MONITORING CHANGES IN ECONOMIC DEVELOPMENT: HIGHER ENERGY PRICES AND PROJECT REAPPRAISAL

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ABSTRACT: The abrupt increases in the cost of energy since 1973 have had far-reaching effects, not only on global wealth distribution and world growth prospects, but also on the selection of appropriate technology in all sectors of countries' investment plans. For the water and wastes sector, the impacts of high energy prices are generally of two types: changes in the cross-country distribution and national demand for water and waste projects caused by macroeconomic changes, and the microeconomic effects on methods of project evaluation and technology choice. This paper discusses these two aspects and concludes that in both developing and industrialized countries, higher energy prices will result in a higher opportunity cost for water, thereby increasing the attractiveness of water-saving technologies.

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Monitoring Changes in Economic Development: Higher Energy Prices and Project Reappraisal

by DeAnne Julius[a]

Introduction

Probably the most significant development of the decade of the 1970s was the large and sudden increase in the world price of oil. The dramatic rise in the price of that one commodity has caused a significant slowing in the economic growth rates of both industrialized counries and the oil-importing developing countries (OIDCs) and a major redistribution of global wealth. It is now generally agreed that the energy problem of the 1970s was not a passing phenomenon but rather marked the end of an era of cheap oil and gas, and the transition to a period of high cost energy.[1]

The implications of this change are far-reaching and affect the work not only of economists and energy specialists but also of engineers and managers not directly connected with the energy sector. Whereas prior to 1974 energy was endowed with no more importance than that of any other input in production, it is now necessary for planners in every sector to reappraise past choices in light of their implications for future energy use or production.

This paper discusses the impacts of the changed energy situation on investment planning and project evaluation in the water and sanitation sector. In general, these impacts are of two types: changes in macroeconomic factors that affect the global distribution of and national demand for water and waste projects; and the microeconomic effects on project evaluation and the choice of technology.

Macroeconomic Effects

At the international level a massive shift in wealth has already taken place. The annual rate of growth per capita of the OIDCs during the 1970s was 2.7% compared with 3.1% during the 1960s. In contrast, the annual per capita growth rate of the oil exporting developing countries (OXDCs) accelerated from 2.8% during the 1960s to 3.5% in the seventies. Projections for the 1980s are essentially for a continuation of these trends (see Table 1).

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Table 1
Economic Growth, 1960-1990

	Population 1980 (millions)	Average Annual Real Growth of GNP per capita		
		1960-70	1970-80	1980-90[a]
Low income oil importers	1133	3.1	0.9	1.6
Middle income oil importers	701		3.1	2.6
Oil exporters	456	2.8	3.5	3.2
Industrialized countries	671	4.5	2.4	2.8

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[a] Average of high and low growth cases.
Source: World Development Report, 1980, World Bank, August 1980.

The OIDCs

With four-fifths of the developing world's population in the OIDCs, these lower growth rates imply increased stringency in the investment criteria that will be applied to projects affecting the bulk of the world's poor. With the International Drinking Water and Sanitation Decade now underway, many countries have pledged to devote a larger proportion of their investment resources to the water and wastes sector. But with the lower growth rate in total capital available, and with inflation levels likely to remain high over the decade, the sector will probably see only a marginal increase in its real available investment resources. This implies that in order to reach the ambitious Decade goals of greatly expanded coverage,[2] the cost effectiveness of sector investment will have to be dramatically improved.

Fortunately, the technical means to do so are now at hand. Recent work, both on water supply technology[3] and on waste disposal,[4] has demonstrated the technical feasibility of providing water service and adequate sanitation at a fraction of the cost of conventional technologies used in industrialized countries. Field applications of these technologies, along with their supporting health and social infrastructure, are now underway in over a dozen countries.[5] The major remaining obstacle to the successful spread of these efforts is the politically difficult change in philosophy needed in some countries to expand sector priorities from improving the service levels and coverage of existing water and sewerage systems to include the wide-spread provision of low cost facilities to those who currently lack them. In addition, the "human infrastructure" requirements for the health and social aspects of introducing new water and sanitation technologies are very large.

The OXDCs

In some of the oil exporting developing countries the situation is surprisingly similar to that in the OIDCs. This is because OXDCs such as Ecuador, Egypt, Indonesia, Nigeria, and others are not capital surplus countries and have large populations with many unserved needs. For some, even when financial resources become available, skilled manpower and other constraints will prevent the effective construction and maintenance of conventional water and sewerage systems.

In the seven capital surplus developing countries,[6] investment capital is not a constraint. Curiously enough, however, all of these countries are very poor in water resources.[7] Since conventional technologies are extremely water-intensive, sector development in the capital surplus countries can follow one of two directions. Either conventional water resources can be supplemented with desalinization or other expensive water production technologies; or water-saving, nonconventional systems can be designed to provide the very high convenience standard that the wealthy population demands. If this latter route is followed, it could have a significant payoff for poorer countries in testing high standard, water-saving technologies that may represent the ultimate upgrading of initially simple and low-cost systems.

The Industrialized Countries

In the industrialized countries, the adjustment to higher energy prices has stimulated interest in developing alternative energy sources. Two of the most promising of these (see below) are highly water intensive and, in the U.S., would be concentrated in the western states where water is a major agricultural input and is already becoming relatively scarce. In economic terms, the impact of these new uses for water is to increase its opportunity cost and thereby signal its increased value in all uses. Only relatively high-valued uses may be able to successfully compete with energy-related water demands, and the incentive for water-conserving technologies in all uses will be increased.

The first economically promising, but water intensive, new energy source is oil shale.[8] Oil shale deposits are found throughout the world. Those in some countries (Scotland, Spain, Australia) have been the sites of small-scale industries in the past; other countries (Brazil, the U.S.S.R., the People's Republic of China) either have such industries or are building them. Large deposits are also found in the eastern and midwestern United States, but because of their richness and accessibility the deposits in the Green River formation of northwestern Colorado, southwestern Wyoming, and northeastern Utah are the ones most likely to be developed in the near future. Overall, these deposits contain the equivalent of over 8 trillion barrels (bbl) of crude shale oil, although only about 400 billion bbl could be recovered economically with existing technology.

Water is a critical resource in the oil shale region. The growing demands of towns, farms, mines, and recreation, along with the requirements for export to urban areas such as Denver, are already beginning to place a strain on the region's water supplies. There is at present enough surface water in the region to establish an oil shale industry, although new reservoirs and pipelines within the area would have to be constructed to supply water to the plants. However, the water resources are not sufficient to sustain a large industry in the longer term without diverting water from other uses.

As shown in Table 2, depending on the technology chosen, producing

50,000 bbl/day of shale oil would consume 4,900 to 12,300 acre-feet/year of water for mining, processing, waste disposal, land reclamation, municipal growth and power generation. A one million bbl/day industry using a mix of technologies might require 170,000 acre-feet/year, which would be about 30% of the amount presently used by irrigated agriculture along the White and Colorado Rivers. Depending upon the assumptions made about the growth of water demands in industrial, residential, and agricultural uses (and excluding recreational and environmental concerns), a surplus of water would be available for oil shale development for the next 25 to 35 years. However, the long lead times necessary to bring the technology up to commercial scale production, coupled with the major environmental concerns raised by large-scale syncrude developments, significantly shorten the period for unconstrained production.

Table 2
Requirements for Oil Shale Production

	1990 production target, bbl/d		
	100,000	400,000	1 million
Resource	Requirements		
Institutional			
Design and construction services, % of 1978 US capacity needed each year	minimal	12	35
Plant equipment, % of 1978 US capacity needed each year	minimal	6-12	15-30
Economic and financial[a]			
Loans, $ billion	$0.9-1.35	$3.6-4.2	$9.0-13.5
Equity, $ billion	2.1-3.15	8.4-9.8	21.0-31.5
Total, $ billion	3.0-4.5	12.0-14.0	30.0-45.0
Annual, $ billion[b]	0.6-0.9	2.4-2.8	6.0-9.0
Water availability[c]			
Water, acre-feet/year	9,800-24,600	39,200-98,400	100,000-250,000
Socioeconomic[d]			
Workers	5,600	17,600-22,400	44,000-56,000
New residents requiring housing and community services	23,000	82,000-95,000	118,000-236,000

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a Third-quarter 1979 dollars.
b Maximum annual requirements for a 5-year construction period.
c Assumes 4,900 to 12,300 acre-feet/year for production of 50,000 bbl/d of shale oil syncrude.
d Assumes 1,200 construction workers and 1,600 operators per 50,000 bbl/d plant. Multipliers used for total increase = 2.5 x (construction workers) + 5.5 x (operators). Ranges reflect phasing of plant construction.

SOURCE: Office of Technology Assessment.

There is evidence to suggest that once water availability does become a constraint, the oil shale industry may be well placed to compete with agriculture and other users. At the margin, the most expensive water supply option (import from other hydrological basins) could cost about $1/bbl of shale oil produced. With the benefit side of the oil shale equation tied to the price of imported oil, the industry could probably afford sufficiently high water costs to crowd out other uses.

The second energy-related technology that is likely to increase the competition for, and thus the opportunity cost of, water in the U.S. is the development of coal slurry pipelines as an alternative to rail transport.[9] A slurry pipeline involves the pumping of finely ground coal suspended in water (or potentially some other liquid medium) through a pipe over a long distance. The technology is proven and, while the economics depend critically on site-specific parameters (e.g., annual volume of coal shipped, distance traversed, mine spacing, security and location of market, etc.), under a reasonably wide range of circumstances, slurry pipelines are economically superior to rail.

The amount of water required to transport coal varies inversely with the moisture content of the coal. For 30 million tons/year of coal with a 20% (10%) moisture content, for example, about 14,000 (18,000) acre-feet/year of water would be required. It has been estimated that a pipeline carrying 125 million tons of coal per year from eastern Wyoming would use about 3% of available surplus water flows in that area. The economic and social impacts depend on the degree to which pipeline water demands infringe on alternate uses for the same water. Sufficient water is physically, although not necessarily legally, available in the three western coal-producing areas mentioned to service both existing uses at present levels and a substantial number of coal slurry pipelines. However, pipelines would compete directly with other possible future uses.

The water-related impacts of coal slurry pipelines can be mitigated if sources of water can be found which are usable for slurry but not for most other purposes. There are three promising possibilities: irrigation return flows, primary or secondary sewage effluent, and saline ground water. In each instance the water may need some purification for use as a slurry medium but this appears to be a manageable requirement. Sewage effluent will not be available in sufficient quantities in many areas to serve as more than a supplementary water source, and the sizes and locations of saline ground water sources are generally not well known. An additional means of mitigating the pressure on limited water resources is to recycle the recovered slurry water by return pipeline. The limiting factors are the high, but not necessarily prohibitive, cost of such a self-contained system and the fact that not all of the water can be readily separated from the coal.

In summary, the major impact of the changed energy situation on the water and wastes sector in industrialized countries is likely to be a positive shift in the demand function due to new uses for water in energy-related activities. In contrast, the LDCs are likely to face a tightened budget constraint. Both of these conditions, however, will have the effect of encouraging water-saving technologies and reuse possibilities in the water and wastes sector.

Microeconomic Effects

At the project level, higher energy prices may affect the choice of technology by discouraging those that are relatively energy-intensive either in their construction (e.g., excavation equipment) or in their operation (e.g., diesel powered pumps). Projects that are energy producers (e.g., biogas digesters for waste disposal) will obviously look more economically attractive.

Because domestic energy prices in many countries are significantly below opportunity costs, it is important for purposes of project evaluation that the appropriate economic cost of energy be used. There is some confusion, however, over how to determine the economic cost of resources which may be depletable (or not), tradeable (or not) and substitutable for each other. This section reviews the basic theory of economic costing as it applies to energy, and indicates the types of problems that may arise in practice.

Tradable Energy Products

The economic price of any product, including any energy product, is its opportunity cost to the country. Since most energy products are tradable, this can often be easily calculated as the highest price for which the product could be traded either within the country or with other countries. Examples of tradable energy products are crude oil and most refinery products. Here the relevant measure of opportunity cost is the FOB or CIF border price for international trade regardless of whether this is set by a cartel of major producers or by the operations of the free market. The value of an extra unit of production is the potential value of foreign exchange that is earned if the product is exported or, if that particular unit is to be consumed domestically, the value of foreign exchange that is released by reduced imports.

This principle also applies to those energy products which are not actually traded but which substitute for products that are. For example, many developing countries use natural gas as a replacement for fuel oil in generating electricity. In some advanced sewage treatment facilities natural gas is used to supplement available biogas. The production cost of the natural gas is often less than $1.00 per million BTU while the equivalent international fuel oil price is above $4.00 per million BTU. Even after appropriate adjustments are made for transport differentials (e.g., pipeline versus tanker) and conversion of the boiler, there is often a substantial differential -- sometimes called "economic rent" -- between the production cost and the opportunity cost of the gas. (Indeed it is this differential that has made indigenous energy investments so attractive in recent years.) Questions may arise about the appropriate distribution of the economic rent, but the economic price of the gas is still the adjusted border price of its tradable substitute.

In many countries, non-traded energy products such as natural gas or coal are or could be used to substitute for a variety of tradable energy products. An important question then arises about which substiture to use for economic cost purposes. For example, an alternative use for natural gas is as a feedstock for fertilizer and petrochemical plants where it might substitute for naphtha whose international price is above $7 per million BTUs.[10] For a country with limited gas resources it is important that the gas first be deployed to its highest value use, and only when that is satisfied should it be used to substitute for lower valued resources. The general rule is that the opportunity cost of the resource will be equal to its value in its marginal use as one moves down the demand curve from higher valued to lower valued uses. Thus, the economic price of gas in a country with very limited reserves will be very high to indicate that at the margin it should still be used only in relatively high value uses. In a country with more gas, where it substitutes for fuel oil as well as naphtha and other higher value fuels, its marginal value would be as a fuel oil substitute. At the extreme, for a country with gas reserves many times larger than projected demand for all its uses, the <u>marginal</u> use may be simply to leave it in the ground. For that country gas should be treated as a nontradable.[11]

Non-Tradable Energy Products

For a product that is neither traded itself nor acts as a substiture for other tradable products, the opportunity cost must be based on the economic value of the resources used in its production. This is a familiar rule to those involved in project evaluation in many sectors, from agriculture to transport to water supply. For certain energy resources, however, it contains an extra twist because an exhaustible resource possesses a scarcity value or "user cost" which must be added to its production cost to determine its economic price. Other things being equal, this user cost will be positively correlated with the current and expected demand for the product, and the expected level of prices for the substitute product which will be used to replace it once stocks run out; and it will be negatively correlated with the size of the exhaustible resource's reserves and with the social discount rate which is a measure of the extra value attached by the country to an extra unit of consumption today versus one in the future.

The precise calculation of the user cost for a particular case is generally impossible because of uncertainties about future demand elasticities, the size of the resource base, and future prices of substitutes. A very rough estimate is sometimes made by taking the present value of the substitute product in the year when reserves are expected to be depleted. Fortunately, however, it is very seldom that there is a need to estimate the user cost since it only becomes important for depletable products which are not tradable and which do not substitute for other products which are traded. This combination of curcumstances does not frequently arise.

Two further considerations are important in estimating the economic cost of energy resources. The first of these relates to the flexible nature of the tradable/nontradable distinction. For many energy products, this depends partly on the availability of appropriate technology and the facilities for storage and transportation and partly on the geographic, economic and political situation of the country of production and the relative product price structure. These characteristics vary considerably from country to country, and a product which is considered nontradable in one context may enjoy a healthy trade in another part of the world. Low-grade coal is an example of this type of energy product; it may only become a tradable if there are convenient transport and storage facilities and a specific, easily accessible market.

The second point relates to the technical problems that may be involved in switching from one fuel to another. It is important that appropriate conversion coefficients for calorific value and fuel utilization efficiency are used in any comparisons. A classic case is that of coal versus diesel in locomotives; theoretical calorific equivalence is about 2.5 tons of coal to one ton of diesel, but if the ash content of the coal, the additional facilities required for using it, the transport losses due to powdering and the very low operating efficiency (about 3%) of steam locomotives is considered, the real ratio is nearer 12:1.

To recap, then, the appropriate measure of the opportunity cost of an energy product is the highest price that it can be traded for either nationally or internationally except in the few instances where the product is neither tradable nor acts as a substitute for other tradables. It is only when the product cannot be traded, and cannot be used to substitute for another product which is tradable, that the opportunity cost of the product is set by its cost of production or replacement.

Conclusions

The impact of the shift from cheap energy to scarce and expensive energy is one that pervades many aspects of economic growth and investment planning. We are only beginning to understand the nature of the adaptation that will be required in the coming years until a competitive substitute is available. Experience in the seven years since the first oil price shock, however, indicates that existing institutions and financial markets are probably flexible enough to accommodate the large transfer of wealth that has taken and will take place. Further, existing methods for investment planning, project selection and choice of technology can be used to translate the higher energy prices into appropriate responses in energy-using and energy-producing sectors.

The magnitude of the changes likely to be induced in the water and sanitation sector -- both in the distribution of investments across countries and in patterns of project design -- are difficult to predict. However, the likely direction is fairly apparent. In developing countries, macroeconomic constraints caused in part by higher energy prices,[12] coupled with ambitious service targets linked to the International Drinking Water and Sanitation Decade will increase the incentive to adopt low-cost technologies. In the industrialized countries, the demand for water as an input to new energy projects will raise its opportunity cost and thus make proper water pricing policies (for <u>all</u> users) an essential concern. Water-saving technologies will become more attractive, and the potential for recycling sewage effluent -- either in coal transport or in competing non-energy uses such as irrigation -- may partially offset some of the increased water costs to residential consumers.

Appendix I.--References

1. Energy in the Developing Countries, World Bank, 1980.
2. The overall Decade goal is to provide safe water and adequate sanitation to all people by 1990. Individual governments may set country-specific targets if that general goal is not achievable during that period.
3. Design of Low-Cost Water Distribution Systems, by Donald T. Lauria, Peter J. Kolsky, and Richard N. Middleton (Part 1); Keith Demke and Donald T. Lauria (Part 2); and Paul V. Horbert (Part 3). December 1980.
4. Appropriate Sanitation Alternatives: A Technical and Economic Appraisal, by John M. Kalbermatten, DeAnne S. Julius, and Charles G. Gunnerson, Johns Hopkins University Press, April 1981.
5. Low-Cost Water Supply and Sanitation Planning and Implementation, by John M. Kalbermatten and Richard N. Middleton, June 1980.
6. This category includes Iran, Iraq, Kuwait, Libya, Qatar, Saudi Arabia and United Arab Emirates.
7. In an indirect way, this lack of water is partly responsible for their being capital surplus countries in that it has historically discouraged settlement and thus populations are very low.
8. Much of the analysis of this section is from An Assessment of Oil Shale Technologies, Office of Technology Assessment, U.S. Congress, 1980.
9. Much of the analysis of this section is from A Technology Assessment of Coal Slurry Pipelines, Office of Technology Assessment, U.S. Congress, September 1980.
10. Of course, this figure would have to be adjusted to account for differing transport and conversion costs in order to determine the opportunity cost of the gas in this use.
11. However, if a country's gas reserves are very large, export either through pipeline or liquefaction may be economic, thereby making the gas directly tradable.
12. Price increases have hurt LDCs, both directly through their increased import bills and indirectly through the effect of lower industrial country growth rates on LDC exports.