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the merits and deficiencies of coal versus fission power.

Permitted radioactive releases depend and ought to depend on hazard, that is, on potential human dose. Thus to disintegration rate one must add transport to humans, bodily acquisition, biological residence time, energy of radiation, absorption probability, ionization density, and the like, to arrive at a man-equivalent dose (in rem's). It is in the sense that restrictions on dose imply in turn restrictions on radioactive release that there are "from fission plants . . . limitations that are severe and—in comparison to other risks we routinely accept or are necessarily exposed to—absurd."[1]

As far as I can discover, it is in fact true that ". . . even confining ourselves just to regular radioactive emissions, the coal-fired plant turns out to be much worse (i.e. more hazardous) than a fission reactor . . ." because the coal-fired plant emits more toxic radioactivities, which are carried to humans more readily, are retained longer and with higher energy, and have higher ionization density radiation than the noble gases (10.7 year Kr-85 and 5.3 day Xe-133) of routine reactor emission. One curie of equal parts of Ra-226 and Ra-228 is approximately radiobiologically equivalent to 400 000 curies of Kr-85 and 400 curies of I-131.[2] In addition (except for short-lived radon) uranium, thorium and their daughters ride along or travel as particulates; krypton and xenon are noble gases, and their higher transport to, and deposition in, the human lung can further multiply the relative biological coal risk, perhaps many fold. Moreover, even the disintegration rates at plant boundary can be 500 to 1 000 000 times higher from a coal-fired plant than from a fission plant, as Jawoworski *et al* have reported elsewhere.[3]

But all this comparison between radioactivities is beside the main point, because the principal hazard of coal is chemical and non-radioactive physical. Radioactive hazard comparisons, which consequently need only be very roughly comparable to coal hazards to make the point, are only mentioned to inform those who feel that cancer, mutations and deaths from radioactivity are somehow more deadly than the same cancer, the same mutations, or the same type of deaths caused by the chemical and non-radioactive physical toxicants of coal. Strict radioactive hazard comparisons are thus for perspective only, and can be omitted from the main thesis. Clearly, to make the proper decision among the available large-scale fuels, one must consider the total hazards from the complete cycles, of course including disposal and the chance of catastrophic accident. Thus far, the best comparative hazard numbers I have found favor use of fission power over coal power by more than sixty to one. Perhaps by very much more than sixty to one, when the details of all toxicants and of particle transport and lung retention are included. Further, the fission wastes are being controlled; not only are the coal wastes not well controlled but, also, much coal waste is emitted in a form guaranteeing nearly maximum human hazard.

My fears expressed in this series of letters to PHYSICS TODAY have early come to pass, for with a sense of utter defeat I note that the new Federal administration is plunging into maximum reliance on coal without regard, indeed without awareness, that coal is so much more hazardous than fission power. They are, in addition, sincerely believing (and reassuring the public) that human health and the environment will not suffer. For what little it is worth, all my private studies indicate that the combined technical, political and economic realities strongly contradict that belief. An additional point about the future is that not only is coal much too hazardous to burn, but it is also too valuable. With the pending early exhaustion of natural gas and oil, coal is now to take up the slack; figuring it then as a replacement for virtually all power sources and as a chemical feed stock, one can come up with numbers as low as only seventy years or so of economically recoverable US coal reserves.

Sadly, I also report that an additional 2000 MWe coal-fired power plant is now to be built near Farmington, New Mexico, and that the Navajo Nation has announced their own 350 MWe coal-fired plant. The Navajos have a chant, an abridged part of which goes: ". . . In beauty, I walk! With beauty before me, with beauty behind me, with beauty above me, with beauty all around me, I walk . . ."

No more.

References

1. A. R. Muller, "Natural Radiation Background versus Radiation from Nuclear Power Plants," Jour. Environ. Sci. July–Aug 1972, page 9.
2. M. Eisenbud, H. G. Petro, "Radioactivity in the Atmospheric Effluents of Power Plants that Use Fossil Fuels," Science **144**, 288 (1964).
3. Z. Jawoworski *et al*, "Environmental Surveillance Around Nuclear Installations," Vol. I, IAEA, Vienna (1974), page 403.

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Correction

July, page 67, middle column, five lines up—"Present solar-cell arrays are about twice as heavy . . . because 20 micron silicon solar cells are used" should read "200 micron silicon solar cells." □