

the American South, but the black struggle in South Africa is for revolution — not reform.

Unfortunately, short of arming the black nationalist movement, there is nothing we can do to bring majority rule to South Africa. Many Americans are unwilling to commit themselves to support a guerrilla struggle and prefer the public display of moral gesturing. Such appeals will not affect the plight of the Africans. As the struggle intensifies, Americans must decide whether they will be willing to support a black revolutionary movement in South Africa.

I have spent most of my time in these last couple of years running around the international energy grapevine cross-pollinating, and in the process I have noticed many people converging on a hopeful view of the energy future which I would like to help you explore by sketching two

Dialogue on Energy: The “Soft Path”

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ways our energy system might evolve over the next fifty years or so. These two paths are hypothetical and illustrative. I think that they are technically realistic, although they are not intended as precise forecasts or recommendations. Rather, they are qualitative vehicles for ideas. I am going to be quite selective, because the thesis on soft energy paths has already been set down in my book. I would like to resist for the moment the temptation to get into the more seductive technical details, so let us concentrate on some basic concepts.

Until perhaps two years ago there was a broad industry-government consensus that the energy future should be like the past, only more so, and that the energy problem is simply how to expand domestic supplies to meet extrapolated demands. I would like to suggest that this qualitative pattern does not work — not only for logistical and political reasons, but also for economic ones. It's easy to see why if you look at how much capital you have to invest to increase delivered energy supplies by the heat equivalent of one barrel of oil per day. You can see that as we go from the traditional direct fuel systems that our economies have been built on, to offshore and arctic and synthetic oil and gas, the capital intensity goes up roughly tenfold. As you go from these, in turn, to

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the central electric system, the capital intensity rises about another tenfold. It is this roughly hundred fold increase in capital intensity that makes it impossible for any major country outside of the Persian Gulf to use these big machines — especially electric plants — on a truly large scale.

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To start with, just to allocate those resources to the energy sector would require a strong central authority outside the market, perhaps something like a War Production Board. Then, once we had these big complex systems, I presume that we would need big complex bureaucracies to run them and allocate their output. Because these systems are centralized, they automatically allocate the energy and the side effects of getting it, the social costs, to different groups of people at opposite ends of the distribution system. That's considered admirable at one end, like New York or LA, and unjust at the other, say Appalachia or Wyoming. That kind of interregional conflict catches up with you. We have now over sixty "energy wars" going on around the country.

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I think there is, however, another way to look at the energy problem that leads us in much more attractive directions. I call it a "soft" energy path. . . . These two paths are distinguished not by how much energy they use, and not only by choices of equipment, but primarily by their very different political and structural implications — a point I shall come back to. They also reflect two quite different perceptions of what the energy problem is. In the hard path there's a tacit assumption that the more energy we use, the better off we are. Energy is elevated from a means to an end in itself; whereas in a soft path, how much energy we use to accomplish our social goals is considered a measure not of our success, but of our failure.

The energy problem the soft path is addressing is not just how to expand supply to meet extrapolated homogeneous demand; it starts at the other end of the problem by asking, what are our heterogeneous end-use needs? And how can we meet those needs with a minimum of energy supplied in the most effective way for each task?

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I can just state flatly that, in practice, by about the turn of the century we could roughly double this end-use efficiency. We could probably redouble that over the next quarter of a century or so and still have a ways to go entirely

through technical fixes, that is, measures that are now economic by orthodox criteria, use today's technologies, and have no significant effect on lifestyle.

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I have not assumed any significant changes in lifestyles, settlement patterns, or patterns of social or economic organization. If you happen to think today's values and institutions are imperfect, as some people do, then you're welcome to assume some mixture of technical and social change. That makes all this easier, but I haven't done that. I've kept my own values out of the analysis as much as I can.

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Soft energy technologies display the following five properties. First, they are diverse; there are dozens of kinds, each doing what it does best without trying to be a panacea. Secondly, they are renewable; they run on sun, wind, water, and organic wastes. Third, they are relatively simple and understandable from the user's point of view. They still may be technically sophisticated: for example, my pocket calculator is a very high-technology and sophisticated device; I don't quite know what goes on in there and I don't think I could make one, but what matters to me as a user is that this calculator is a tool, not a machine. I run it; it doesn't run me. It's not some mysterious giant lurking over the horizon, presided over by a technological priesthood.

Fourth and fifth, soft technologies produce energy at the appropriate *scale* and *quality* for our range of end-use needs. These are very important concepts which I should amplify. Let me start with scale.

We are all told that energy systems must be enormous to be affordable, and there are often some real economies of scale in construction. But there are also some equally real diseconomies of large scale which we have not properly taken into account before. For example, if you make a refinery, power plant, gas plant or whatever bigger and more centralized, you have to pay for a larger distribution network to spread out the energy to dispersed users. . . . That's a diseconomy of centralization; and some of the energy, of course, gets lost along the way. If there were an opportunity for mass production, if we could turn out power stations the way we do cars, they'd cost at least ten times less than they do; but we can't because they're too big. Big systems tend to be less reliable than smaller ones and they also tend to need a lot more reserve margin: backup capacity must be standing by to take over if this big block of capacity suddenly drops out. There are also indirect diseconomies of scale that arise from long lead

times, which greatly increase your exposure to interest and cost escalation, premature completion risk, and changes in regulatory requirements during construction. Short lead times give you a low initial investment with low risk and rapid adaptation to technical and social change.

There are some other more subtle diseconomies of scale which, I think, are probably more important — even though they are much harder to quantify. There are the high political costs of energy growth which I mentioned earlier and which I think now dominate our energy choices. There is increased local social and environmental stress, which makes it harder to find a site, so the utility would probably try to pack as much capacity onto that site as possible, but that makes the plant a worse neighbor, and the political response to that raises transaction costs for the next site, and so on exponentially. . . .

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What are these tasks that we want the energy for? Well, in this country right now 58 percent of our end-use needs are for heat, mainly at low temperatures. In fact, about half of our total end-use needs are for heat below 350° C. Another 34 percent is for portable liquid fuels for vehicles. A total of eight percent of our end-use needs represents the premium end-uses that need electricity and can give you your money's worth out of it — because it's a very special, high quality form of energy and is correspondingly expensive. At the margin it probably comes in at over \$100 per barrel on a heat basis. You wouldn't want to heat your house with something that costs a hundred bucks a barrel. Now, if you were going to use it to run overhead projectors, PA systems, motors, lights, things that *need* electricity, you might be willing to pay that price. But today we have not eight percent but 13 percent supplied as electricity, with more on the way, and the difference, the extra 5 percent, is already going inappropriately to low-grade heating and cooling — which is where more electricity would have to go if we made more. That is rather like cutting butter with a chainsaw. It's inelegant and expensive and messy and dangerous and bad for chainsaws.

To recap this key point, which is really where all the soft path logic flows from, our energy supply problem is overwhelmingly a problem of heat and of portable liquid fuels. More electricity is not a rational response to that problem. It's too slow and much too expensive.

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Lately, especially in the past year or two, we've had extraordinarily rapid progress in developing a wide range of soft technologies. If you go shopping

around for best buys and add up what we've got already in soft technologies that are in or entering commercial service somewhere in the world, then you find that we've already got more than enough to meet our end-use needs, even for the long run — and even for countries like Denmark and Japan which are the first ones I looked at.

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Each of these paths entails difficult political problems of very different kinds — in the hard path, such problems as centrism, autarchy, vulnerability, technocracy, inequity; in the soft path, problems of pluralism. We are getting used to the idea that in a country this big and diverse, central management is much more a part of the problem than part of the solution. We can't get away without social problems. I think we have to choose which kind we prefer. And I argue that the social problems of the soft path are much more tractable and get easier as we go, not harder. Indeed, I contend that the political and economic advantages of a soft path are so great that if we let them show themselves it would largely implement itself through the existing market and political process.

To get that ball rolling we need to do three kinds of things. First of all, mainly at the state and local level, we need to clear away many institutional barriers — market imperfections, if you like. It's a long, messy list of 3000 obsolete building codes, obsolete mortgage regulations, inequitable access to capital, restrictive utility practices, architectural fee structures that encourage inefficient design, split incentives between builders and buyers or between landlords and tenants, and so on.

Secondly, at the federal level, we ought to stop subsidizing conventional fuels and power to make them look cheaper than they really are. We have got to the point where California's 55 percent solar tax credit cannot compete with the larger federal tax subsidies being offered to Alaskan gas. We cannot afford to give that kind of subsidy even once to the conventional sources, let alone twice to both hard and soft. Third, we ought to move gradually and fairly, as I think we can, towards pricing depletable fuels at levels that reflect long-run replacement costs.

It's not easy to do any of these things; but I think if done right, they'll be easier than *not* doing them. And they can have great political appeal, because a soft path, unlike a hard one, offers something simultaneously to almost every constituency. It offers, for example, jobs for the unemployed; capital for businesspeople (otherwise their capital goes to energy and they never see it again); savings for consumers; chances for small businesses to innovate and for big business to recycle itself; better national security for the military; environmen-