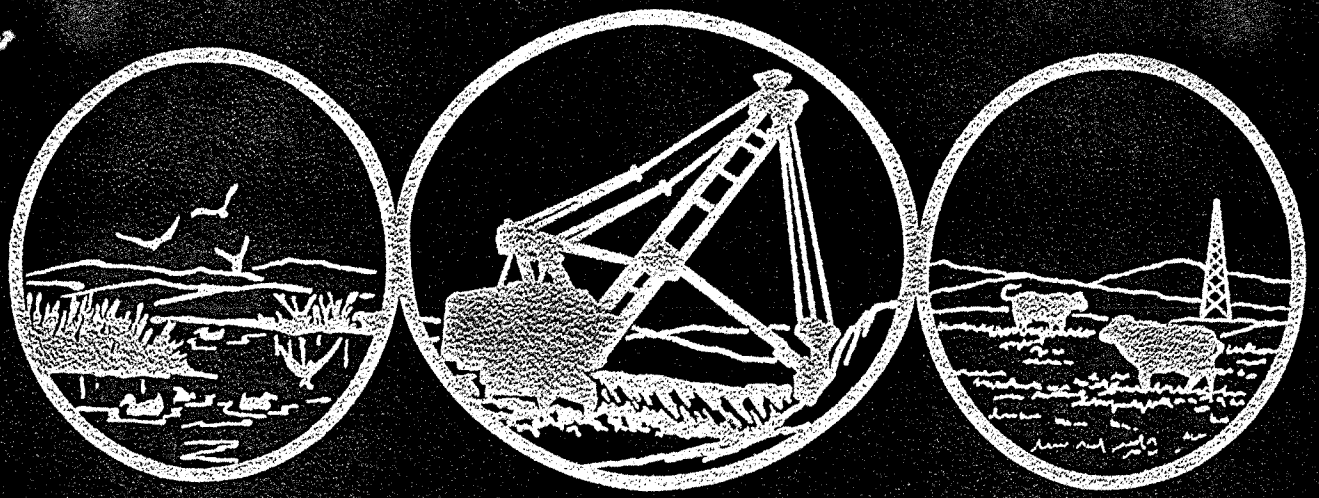

Proceedings:

Rocky Mountain Energy - Minerals Conference

Billings, Montana

October 15 & 16, 1975

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

GOOD AND BAD GAMBLES IN THE SEARCH FOR ENERGY INDEPENDENCE

by

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Before 1973 and the Arab embargo, there were only a handful of scattered individuals in government, industry and the universities who had any coherent view of United States energy problems or a coherent set of policy prescriptions to deal with them. Today there is a broad and detailed body of consensus in the Executive Branch, the energy industries and among teaching and research pundits concerning the situation and what to do about it. It may be worth a few moments to review the main elements of a view that is now the consensus of the American energy "establishment".

This new consensus starts with the historical observation that consumption of energy increases roughly in proportion to both population and real income. The growth of GNP therefore requires a growing energy supply. Over the last generation the United States depended for the growth of its fuels and energy supply mainly on domestic oil and natural gas. Production of both fuels peaked in the early 1970's, however, and is presently declining steeply. The growing gap between consumption and domestic production is being filled by oil imports, increasingly from the Middle East. The concentration of reserves and production in the Persian Gulf region makes import dependence politically intolerable, and the control of prices by the Organization of Petroleum Exporting Countries potentially makes the cost of imports economically intolerable.

According to the establishment consensus, the national response should be to reduce energy consumption, or at least slow its rate of increase. The decline in domestic oil and gas production must be halted or slowed (or even reversed temporarily) through price incentives and through the leasing of new acreage on the Outer Continental Shelf and in Alaska. Utilities should replace oil (which increasingly comes from abroad) and natural gas (which is more valuable in other uses) with coal and uranium as fuel for electrical generation. A pipeline must be built to bring natural gas from the Arctic to the lower 48 states.

There is also a broad agreement among the experts in government, industry and elsewhere on the need for an urgent program to develop new kinds of energy. They would have the United States move promptly toward commercial production of pipeline gas from coal, and petroleum from oil shale, for example. Also, the effective supply of uranium would be extended by development of the breeder reactor. Finally, the energy needs of the next generation should be provided for by means of greater outlays of money now for research on solar power, thermonuclear fusion and other clean and renewable sources of energy.

Despite many differences on details there is also a widespread agreement among the advocates of this program on the policies to achieve it. The key slogan of the consensus is probably,

"The era of cheap energy is over". An adequate conservation effort, according to this view, requires consumer prices for fuel and energy to reach levels corresponding to present OPEC oil prices -- or even higher. Producers must get such prices for "new" oil and gas as incentives for a more intensive exploration effort in traditional areas, for new searches in deeper offshore areas, the Arctic and deeply buried structures. Higher prices for so-called "old oil" are also regarded as necessary in order to slow or halt the decline in production from older fields and to increase the proportion of discovered oil actually extracted. Higher standards for occupational health and safety and for environmental protection also add to the cost of production and fuel processing (oil refining, electrical generation, etc.), and therefore require additional price increases.

Not least, according to the new consensus, is the need for high prices to cover the expected cost of new and unconventional energy sources. It follows, of course, that existing price controls on "old" oil and on natural gas, abandonment of preferential tax treatment of the energy industries, and stricter standards for health and safety, air quality, and coal mine reclamation, can be serious obstacles to assuring the American economy of an adequate supply of domestically produced fuels and energy.

Much of the analysis, program and policy I have just related is supported by a compelling body of fact and logic. In a modest way I suppose that I have contributed to the development of this consensus. But it is flawed in places -- seriously flawed I believe, by intrusions of self-interest, ideology and wishful thinking.

My own reservations are, firstly, that new sources of fuels or massive capital-intensive energy projects of any unconventional sort are not going to play a significant role for the next decade or two. Any major increase in domestic fuel supply will come from oil and natural gas, conventionally discovered and extracted, and from coal, utilized almost entirely as electric utility fuel and to generate industrial process steam.

Secondly, it is virtually impossible to predict how much we will be able to increase production from these conventional sources. Good luck might conceivably leave the United States nearly self-sufficient in energy within a decade. More likely, however, the prospect is for growing imports no matter what policy is adopted, and the big challenge of national energy policy will be to find a way to live with growing imports.

Finally, attempts at a crash program to reduce energy consumption or increase domestic production -- either through private responses to deliberately increased fuel prices or through administrative measures by the government are likely

to amount to unwise suboptimization. That is, the damage in greater inflation, and to employment and environmental quality from radical measures to achieve energy "independence" may far outstrip their potential contribution in security of fuel supplies or foreign exchange savings.

It is no secret that most of the investments now being proposed for new energy sources have high capital costs per unit of output, compared to existing sources. We are looking at investments for coal gasification, shale oil, nuclear power and transportation of Arctic natural gas that are estimated by their sponsors at ten to twenty thousand dollars for each energy equivalent of a barrel of oil per day.

These investment projections are not just marginally higher than recent experience with conventional fuels, but never less than two and in some cases as much as fifty times higher! The real contrast between "old" and "new" energy forms is likely to be far worse. If the history of recent large, custom-engineered construction projects is a guide, their sponsors are underestimating actual costs by a factor of two to five. A study recently done for Senator Jackson by the Library of Congress found that ultimate costs of major construction projects were typically two or three times their original projections (which usually claimed to take into account expected rises in labor costs and materials prices).

The comparable overruns have been four and one-half times, on the average, for nuclear power plants, and will finally be on the order of six to nine times for the Alaska oil pipeline.

There seems to be a rough predictability about cost escalation. The smallest overruns occurred on the interstate highway system, where similar projects were repeated again and again by many different contractors. But the bigger the unit of construction, the more unique the design, the more arcane the technology, the larger the numbers of governmental entities and permits or licenses involved, the greater the cost overruns we can expect.

Evidently the cost engineers on big projects do take into account the expected inflation of wages and materials prices. But those are about the only escalation factors in common use. Cost estimators do not (and perhaps cannot) allow for the fact that the original designs don't often work, that major equipment components are often defective and almost always delivered late, that both the owner and the licensing authorities usually change their minds about what they want several times during design and construction, and that big projects are usually clumsily managed and are particularly vulnerable to labor trouble.

Let me suggest one example. The two applicants before the Federal Power Commission to build a transportation system for North Slope natural gas have estimated their system costs at about $6 billion and $8 billion respectively. Taking normal

luck with such things into account, however, it is hard to imagine either project being completed for much less than $20 billion (including the allowance for interest on funds used during construction). Amortized over twenty years, with a pre-tax return on invested capital of 15 percent, a $20 billion project would have to return an annual cash flow of $4 billion to cover capital costs. With a throughput of about one trillion cubic feet per year, the capital charge alone to bring Arctic gas into existing distribution systems would be $4 per thousand cubic feet.

It is true that gas utilities are already paying prices on that order for relatively small amounts of SNG used for peaking purposes. And it is true that transmission companies and distributors can "roll in" the costs of high cost gas supplements with the prices of their cheaper gas from traditional sources. Even so, I wonder whether the market will accept 1 trillion cubic feet of base load gas -- summer and winter, take or pay --? Will it accept that kind of price if Lower 48 gas were deregulated? Deregulation would increase conventional supply and reduce the volume of gas demanded. It would also mean that there would no longer be a supply of flowing gas priced at less than its commodity value, to blend with gas from new sources whose cost is more than its value. I wonder, would the market accept gas at such prices if the OPEC oil price fell, or even if the price of oil stuck at about its present level while other prices in the economy continued to advance?

Industry sponsors of the Arctic gas pipeline and the energy bureaucrats answer yes to these questions. The Aerospace Corporation, which studied the issue for the Interior Department, answers yes (but their construction cost estimates were, of course, built up in the conventional way).

I wonder, moreover, whether the sponsors will persuade the various state public service commissions that the gas utilities under their jurisdiction ought to sign iron-clad, no recourse contracts for base-load gas that might cost three, four or even five dollars per thousand cubic feet?

I am not convinced that the answer to all these questions is yes. Now, my opinion isn't too important. I don't buy that much natural gas, and I suppose I'll be willing to pay $5 per thousand if I have to. But I am sure that the sponsors are not going to convince the bond market that this project is a totally safe venture.

Among the big-ticket investments in energy independence, the Arctic gas pipeline is probably the soundest of a shaky lot. At least we know that a 48 inch pipeline will carry gas, and that there is a lot of industry experience directly relevant to the project, including that of the Trans-Alaska oil pipeline.

The rival proposal for a Trans-Alaska gas pipeline and LNG tanker system avoids some of the licensing and regulatory risks of the Arctic gas system in dealing with two national

governments, but at the cost of adding substantial technological uncertainties. The LNG system proposed by El Paso would be a big scale-up of existing LNG experience, and some of the major contractors would be firms without experience with LNG on any scale. Here again, however, I think that we can be confident that the system would eventually work, if unlimited money were available to pour into it. But when and at what price is completely speculative. I wouldn't want to have to underwrite the bond issue on this project.

When we move on to making pipeline gas from coal or oil from shale -- not to mention that distant and fading star, the liquid metal fast breeder reactor -- we don't even know whether they will work on a commercial scale, nor whether their environmental and safety problems can ever be overcome, much less when they will go on line or what the ultimate cost of their product (if any) will be per unit of output.

The only way these big-ticket new energy sources will be built is if the federal government pays for them or guarantees them (which in most cases will amount to about the same thing). We are considering Federal commitments of tens, even hundreds of billions of dollars. Mr. Rockefeller's $100 billion Energy Independence Agency may be a crazy idea, but he has the order of magnitude right if our effort is to be directed at "new"

energy sources. I do not think that the federal government is in fact going to spend this kind of money, but even if it did, the maximum conceivable effort could make only a small dent in the deficiency of domestic supply.

Consider: between now and 1985, output from presently producing oil and gas reserves in the United States can be expected to decline by something on the order of 10 million barrels of oil equivalents per day. It would be a near-miracle if the total output of gaseous and liquid fuels from coal and oil shale, plus natural gas from the Arctic, plus electricity from nuclear generating plants not now already under construction, took care of one-fifth of that decline.

Where does pessimism about new kinds of energy leave us? Firstly, with energy conservation, which, because of time, I'll have to skip over here with one observation, that there is a great deal of energy saving that can be achieved with a capitalized cost for less than $20,000 per daily barrel in oil equivalents.

Secondly, we still have immense undiscovered resources of oil and gas. Oil and gas exploration is an entirely different kind of business from producing synthetic fuels or building major gas transmission projects or the maximum scale electrical generating plants. There are literally thousands of enterprises in the oil and gas producing industry, with perhaps hundreds that are large enough and progressive enough to stand on the

cutting edge of new technology. The minimum unit of physical capital, a single wildcat well for instance, ranges in cost from tens of thousands of dollars to several millions -- a scale on the order of one thousand times less than the investment thresholds for SNG, oil shale, nuclear power or gas transmission. The journey to new frontiers of oil and gas exploration and recovery, whether they are technological frontiers, deeper or stormier water, permafrost or deep rocks, can be taken in small steps, with part of the industry consolidating information and techniques from the last step while other firms take the pioneering risk.

Onshore, the payoff to exploration investment can be a matter of weeks, and is seldom more than two years. Offshore and in the Arctic, it may be three, five or seven years, but seven years is probably the minimum lead time for the big-ticket projects I discussed earlier.

It is unfortunate that so much propaganda has been made over the alleged riskiness of the oil business, because for a reasonably big operator, exploration risk can pretty well be swamped by the law of large numbers. Exploration is indeed a gamble, but the industry has always treated it as a fair gamble; that is, the gains of the winners tend to offset the losses of the losers. We have good evidence that the industry has in fact been a fair gamble, in that its return to stockholders'

equity has tended over time to be almost identical with that for all manufacturing.

In my judgment, domestic oil and gas -- particularly on the unexplored provinces of the Outer Continental Shelf and Alaska -- is still the nation's best bet for quick and relatively inexpensive replacement or additions to our supply of domestic energy.

It is preposterous even to consider a major effort to produce new kinds of fuels from investments that cost ten, twenty or thirty thousand dollars per daily barrel of oil equivalents, and take a decade or more to complete, while we have yet to drill 95 percent of the sedimentary acreage on the Outer Continental Shelf. The cost per daily barrel on the OCS is likely to be nearer to $5,000 -- or even $500 -- per daily barrel than $20,000, and the payoff time, a fraction of that required for the synthetics. It is also preposterous to consider manufacturing synthetic gas, moving it by pipeline five thousand miles, or importing methane in liquid form, for three, four or five dollars per thousand cubic feet while price regulations still effectively prohibit producers from looking for or developing conventional natural gas that costs more than 52 cents.

Ten wells could be drilled in each of the twenty most promising geological structures on the Outer Continental Shelf (or onshore Alaska) in two or three years at a cost of perhaps

five billion dollars. This effort would likely turn up at least one supergiant oil field, capable by itself of producing as much fuel as all the synthetics, new nuclear plants, or long distance gas transport projects could provide ten times the investment. And the payoff to this effort might conceivably be far greater still.

Oil and gas are our best gambles, but gambles they remain. We simply do not know how much is there, and how much is likely to be discovered at any given price.

A really good geoeconomic model could conceivably predict with some confidence the average impact of price changes on reserve extensions and revisions in known fields, and on the discovery of new reservoirs in established producing provinces. I suspect that such a model would show that we bought lots of new oil by letting the price go from $3 per barrel to perhaps $7, but that we won't get very much more by letting it go from $7 to $14. This is just one non-expert's intuition, of course, but in the absence of that non-existent geoeconomic model, we are all non-experts.

No matter how sophisticated our geoeconomic model was, however, it wouldn't have predicted the discovery of the Prudhoe Bay and Santa Ynez fields. Nor would it tell us that Destin Dome would yield nothing but dry holes. The so-called

giant and supergiant fields -- structures with a billion barrels or more of recoverable oil or its equivalent in gas -- will make the big difference in the United States energy balance through the 'eighties and 'nineties. When and if we find these fields, their production is likely to be extremely cheap per barrel of oil or cubic foot of gas, even by preembargo standards. But, because their discovery is a random -- and rare -- event, our estimates of the cost of new oil and gas tell us nothing useful about the prospects that in fact determine whether the United States will achieve energy independence.

For this reason, I don't have much use for oil and gas "supply functions" that purport to relate prices to rates of production. There seems to be a very good fit between exploratory drilling and reserve additions in the United States since 1950 -- showing a steady decline in the success rate -- if we leave out Prudhoe Bay. Include Prudhoe Bay and the trend in the success rate is positive, but statistically insignificant. In other words, there is no discernable trend unless you deliberately bias your sample.

Bluntly, the national energy posture ten years from now depends more on luck than anything else. It is possible, however, for the United States to make itself unlucky -- by not leasing the OCS, by certain well-meaning but poorly thought out changes in the leasing system (requiring royalty bidding, or excluding

the major companies for example), or by giving a government corporation (or anyone, for that matter) a monopoly on frontier oil exploration.

Coal is the third real hope for improving the national energy posture within the horizons of today's investments. Turning coal into electricity is expensive and the investment in conversion comes in big lumps that take a long time to pay off. But technological risk is almost absent and market risk is far less than it is for the synthetics, for example. The electric utilities and their vendors know (more or less) how to build and operate fossil-fired plants at high load factors, and the capital market at least knows how to evaluate the securities of electric utilities.

Even with the new union scales and the new health and safety standards, even with surface mine reclamation standards as stiff as any yet seriously proposed, there is no engineering or economic reason why increasing volumes of coal cannot be delivered to utility and industrial boilers as rapidly as they can convert, at a cost far less than the price of OPEC oil -- and with plenty of margin to solve the emissions problem (if the utilities really want to solve the emissions problem).

The coal industry evidently does not face a general capital shortage; investment in some new or expanded mines can be turned

over in one or two years, and a contract to deliver coal to a utility is literally money in the bank, if you have a producing mine. The constraints on expansion of coal production and use are many but they are mostly institutional. They include decades of neglect of coal research by both industry and government; neglect of coal policy generally by the federal government; and stubborn, unimaginative and backward-looking leadership in the mining industry, the utilities and the railroads.

I do not know whether the United States will in fact realize the great possibilities for coal. Again, I can offer only an intuition -- that a breakthrough would be only inches away if there were imaginative policy leadership in Washington from a few individuals who really knew the coal business and the utilities, yet who recognized that health and safety, unions, air quality and other environmental standards, and a local voice in coal development policy, are here to stay.

Let me return for a moment to the consensus I described at the beginning of this talk. My differences with the establishment view are mainly differences of emphasis, but they are significant differences. The responsiveness of new capital-intensive kinds of energy supply to current prices is almost non-existent, and the cost-effectiveness of investment in them is uncertain and probably low. Most of them will not get underway at all without large and costly federal involvement.

These are not simply unfortunate handicaps that must be overcome, to otherwise desirable or essential programs. They are indications that at least some of these programs really don't make economic sense.

Federal support is desirable for a limited number of first generation commercial-scale synthetic fuel plants, but only to explore possible options for a future generation. No one should suppose that they will -- or ought to -- make a significant contribution to energy independence within today's investment horizons. I have two qualifications to this negative evaluation: In situ processes for extraction of shale oil, tar sands or heavy oil (as opposed to the cumbersome process of mining, retorting and replacing the spent mineral) could conceivably break through the heavy capital cost, materials handling and water supply barriers that now make commercial production so uncertain. And solar heating and cooling might well make rapid and significant progress in the residential-commercial sector (central station solar power is, at least, decades away)

The big hope for real improvements in the domestic fuel supply outlook is in oil and gas -- but it is only a blind guess what reserves will be ten years from now. Except for a purely psychological effect on industry attitudes, it may not matter much whether the new oil price is $7.50 as recently

proposed by the House of Representatives, instead of about $15, where it will settle if Mr. Ford's tariff and OPEC's 1975 price increase survive. Natural gas pricing policies and OCS leasing schedules, however, might make a huge difference.

The conversion of electric generation from oil and gas to coal offers the second largest potential for improving the domestic supply picture, and an even more certain prospect technically. The obstacles to this conversion are each relatively minor but they are many and some of them are stubborn. Coal hasn't been glamorous enough to attract serious analysis of policy debate, and we are not yet doing much to realize its potential.

In summary, there is no crash program that will achieve energy independence. Throwing big chunks of federal money at the problem, as Mr. Rockefeller has proposed (and Mr. Ford has agreed upon) is likely to misallocate resources grossly with only tiny and uncertain effects on output. The federal government's most effective contributions to increased production of domestic energy would be first, to encourage oil and gas producers to do what they want to do and are equipped to do, without letting their profits outrage public decency. Second, the government must induce the coal and electric utility industries to do what they have to do but are evidently incapable of mobilizing themselves to do. Third, only the

central government (and the Federal Reserve) can execute policies and end the recession and runaway inflation, which creates both a shortage of capital and a disincentive to investment in all industries, and which assures popular resistance to many necessary long term measures in the energy area.

Finally, we have to face up to the fact that there may be no policy that will halt the growth of oil imports. For this reason the United States ought to devote more attention, firstly, to insuring against supply interruptions by establishment of a system of strategic oil storage; secondly, to market innovations directed at weakening the power of the cartel; thirdly, to encouraging the United States-based multinational oil companies to expand their worldwide exploration efforts (rather than contract them, as implied by some current political rhetoric) in order to decentralize the sources of potential oil imports; and fourthly to assisting in the economic development of the oil exporting nations and growth of their non-oil trade.

Let me enlarge on only one of these points, weakening the power of the cartel. There are indications that the OPEC price has about reached as high as it can without generating intolerable strains among its members. While world petroleum demand is still price-inelastic, that is, while further price increases can still swell the revenues of OPEC as a group, this is no longer true for Saudi Arabia alone, upon whose forbearance

the cartel's viability depends. Several of the poorer producers (including some of the most militant with respect to price) will not, or cannot afford to, cut back their liftings in order to support a new, higher price. Saudi Arabia is thus forced to accept far more than its proportional share of production cut-backs, and it appears now that higher OPEC prices mean reduced revenues for this one country. I wonder just how long the Saudis will continue to forbear for the sake of higher incomes for Iraq, Iran, and Libya. Now is probably the opportune moment to give serious consideration to the proposal of Professor Adelman to encourage secret price-cutting by the producer governments through a secret bid auction of import quotas.

Finally, a word on the politics of energy. There is, as you may know, an alternative view of energy matters to the establishment consensus I described at the beginning of this paper. Most Americans of course do not have a coherent theory of the energy crisis or a coherent energy program. But the attitudes expressed by Ralph Nader, Jack Anderson or the Sierra Club are probably far more popular than those of Mr. Ford, the National Petroleum Council or most academics with an interest in energy.

Many Americans believe that OPEC and the multinational oil companies share a common interest in high world energy prices and that together they operate a system of production control

that supports these prices. According to this anti-establishment view, the oil industry together with the automobile and appliance manufacturers; the utilities, real estate developers, construction unions and others, resist all serious efforts to conserve energy because they make their profits from selling American consumers expensive and energy-wasteful hardware and lifestyles.

Most citizens, moreover, probably take it for granted that collusion, conspiracy and corruption are the life blood of these industries, big oil above all. The recent exposures of real-life collusion, conspiracy and corruption have not enhanced people's willingness to take advice from the oil industry or a Republican administration to the effect that high fuel prices and relaxation of environmental standards are in the public interest.

While few members of Congress believe full-blown populist conspiracy theories about oil prices and other energy matters, their votes do tend to reflect the beliefs and attitudes of their constituents, as well they should in a democracy. And although most members of Congress are sensitive to energy issues other than price, they do share the voters' view that economic conditions take precedence over prompt reductions in oil imports. Not only is this a circumstance which is appropriate in a democracy; on this issue I believe the citizens and the Congress are wiser and more responsible than the energy experts.

I have taped to my desk a fortune cookie paper that says, "Beware of what you want; you may get it". With the present consciousness of the American people, the worst thing that might happen to the energy industries would be for the power of Mr. Ford's vetos to give them what they think they want: decontrol of prices, relaxation of environmental standards and billions in subsidies for otherwise uneconomic hardware. These measures would undoubtedly stuff the companies full of profits; they would probably worsen inflation and unemployment; but they just might not accomplish much for our national energy position.

I cannot imagine a better formula for a very cruel -- and counterproductive -- popular backlash against private enterprise in the energy business.