Postscript: Population Growth and Energy Use--E. F. Schumacher as Prophet

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E. F. Schumacher became world famous because of his thesis that "small is beautiful." But in the article reprinted above, from the Proceedings of the World Population Conference in 1954, he dealt on a global scale with two of mankind's largest problems—future population growth and energy resources—as they appeared 25 years ago. He first projected the size of the earth's population in 1980, the rate of use of energy in 1980, and total world energy consumption during the 26 years between 1954 and 1980. He then allowed himself to speculate about the global (and regional) energy problems of the year 2000 and on into the twenty-first century.

Schumacher's main conclusion was, as he himself said, self-evident and noncontroversial, but its cogency has been painfully sharpened by the recurring energy crises of the past few years. It was that "Western" industrialism, which has, for its growth, depended on an ever-increasing use of fossil fuels, "does not at present possess a permanent energy basis," and consequently, within the foreseeable future, "far-reaching changes in all price-relationships and in the fundamental pattern of consumption and investment will produce a new economy, unrecognizable from the one we know today." Some of his conclusions about the world energy situation in 1980 have proven to be remarkably prescient, even though his supporting calculations were far too conservative.

Schumacher estimated that world energy consumption in 1980 would be twice that of 1954. In 1979, it is already more than three times as large. He calculated that the total consumption of energy from fossil fuels (petroleum, natural gas, coal, and lignite) between 1954 and 1980 would be equal to the energy contained in 118 billion tons of coal, whereas it will certainly be nearly 150 billion tons. These underestimates resulted from his failure to foresee the enormous growth of world population during the last 25 years, from 2.65 billion

to nearly 4.5 billion people—he assumed that world population in 1980 would be 3 billion—and from his projection that world per capita use of energy from all sources (coal, lignite, petroleum, natural gas, water power, wood, and agricultural residues) would increase by 2 percent per year, whereas the actual rate of increase has been about 2.4 percent.

Increases in energy use keep pace approximately with overall economic growth, as measured in terms of gross national product, and in both developed and developing countries the rates of economic growth have been high during most of the past three decades. According to Ruth Leger Sivard's *World Energy Survey* (New York: The Rockefeller Foundation, 1979) average per capita gross national product for the developing countries increased by slightly more than 3.9 percent per year between 1961 and 1976. Per capita energy use from "commercial" sources (Schumacher's "capital fuels": coal, lignite, petroleum, and natural gas) increased at the same rate. The average annual rates of economic growth and fuel use for developed countries were 3.2 percent. Because of the great differences in economic levels between the two groups of countries, however, the *average world rates* of increase in per capita gross national product and commercial energy use were smaller, about 2.7 percent. As Schumacher suggests, the ratio of energy obtained from commercial fuels to energy from all sources in developing countries increases with the rising energy use that accompanies economic growth, and the efficiency of energy use also increases. Hence, the rate of growth in total energy use (energy obtained from Schumacher's "income fuels" as well as his "capital fuels") has been less in the developing countries than that for energy from "capital fuels" alone.

A word is in order at this point about units. Schumacher's "Q," defined as 10^{18} British Thermal Units (BTU), is 1,000 times the "Quad" (10^{15} BTU—or 1 quadrillion BTU) now usually employed in global energy discussions. One Schumacher "Q" unit corresponds to the heat energy in 33.6 billion standard, or "equivalent" tons of coal, or in about 22 billion tons of petroleum. Another unit that is coming into widespread use is the terawatt—10^{12} watt-years or 8.76×10^{12} kilowatt hours, the heat energy in approximately 1 billion tons of "equivalent" coal. One Schumacher "Q" unit is about 33 terawatts.

One of Schumacher's important insights was that the costs of production of petroleum and natural gas, unlike those of other nonrenewable resources, tend to increase much more slowly than the global rate of depletion of the resource. The total real costs of exploration, drilling, and production of Saudi Arabian oil, for example, are probably considerably less than 50 US cents a barrel. It is this "peculiarity" of the liquid and gaseous hydrocarbons that lulled the developed world into their profligate use during the past quarter-century. The present confrontation between OPEC and other countries stems in large part from their differing perceptions of the significance of this "peculiarity."

If, as now seems likely, per capita use of petroleum and natural gas in developed countries remains virtually constant during the next 21 years, while the rate of growth of total commercial energy use and the ratio of coal plus lignite to petroleum plus natural gas remains constant in the developing countries (unfortunately because of high energy costs, the overall rate of growth is likely to decline), then the quantity of petroleum and natural gas used in the year 2000 would correspond to more than 9 billion tons of coal-equivalent

per year—nearly twice the 1976 value, and total energy from fossil fuels (petroleum and natural gas plus coal and lignite) would be nearly 16 billion tons of coal-equivalent—twice total commercial energy in 1976. The cumulative total between 1950 and 2000 would be 191 billion coal-equivalent tons of petroleum and natural gas and 183 billion tons of coal and lignite. In Schumacher's "Q" units, total consumption of hydrocarbons between 1950 and 2000 would be 5.7 "Q," and about the same for coal and lignite.

Using Schumacher's estimates for economically recoverable oil and gas and coal and lignite reserves of less than 6 Q and about 40 Q, respectively, the earth's store of hydrocarbons would be virtually exhausted by the year 2000, and one-seventh of the total coal and lignite would have been consumed. Recent estimates of reserves, however, are much larger than those given by Schumacher. The World Energy Survey puts hydrocarbon reserves at 750 billion tons of coal-equivalent, or 22.4 Q, almost equally divided between petroleum and natural gas. Economically recoverable reserves of coal may be on the order of 5,000 billion tons (150 Q). (The World Energy Survey gives an estimated total of 10,000 billion tons.) Even if all future energy supplies were to come from coal, probably less than half the reserves would have been consumed by the end of the twenty-first century.

If the new reserve estimates are approximately correct, the world energy situation with regard to fossil fuels, though seriously worrisome, is not as desperate as Schumacher indicated. The world society still has a little time to establish a more permanent energy base, even allowing for a considerable increase in per capita energy use in the developing countries. A problem he did not consider, however, is the inevitable increase in atmospheric carbon dioxide and the resulting possibly drastic climatic changes that will occur if future world reliance for energy is placed primarily on fossil fuels. These effects may place a limit on fossil fuels long before the resources are exhausted.

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