now, an exotic new energy technology had been cultivated nearly to the point of commercial practicality, but formidable financial risks and engineering difficulties faced the builders and buyers of the first few plants. The problem was one of persuading utilities to pick the fruits of government and industry research, while minimizing the cost to the public of subsidized sweeteners.

In the case of synthetic fuels, the central problem is perceived by the Administration as being much the same. As OMB director Roy Ash expressed it in December to the Senate subcommittee on research and reorganization, "We must harness the capability of the private sector . . . in a way that does not unjustly enrich private groups." This, Ash observed, may be "just as big a problem as doing the R & D in the first place."

Some of the same peripheral questions that arose 20 years also arise with the launching of a synthetic fuel industry. How rapidly, for example, can or should shale oil and coal conversion plants be built? What, if anything, can be done to prevent monopolistic concentration in the new industry? While special subsidies and exemptions to regulatory laws may be appealing to the private sector, to what extent are they necessary?

To all appearances, the Administration is groping for answers in a fog of uncertainty. About the only areas of general agreement in and out of government concern the immensity of the coal and shale resources awaiting exploitation and the relative maturity of the various synthetic fuel technologies. Thus "existing" technology consists of two processes for cooking oil out of shale in large retorts, or pressure vessels, and two similar processes for generating a substitute for natural gas from coal. Technology for making synthetic crude oil and a low-grade liquid or gaseous industrial boiler fuel from coal lags as much as 5 years behind, according to some authoritative estimates.

As for costs, a shale oil plant producing 100,000 barrels of oil a day is variously—and perhaps optimistically



Shale oil pilot plant in Colorado.

—estimated to run between $400 million and $500 million; production costs are pegged between $4 and $6 per 42-gallon barrel, or about the same as the current price of conventional oil in the United States. A single gasification plant turning out 250 million cubic feet of gas a day (about the minimum scale thought to be profitable) has generally been estimated at $500 million, but $625 million may be closer to the mark.

Opinions on the necessary or desirable size of a synthetic fuel industry vary a good deal more wildly than predictions of costs. The urgency (or lack thereof) for building shale and gasification plants depends critically on how one believes the recent doubling of oil prices will affect supplies of oil from conventional sources in the United States. Those who interpret their tea leaves grimly tend to opt for something on the order of a crash program —modeled on the almost overnight creation of a synthetic rubber industry in the United States during World War II—while the optimists and those who are simply uncertain urge restraint.

Toward the pessimistic end of the spectrum is Alvin M. Weinberg, now William Simon's R & D adviser, whose vision of maximizing synthetic fuel production would entail what Weinberg has called a "grand mobilization" of the oil and chemical industries. Last December, while he was still director of Oak Ridge National Laboratory, Weinberg told a Senate subcommittee that it was certainly prudent to find new oil fields and squeeze all that could be gotten out of old ones, but that "it is clear that these measures will not really be sufficient." Accordingly, he endorsed a proposal to build some 40 plants by 1980, which would produce 2 million barrels of shale oil a day and an equivalent amount of gas from coal. All this would cost between $30 billion and $50 billion, Weinberg said, but the idea had about it a "certain American attractiveness" and might be good for the economy "if indeed the energy crunch is going to throw us into a depression."

On the opposite end of the spectrum are a number of reputable economists whose chief concern is not a depressed and oil-starved economy but rather, as the London *Economist* phrases it, "the coming glut of energy."

This school holds that oil production is a textbook example of price-supply elasticity, and that the response to recent price rises—if they are maintained —will be dramatic. Or, as MIT oil economist Morris A. Adelman told a Washington energy meeting in January, "oil is going to be coming out of the woodwork all over the world." Similarly, Hendrick S. Houthakker, a former member of Nixon's Council of Economic Advisers, believes that the now-doubled price of oil could lead to a doubling of North American production without any help from synthetic fuels, although he favors government assistance for a small shale oil program. According to Houthakker, the United States could become an oil exporter by the early 1980's.

Economists are scarcely of one mind on the subject, however. Oscar Gass, a well-known consultant in Washington, is highly skeptical of Houthakker's predictions; he contends that individual oil companies have no clear idea of how much oil they can find and produce at a given price, "so how can you model a whole country like this?" Houthakker replies that his own estimates may be conservative—that some industry economists believe doubled prices could *triple* production.

Yet another question on which opinions conflict is how fast synthetic fuel plants could be built if in fact they are needed. One difficulty is that shale oil, coal gasification, and nuclear power plants would all compete for some of the same skilled labor (welders and pipefitters) and the same basic components (heavy-duty plumbing and large steel pressure vessels), and there may not be enough to go around.

All of these uncertainties have led the AEC, which seems to be devoting as much thought to the matter as any agency, to the conclusion that a massive synthetic fuel program cannot now be justified. Accordingly, the AEC is floating a rather modest proposal for what the agency calls a "Synthetic Fuels Pioneer Program."

It would involve offering loans and other incentives to industry to build one plant† to demonstrate each reasonably mature technology, perhaps half a dozen plants in all. This would be sufficient, the AEC contends, to work out remaining bugs in each technology and provide a basis for standardized, mass-produced commercial plants; the pioneer facilities would also serve as "test beds" for advanced components.

It's hard to tell how much thought has gone into the plan, and the AEC is still vague about its mechanics. One federal energy official says scornfully that it was just "cobbled up one Saturday afternoon" as part of Dixy Lee Ray's hurried efforts to assemble a 5-year plan for energy R & D (*Science*, 30 November 1973). Some of Ray's advisers, in any case, lean toward guaranteed loans and a guaranteed market as the tidiest incentives.

One favored device for assuring a minimum price for synthetic fuels is the Defense Production Act of 1950. This law—used during the Korean War to stimulate production of such materials as tantalum, fluorspar, and tungsten—allows the government to buy up (at a prearranged price) and stockpile materials deemed "strategic and critical to the national defense," thereby creating an artificial and publicly subsidized demand. If everything works the way it's supposed to, the government can recoup its losses later by selling the stockpiles at higher prices.

The Defense Production Act (which expires this June) also gives the President power to grant guaranteed loans up to $20 million without congressional approval, but Administration opinion is sharply divided as to their necessity. Indeed, some bureaucrats view a loan program as a potential administrative and political disaster.

"It places the burden on us, rather than industry, for deciding whose technology is best; we'd end up backing a lot of white elephants," says one Interior Department administrator. "Can you imagine the uproar if Exxon came looking for a loan," he adds. "I'd have 43 Senators and Ralph Nader threatening to hang me and another bunch of calls supporting little Teakettle Products, Inc. in eastern Oklahoma."

For an oil company thinking about building a half-billion dollar shale plant, a guaranteed loan offers two big advantages: In the event of failure, the public, not the company, would absorb the loss; and banks, assured of repayment in any event, would offer preferential interest rates, thus reducing the company's expenses and widening its margin of profit.

But while government backing may be desirable from the company's standpoint, there is reasonable doubt that it's necessary. For one thing, estimated costs of a shale or a gasification plant are not much higher than the tabs for nuclear power plants that utilities are building by the dozen without benefit of government financing. "Industry's hangup," says one Interior Department official, "is that a synthetic fuel plant involves more than the usual risks of putting up a refinery. But all the collateral they need to get financing is a government purchase contract for the product."

Countering the Oil Weapon

As if the pros and cons of public help for private industry were not complicated enough, yet another factor—foreign policy—weighs in the balance. The notion is widely accepted among oil analysts in and out of government that a "credible commitment" to launching a synthetic fuel industry would be a useful bargaining chip in dealing with oil exporting nations—a kind of technological countermeasure to the "oil weapon."

The thesis is that OPEC, like any cartel, can be induced to talk sweet reason (perhaps even to collapse) if the cartel believes its market is genuinely threatened by new sources of petroleum. If OPEC nations were not actually driven to unilateral price cutting, or so the scenario goes, they might at least be driven to accept an international commodity agreement with importing nations that sets prices agreeable to both sides. New oil straight from the ground would serve this purpose as well as any made from shale or coal, but synthetic fuel is nevertheless regarded as a potentially valuable supplement, especially for Western Europe, where coal resources are large and there is only the North Sea to look at for additional supplies of old-fashioned oil and gas.

That OPEC members might be having similar thoughts is suggested by the Shah of Iran's recent promise to peg the future price of his country's exported oil at the cost of making synthetic fuel. His objective, the Shah indicated, was to encourage the conservation of petroleum for petrochemicals and other purposes more sensible than driving three blocks to the supermarket. This policy, though, if generally adopted by OPEC, could also leave synthetic fuels only a thin margin of profit (if any at all), and thus would serve to discourage development of an industry large enough to hurt OPEC.

The foregoing scenario would collapse long before OPEC, of course, if shale oil and crude made from coal turned out to cost very much more than the predicted $4 to $8 a barrel. And opinion, naturally, is divided as to what constitutes a "commitment" credible enough to impress Arab oil managers graduated from the Harvard School of Business. Certainly a cooperative R & D program among importer nations would help, which is one reason R & D ranks high on the agenda of the foreign ministers' meeting in Washington scheduled for 11 February.

Ultimately, much of the responsibility for sorting sense from nonsense in the synthetic fuel debate will come to rest on Robert H. Shatz, an aeronautical engineer who left the Hudson Institute late last year to become assistant administrator for production in the Federal Energy Office. For the moment, Shatz is still busy hiring people to think about such things as synthetic fuel, but aides say they hope to produce some recommendations before summer.

After that, a synthetic fuel program would face an uphill fight in Congress. For the petroleum industry, surely one of the least loved and most profitable sectors of American business, this is not a good year to be seeking special consideration.

—ROBERT GILLETTE

† The term "pioneer" connotes a plant with commercial-scale components, but with only one of each necessary process train; a fully commercial plant might use multiples of each process train.