ternal change seem vital to the maintenance of public support, and even the survival of universities, and thus hasten changes in either departmental structure or departmental power. Within universities, resistance to such change is generally supported on the assumption that academic freedom will be threatened. Obviously, all change involves some risk, but a very significant limitation to academic freedom already exists in the pressures that many departments exert on members to restrict their intellectual activity to fit the departmental mold. Departments can regain their important role in fostering both academic freedom and academic responsibility for excellence if they will redefine their discipline-oriented identities and realign their priorities to include cross-disciplinary inquiry and teaching and greater responsiveness to the responsibilities and expectations of the university and society.

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NEWS AND COMMENT

Energy R & D: Under Pressure, a National Policy Takes Form

With a 1 December deadline from the White House bearing down, the rough outline of a national energy strategy is quickly taking shape in the offices of Dixy Lee Ray, the chairman of the Atomic Energy Commission and—for now, anyway—President Nixon's chief adviser on energy technology. One firm conclusion that has already come out of 2 months of high-speed planning is that, presidential promises notwithstanding, $10 billion or even $30 billion is not by itself going to buy the nation self-sufficiency in energy. The best that can be said is that about half the promised $10 billion might begin to show an "initial impact" on domestic energy supplies by 1980.

Nor, it seems, does anyone but President Nixon seriously regard this R & D effort as an analog to the Manhattan and Apollo projects, except perhaps, in terms of cost. In this case, creation of new technology is only half the battle; commercial application of the new technology depends on myriad policy decisions—bearing on things from oil shale leasing to power plant siting—that fall outside the realm of R & D. The success of Project Independence thus depends as much on politicians as on technicians; among the latter, the project's Mad-Avenue name is not catching on.

The 5-year, $10 billion energy R & D plan the President requested from Ray last June (*Science*, 28 September) was unveiled in a tentative, preliminary form on 14 November during a public meeting of the newly constituted Energy R & D Advisory Council of the White House Energy Policy Office.* The event was low-key but nonetheless unusual: Traditionally, the federal bureaucracy cloaks future budget plans in impenetrable secrecy, mainly out of fear that a public airing of rough-hewn plans would make subsequent changes of mind and heart a source of keen and frequent embarrassment. The difference in this case stems partly from Dixy Lee Ray's willingness to open the planning process to public view, and mostly from a new law, pushed through Congress last year by Senator Lee Metcalf (D–Mont.) and others, requiring such advisory groups generally to open their meetings to the public; the White House complied in letter and spirit, and about 40 outsiders dropped in to listen and sometimes to take part in discussions. All of which prompted one council member, MIT's Manson Benedict, to compare the event to a New England town meeting.

The plan was outlined by Gorman C. Smith, one of Ray's chief assistants on the project. Smith said an "overview" panel of ranking officials from seven federal agencies had reached concurrence on how the $10 billion should be divided up among contending technologies over the next 5 years, and that Ray, while reserving the right to alter the distribution as she saw fit, nevertheless regarded it as "close to the mark."

For the most part, the draft plan casts conventional wisdom as national policy. Technologies that are thought to hold out the promise of enhancing national security—by reducing reliance on foreign resources—are accorded topmost priority. An "improved environment" is ranked as the second priority, with the implication that pursuit of domestic security won't sully the environment any faster than it is being sullied right now. The third priority is R & D that could help cut the cost of producing energy.

On this basis, the technological tasks ahead fall into the following order of immediacy:

► Conserve energy through more efficient technologies.

► Increase production of oil and gas to the maximum feasible extent.

► Begin substituting coal for oil and gas in "massive amounts," during the "transition period" to heavy reliance on nuclear power.

► Guarantee the success of nuclear power through further R & D on safety, waste management, and alternative concepts such as gas-cooled and molten salt reactors.

► Plug away at long-range sources such as fusion and solar power.

Accordingly, research programs aimed at increasing both domestic supplies of fossil fuels and the efficiency of their use would receive $2.3 billion and $1.1 billion, respectively (see table). By comparison to current fossil fuel programs, this would mean a massive infusion of new money, but nuclear fission would nevertheless retain its dominant position, with total federal funding over 5 years of $4.39 billion. The liquid-metal breeder, not surprisingly, would remain the stellar attraction, or, as Smith described it to the council, "the first leg up on self-sufficiency."

Fusion R & D is slated for $1.55 billion, about 10 percent more than the

* Members of the council are: H. Guyford Stever, National Science Foundation (chairman); William O. Baker, Bell Telephone Laboratories; Manson Benedict, MIT; Lewis M. Branscomb, IBM; Paul F. Chenea, research laboratories, General Motors; Murray Gell-Mann, Caltech; Edward J. Gronowski, Esso Research and Engineering; Henry R. Linden, Institute of Gas Technology; Gordon J. F. MacDonald, Dartmouth; Elliot Montroll, University of Rochester; Ruth Patrick, Philadelphia Academy of Natural Sciences; Simon Ramo, TRW; Eric Reichl, Consolidation Coal; Louis H. Roddis, Consolidated Edison, New York; Chauncey Starr, Electric Power Research Institute; Alvin Weinberg, Oak Ridge National Laboratory.

AEC and the National Science Foundation had previously planned to spend in the same period. Solar energy support would increase substantially in percentage terms, but would remain a relatively miniscule part of the overall energy program.

In sum, said Smith, "there's nothing dramatic, nothing to really grab you" in the plan, although he added that its predictability by no means lessened its importance.

One reason for the energy plan's staidness is that $10 billion turns out to be barely enough to cover the essentials of a hardware development program (and by some lights, not even that), with nothing left over for imaginative gambling. Mindful of this limitation, the overview panel has recommended that any national energy strategy include a call upon industry for a major commitment of its own—perhaps another $10 billion. Smith said the plan in its present form includes about $1.1 billion for "environmental control technology" and another $400 million to $500 million for what might be considered basic research. Ray, however, is expected to recommend spending an additional $1 billion in federal funds for environmental and health effects studies and for more basic research—in effect, telling the President that new technology is going to cost a good deal more than he has explicitly pledged so far.

The drafting of this plan, Smith told the council, was begun in October by 16 panels composed of some 90 officials recruited from a spectrum of federal agencies dealing with energy. (In addition, some 200 outside "consultants" were called upon.) The panel's assignment was to "update" a 12-volume study of promising new energy technology put together by the Office of Science and Technology before it went out of business; that done, the 16 panels were told to come up with the familiar triad of options—the "minimum viable" effort, an "orderly" program, and an all-out "crash" program.

The 16 panels worked diligently for a month, but ultimately failed in their mission, Smith said. The aggregate cost of the minimum viable effort came to more than $11 billion; the orderly program, to $16 billion; and the crash program, to a staggering $30 billion.

This left the overview panel (headed by Stephen Wakefield, Assistant Secretary of the Interior for Energy and Minerals) with the procrustean assignment of paring a "balanced" national program to fit a $10 billion budget.

Or at least that was the way Ray interpreted her duty in directing the project. There were indications, though, that she has been more rigid or literal in her adherence to presidential orders than the White House had intended. What the President wanted, said John Sawhill, an associate director of the Office of Management and Budget, was a package of alternative plans, each with a different order of priorities. William T. McCormick, of the White House energy policy staff, added that there was "nothing magic" about the $10 billion figure. "If it takes $11 billion or more over 5 years," McCormick said, "we'll spend it."

"I wish you'd made that statement in August," the AEC's Smith responded, wistfully. "You'd have made my job a lot easier."

The precise numbers in the energy plan may shift, of course, in coming weeks, first as Ray amends it and later as the plan passes through the OMB and White House energy office. The new R & D advisory council presumably will have most of its influence in this period, both through its connection to the energy staff and through its chairman, Guyford Stever, the director of the National Science Foundation. The NSF has its own small energy policy staff, which has held itself more or less aloof from the planning process, so far; instead, the NSF will concentrate on helping OMB staff put the final touches on the plan that eventually will find its way to the Oval Office. The plan is unlikely to change dramatically before then, although some members of the council wondered aloud whether coal technology—at $2 billion—was down for its due share. The NSF, for its part, may press for greater emphasis on solar energy.

Whatever the final form of a national energy R & D plan, though, the consensus of those involved in assembling it is that R & D will have relatively little effect on energy supplies by the end of the decade. About $4.5

Comparison of base and recommended energy R & D programs for fiscal years 1975–1979.*

	Base	Recommended	Percent increase
Fossil option	**1,027**	**3,675**	**258.0%**
Conservation	95	1,340	(1,310.0%)
Reduced consumption	15	210	
Endorse conservation	5	150	
Improved management	10	60	
Increased conversion and distribution efficiency	80	1,130	1,313%
High temperature gas turbine		225	
Other (low-temperature cycles, waste heat and fuels, fuel cells, and so forth)		200	
Advanced auto propulsion		300	
Rail, bus, and ship systems		205	
Energy and fuel transfer, distribution, and storage		200	
Increased supply	892	2,335	(162.0%)
Oil and gas	50	310	
Fluid injection		71	
Stimulation		97	
Oil shale in situ		126	
Drilling		16	
Coal	842	1,875	
Clean combustion		200	
Low BTU gas		250	
High BTU gas		265	
Liquefaction		375	
Support R & D		120	
Magnetohydrodynamics (MHD)		80	
Mining technology		325	
Environmental control technology		260	
Resource assessment	40	150	(275.0%)
Fission option	**4,090**	**4,390**	**7.3%**
High temperature gas reactor, safety and waste management, etc.	1,560	1,660	(6.4%)
Breeder reactors	2,530	2,730	(7.9%)
Other programs	**1,505**	**1,935**	**28.5%**
Fusion	1,405	1,550	(10.3%)
Solar	80	200	(150.0%)
Geothermal	20	185	(825.0%)
Total program	**6,622**	**10,000**	**51.0%**

* In millions of dollars. All "base" figures are totals of 5-year budget projections made by federal agencies before the White House committed itself to a $10-billion program. [Source: The President's Advisory Council on Energy R & D]

billion of the $10 billion program "could have its initial impact" by 1980, Smith said, but even that is felt to depend critically on finding the right answers to some thorny policy issues. Among these are the pace of oil shale leasing in the West; pricing policies on energy that can make or break the economic attractions of new technology; government's role in subsidizing such things as coal gasification or liquefaction plants, or otherwise softening the economic risks of pioneering plants; and problems of siting and licensing energy plants.

The most immediate policy issue, however, concerns the management of energy R & D. With a herd of federal agencies—from the AEC to Interior to the NSF—all heading off along traditional and potentially conflicting or duplicative paths, the overview panel's most emphatic conclusion, Smith said, was that the grand plan is "not going to work unless someone is put in charge. . . . Somebody has to drive this train."

—ROBERT GILLETTE

Astronomy in Britain: Fogged Up by Cloudy Skies and Schisms

The British astronomical establishment has been shaken by its second top-level resignation in 18 months, a sign at best of failure to resolve internal differences. The latest departure is that of observational astronomer Margaret Burbidge, who last month resigned as director of the Royal Greenwich Observatory to return to the University of California at San Diego. In May last year, for somewhat different reasons, theoretical astronomer Sir Fred Hoyle gave his notice as director of the Cambridge Institute of Theoretical Astronomy (*Science*, 2 June 1972).

The basic reasons for her resignation, Burbidge said in a statement issued last month, were "lack of support for my vision of the way in which optical observational astronomy in the United Kingdom could be revitalized, and an environment in which I have felt it increasingly frustrating to work." Just what has gone wrong in British astronomical politics is hard to figure out from across the Atlantic, but part of the trouble seems to have been the emergence of two camps, based to some extent on earlier animosities but which have quarreled most recently over the future development of British optical astronomy. The camp that is easier to identity, because it has been more willing to go public with its version of events, is that associated with Hoyle and his colleagues, including several whom cloudy skies have driven to work overseas, such as Margaret Burbidge and her husband Geoffrey.

Friendly relations between the two camps were not assisted when Geoffrey Burbidge decided recently to "share a few home truths" with the readers of *Nature*. "Optical astronomy as it is currently being practiced in Britain is only third-rate," Burbidge stated. The primary reason was that the British astronomical establishment "has consistently, over the period since the war, refused to face the real world or accept that anything was the matter, and when important decisions were made, they were either hopelessly wrong, or too late or both." Citing eight "key mistakes" that flowed from this attitude, Burbidge alluded to the pettiness of English astronomical politics and the "never-ending consultations" involved in the planning committee system operated by the Science Research Council (the British equivalent of the National Science Foundation); this kind of situation, he noted, was what had led up to Hoyle's resignation. Hoyle, Burbidge said, had "attempted to reverse the trend from almost complete to absolute mediocrity. Some of us have tried, peripherally, to help. We have so far failed."

Burbidge's support of Hoyle against the British astronomical establishment was also an expression of his own troubles with that establishment. At the time his letter appeared in *Nature* (8 September 1972), it was already clear that the SRC was not able to offer him an acceptable post in England from which he could continue his partnership with his wife.

Another difficulty between the Burbidges and the SRC arose over plans for a new British observatory in the Northern Hemisphere. Several years ago, the SRC appointed a committee to advise on the feasibility of building a Northern Hemisphere observatory in a site suitable for modern observing, and therefore outside Britain. The committee was chaired by Hoyle and included as members Geoffrey Burbidge; another expatriate, Wallace Sargent of Caltech; and the astronomers royal of England and Scotland. The SRC, whose commitment to keep the public informed on important issues of science policy is less than passionate, suppressed the committee's report and with it any outside debate of the issues raised. The report is believed to have recommended that a national center be set up, financed by the council, but managed, after the model of the national centers in the United States, by an independent consortium of universities. Implicit in the report was that the two royal observatories should be closed down or otherwise reduced in scope.

The last suggestion, whatever its merits, was a tactical error. It antagonized the many astronomers working at the royal observatories and particularly the Astronomer Royal, then Sir Richard Woolley.

Woolley, the most vocal critic of the national center plan, retired last year, renewing the hopes of the proponents that they could persuade the SRC to act. Hoyle at that time still held the chairmanship of a critical SRC committee, the Astronomy Policy and Grants Committee, and seems to have persuaded some of the British expatriates in the United States to return to England if the plans for the national center should move ahead. The inducement seems to have been the amount of money the SRC was prepared to put up—enough for one 150-inch telescope and a smaller instrument. And the favored site for the new observatory, after the Spanish refused to let it be built on the Canary Islands because of the dispute with Britain over Gibraltar, was Hawaii.

At first, things went well. Margaret Burbidge was appointed to succeed Woolley as director of the Royal Greenwich Observatory (though not as astronomer royal), and the SRC apparently agreed to find a place for her husband and make available other senior positions for the appointment