ENERGY/WAR:

Breaking the Nuclear Link

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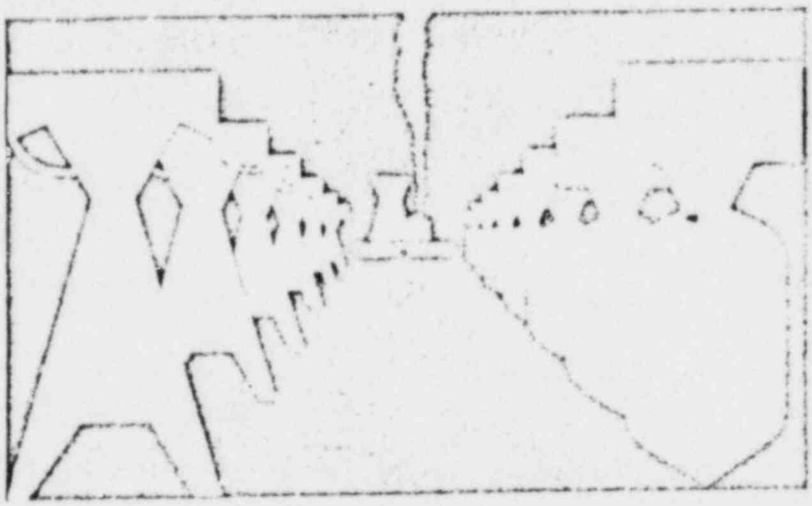

FRIENDS OF THE EARTH
San Francisco

thing from each shelf, but seeks the best bargain in a balanced diet, so every dollar devoted to relatively slow and costly energy supplies actually *retards* oil displacement by not being spent on more effective measures. Nuclear power programs have so far been justified not by this rational test but by intoning the conventional wisdom stated by Sir Brian (now Lord) Flowers of the UK Atomic Energy Authority:

> Alternative sources will take a long time to develop on any substantial scale. . . . Energy conservation requires massive investment . . . . and can at best reduce somewhat the estimated growth rate. Nuclear power is the only energy source we can rely upon at present with any certainty for massive contributions to our energy needs up to the end of the century, and if necessary, beyond.[101]

Failure to assess *comparative* rates of oil displacement, as we shall do in Chapter Seven, runs the risk that, having like Lord Flowers dismissed alternatives as slow, conservation as costly, and both as inadequate, one may choose a predominantly nuclear future that is simultaneously slow, costly, *and* inadequate.

What is the energy problem?

Nuclear power is not only too slow; it is the wrong kind of energy source to replace oil. Most governments have viewed the energy problem as simply how to supply more energy of any type, from any source, at any price, to replace oil—as if demand were homogeneous. For planners unaware of other possibilities, this boils down to which kind of new power station to build—which is why nuclear power is often loosely described as a source of "energy." But it is actually a source of electricity, which is only one form of energy. There are many different forms whose different prices and qualities suit them to different uses. It is the uses that matter: people want comfort and light, not raw kilowatt-hours. Assuming (as we do) equal convenience and reliability to the user, the objective should be to supply the amount and type of energy that will do *each task most cheaply*[102].

[101] B. Flowers, "Nuclear power: A Perspective of the Risks, Benefits and Options," *Bulletin of the Atomic Scientists* 21–26&ff, March 1978. Lord Flowers is here quoting the conventional view—apparently with approval, as one can infer from his personal statements later in the same article.

[102] This economic comparison should in principle take account of all social costs, including those now "external" to market prices. As a conservatism, however, we base our comparison in this book on internal costs only, and generally on private (rather than social) internal costs. Internalizing the externalities—counting, for example, effects on health and safety, environment, jobs, political freedoms, vulnerability, etc.—would only strengthen our case.

This common-sense redefinition of the problem—meeting particular, concrete needs for energy services with an economy of means, using the right tool for the job—profoundly alters conclusions about new energy supply. Electricity is a special, high-quality, extremely expensive form of energy. Electricity delivered from a newly ordered nuclear plant will probably cost (in 1980 dollars) about as much per unit of heat content as oil at $130 per barrel, or roughly four times the 1980 OPEC crude oil price.[103] This costly energy may be economically worthwhile in such premium uses as motors, lights, smelters, railways, and electronics; but no matter how efficiently it is used, it cannot come close to competing with presently available efficiency improvements, or with present direct fuels, or with presently commercial renewable sources, for supplying heat or for operating road vehicles. These uses plus feedstocks account for about ninety percent of world oil use and for a similar or larger fraction of delivered energy needs. The special, "electricity-specific" applications represent typically only seven or eight percent of all delivered energy needs—much less than is now supplied in the form of electricity.[104]

In most industrial countries, therefore, a third to a half of all electricity generated is already being used, uneconomically[105],

[103]This is in terms of the heat content of electricity or oil without regard to the end-use efficiency of either: that is, 1 kW-h of electricity is considered to contain 3.6 MJ or 3413 BTU, so that 8¢/kW-h corresponds on a heat basis to $129/bbl. This is a typical US utility estimate of short-run marginal price to residential or commercial customers; typical European values are comparable or higher. Our calculations lead to a similar US result—about 3.7¢/kW-h busbar or 6.3¢/kW-h delivered (1976 $) from a 1.1-GWe PWR ordered in 1976. The details are set out at 105–113 in A. B. Lovins, *Soft Energy Paths,*[74] and schematically summarized at 42 in "Is Nuclear Power Necessary?"[97] The nuclear costs are debated in letters in *Science*—*200*:381–82 (28 April 1978), *201*:1077–78 (22 September 1978), *202*:1242–43 (22 December 1978), and *204*:124–29 (13 April 1979), of which the last is the most detailed. (Its note 18 cites a higher estimate by the Electric Power Research Institute.) For a comparison of capital costs and delivered energy prices with other options, see A. B. Lovins, "Soft Energy Technologies," *Annual Review of Energy 3*:477–517 (1978), updated in "Re-examining . . ."[97]

[104]See "Re-examining . . ."[97] and "Economically Efficient . . ."[97] for national data. Electrification though appropriate for only about 7–8% of delivered energy needs (12% in Japan, the highest figure for any major industrial country), typically gets about three-quarters of all energy investment and research funding. A notable exception, at least in research, is Sweden, whose 1978–81 R&D budget is 32% conservation and nearly all the rest end-use-oriented renewables: see Energy Research & Development Commission (Sveavägen 9–11, 9 tr, 11157 Stockholm), *Energy Research and Development in Sweden 1978/81*, DFE-13, September 1978. The fission budget, 2% of the total, was to be phased out in 1979.

[105]That it is uneconomic may not be immediately obvious to a consumer from whom the high marginal cost of recently built or newly ordered plants is concealed by "rolling in" their price with that from older, cheaper plants; nor when electric

for low-temperature heating and cooling—space-conditioning buildings and heating water.[106] Additional electricity could *only* be so used. Arguing about what kind of new power station to build is thus like shopping for brandy to burn in the car or Chippendales to burn in the stove.

If one does not build a nuclear power station, the substitute for it is neither an oil-fired nor a coal-fired power station. It does not matter in the least which kind of new power station can send out the cheapest electricity, because *none* of them can even remotely compete in either cost or speed with the *real* competitors—the cheapest ways to do the same unsaturated end-use tasks—such as weatherstripping, insulation, heat exchangers[107], greenhouses[108], window overhangs and coatings,

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heating is promoted by special tariffs cross-subsidized by other users. New nuclear plants are commonly justified by economic calculations based on perhaps 6000 hours of annual use, and their output then sold at a corresponding tariff, only to be used for "peaky" heating whose load factor is a quarter that much or even less. Further, many countries provide large direct and indirect tax subsidies to nuclear power or otherwise artificially depress its apparent price. EURATOM loans, for example, are now being expanded to help European reactor-building. Many US states allow consumers to be charged compulsorily for building plants which shareholders are unwilling to finance. Canada gives Federal grants for the first reactor in any Province. Other, more peculiar examples abound. In the US, a preliminary survey of Federal subsidies to nuclear power identified about twenty categories of subsidy, of which several had effectively infinite value (the industry could not exist without them), most were unquantifiable, and three which were quantifiable were together enough to reduce the apparent price of nuclear electricity by more than half. (A. B. Lovins, "Federal Subsidies to Nuclear Power," statement supplemental to testimony of 20–21 November 1979 before the District Court of Rogers County, Oklahoma, submitted 11 January 1980, and available from FOE Inc.[29]) At this writing, the Canadian Federal government is preparing an "off-oil" program of grants to help householders to switch to, among other options, cross-subsidized off-peak electric-resistance space heating—a way to provide a load for looming nuclear overcapacity.

[106] For example, between a third and a half of all electricity now purchased in the US, UK, France, FR Germany, Switzerland, and Sweden is now used for these purposes, which are also responsible for most of the projected growth in electrical demand.

[107] These simple devices can cut water-heating loads by about a third by preheating incoming domestic water with heat recovered from outgoing graywater. (See the September 1980 *Solar Age* survey on reducing water-heating loads.) They can have an even more dramatic effect on buildings' energy needs when used to recover heat (or coolth) from exhaust ventilation air. Provided the building is tight enough that most of the ventilation is controlled, rather than through cracks, increasing thermal insulation soon makes air exchange the dominant heat loss. For dry climates, an average of about 80% of the heat in the outgoing air can be recovered with a simple "recuperator" (technically, a counterflow heat exchanger) whose design is described by R. W. Besant, R. S. Dumont, and D. Van Ee, "An Air to Air Heat Exchanger for Residences," 1979 (Dept. of Mech. Eng., U. of Saskatchewan, Saskatoon S7N 0W0, Canada). A crossflow heat exchanger which also exchanges latent heat is commercially available (Mitsubishi Lossnay™)

pyrolysis of logging wastes, etc. Indeed, because these measures, intelligently done, generally cost less than the running cost *alone* for a nuclear plant, a nation that has just built such a plant would probably save money by writing it off and never operating it.[109]

at a similar price—about $200. Performance data are available from A. H. Rosenfeld (Lawrence Berkeley Lab., Berkeley, CA 94720), who reports that a residential Lossnay™ with a 45 W blower can typically save about 500 W of heating in a cold climate or 750 W of cooling in a hot, humid one.

[108]Greenhouses with a double shell of translucent material, good thermal insulation on sides not exposed to much solar input, and an adequate thermal mass (heat storage capacity in water, rocks, masonry walls, etc.) are a cheap and effective method of space heating; provide a pleasant "sunspace" and fresh fruits and vegetables most or all of the year; can be built by unskilled people using scrounged materials[249] or cheap plastics; and work especially well in cloudy climates. Solar water-heating panels put inside the upper part of such a greenhouse cannot freeze and hence can be built far more simply and cheaply than on a roof. Greenhouses can be designed into or retrofitted (added after construction) to most types of buildings, e.g. as an attached lean-to on the south side.[248]. Alternatively, other "passive solar" measures—those by which a building captures and stores solar energy in its own fabric rather than needing special collectors—can be designed in or retrofitted, e.g. by painting a south-facing brick wall black and glazing it as a conductive Trombe wall. See *Passive Solar Design Handbook*, DOE/CS-0127/1–2 (1980) and *Passive Solar Buildings*, SAND 79-0824 (1979), Sandia Laboratories (Albuquerque NM 87185).

[109]The extra electricity can be used only for low-temperature heating and cooling. All it is worth paying for those functions is what it costs to do them in the cheapest way: efficiency improvements and passive solar. Those generally cost considerably less than the total marginal running cost of a new reactor, which is in the vicinity of 2¢/kW-h (1980 $): about 1¢/kW-h for fuel-cycle costs including spent fuel management. 0.3¢ for operation and maintenance costs for the plant, 0.6–0.9¢ for operation and maintenance costs for the associated marginal transmission and distribution capacity, and perhaps 0.1¢ (probably a great underestimate) for decommissioning. In contrast, most utility conservation programs being implemented in 1979–80 are reporting a cost of electricity savings around 1–1.5¢/kW-h in residences (despite a general failure to pursue optimally cost-effective measures) and much less in the commercial sector. A detailed analysis of conservation costs by the staff of the California Energy Commission found that commercial-sector savings could provide more than half of the expected 6.7 GWe of peak savings by 1995 at an average cost of only 0.3¢/kW-h (compared to 3¢ for residential). (Conservation Division, Supporting Document #16 to Staff Summary Report for AB1852 Proceeding, January 1978, Ca. Energy Commission, Sacramento.) Most of the conservative empirical studies of conservation costs for building retrofits or for all sectors—e.g. those by Ross and Williams[210] and by Sant[113]—find average costs around $12–14/bbl, equivalent to about 0.7–0.9¢/kW-h. The Santa Cruz Summer Study[210] estimated about $10/bbl for all buildings. Preliminary data from Lawrence Berkeley Laboratory's detailed supply curve for California energy conservation suggest that with a 5%/y real discount rate and 10-y time horizon, electricity equivalent to 1.1 GWe at 69% capacity factor can be saved by efficiency improvements costing less than 1.7¢/kWe-h in the residential sector alone; savings worthwhile against marginal cost are nearly twice as large, and if the commercial sector were included, the savings would be probably at least five times as large.

cost of electricity savings -- but what does it cost to install & operate the conservation schemes?

Under US tax law, the additional saving on future profits and tax subsidies would probably permit the recovery of the sunk capital cost too [110,111].

The importance of redefining the energy problem as "how to provide end-use services in the cheapest way" is vividly illustrated by a sad story from France. Energy planners there, as elsewhere, contemplated a chart of national energy flows, looking somewhat like a tangle of spaghetti (stylized in Fig. 1): primary fuels and electricity entering on the left-hand side, going through various conversion processes, and emerging on the right-hand side as various delivered energy forms that perform such services as heating buildings, making steel, and running cars. Several years ago, the energy conservation planners in the French government started on the right-hand end. Observing that their largest single use of energy was for heating buildings, they sought the best method, and decided that the worst, even with heat-pumps, was to use electricity. They won a highly publicized battle with Électricité de France, as a result of which electric heating in France is supposed to be discouraged or even phased out because

[110]The post-commissioning stream of utility profits and unpaid Federal tax subsidies adds up to the equivalent of two-thirds of the capital cost. (D. Chapman, "Nuclear Economics: Taxation, Fuel Cost and Decommissioning," Report A.E.Res. 79-26 to California Energy Commission from Dept. of Agricultural Economics, Cornell U. (Ithaca, NY), October 1979. An improved model is in preparation. Exact values depend on state and local conditions. We have not discounted the stream of future savings because, we would argue, it is hard to find long-term investments today that actually yield significantly positive real interest.) The other third of the sunk capital cost can also be recouped if the measures that replace the plant[109] are cheaper than its total running cost by ≥ 0.3¢/kW-h. This means that the conservation and passive solar measures used must be cheaper than about $20–25/bbl—an easy target to beat.[210] Our comparison implicitly assumes that the capital cost has somehow been socialized; otherwise we would be comparing a social saving with a cost internal to the utility.

[111]The same argument applies *a fortiori* to partly built, partly amortized, or fossil-fueled plants, down to the capacity needed to meet electricity-specific end-use needs at a cost-effective level of end-use efficiency.[116] (Re partly built plants, see J. D. Peach, US General Accounting Office, letter B-198245 (4 April 1980) to Rep. J. H. Weaver, USHR.) A further subtlety must be noted: it may be argued that additional nuclear electricity displaces existing fossil generation. But to justify nuclear investment for mere displacement, its total cost must be less than the running cost of the fossil plant (which is implausible for coal and dubious even for very efficient oil-fired plants) *and* all the cheaper alternatives to central stations, as noted below, must have been exhausted first. The latter must be shown even to justify continuing to operate *existing* nuclear plants: all opportunities below about 2¢/kW-h (including at least the first three categories bulleted under "Economic priorities" below) must have been fully used before it is worthwhile to operate the nuclear plant even assuming its external social costs to be zero.

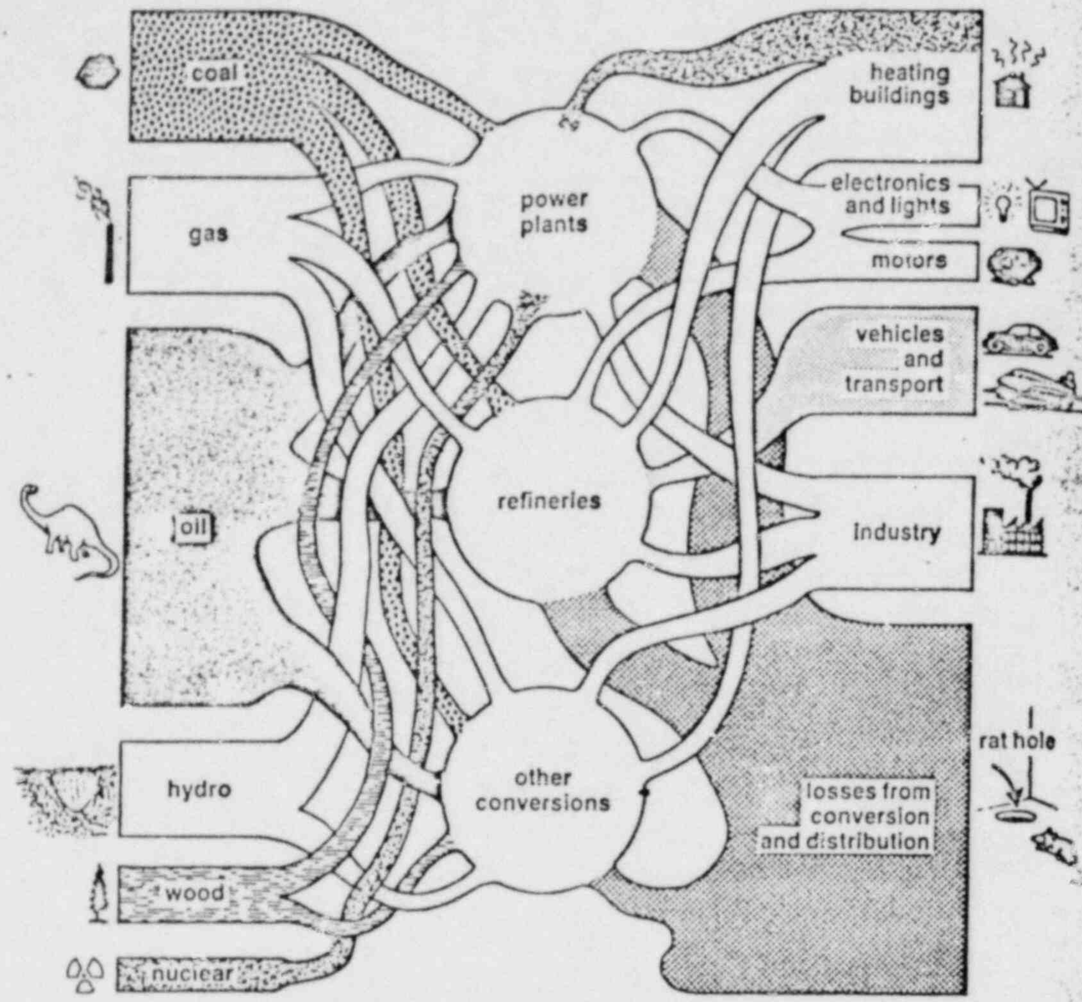

Figure One: A schematic, stylized "spaghetti chart."

it is so wasteful of [illegible] and fuels.[112] But meanwhile, down the street, the far more influential energy supply planners in the French government had started on the left-hand end of the chart. Obsessed with its large input of nasty imported oil, they asked: "How can we replace that oil? Oil is energy," they mused. "We must need some other source of energy. Voilà! Reactors give us

[112]In practice, ÉdF has been able largely to evade this mandate: upwards of 40% of new French housing starts are electric-resistance heated, keeping electrical demand growth on target—at a ruinous economic cost.

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