Letters

Economics of Nuclear Power

The article by John E. Ullmann on "Economics of nuclear power" [*Science* **127**, 739 (1958)] reaches conclusions that appear to be based on highly tenuous assumptions. Basically, the findings of the author depend on a graphical extrapolation of past-performance trend lines. Such an evaluative technique, not coupled with a specific analysis of the processes involved, can readily produce misleading conclusions.

The assumption is made that the long-term pattern of cost reduction noted for conventional steam plants since 1910 to the present will prevail for nuclear power. However, inasmuch as the actual cost reduction in conventional plants has not been significant since 1945, it is further postulated that the trend will reverse and start to rise for the conventional steam plant. This up-for-one and down-for-the-other type of analysis completely ignores the common elements involved in the two processes being compared.

The author's study relates exclusively to steam power, inasmuch as he has specifically excluded from his analysis any direct-generation fission or fusion power which might circumvent the steam cycle. Thus, a proper steam-power analysis would require a distinction being made between those costs that are inherent to the use of a specific fuel and those costs that relate to the generation of steam irrespective of the nature of the fuel. If, as appears likely, those costs associated with steam generation per se will rise—and they represent a major aspect of the total cost of steam-power production—then such a rise will also be reflected in the projected nuclear power costs. This consideration would appear to invalidate a substantial portion of the author's analysis.

Further—and this was not even mentioned—actual fuel costs for nuclear versus conventional fuels are at present difficult to determine realistically. A substantial credit is now allowed for the used nuclear fuel, and this situation would presumably not prevail under competitive nonsubsidy conditions. Incidentally, reference 6 is in error and should refer to volume 77 (1955) [of *Trans. Am. Soc. Mech. Engrs.*].

HENRY KOLIN
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In his article "Economics of nuclear power" [*Science* **127**, 739 (1958)], John E. Ullmann comes to some conclusions which are contrary both to economic analysis and to common sense. Ullmann predicts, for instance, that investment costs for conventional steam power plants will steadily increase in the future, whereas investment costs for nuclear power plants will decline continuously. Thus, he states that by 1966 investment costs per kilowatt of capacity will be equal, whereas by 1980 investment costs per kilowatt of capacity in conventional steam power plants will be close to $450 per kilowatt, while in nuclear power plants they will be around $50 per kilowatt.

As a nuclear power plant requires practically all the investments necessary in a conventional steam plant and, in addition, special investments for containment, control, safety, moderating and cooling materials, and so on, it is obvious that, per kilowatt of capacity, a nuclear power plant must, under existing and foreseeable technology, be more expensive than a conventional steam power plant. A calculation, therefore, which foresees higher investment requirements for a conventional power plant than for a nuclear power plant of the same size is as logical as a cost calculation which indicates that the construction of a whole house is cheaper than the construction of a single room in that house.

The United States Government in its

reply to the questionnaire of the Secretary-General of the United Nations assumed that, by 1975, investment costs for conventional power plants will amount to $150 per kilowatt and, for nuclear plants, to $300 per kilowatt, including fuel inventories [see *Economic Applications of Atomic Energy* (United Nations, New York, 1957), p. 83].

In addition to the point raised above, there are a number of other points in the article that might be challenged, in particular the method employed for forecasting power costs. This method, it is true, is frequently used by engineers, but its use is to be regretted as it has no sound economic basis. The highly speculative character of such forecasts should be made clear to the reader.

JOSEPH BARNEA

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Both Kolin and Barnea seem to question my predictions for the same reason —my alleged failure to give weight to the common elements of conventional and nuclear power. These, however, are much less "common" than may at first appear. On the one hand, we have conventional equipment reaching a practical limit in size of units and a theoretical limit in operating conditions. On the other hand, in nuclear stations, steam operating conditions are now the same as in the conventional plants of 30 or 40 years ago, so that a cost reduction similar to that of the past seems to me to be very likely.

Nuclear plants can also be built much smaller, again paralleling conventional units for which the economic optimum size was much less in the past. The optimum size, in fact, went up with working temperature and pressure. The comparison of plants of "equal" size, as made by Barnea, is therefore not valid. In the words of his simile, the room is part of another house. Barnea's "extras" in nuclear plants have been declining in cost, as stated, and will no doubt continue to do so. In any case, their cost is offset by the elimination of much of the fuel- and ash-handling equipment in modern conventional plants. In part, they are included in the nuclear "boiler."

With regard to my statistical method, the confidence bands of extrapolations widen sharply as we go into the future. In this sense, all forecasts are speculative.

I agree with Kolin that nuclear fuel costs are quite artificial at present. Under freer conditions there is no reason why fuel reprocessing should not be done at a reasonable rate. Several large companies are interested in this field. The present distressed condition of the uranium mining industry also offers hope for cheap

nuclear fuel, especially if the dominant role of nuclear weapons in the market is eventually reduced.

Since my article was written several studies and proposals for plants in the United States and England have confirmed or even exceeded my expectations. Furthermore, as I am sure Barnea knows, we have just had a rate increase in New York, and more are to come. Kolin's "up-for-one and down-for-the-other" may well be upon us.

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Meetings

Forthcoming Events

August

11–13. International Mathematical Union, 3rd general assembly, St. Andrews, Scotland. (F. Smithies, Mathematical Inst., 16 Chambers St., Edinburgh 1, Scotland.)

11–16. Occupational Therapists, World Federation's 2nd intern. cong., Copenhagen, Denmark. (Mrs. I. Worsoe, Hvidklovervej 10, Aarhus, Denmark.)

12–13. Economic Botany Conf., New York, N.Y. (D. J. Rogers, New York Botanical Garden, Bronx Park, New York 58.)

13–15. Electronic Standards and Measurements Conf., Boulder, Colo. (J. F. Brockman, National Bureau of Standards, Boulder.)

13–15. Industrial Applications of X-ray Analysis, 7th annual conf., Denver, Colo. (W. M. Mueller, Metallurgy Div., Denver Research Inst., University of Denver, Denver 10.)

13–19. Seaweed Symposium, 3rd Intern., Galway, Ireland. (C. O. hEocha, Chemistry, Department, University College, Galway.)

13–20. Insect Pathology and Biological Control, intern. conf., Prague and Smolenica, Czechoslovakia. (J. Weiser, Inst. of Biology, Nacvicisti 2, Prague XIX, Czechoslovakia.)

13–20. International Astronomical Union, 10th general assembly, Moscow, U.S.S.R. (P. Th. Oosterhoff, IAU, Leiden Observatory, Leiden, Netherlands.)

15–20. World Medical Assoc., 12th general, Copenhagen, Denmark. (World Medical Assoc., 10 Columbus Circle, New York 19.)

17. American College of Hospital Administrators, 24th annual, Chicago, Ill. (ACHA, 620 N. Michigan Ave., Chicago 11.)

17–21. Health Conf., 7th annual, University Park, Pa. (M. Cashman, Pennsylvania Dept. of Health, P.O. Box 90, Harrisburg.)

18–19. American Astronautical Soc., Western meeting, Palo Alto, Calif. (N. V. Petersen, Lockheed Missile Systems Div., Palo Alto.)

18–21. Conservation Education Assoc., 5th annual, Salt Lake City, Utah. (S. D. Mulaik, Biology Dept., University of Utah, Salt Lake City.)

18–21. Heat Transfer, AIChE conf., Evanston, Ill. (F. J. Van Antwerpen, AIChE, 25 W. 45 St., New York 36.)

18–22. Clinical Chemistry Workshop, Houston, Tex. (Division of Clinical Chemistry, Dept. of Biochemistry, Baylor Univ., College of Medicine, Houston 25.)

18–22. Occupational Medicine and Toxicology, 2nd Inter-American conf., Miami, Fla. (W. B. Deichmann, Dept. of Pharmacology, Univ. of Miami School of Medicine, Coral Gables, Fla.)

18–22. Plant Science Seminar, 35th annual, Big Rapids, Mich. (E. P. Claus, Div. of Pharmacy, Ferris Inst., Big Rapids.)

18–22. Semiconductors, intern. conf., IUPAP, Rochester, N.Y. (D. L. Dexter, Dept. of Physics, Univ. of Rochester, Rochester.)

18–23. New England Assoc. of Chemistry Teachers, 20th summer, Kingston, R.I. (J. A. Martus, College of the Holy Cross, Worcester 10, Mass.)

18–25. Religion in the Age of Science, 5th summer conf., Star Island, N.H. (Institute on Religion in an Age of Science, 280 Newton St., Brookline 46, Mass.)

20–23. Photofluorography, intern. cong., Stockholm, Sweden. (International Cong. of Photofluorography, P.O. Box 5097, Stockholm 5.)

(See issue of 20 June for comprehensive list)