Letters

Geothermal Energy's Future

I would like to comment on the Briefing of 22 November (p. 1113) concerning the outlook for geothermal energy in California. The Briefing's somewhat gloomy outlook is due largely to a confusion of the geothermal *resource* estimates made by the U.S. Geological Survey (USGS) in 1979 (contrary to the assertion in the Briefing, the 1979 inventory is the most recent USGS inventory) with the geothermal *reserve* estimates made by Ebasco Services in 1991. By definition, reserves represent only that fraction of the resource that can be exploited profitably with current technology. With an understanding of this difference, one can see that there is no actual conflict between the 1979 USGS study and the 1991 Ebasco report.

Although production at The Geysers has dropped significantly [to 1380 megawatts-electric (MWe) from the installed capacity of 2000 MWe], much of this drop can be attributed to overoptimism and overexploitation by the field developers. (The 1979 USGS study estimated a 1610 MWe capacity for The Geysers.) With new technological developments such as fluid injection, jointly researched by industry and government, it should be possible to recapture some of the lost generating capacity.

California's geology (and that in neighboring states) still promises an abundance of economical, environmentally acceptable geothermal energy. Supporting studies for the National Energy Strategy indicate that under reasonable assumptions approximately 11,000 MWe from hydrothermal resources can be on-line nationally by 2010, and 22,000 MWe by 2030. In addition, more advanced geothermal resources (hot dry rock, geopressured geothermal systems, and magma) can potentially play a significant role in satisfying America's long-term energy needs. Geothermal energy truly has a bright future in helping to satisfy America's energy needs.

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Response: Contrary to the comment by Mock, we find no methodological differences between the 1979 inventory by the U.S. Geological Survey (USGS) and the 1991 report by Ebasco Services, both of which estimate California's geothermal resources. According to Patrick Muffler of the USGS, who supervised the 1979 inventory, the terms "reserves" and "resources" were inconsistently applied in the Ebasco report, but the methods used were the same in the two studies. Muffler cannot vouch for the application of those methods in the "gloomy" Ebasco report, but finds it appropriate to directly compare the two studies.—EDS.

Bellcore Basic Research

Contrary to the impression created by the ScienceScope item "Bellcore basic researchers out of work" (10 Jan., p. 147), Bellcore is *not* "phasing out its basic research effort and closing down facilities." We have made a small reduction in the size of our effort in physical sciences and materials research and we are increasing our research in software and information technologies, but these changes are modest and do not involve the large-scale "retrenching" indicated in the ScienceScope piece. Only a handful of people were involved in our work with superconductivity, not the "20 to 25" mentioned in the ScienceScope piece. That is the number of *all* the affected people in physical sciences research. Several of our physical science researchers have been placed elsewhere in our research efforts, a few have chosen to retire, and ten have indicated they want to continue in their specific fields of research elsewhere.

The shifts we have made in our overall program, while significant to the individuals involved, are small and are the normal ones to be expected from time to time as technological progress is made. It should not be necessary to state that Bellcore intends to continue being a leader in those areas of research important to our owners and to the telecommunications industry, including materials and device research.

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Fullerene Superconductivity and the Dynamic Jahn-Teller Effect

C. M. Varma *et al.* (Reports, 15 Nov., p. 989) attribute superconductivity in the fullerenes to electron-phonon coupling of H_g vibrational modes of the component C_{60} molecules induced by the dynamic Jahn-Teller effect of partially occupied degenerate $t_{1u}(p\pi)$ molecular orbitals. Superconductivity theory based on dynamic Jahn-Teller vibronic coupling of degenerate molecular orbitals was applied to organic superconductors in 1983 (*1*), to high–transition temperature oxides in 1987 (*2*), and to superconductive fullerenes in May 1991 (*3*). Indeed, dynamic Jahn-Teller coupling may provide a unifying quantum-chemical basis for high–transition temperature superconductivity in ceramics, organics, and fullerenes (*4*).

Experimental evidence for this mechanism in fullerene C_{60} can be found in the unusual electron-spin-resonance spectrum (*5*), which shows temperature-dependent line width and highly shifted g value, well-established signatures of the dynamic Jahn-Teller effect (*6*). Raman spectra for superconductive fullerenes show only the lowest frequency H_g vibrational mode (*7*), consistent with the dynamic Jahn-Teller scenario of (*3*). A recently reported carbon isotope shift exponent of $\alpha = 0.37 \pm 0.05$ for the transition temperature of superconducting Rb_3C_{60} (*8*) is close to the value predicted from the dynamic Jahn-Teller mechanism in (*3*).

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Response: We are happy to note that Johnson *et al.* have also thought of the intramolecular vibrations in metallic fullerenes as responsible for effective electron-electron attraction in the fullerenes. We would like to point out that there are essential differences between our results and theirs. (i) Johnson *et al.* consider the prob-