The senators were pleased but not placated by the DOD's shift in design. Garn said it is still "essential" that the Air Force review in earnest the concept of split basing, which would place some of the MX missiles in states such as Texas and New Mexico, or possibly on submarines at sea. He made Secretary Brown promise that the study would not be done in a "half-hearted" way. "We are willing to bear our fair share of the burden," Garn said, but the present basing scheme seems to demand more than that. Both senators took pains to point out that they were not objecting for antimilitary or anti-MX reasons but out of sheer parochial self-interest. Laxalt said that his state would be happy to make sacrifices for the rest of the nation, but it would do so only if (i) the least disruptive basing design is used, (ii) part of the system is moved elsewhere, and (iii) federal economic compensation is given "in sufficient quantities to cushion remaining difficulties." The Southwesterners are thinking in figures of $1 billion and up. Laxalt's experience, he said, informed him that it is unlikely that the MX project will be completed within the time or cost limitations cited by the DOD.

Although it would be technically feasible to put some of the missiles in New Mexico and Texas, Perry said, this split basing approach would add significant new costs because it would require additional command and communication facilities. The Pentagon expects to recommend that Congress *not* push for this option, but limit the MX to Nevada and Utah. Perry and Brown ruled out all the other alternatives the Southwesterners had suggested.

Vertical shelters, which demand less land than the chosen horizontal type, were dropped because they require an elaborate and time-consuming method of missile transport and emplacement. They would not allow for a quick reconfiguration or shuffle of missiles within shelters, as might be necessary in a time of crisis. Airplane basing was ruled out because it would require planes with heavier armor plating (and thus more power) than the present fleet, making it an unacceptably expensive choice.

Most attention was given to the alternative with the best credentials, known as the shallow underwater missile (SUM) concept, proposed by Richard Garwin of IBM and Sidney Drell, deputy director of the Stanford Linear Accelerator Center (*Science*, 12 October 1979). According to the SUM plan, missiles would be placed in submersible launching tubes and mounted on the outside of 50 to 100 small diesel-electric submarines, which would patrol in shallow depths just beyond the U.S. continental shelf. These small subs, the proponents claim, would be more difficult for the Soviets to find and hit than the giant Trident submarines. (The small subs would augment, not replace, present seaborne strategic forces.) Air Force spokesmen have criticized the concept informally for the last 2 years, but Drell charged in these hearings that the DOD has never conducted a thorough technical analysis of the idea.

Secretary Brown dismissed SUM for two reasons. By shifting the MX from land to sea, he said, America would effectively give up hope of improving its land-based missiles and concede "an important perceptual advantage to the Soviets, a dangerously misleading signal." Second, Brown said that taking this step would be tantamount to abandoning the triad of strategic forces (bombers, land-based missiles, and submarines) for a dyad of submarines and bombers. This would simplify the technical task the Soviets would confront if they wished to launch a first strike against these missiles. Brown added that although he can guarantee that American submarines will be untargetable through the 1980's, there can be no such guarantee for the 1990's. In addition, the DOD attacked the small submarines in a brief report issued on 9 April ("An Evaluation of the Shallow Underwater Missile Concept"). It found that "SUM is unlikely to be cheaper than MX" on land, and "SUM is unlikely to be available before the 1990's."

Cost estimates for a new weapon are notoriously unreliable, particularly when they are being put forward by advocates of competing systems. Drell claims that the DOD has overestimated the cost of SUM by at least $10 billion, larding the system with unnecessarily large figures for research, development, and basing. The senators wisely declined to get into this part of the debate, declaring themselves skeptical of both the DOD's and Drell's estimates. But it is safe to say that SUM would be no more costly than a land-based MX.

Drell said he "searched in vain for an analytic basis" supporting the DOD's conclusion that the submarine system

Roll with Coal

A rare note of optimism about the world's energy future is sounded in an international report produced under the direction of Carroll L. Wilson of Massachusetts Institute of Technology.

Oil is likely to become less available over the next two decades, and nuclear and alternative sources of energy will not be sufficient to meet the world's growing energy needs. But a solution is at hand: "Coal can provide the principal part of the additional energy needs of the next two decades," conclude the participants of the World Coal Study.*

To achieve this goal, world coal production will have to increase by 2.5 to 3 times, and world trade in coal will rise by an order of magnitude. The United States, which possesses the largest economically and technically recoverable coal reserves in the world, will become a major exporter.

A less upbeat view of the future of coal, at least in the near-term future, is presented by the National Coal Association in its 7 May annual report to the President. Total demand for U.S. coal will be between 880 and 1080 million tons by 1985, compared with the goal of 1200 million tons by 1985 called for in the President's April 1977 energy message. The reason for the shortfall, complains the National Coal Association, is that "A complex web of government policies and requirements is now holding down coal demand." The NCA would like to see environmental and other standards rolled back.

The World Coal Study is less critical of the government's role, believing that existing market forces are compelling enough to bring more coal on stream at the right rate. "We believe that regulatory standards can be complied with at costs which keep coal economic," says J. Michael Gallagher of MIT, the study's technical director. As for the climatic consequences of increased coal use, the study takes the position that "present knowledge of possible carbon dioxide effects on climate does not justify delaying the expansion of coal use."—N.W.

**Coal—Bridge to the Future.* World Coal Study. Ballinger Publishing Company, Cambridge, Mass. 248 pages.

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