new wells to be drilled each year—twice the rate in 1973—new methods for recovering oil from marginal wells would have to be developed and environmental problems associated with offshore production would have to be resolved. But even if all those programmes are successful, domestic oil and gas production would reach only about 27 million barrels per day equivalent in 1985, which is about 1.6 million barrels short of the demand in 1973.

- Electricity production. The total generating capacity of the United States electrical industry in 1973 was about 435 million kW and the NAE study concludes that this could be doubled over the next 10 years with capital investment of about $300,000 million. First, nuclear power would have to be expanded greatly above present projections, to reach about one third of total electrical capacity by 1985. This will require between 2 and 3 new nuclear units to be built every month, uranium production would have to be expanded by a factor of 6, between 30,000 and 40,000 plant operators and maintenance personnel would have to be trained, 30 reactor pressure shells and turbine generators will have to be manufactured and delivered each year, and the time it takes to license and construct nuclear plants will have to be greatly reduced from the present 10-year average.

Another key programme in the electrical energy sector is the expansion of coal-fired power station capacity. This, the NAE study suggests, will require five oil-fired power stations to be reconverted to coal every month for the next four years, two new 700 MW stations will have to be brought on line each month for the next decade, and 10 new plants will have to be constructed to produce medium-BTU gas from coal to fuel 50 power stations which are now fired with natural gas. All of that, however, would have to rely on the development of new technologies to control the emission of sulphur dioxide from power plants, or alternatively, environmental regulations would have to be greatly relaxed.

- Synthetic petroleum, natural gas and shale oil. In order to meet the predicted shortfall in oil and gas, it is estimated that new technologies must be developed to produce the equivalent of 1.1 million barrels of oil per day from coal gasification, 0.6 million barrels per day of synthetic petroleum from coal, and 0.5 million barrels per day of shale oil. Apart from a massive research and development programme, it will take a capital investment of between $16,000 and $22,000 million for the coal conversion projects, and between $3,000 and $5,000 million for the shale oil production.

The NAE analysis points out that the cost of those processes is likely to deter early production, and constraints such as the availability of water and environmental regulations are likely to set a limit on the ultimate capacity of some of the processes. And the MIT study is even more pessimistic, for it states that at present oil prices, there is insufficient financial incentive for the energy industry to move into those fields. Both studies therefore recommend that the federal government should provide a variety of incentives such as guaranteed prices, tax breaks and joint financing of development plants to bring the technologies on line as early as possible.

- Conservation. The prospects for the success of Project Independence hang to a great extent on whether or not the United States' insatiable appetite for energy can be curbed. Although the rapidly increasing cost of energy will work to reduce demand through the normal market forces, it is clear that the federal government must take a strong lead in encouraging conservation by a variety of measures such as allocation of funds to mass-transit systems, promoting research and development on more efficient ways to produce and transport energy, and by continuing such measures as speed limits on highways and encouraging car pooling.

The NAE study identifies four chief constraints which lead to its prediction that it is highly unlikely that all the projects necessary to achieve energy independence will be carried out. First, the capital investment required—$600,000 million over 10 years—is almost double the present investment rate in the energy industry, and it should be compared with the total investment in all industrial plant and equipment of about $100 million in 1970. Second, the availability of water is "a serious concern for producing oil from shale or synthetic fuels from coal". Third, environmental damage resulting from strip mining—particularly in the remote Western coalfields—and from burning large quantities of coal will have to be overcome by the development of new technologies, otherwise environmental regulations will have to be relaxed. And finally, a huge manpower problem could arise since several hundred thousand people will have to be recruited and trained in the energy industry during the next decade; in particular, the NAE study points out that enrolment has been dropping in university engineering courses.

One thing is clear from the study—a number of complex decisions must be taken by the federal government within the next year, and a coherent national energy policy must be formulated. So far, however, neither the Administration nor Congress has matched Presidential rhetoric with concrete action.

ESRO awards Spacelab contract

THE European Space Research Organisation has decided to award a contract worth approximately 180 million accounting units* for the design and development of the manned orbital laboratory Spacelab to VFW-Fokker/Erno of Germany, as prime contractor for a European industrial team whose composition reflects the financial contributions to the Spacelab programme by participating ESRO member countries. The unanimous decision was made by ESRO's administrative and finance committee, composed of member country delegates, at a meeting in Paris. It followed six weeks of evaluation by ESRO officials of two industrial proposals of high technical quality.

This six-year contract provides for the delivery of one Spacelab flight unit, fully qualified and ready for the installation of experiments, by April 1979. Other main deliverable items are two engineering models, three sets of ground support equipment and initial spares.

The Spacelab project is the most important cooperative programme between ESRO and NASA. ESRO is responsible for the design, development and construction of the laboratory, which NASA will launch in its space shuttle and operate. The first Spacelab launch is scheduled for early in 1980. NASA will soon commit itself to purchase a second Spacelab unit from ESRO and has indicated its intention to purchase such additional Spacelabs as may be required.

Unlike earlier space laboratories, Spacelab will be reusable. It will be designed for 50 missions of a week to a month, or a nominal life of 10 years. It will enable, for the first time, scientists, engineers and technicians to travel and work in Earth's orbit without undergoing intensive astronaut training. Spacelab is designed to reduce significantly the cost and time needed for space research and its applications, and to provide to a large number and wide variety of American and European users a versatile laboratory in which experimenters can work in comfort.

* At mid-1973 price levels 180 MAU is equivalent to approximately £95 million, FF 1,000 million, DM 578 million and $226 million.