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OIL-RISK INSURANCE: CHOOSING THE BEST BUY

The wisest course may be simply to stop wasting oil and focus on energy efficiency.

GAO'S NEW REPORT on the world oil market suggests that "insurance" against the risks of uncertain oil prices and supplies would be desirable, but costly and unattractive. The report considers mainly supply-side insurance — getting more oil (or other fuels) from more places — on the premise that how much oil we need is largely beyond our own control, save under mandatory cutbacks in emergencies.

This article starts from a different premise: that over an extremely wide range, how much oil we need is not fate but choice. That such flexibility exists has already been amply proven by past energy-efficiency gains that, with relatively little effort or federal support, quietly became so large that they are generally agreed to have chiefly *caused* the soft oil market that culminated in the 1986 price crash. Yet far more remains to be done.

America's most important, yet most overlooked, fuel resource—wringing more work from the energy we already have — can transform risks into opportunities, costs into savings, environmental damage into benefits, insecurity into lasting security, and political disputes into win-win solutions. Energy efficiency is not just a necessity for the transition beyond oil, and a superlative oil-insurance policy meanwhile; it's insurance with a *negative* premium. By systematically saving energy more cheaply than producing it, Americans could put as much as $200 billion a year back in their pockets. Proven, practical ways to do this are available; what's missing is the decision to use them.

PROVEN, PRACTICAL WAYS TO SAVE ENERGY SYSTEMATICALLY ARE AVAILABLE; WHAT'S MISSING IS THE DECISION TO USE THEM.

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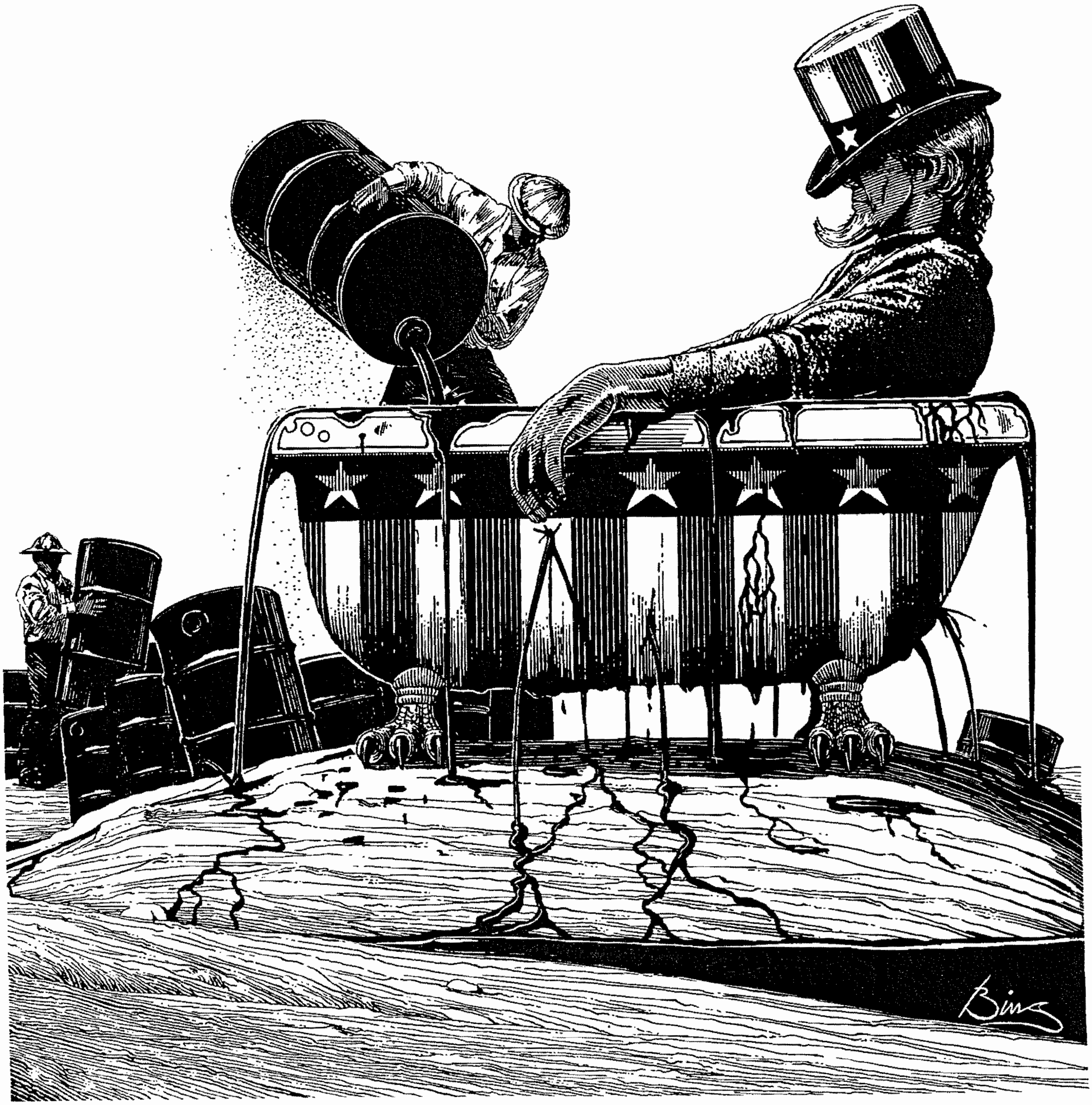
Efficiency: the quiet revolution

The efficiency revolution has taken place in so many millions of small, unglamorous places — an insulated attic here, a plugged steam leak there — that its full dimensions are seldom realized.[1] Yet by 1986, the 13-year-old "energy efficiency industry" *was producing the equivalent of two-fifths more oil per year than the century-old oil industry was extracting.* Moreover, oil has rising costs, falling output, and dwindling reserves, while efficiency has falling costs, rising output, and expanding reserves. As those reserves are exploited — as Americans "drill for oil" in their boilers, windows, and gas tanks — they are flooding the market with savings far too cheap for the Organization of Petroleum Exporting Countries (OPEC) to compete with.

These savings can be realized so quickly that from 1977 to 1985, the United States saved oil at an average rate of 5 percent per year, four-fifths faster than the economy grew and domestic oil output shrank. That's why oil imports fell throughout that period. Since 1973, the United States has gained 3.5 times as much new energy from savings, or at least 3.8 times as much from savings and renewables combined, as it has lost from the decline in domestic hydrocarbon output. Even in 1985 and 1986, Americans saved 78 percent more oil



and gas than was lost in domestic output.

GAO's report describes how increased supplies of other fuels have helped to save oil. Yet more efficient use of energy has outpaced all net expansions of energy supply since 1973 by more than 7 to 1 and, since 1979, by more than 13 to 1. From 1973 to 1986, the energy intensity of the Gross National Product (GNP) fell by one-fourth, its oil intensity by one-third, OPEC's market share by one-half, and national energy bills by some $150 billion *per year*. By 1986, the improvement in national energy productivity since 1973 was equivalent in annual output to 6.4 Alaskan North Slopes, or 12.8 times oil imports from the Persian Gulf, or 2.2 times total net U.S. oil imports.

Very little of this savings was due to lifestyle changes. The average U.S. passenger car, for example, was driven only 6 percent fewer miles in 1986 than in 1973, despite 4½ percent lower real gasoline prices. Only 4 percent of automobile fuel savings from 1976 to 1987 came from making cars smaller.[2] But the *technical* improvement in the car fleet from 13.3 to 18.3 miles per gallon (mpg) amounted by 1986 to a new Alaska or more than two Persian Gulfs.

The impressive energy savings of recent years rest mainly on such simple things as caulk guns, duct tape, and lighter materials. Given today's powerful new energy-saving technologies, the United States has barely scratched the surface of how much energy efficiency is available and worth buying. Rocky Mountain Institute's (RMI) latest analyses suggest that full use of the best oil-saving technologies either on or entering the market would save roughly *three-quarters of all the oil now used*, at an average cost below $10 a barrel. That's cheaper than finding new domestic oil, let alone frontier oil or exotic substitutes.

The need for oil insurance

The reasons GAO cites for concern about oil security are all valid. One—the risk of sabotage or terrorism—is understated, because it can occur not only in the Middle East but also here at home, cutting *domestic* fuel flows far larger than imports. Our 1981 analysis for the Defense Civil Preparedness Agency[3] found that a handful of people could turn off three-fourths of the oil and gas supplies to the eastern United States, for upwards of a year, in one evening's work, without even leaving Louisiana. The Trans-Alaska Pipeline System is one of the gravest threats to national energy security: It carries several times as much oil as the United States gets through the Strait of Hormuz; it is the only way to deliver Alaskan oil; it is largely accessible to saboteurs but could be very hard to mend; and the Army has already declared it indefensible. Indeed, it has already been shot at, and bombed twice, but, fortunately, not competently; apparently the attackers were more interested in theater than in doing serious damage.

In this light, the Strategic Petroleum Reserve, whose delivery system completely depends on three easily cut pipelines to vulnerable refineries, is disturbingly insecure. Oil stockpiles are essential, but they should be in the forms and near the places where they will be needed. Future stockpiles should, in European fashion, be of refined products (replaced periodically, since they deteriorate with age), be far less centralized (so less is at risk per site), and be stored near—but a safe distance from — major points of use.

Supply interruptions are less likely, too, if we pursue friendly relations with major suppliers. Today, most U.S. oil imports come from the Western Hemisphere and Britain. The share supplied by Mexico, Canada, and Venezuela may well increase. Yet across a range of issues—immigration, debt, Nicaragua, acid rain, Arctic protection, economic self-determination, cultural attitudes — U. S. policy could hardly be better crafted to make these three neighbors hold deep and lasting grudges. Building solid long-term relationships is a critical part of any oil "insurance policy."

Even with good foreign relations, stockpiling, and diversification of suppliers, however, some risk of price and supply shocks remains. Price fluctuations are indeed unavoidable: Oil prices have behaved randomly for nearly 90 years[4] and, despite hedging in futures markets, seem to be getting, if anything, more volatile, not less. This is inherent in any market commodity, whether its supply is politicized and cartelized or not: The price of oil is simply behaving as the prices of wheat, copper, or sowbellies have always behaved. The only remedy is to invest so that, as far as possible, one becomes *indifferent* to oil prices — and to dampen price volatility somewhat by ensuring that oil productivity improves faster than oil resources are depleted.

Many who have an interest in exaggerating the residual risks of oil imports seek to substitute for trade (buying foreign oil whenever it's cheaper than domestic oil) a very different prescription, which in a recent article[5] we called by its right name — protectionism. This means resubsidizing domestic oil so it looks cheaper than foreign oil, or taxing foreign oil so it looks costlier than domestic oil, or both. Intervention in the oil market to drive users toward other fuels creates "interfuel distortions" that cause vast and unforeseeable mischief. Also, making domestic oil look artificially cheap discourages its efficient use. And worst, protecting domestic oil from competition by cheaper foreign oil deliberately enables and encourages the domestic oil industry to speed up the very depletion of domestic oil reserves that supposedly prompted the policymakers' concern in the first place: a paradoxical policy David Brower had called "strength through exhaustion." If depletion is a problem, the solution isn't to deplete faster, but to use what we have more efficiently, and thus buy the time to build a sustainable postpetroleum energy system.

IN THE TRANSPORTATION AREA, FUEL-EFFICIENT VEHICLES ARE ONLY HALF OF WHAT'S NEEDED: SUSTAINABLE LONG-RUN SOURCES OF FUEL ARE NECESSARY, TOO.

Energy efficiency is especially vital in transportation: No supply option makes sense for long with a 20- or 30-mpg car fleet. Yet even cost-effective efficiency (perhaps around 60 to 80 mpg for cars and analogously for other vehicles) is only half of what's needed: Sustainable long-run sources of fuel are necessary, too. Efficiency can both make those sources viable and buy the several decades needed to switch to them. While such long-run options as oil shale, tar sands, and coal synfuels cannot possibly compete, diverse biomass fuels do appear to provide a feasible, minimum-cost replacement for oil — the next-best buy after efficiency. With careful management to make farming and forestry sustainable (now they are mainly mining operations), liquid fuels made from their wastes could probably run an efficient U.S. transportation system forever after.[6] Unlike fossil fuels — synfuels being the worst in this respect — such biofuels also would not endanger the earth's climate.[7]

Beware of insurance fraud

The most commonly suggested form of "oil insurance" would, if bought, amount to insurance fraud: It wouldn't deliver on its promise and would, in fact, make matters worse. This fraud is the notion that producing more domestic coal and nuclear power is vital to keeping oil imports at bay. The argument is, in essence, that coal and nuclear power plants have saved a huge amount of oil in the past, so building more of them in the future will save even more oil. All three steps — premise, inference, and conclusion — are false.

DOE statistics through 1986, showing nuclear and coal output in "primary" terms (i.e., the steam they raise in boilers, rather than their electrical output, which is only one-third as large), show that energy savings have outpaced the combined contribution of coal and nuclear power by threefold since 1973, by fourfold since 1979, and by sevenfold since 1985. Of the total increase from 1973 to 1986 in national primary energy supply, savings provided 69 percent; coal, 15 percent; nuclear power, 10 percent; and renewable sources, at least 6 percent. (Renewables probably supplied about twice that much, but DOE stopped counting most dispersed renewable sources years ago, so we use here conservative official estimates[8] showing that renewables now provide about 11 percent of the total U.S. energy supply and constitute the fastest-growing part.

Coal and nuclear electric generation did save a good deal of oil that was formerly burned in power plants — but that oil can be saved only once. In 1973, the burning of oil generated 17 percent of U.S. electricity, and utilities burned 10 percent of all oil used nationwide, but by the 1984-86 period, these levels had plummeted to only 6 percent and 4 percent, respectively. Indeed, nuclear expansion since 1973 *already* has exceeded the oil available to be saved in power plants: At least 27 percent of that expansion actually displaced not oil but coal, America's most abundant fuel. Today, electricity and oil are so nearly unrelated that a doubling of the price of oil would directly raise the average U.S. electric rate by only 1.5 percent.

Worse, the *type* of oil saved by coal and nuclear power was nine-tenths "residual oil," a tar-like refinery byproduct hard to use for anything but boiler fuel. Even if we ignore that important distinction and assume that every barrel displaced by coal and nuclear power would otherwise have been imported, DOE statistics show that if the coal and nuclear expansion of 1973 to 1986 hadn't occurred at all, oil imports would have risen by, at most, 5 percent.

The oil displacement achieved by coal and nuclear plants came at a ruinous cost. From 1973 to 1986, the United States spent some $200 billion on coal and nuclear plants, plus more than $100 billion in direct federal subsidies.[9] (Nuclear subsidies alone were running about $16 billion a year in fiscal year 1984. Per Btu supplied, that's about 80 times the level of subsidy to efficiency sources and nonhydro renewable sources, or about 200 times the subsidy to efficiency sources alone. Yet so great was the cost advantage of efficiency improvements that they wiped nuclear power out of the market anyway!) The nation's investment of $300 billion in nuclear plants doesn't even count the cost of operating those plants, which, with their maintenance needs, currently averages around 5 cents per kilowatt-hour — more than it would cost if they burned oil. Nor does it count any environmental costs, such as risks of climatic change from coal, and bomb proliferation from nuclear power.[10] Even so, just the utilities' own direct investment of $200 billion — to save what their own advocates reckon to be about $14 billion a year worth of oil — can hardly be termed a good deal.

THE OIL THAT COAL AND NUCLEAR POWER SAVED COULD HAVE BEEN SAVED INSTEAD — AT ABOUT 1 PERCENT OF THE COST — BY THE MODESTLY WIDESPREAD USE OF EFFICIENT LIGHTS, MOTORS, APPLIANCES, AND BUILDING COMPONENTS.

Choosing the wrong option makes matters worse

There is, however, a more fundamental point to be made: Even if oil burned in power plants hadn't been displaced by coal and nuclear power, *we needn't have kept on burning the oil.* The real alternative was and is *using the electricity efficiently.*[11] The oil that coal and nuclear power saved could have been saved instead — at about 1 percent of the cost — by the modestly widespread use of efficient lights, motors, appliances, and building components. This could have been completed, using utility-proven delivery methods, in just a few years, and still have left three-fourths of electric efficiency's potential untapped. Today, the potential is even bigger and cheaper: Remarkable new technologies for raising our electrical productivity now make it possible to save three-fourths of all electricity used in the United States (i.e., the output of all the oil, gas, and nuclear plants, and of most of the coal plants, too), at an average cost below 1 cent per kilowatt-hour. That's less than it costs just to *run* a coal or nuclear plant, even if building one cost nothing.

Nor are large, inexpensive electrical savings merely theories. If all Americans saved electricity as fast as the 10 million people served by Southern California Edison Company have actually done in recent years, the nation's long-term power needs would decrease by the equivalent of about 41 one-thousand-megawatt (Chernobyl-sized) plants *per year*, at an actual cost to the utility of 0.1 or 0.2 cent per kilowatt-hour. And that's still without employing many of the latest technologies or delivery methods.

Not only, then, are coal and nuclear plants the slowest, costliest, and environmentally least attractive known ways to save oil; worse, America imports oil today precisely *because* it bought these plants *instead* of more energy efficiency. The cost of these plants can be measured in lost opportunities: The $300+ billion spent on them could have been spent on rapid and direct oil savings in vehicles, buildings, and factories.

The reality of this competition for resources and attention is demonstrated by utility behavior. Many utilities built costly new coal and nuclear plants that now make far more electricity than people want to buy at the high prices the utilities charge in an effort to pay for the plants. Some overbuilt utilities, desperate to recover their costs, are now ordering their previous efficiency-promoting staffs to start marketing more electricity instead. As a result, the Electric Power Research Institute estimates[12] that some 35,000 megawatts of new, on-peak demand will have been deliberately created by 2000. Thus, buying more power plants in a misguided effort to save oil not only retarded more effective oil savings, but also resulted in artificially boosting energy demand, and the strenuous efforts of many utilities to prevent the completion of competing alternative-energy projects, many of them involving renewable energy sources. Before its recent bankruptcy, for example, Public Service Company of New Hampshire rebuffed offers of independent power generation exceeding *three times* its share of the supposedly indispensable Seabrook nuclear plant, and costing less.

Best buys first

The sad story of electric overcapacity has a wider moral. After two previous oil shocks, the federal government sought to spur supply, weaken environmental and procedural safeguards, and dispense lavish subsidies upon hopelessly uncompetitive options, while treating efficiency improvements mainly with benign (or, lately, malign) neglect. Those grandiose supply schemes collapsed of their own weight, strewing fiscal wreckage across the land, while the market, noticing that energy can more cheaply be saved than made, cheerfully produced a gush of efficiency, drowning the supply industries in their own surpluses.

Many of the most vocal participants in today's energy-security debate seem determined to repeat this mistake for a third time. Those who advocate (at least rhetorically) pursuing expanded energy supplies *and* increased energy efficiency must consider the risk of getting neither — through their debilitating competition for resources — or, almost worse, the risk of getting both, and thereby bankrupting the energy industries, which cannot pay for expanding the supply without an even faster growth in demand.

Furthermore, indiscriminately producing "more energy," without regard to kind, doesn't necessarily displace oil. Oil imports have risen recently even as most regions struggled with painful surpluses of electric capacity. The two are not equivalent: It's impractical, or grossly uneconomical, or both, to use electricity for nonrail transportation or for heat — the uses that consume 96 percent of all oil. Electricity, after all, is an extremely expensive form of energy: The 1986 average rate of 6.4 cents per kilowatt-hour is equivalent in heat content to buying oil at $110 a barrel, or about six times the world oil price. Electricity cannot provide heat six times as efficiently as oil; three or four times would be pushing the limits of practical technology, and a factor of two is more realistic. *New* coal or nuclear plants would be about two to three times *less* competitive still. And even in principle, electric cars cannot compete with efficient fueled cars.

ALL USES OF OIL CAN BE GREATLY REDUCED BY TECHNOLOGIES THAT COST FAR LESS THAN BUYING OPEC OIL TODAY, LET ALONE GOING TO THE ENDS OF THE EARTH TO DRILL FOR MORE.

Fortunately, all uses of oil — the 4 percent (as of 1985) burned in power plants, the 8 percent that directly heats buildings and water, the 25 percent directly used by industry, and the 63 percent that fuels vehicles — can be greatly reduced by technologies that cost far less than buying OPEC oil today, let alone going to the ends of the earth to drill for more. Just the savings available in American light vehicles, for example, are equivalent to discovering a new and inexhaustible domestic oil field bigger than the biggest in Saudi Arabia — one producing (not just extracting) some 5 million barrels a day for a few dollars a barrel.

Oil-saving opportunities

We at RMI have developed perhaps the most detailed and up-to-date information available on new ways to save electricity. Now we're starting to examine the analogous potential to substitute modern efficiency-raising technologies for oil. While the oil analysis is at a much earlier stage of development — we're attempting to do the kind of least-cost, all-options analysis that the far more resource-laden DOE has never done[13] — our preliminary findings[14] indicate an unexpected bonanza. For example:

- Improving the car fleet by 1 mpg from the 1986 level of 18.3 mpg would *eliminate* 1985 imports of oil from the Persian Gulf. DOE assumes a 28-mpg fleet in 2010 — slightly worse than the average new 1986 car, and exactly half as efficient as the most efficient American-made 1988 model — and projects a "potential" to achieve 39 mpg "with successful R&D [research and development] effort." Yet at least seven manufacturers' prototypes already have beaten 67 mpg. Volvo's LCP-2000, for example, achieves a composite on-road performance of 71 mpg. It's reportedly a peppy, comfortable five-passenger model, meeting all safety and environmental standards with ease. Volvo is said to be ready to produce it on demand and estimates its extra production cost at approximately zero. A 71-mpg U.S. car fleet would eliminate 1986 Gulf imports more than three times over. Furthermore, Renault's four-passenger Vesta 2 prototype has been measured at 121 composite mpg (101 in the city, 146 on the highway), and the potential for further gains is far from exhausted.
- Today's most efficient commercial jetliners (the Boeing 757, the Boeing 767, and the McDonnell Douglas MD-80) are 2.6 times as efficient as the 1973 fleet and 1.4 times as efficient as the 1986 fleet, and the next generation of aircraft will save another 40+ percent. From the airlines' routine purchases of high-efficiency aircraft at prevailing fuel prices, one can infer that the marginal cost of these airliners' fuel savings is a few dollars a barrel.
- Available technologies can save about 60 percent of heavy-truck fuel and a comparable or larger fraction of light-truck fuel without affecting performance or safety.
- During 1980 and 1981, two National Laboratories showed a potential to save 50 percent of U.S. buildings' space-heating fuel at an average cost of $10 a barrel (in 1986 dollars), or 75 percent at $20 a

barrel.[15] More recent advances include commercially available superwindows—insulating two to four times as well as triple glazing—the full use of which would save more oil and gas than Alaska now provides, at a cost of about $2 to $3 a barrel. (Solar gain through such windows heats RMI's headquarters in temperatures dropping as low as −47 degrees F). Thus, spending 1 year's U.S. military costs in the Persian Gulf to make American buildings more heat-tight would more than eliminate imports of oil from the Persian Gulf.

- The same National Laboratories analysis was ridiculed for projecting a 30-percent savings in industrial fuel during the period from 1977 to 2000. In fact, that saving was *achieved* by 1985, at an average cost of a few dollars a barrel. A similar potential remains untapped.

- RMI has documented how modern technologies can save three times as much electricity as all U.S. oil- and gas-fired power plants now make, at zero net cost to society (because the measures would pay for themselves via reduced maintenance costs).

Since the costs of attaining such savings range from zero to about $10 a barrel (up to twice that for saving 75 percent of space-heating fuel), their *average* cost must be well under $10 a barrel—less than the cost of finding new domestic oil. Yet collectively, these and similar measures appear to have a full practical potential to save about *three-fourths of all oil now used in the United States*, while providing unchanged or improved services—mobility, comfort, shaftpower, light, and the like. That potential is equivalent to finding the hoped-for mean reserves beneath the Arctic National Wildlife Refuge (ANWR) *every 9 months*, forever—at no dry-hole risk, with great environmental and security benefits rather than damage, and at an average cost less than one-third that of ANWR oil. Capturing a mere one-twelfth of that potential would eliminate the 1986 rate of U.S. oil imports from the Persian Gulf—a region where the direct costs of U.S. military force as of fiscal year 1985, not counting the associated risks of conflict, were running about $495 a barrel, 18 times as much as for the oil itself.[16]

Of course, how much of the potential is *actually captured* is a policy variable, but capturing a lot of it is evidently considered feasible by at least some industry experts: Among scenarios considered plausible by Royal Dutch/Shell planners is one with zero U.S. oil imports in 2000. The first step in securing America's oil future is to consider how that result, or an even better one, can be achieved with confidence.

Policy implications

In competitive sectors, such as industry and deregulated public transportation, market forces can continue to drive rapid efficiency gains. Buying as much efficiency as is cost-effective can be aided by modest federal information programs and R&D investments, and by prices that tell the truth. (Desubsidizing the entire energy sector would be a good start, and would save about one-fourth of the entire federal deficit.) But these market-driven savings do not work well in the public sector, in much (particularly low-income rental) housing, and especially in the most important area of all: light vehicles.

Even in the early 1980s, when Americans paid (in effect) a heavy gasoline tax to OPEC, gains in car efficiency came mainly from federal Corporate Average Fuel Efficiency (CAFE) standards and gas-guzzler taxes, not price. Conversely, much of the 1986 dip in U.S. oil productivity came from the administration's rollback of these standards, cutting car-efficiency gains to their lowest level since 1976. That rollback, carried through the next car fleet, will assuredly *waste* oil faster than either ANWR or the currently closed lease areas off the coast of California could *yield* it. Indeed, the 1986 light-vehicle-standard rollbacks directly doubled 1985 U.S. imports of Persian Gulf oil.[17]

Gasoline taxes are the weakest possible signal to buy efficient cars, because most of the people who own the least efficient cars can't afford better ones; fuel cost is less than one-fifth of the total cost of owning and operating a car; and efficient new cars tend to cost about as much more to buy as they cost less to run, leaving the purchaser indifferent to efficiency over a range of perhaps 20 to 60 mpg.

The resulting market failure is severe and can scuttle any chance of successful long-term oil policy. It is so expensive, not the least in short-run military costs (such as the present $50+ billion *per year* in the Persian Gulf), that correcting it by carefully targeted subsidies, which we generally dislike, would be a better buy. Balanced tax/rebate programs or standards or both would also suffice, and could cost the Treasury nothing. Whatever their form, the purpose of these interventions should be to influence car-buying decisions strongly and directly.

Federal standards (or, if the federal government continues to abdicate its responsibility in this area, perhaps state or regional standards) are quick, cheap, and predictable. Other options also merit attention. President Carter proposed rebating gas-guzzler taxes to gas-sipper buyers. The idea was dropped because no efficient American cars were then available; but now they are, and tax/rebate combinations deserve an immediate new look. Existing car excise and ownership taxes could become efficiency-based. Bounties for scrapping Petropigs and replacing them with very efficient cars (or with nothing), so as to maximize the mpg spread between them, are also highly cost-effective: *Giving* people a free 40+-mpg car in exchange for a scrapped Brontomobile would be cheaper than building synfuel plants, none of which would ever be built without huge federal subsidies. Yet no such incentives have ever undergone serious federal analysis.

These and related light-vehicle-efficiency policy initiatives are the crux of any coherent federal approach to insurance against oil risks. Yet inexplicably, policy remains overwhelmingly oriented toward costly, difficult, slow, risky, supply expansions — options that are the enemy of far cheaper, easier, faster, and surer investments to sustain and increase the 5-percent annual gain in oil productivity readily achieved during the period of 1977 to 1985. This lopsided emphasis on "worst buys first" is dithering away the scarcest resource in the decades-long transition beyond oil: not dollars, not barrels, but *time*.

FAR FROM *COSTING* MONEY, THE "EFFICIENCY OIL-INSURANCE POLICY" WOULD YIELD CONTINUAL "PREMIUM REBATES" — AND COULD SAVE TRILLIONS.

Time is of the essence. Accelerated oil savings could shrink or phase out oil imports while stretching domestic oil reserves to fuel the transition to sustainable alternatives. But delaying or muting efficiency gains, while diverting resources to unneeded power plants and frontier oil ventures, will deplete those domestic reserves fruitlessly, and throw America back onto the world oil market at the worst possible time, just as OPEC reasserts supply and price dominance. Very efficient use of oil is not just a sound insurance policy and a very profitable investment; it is essential for a smooth transition beyond oil. The nation needs as much efficiency as it can cost-effectively get, and needs it soon. All supply options are, by comparison, mere drops in the bucket,[18] and a dangerous diversion.

Strong efficiency can secure America's oil and postoil future with room to spare. We don't need efficiency *and* elaborate supply expansions. We can't afford both — they compete for scarce resources — so it's time to pick what works and get on with it. Yet, far from *costing* money, the "efficiency oil-insurance policy" yields continual "premium rebates" — net dollar *savings* — totaling, by 2000, several trillion of today's dollars: enough, if the nation so chose, to pay off the national debt. •

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1. Data presented here on historic energy and oil savings are from various issues of the U.S. Department of Energy's (DOE) *Monthly Energy Review*, supplemented by standard sources, such as the Edison Electric Institute's *Statistical Yearbook* and the Department of Commerce's *Economic Indicators*. Energy intensities are evaluated either by sector per unit of output, or in aggregate per unit of real Gross National Product (GNP), as indicated by the context. Most aggregate savings (reductions in ratios of energy or oil consumption to GNP) are due to technical improvements, less to compositional change, still less to behavioral change. There is strong evidence that nearly all of each kind of saving is irreversible; people do not deinsulate their houses when oil prices dip. This article's calculations are documented in detail in a technical paper, "Drill Rigs and Battleships Are the Answer! (But What Was the Question?)," to be published by Westview Press later in 1988 in an anthology edited by F. Fesharaki and R. Reed, tentatively entitled *The Petroleum Market in the 1990s*.

2. The 4-percent influence of downsizing is from Phil Patterson, *Periodic Transportation Energy Report 1*, DOE (Nov. 16, 1987), p. 1.

3. Amory B. Lovins and L. Hunter Lovins, *Brittle Power: Energy Strategy for National Security* (Andover, Mass.: Brick House, 1982). Our findings were summarized in "The Fragility of Domestic Energy," *The Atlantic*, vol. 252, no. 5 (November 1983), pp. 118-126.

4. H. R. Holt, "Boom and Bust: Chaos in Oil Prices, 1901-1987: A Statistical Analysis," unpublished preliminary analysis, DOE (Mar. 18, 1988).

5. Amory B. Lovins and L. Hunter Lovins, "Energy: The Avoidable Oil Crisis," *The Atlantic*, vol. 260, no. 6 (December 1987), pp. 22-30.

6. We have explored this menu of options in appendixes 2 and 3 of *Brittle Power*, cited above; in an essay with Marty Bender in Wes Jackson *et al.*'s anthology, *Meeting the Expectations of the Land* (San Francisco: North Point Press, 1984), pp. 68-86; and less technically with S. Zuckerman in *Energy Unbound: A Fable for America's Future* (San Francisco: Sierra Club, 1986), a lighthearted introduction to running DOE more sensibly. The alternative fuels now in, entering, or ready for significant use include diverse alcohols, esters, and pyrolysates from biofuel wastes; vegetable oils and terpenes; and, for temporary transitional use, liquefied petroleum gases, compressed natural gas, and perhaps gasoline made from natural gas. Some cost less than today's oil; others can compete only with frontier and synthetic fuels.

7. This is because biomass carbon is "on current account," being temporarily borrowed from the air by photosynthesis; it is immaterial whether the carbon returns to the air by being burned as a fuel, by rotting, or by being metabolized by insects and other animals.

8. We include the Gas Research Institute's (GRI) latest (1985) estimate of wood and wood-waste fuel use, 2.653 q (quadrillion Btus), consistent with DOE's last published estimate of 2.633 q in 1984, up from 1.528 q in 1973, from *Estimates of U.S. Wood Energy Consumption from 1949 to 1981*, Energy Information Administration, DOE/EIA-0341(82) (Washington, D.C.: 1982), and *Estimates of U.S. Wood Energy Consumption, 1980-1983*, Energy Information Administration, DOE/EIA-0341(83) (Washington, D.C.: November 1984). We also include DOE's last published estimate (0.251 q in 1984) for alcohol fuels and miscellaneous crop wastes from *Annual Energy Review 1986*, Energy Information Administration, DOE/EIA-0384(86) (Washington, D.C.: 1987), p. 215; plus GRI's latest published estimate for direct solar capture by nonutilities (0.040 q in 1985); plus DOE's 1986 estimate of 0.01 q

for renewable generation owned by utilities. (GRI, however, estimates the latter at 0.3 q. See Paul D. Holtberg et al., *1987 GRI Baseline Projection of U.S. Energy Supply and Demand to 2010*, GRI (Chicago: December 1987), p. 26.) We conservatively omit the 0.02+ q/y from private wind farms (1.4+ GW installed); non-electric uses of other renewables (DOE's *Energy Security* (Washington, D.C., March 1987) report estimates geothermal direct heating as >0.002 q) (see p. 203 of the report); small hydropower (the same DOE report estimates this fast-growing source at "nearly 0.4 primary q" in 1984 (p. 206), and GRI says DOE's summary statistics exclude it); municipal solid waste's recovered renewable energy component; and such miscellaneous sources as sewage and landfill gas (GRI says that these, along with refinery offgas, coke-oven gas, and blast-furnace gas, totaled 1.26 q in 1983, and believes all these are also excluded from DOE's totals).

9. Our colleague, H. R. Heede, has analyzed these subsidies in detail; see "A Preliminary Assessment of Federal Energy Subsidies in Fiscal Year 1984," RMI, Publication #85-7 (Snowmass, Colo.: June 1985) or, for a summary, H. R. Heede and Amory B. Lovins, "Hiding the True Cost of Energy Sources," *The Wall Street Journal* (Sept. 17, 1985), p. 28.

10. These are extensively analyzed in many publications by RMI staff, such as (1) Amory B. Lovins et al, *Least-Cost Energy: Solving the CO2 Problem* (Andover, Mass.: Brick House Publishing Co., 1981); (2) Amory B. Lovins and L. Hunter Lovins, *Energy/War: Breaking the Nuclear Link* (San Francisco, Friends of the Earth, 1980); and (3) Patrick O'Heffernan et al, *The First Nuclear World War* (New York: William Morrow and Co., 1983). For summaries, see Amory B. Lovins, L. Hunter Lovins, and L. Ross, "Nuclear Power and Nuclear Bombs," *Foreign Affairs*, vol. 58, no. 5 (Summer 1980), pp. 1137-1177, and Amory B. Lovins, *Climatic Change* (Dordrecht, Holland, and Boston, Mass.: D. Reidel Publishing Co., 1982), pp. 217-220. A forthcoming RMI paper by W. N. Keepin and G. Kats shows in detail that nuclear power, far from being a potential solution to the carbon dioxide problem, is a logistically and economically impractical approach that actually *increases* net carbon releases.

11. RMI produces numerous popular and technical publications documenting in detail our assertions about the hardware, economics, and implementation of electric end-use efficiency. A list is available from RMI upon request.

12. *Impact of Demand-Side Management on Future Customer Electricity Demand*, Electric Power Research Institute, EM-48150SR (Palo Alto, Calif.: October 1986), pp. 4-9.

13. One of us (Amory B. Lovins) has been pressing unsuccessfully for such an analysis from DOE and its predecessor agencies for about the past 15 years, especially when he served from 1980 to 1981 on DOE's senior advisory board. An amendment to require such an analysis before the Congress would consider supply-side initiatives, such as opening new Alaskan and offshore areas to oil exploration, was recently offered in the Senate Energy Committee by Senators Wirth, Evans, and Bumpers; was defeated by only one vote; and will surely reappear.

14. These will be documented in the forthcoming "Drill Rigs and Battleships . . ." cited above.

15. Solar Energy Research Institute, *A New Prosperity: Building a Sustainable Energy Future* (Andover, Mass.: Brick House, 1981). This part of the analysis was done by Lawrence Berkeley Laboratory experts.

16. Amory B. Lovins and L. Hunter Lovins, "Energy: The Avoidable Energy Crisis," cited above. The corresponding figure today is probably closer to $150 to $300 a barrel, since imports probably rose by more than costs. Recent RMI analyses by T. Sabonis-Chafee ("Projecting U.S. Military Power: Extent, Cost and Alternatives in the Gulf," paper for Pugwash Conference in Gmunden, Austria, RMI, Publication #87-23 (Snowmass, Colo.: September 1987)) suggest that a major conventional war in the Gulf could cause the American military to *use* more oil there than the United States *gets* from the Gulf during an equivalent period. See also *Energy Security Reader* anthology, RMI, Publication #87-26 (Snowmass, Colo.: 1987).

17. This will be documented in the forthcoming "Drill Rigs and Battleships. . ." cited above. The annual increase in crude oil consumption caused by the rollbacks also equals the annual output hoped for from the ANWR over 30 years.

18. For example, the U.S. Department of the Interior in *Arctic National Wildlife Refuge, Alaska, Coastal Plain Resource Assessment* (Washington, D.C.: November 1986) claims a 19-percent chance of finding ANWR reserves averaging 3.2 billion barrels — enough to meet 1986 U.S. oil needs for 198 days. (See p. 72 of the publication.) That amount was halved by Alaska's own geologists using more complete data, and the probability of finding it was cut by three-fourths when a Wilderness Society mineral economist updated Interior's 1985 tax-law and price assumptions to 1987. (See W. Thomas Goerold, "Environmental and Petroleum Resource Conflicts," *Materials and Society*, vol. 11, no. 3 (1987), pp. 279-307). These corrections reduce the "risked mean" reserve in ANWR (i.e., the amount one might reasonably expect to find) to about *2 percent* of 3.2 billion barrels, or about *5 days'* U.S. demand. A Prudhoe-sized discovery 5 times that big would, Interior says, be about 19 times less likely still. Yet the wildest dreams of ANWR oil enthusiasts pale beside the realities of efficiency. About a week's worth of oil doesn't do much for a decades-long transition; the nation might as well get smart a week earlier.