speculation that the fields generated outside the test area could damage electronic devices, including navigation equipment. There has also been criticism that, because shipping would be excluded from an area 2 nautical miles in radius around the facility during testing, the impact on fishing and shipping would be unacceptable.

Draft environmental assessments produced by the Navy were criticized, even by other government agencies, as being inadequate. The Navy has since sponsored tests on numerous organisms and found no effect from very powerful pulses, however. It argues in a final environmental impact statement published last month that fields generated outside the 2-mile exclusion zone would be so small that there would be no conceivable effect on electronic equipment.

Nevertheless, Congress last December passed legislation prohibiting the Navy from operating Empress II in the Chesapeake Bay unless the Secretary of the Navy determines that such testing is essential for national security and that alternative test sites are unsuitable. In the settlement of Rifkin's lawsuit, the Navy has agreed to conduct yet another environmental assessment if it chooses an alternative test site.

The skirmishing over Empress II apparently sparked Rifkin's interest in the whole EMP testing program. He says he filed suit in part to launch a campaign against what he calls "electronic pollution" in the United States, by which he means the hazards that some have conjectured from fields associated with high-voltage power lines, microwave transmissions, and the like.

Kosta Tsipis, an MIT professor who recently completed a study of the military implications of EMP, says equating the radiation from power lines with the transient fields produced by EMP simulators indicates "gross confusion" about the EMP program. Tsipis, often a critic of defense programs, says he reviewed data on Empress II, and "there was nothing in terms of environmental damage that we could see."

Rifkin has charged that the EMP testing program is designed in part to provide a database for the development of electromagnetic weapons. He cites in particular a program sponsored by the Strategic Defense Initiative (SDI) to develop electromagnetic guns and allegations by the Pentagon that the Soviet Union is developing electromagnetic weaponry. A Pentagon spokesman points out, however, that these have nothing to do with EMP. The SDI project uses electromagentic fields to accelerate projectiles, while the alleged Soviet efforts focus on high-power microwaves, which operate in an entirely different part of the spectrum from EMP simulators. ■ COLIN NORMAN

Norway: Boosting R&D for a Post-Oil Economy

Research spending lagged during the oil boom but it is now being reemphasized with focus on improving quality

Oslo

"It's been a bit like the arrival of winter," says an official in Norway's Royal Ministry of Cultural and Scientific Affairs. "Everyone knew that one day the oil money was going to start drying up; but it was still a shock when it started to happen."

The discovery of major oil fields in the North Sea in the early 1970s led to a boom in the Norwegian economy and to a relative decline in the country's interest in research outside the oil industry. The proportion of government spending devoted to research and development fell from 2.7% in 1972 to 2.3% in 1980; support for basic research dropped from 48 to 42% of the science budget between 1977 and 1980 alone.

In the early 1980s, a growing realization that the oil bonanza would not last forever and that the economy needed to diversify into the production of high-technology goods led to the beginning of a turnaround. Most of the increased spending, however, remained concentrated on applied research, much of it paid for by oil companies flush with excess funds.

With the collapse in oil prices over the past couple of years, these funds are becoming more scarce. The government is now stepping into the breach, putting a new emphasis on long-term fundamental research and moving to restructure its research funding procedures along lines already adopted by many other Western nations.

At the same time, it is also trying to maintain the social priorities embedded in its science policy—such as positive discrimination in favor of recruiting more women into science and a new boost to environmental research—that countries more wedded than Norway to a free market social philosophy are sometimes reluctant to adopt.

"Research is one of the top priorities of the present government," says Hallvard Bakke, Minister of Cultural and Scientific Affairs, pointing out that one of the first moves of the current Labor Party government when it came to power in May 1986 was to secure a 7.6% real increase in the nation's research budget for 1987. "Our main objective is to expand the possibilities of the Norwegian economy, and to give it more feet to stand on, so that it does not have to rely on oil and oil-related industries."

A similar increase has been promised for 1988. And although this may, like all other areas of government spending, be trimmed in the light of economic difficulties currently facing the government, officials in Bakke's ministry say they are confident that R&D spending "will probably be the only sector whose budget will increase."

Much of the government's strategy in selecting priority areas for research support follows a familiar pattern, for example its decision to boost funding for research in information technology, in new materials and biotechnology. However it has decided to go further than some in simultaneously stimulating both fundamental research in new technologies and their integration into society.

A prime example of this is the decision by the Department of Industry, in a country with only 4 million inhabitants, to launch an ambitious $170-million information technology program. "It is a unique program that does everything from basic research to stimulating new demands for information technology in the health sector," says Jens Erik Fenstad, professor of mathematical logic at the University of Oslo.

In the case of biotechnology, a special emphasis is being placed on the potential long-term contributions of genetic engineering techniques to one of Norway's newest and fastest growing industries, namely aquaculture. Last year, the government promised to increase aquaculture research funds by 31% in 1988. Already, intensive studies are being carried out of ways of using the unique environment offered by Norway's fjords to raise not only salmon, but also more mass-market fish such as cod and halibut.

Two other fields of research are being given special emphasis in the government's plans. One is the social sciences, a field with a long and distinguished history in Norway closely linked to the country's highly developed social welfare system. "As a result, we have a very strong base for carrying out

research and development in this field, for example looking at the future needs of the service sector" says Tore Olsen, director general of the science ministry's department of research policy.

The second area is environmental research. This is a subject whose public profile has recently been raised in Norway both by growing problems, such as the acid rain that is often blamed on the United Kingdom, and the fact that the country's Prime Minister, Gro Harlem Brundtland, was chosen by the United Nations in 1983 to head a special commission on environment and economic development whose report *Our Common Future* was published last October.

"Previously, environmental activity was primarily a question of cleaning up after the damage had been done," says Fenstad, who is chairman of the natural science subcouncil of Norway's Research Council for Science and the Humanities. "There is now a shift towards more preventative research, making long-range, basic science in the area more prominent."

The new emphasis on basic research in all sectors of the economy poses a number of challenges. At the pragmatic level, for example, there is growing concern—as in many European countries—that when the present generation of university teachers retires, there will be not enough teachers to replace them.

"Even if we are able to make more research funds available, we are having greater and greater difficulty in recruiting competent people into research, and we are having to make substantial efforts to encourage the best graduates to take up a scientific career," says science minister Bakke.

A second challenge is how to introduce more flexibility into the research system without excessive disruption. To many outsiders, it is the rigidities of the research system—itself often a reflection of broader social commitments that have been reinforced by the oil glut of the 1970s—that are to blame for the low productivity of much of Norwegian research.

Three years ago, for example, a report on Norwegian science policy carried out by the Organization for Economic Cooperation and Development strongly criticized as "important impediments to necessary change" several key features of this policy, such as the regionalization of the research system and what it described as a "preoccupation with sex ratios in the scientific community."

Many Norwegians dispute such sweeping conclusions, supporting such policies as important social commitments. However, there is also a growing feeling that change is necessary. In a recent report on the Norwegian research council, for example, Stuart Blume, professor of science policy at the University of Amsterdam, argued that the "essential danger" facing the agency is "less irrelevancy than mediocrity."

Government officials point to a number of steps that have recently been taken to improve the quality of Norwegian science and help bring it up to international standards. One innovation, for example, has been the decision to award annual prizes of 5 years' unrestricted research funding to scientists in different disciplines.

The first of these, worth $425,000 over the 5 years, has been awarded to neurophysiologist Per Andersen at the University of Oslo. Other awards are due to be announced soon for the natural sciences, the social sciences, and the humanities.

A second step being pursued by the government is to introduce more block grants for university research, with the intention of reducing the amount of time that many scientists are required to spend on preparing paper work for grant applications. "We appear to have some of the same problems as other countries, such as a tendency to overadminister research," says science minister Bakke.

A third strategy has been to increase the involvement of Norwegian research workers in international research organizations. After several years of hesitation, for example, the government decided in 1986 that it would join the European Molecular Biology Laboratory (EMBL) in Heidelberg, and last year that it would become a full member of the European Space Agency.

International commitments are seen not only as increasing the foreign contacts of Norwegian scientists and giving them access to large research facilities but also as a way of developing a more critical evaluation of research that is carried out in Norway itself. "We want more Norwegian scientists to be involved on the international scene so that they can be measured by international standards," says Fenstad.

Similarly, whereas Norway has up to now been able by special arrangement to take part in some of the scientific programs run by the European Economic Community in Brussels (the Norwegian government's efforts to join the EEC in 1971 were rejected by a national referendum 2 years later), their participation as non-EEC members has recently been questioned by new member Spain and Portugal.

The schizophrenia shown by the apparent contradiction between Norway's continued refusal to consider joining the EEC and its enthusiasm for participation in European-level research programs is striking. "It's as if we were trying to head into Europe backwards" says one scientist, pointing out that Norway was one of the first countries to sign up for the EUREKA program of joint technology development projects.

Domestically, the government is treading a delicate path between similar pressures. Although keen to adapt its science base to an increasingly competitive global environment, it remains aware of the need to respect deeply held national values. Indeed, one of its newly agreed scientific priorities is for research "related to the dissemination of tradition and culture."

But change is being seen as inevitable—and the collapse in oil revenues has only made it more so. As the science council put it in a report a few years ago, using words that have been frequently quoted in both the scientific and political community: "Norway is compelled, both economically speaking and from the international policy standpoint, to base its society on science." ■

DAVID DICKSON

Henrik Orsted/Norwegian Information Service

Oslo University. *When the current generation of university teachers retires, will there be enough academics to replace them?*