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TECHNOLOGY AND ECONOMIC DEVELOPMENT: THE CASE OF HYDRO VS. THERMAL POWER *

IT HAS been argued that nominal cost comparisons of hydroelectric and thermal plants tend to understate the real cost of the heavier investment required for a hydro power installation. Since the nominal cost of capital available to power enterprises in capital-scarce countries usually understates the real cost of capital to the economy, hydro may get an undeserved edge on thermal in these nominal cost comparisons.

It might be suggested, however, that although hydro is extravagant with scarce capital, it has a number of advantages over thermal power which, though difficult to quantify, may materially alter the balance of the argument. Hydro, in brief, has certain technological and economic characteristics, relative to thermal, that enable it to take root in the country that produces it, and that in various ways propel the country's development.

That hydro and thermal might have these differential effects on development was first suggested to the writer by a comparative study of the Argentine and Brazilian electric power industry. The industry's pattern of growth was similar in both countries: development by private foreign power companies and a general postwar transition from private to public power. Both countries, moreover, had serious power bottlenecks in the nineteen-fifties. Their attempts to solve the problem, however, met with strikingly different degrees of success. Brazil was able to allay the serious shortage by the late nineteen-fifties, and in the process set up a viable government-sponsored power program. Argentina, in contrast, was still coping with a crippling power deficit in the early nineteen-sixties, its attempts to provide a substantial program of government power having met with very limited success.

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The difference in technology between Brazil's and Argentina's power industries—Argentina having an unusually high proportion of thermally-~~governed~~ generated power and Brazil, an equally high percentage of hydroelectric power—seems to have had much to do with the greater facility with which the Brazilian government has managed its power industry. In short, the construction and operation of hydro in a developing country, although incurring a greater real capital cost than is usually believed, also confers real benefits on the economy—in the form of stimulation of local production, in the creation of skills, and in training for planning.

These characteristics of hydro technology have much the same effect as do certain production processes described by Albert Hirschman:

> Certain types of modern technology perform a crucial function in aiding management in the performance of new, unfamiliar, and perhaps somewhat uncongenial tasks. By predetermining to a considerable extent what is to be done where and at what point of time, the machines and the mechanical or chemical processes they perform reduce these difficulties immeasurably in comparison with a situation where work schedules depend exclusively on the convergence and coordination of many human wills and actions. . . . The technical processes carried out by machinery provide factory operations with a basic structure and rhythm which in effect deal out functions and determine sequences.[1]

Hydro works much the same way on the *system* level, with the technology itself pacing and coordinating investment decisions, impelling and encouraging refinement and growth of the system. Thermal, on the other hand, is like the operator-paced production process which Hirschman refers to—dependent on the "convergence and coordination of many human wills and actions." If this coordination and continuity in investment is such a scarce factor in developing countries, then a case can be made for the technology that brings it about. Hence hydro's greater capital intensity in construction—like Hirschman's more capital-intensive process-centered industries—may be justified because of the better performance it compels.

This paper presents some of these conclusions about hydro

[1] Albert O. Hirschman, *The Strategy of Economic Development* (New Haven, 1958), 146–47.

and thermal, which emerged from the writer's study of the Argentine and Brazilian cases.

I

A hydroelectric project, whether private or public, draws on local resources and population much more than a thermal project, at every stage of its execution. Building a hydro plant is a long, drawn-out operation; preparing for it may take as long as constructing it. The terrain must be surveyed. Average annual rainfall and run-of-the-river measurements must be taken over a considerable period of time. The river must be carefully studied so that it is thoroughly understood. Teams of civil engineers must traverse the distance from dam to consuming center, marking out transmission tower sites every several hundred feet, haggling with local landowners for rental rights.

Each hydro project, then, requires its own solution, its own adaptation to the particular locale. A thermal plant, on the other hand, requires only a large space to put it down on, near the area it will supply. It is a much more technologically complex collection of equipment, but its complexity is internal and does not have to do with molding it to its site. In fact, "package plants" for steam power may now be purchased from the industrial countries. The buyer has only to supply the foundations and general site improvement.

This difference between hydro and thermal construction requirements parallels that between civil and mechanical engineering. In developing countries, most trained engineers are civil and electrical, rather than mechanical engineers. Except possibly for the setting of the turbine, civil and electrical engineering are the skills required for the planning and construction of a hydro plant.

Private foreign companies, then, could use—and, hence, train—the available engineering talent in Latin America for the execution of their hydro projects. It was even to their benefit to use local engineers: they knew the terrain, they did not cost as much as imported engineers, and they knew the language and ways of the people who had to be persuaded to allow transmission towers on their land.

In contrast, the few local mechanical engineers who might be available for a thermal project would be less likely to

Mechanical Engineering, on the other hand, is the skill most important in thermal design and construction.

have been used by the foreign power companies. The more refined and complex nature of thermal equipment, compared to hydro, made it necessary to import personnel along with the equipment. There was—and still is—a kind of finicky ethnocentrism about entrusting such sophisticated equipment to local personnel.

Engineers even personalize this difference in thermal and hydro equipment. Hydro is a big lumbering piece of machinery, they say, slow to respond but responsible, easy to deal with and hard to insult. Thermal, on the other hand, is delicate and high strung, precise and temperamental. Any engineer can plan a hydro plant, they say, but a thermal plant is a frightening thing.

Thus thermal's complexity and compactness put it out of the range of local experience and talent. In addition, rapid changes in technology are being made in thermal, rather than hydro, engineering. The technology of hydro equipment is relatively stable. Thus the foreign companies and their consultants, who are forging the changes in technology, would be in much closer touch with the requisite engineering for thermal plants.

Hydro, in sum, uses the engineering, the problem-solving, construction, and maintenance work of the local population. It creates a corps of technicians familiar with the planning and execution of hydro plants—in a truly creative way, due to the problems unique to each hydro project. The thermal plant, in contrast, leaves much less of its technology among the population. It clings to the edge of the city, dependent on the expertise of foreign engineering. The country with hydro, then, is more capable of entering the field of power production.

Brazil's training in hydropower was evident in the preparation of the 1961–71 investment program for power. The entire civil engineering project—which determines the basic specifications of a hydro plant—was carried out by Brazilian engineers, most of whom had no connection with foreign firms. A further example is CEMIG's[2] recent collaboration with the UN Special Fund in a projected complete survey

[2] CEMIG stands for Centrais Elétricas de Minas Gerais, the autonomous government power corporation founded by Juscelino Kubitschek in the early nineteen-fifties, during his term as Governor of the Brazilian state of Minas Gerais.

of the hydrologic potential of the state of Minas Gerais. Though foreign engineering firms were taking part, they supplied only five of the twenty-five necessary engineers specialized in hydroelectric planning. The remaining twenty came from CEMIG itself.

II

The necessity for long-run planning is considered one of the major disadvantages of hydro as opposed to thermal power, especially in developing countries. Costly and extensive investigations are required for the evaluation of a hydro project, and large projects necessitate estimates of demand for ten to fifteen years into the future. A hydro plant, moreover, cannot be developed in stages to the same degree as thermal. The construction of thermal stations, in contrast, may be phased to coincide more closely with the expected increase in power demand. The investment in thermal, then, is not only utilized more fully at all times, but a significant share of total investment is postponed to a time when demands on scarce capital resources may be less pressing in relation to their availability. Although the various units of a hydro plant might be installed at different stages, the *final* capacity must be determined before the project is ever started. In contrast, plans for thermal plants, which are flexible enough to allow for successive expansions, often provide only for the capacity of the initial installation.

These considerations are particularly important in a developing economy where demand is exceedingly difficult to forecast, and where it is almost impossible to make cost estimates that will be relevant several years hence. In brief, then, thermal does not make the impossible demands upon foresight that hydro does. Thermal can follow demand as it grows, and thereby avoid costly periods of under- or oversupply. This however, may be precisely the cause of the unplanned, emergency state that characterized the Argentine power system, while the difficult requirements of hydro planning might underlie the success of Brazil's experience with power.

Hydro, that is, can never be an emergency solution; it takes too long to execute. Of necessity, it is planned to satisfy a demand that is not yet in existence because of the years

that will intervene between its conception and its final execution. A country like Brazil, with predominantly hydroelectric power, is thus forced into planning for its electricity because the penalties for not doing so are high. Hence Brazilian power managers are always warning not of the immediately imminent crisis in power supply, but of the crisis to come several years in the future. John Cotrim, past director of CEMIG, wrote in 1960 that all power plants in construction then were planned to meet 1962, 1963, and 1964 demands because they would take five or six years to construct. But the problem at hand was that if *new* projects were not started immediately, the government would be "abetting a tremendous electric power crisis, which will make itself felt by 1964." [3]

If hydro forces its managers to plan, then it instills planning as a habit. Moreover, power planning is good training for economic planning in general. The power economist does not have to be a power engineer. The training that power provides is not specific, and those who have learned to plan in power can apply their talents to other sectors of the economy. Moreover, the power sector in developing countries in many cases attracts the best people in the country, because power management seems so directly bound to the country's development. Two examples of government power managers who moved on to positions of general economic planning are Lucas Lopes, former finance minister of Brazil, and Pierre Massé, at present Commissaire Général du Plan d'Equipment et de la Productivité of France. The experience of both men had been primarily with hydropower.

To the extent, then, that hydropower forces planning, it is a much better training school than thermal for economic planning in general. Planning, of course, is desirable for any kind of electric power supply. A thermal system should also be planned so as to operate efficiently and meet increases in demand. But because of its flexibility, its much shorter construction period (a crash program to plan and construct a thermal plant can now be carried out in six months), and

[3] "O Problema da Energia Elétrica no Brasil," *Revista do Conselho Nacional de Economia*, IX (1960), 104. This and all further translations are mine.

its smaller initial investment, thermal does not *require* planning. When one knows that the deadline for power supply can be pushed further and further ahead—especially when other urgent matters are pressing—one is likely to let planned expansion slip by, and attend to other things. And this is exactly what thermal enables its government managers to do. Needless to say, when a country is forced to operate its electric power industry with an eye to future demand, its supply will keep up with demand more than in a country whose government is able to add a little power every time it sees a shortage.

The predominance of thermal power in Argentina, in fact, is actually blamed by many Argentines for having stifled hydroelectric development, as well as successful power development in general. "Thermal electricity," says one writer, "postponed the integral solution of the energy problem—that is, the hydroelectric complex." [4] Another writes that the "high percentage of thermal plants in Argentine production is due solely to a state of emergency and neglect to make studies." [5]

Hydro, in sum, trains its managers to see crisis in the future. For thermal managers, the crisis is a reality only when it exists, because it can be met almost immediately. The more this type of *post hoc* expansion of a thermal system takes place, the less feasible economic hydro projects become. The shortage is too severe to wait for the planning and execution of a hydro project, and the country is not likely to have the resources to invest in both. It is interesting to note, in this connection, that state action in the Argentine power sector was characterized by a definite aim to take advantage of the country's hydroelectric resources. Yet the percentage share of thermal in the government's past and present power construction program turned out to be much higher than was originally envisioned.

The Special Fund's appraisal of Argentina's dream hydroelectric project, Salto Grande, carries the same implications:

> Our economic comparisons show [the study concluded] that

[4] Bruno A. Defelippe, *La Politica Energética Argentina* (Buenos Aires, 1953), 157.

[5] Horst Carlos Fuldner, *Consideraciones y Comentários sobre la Economia de la Electricidad . . .* (Buenos Aires, 1956), 59.

> Salto Grande could furnish power to the Gran Buenos Aires-Litoral area *more cheaply than equivalent thermal* capacity. However, the additional US $97,500,000 of Argentine capital needed, and the *eight-year period required* for engineering and construction, are practical reasons which prompted the selection of alternative thermal power in the ten-year program.[6]

In this case, time and the initial expense are the major obstacles. And these are the two obstacles that hydropower experience helps a country to overcome.

III

The technology of hydropower creates strong impulses toward its own perpetuation, impulses which thermal does not have. Like the planning that hydro forces upon its managers, the effects of these impulses—continuing reinvestment and refinement of the system—are also "scarce resources" in developing economies. They are therefore an essential part of the hydro-thermal comparison.

One of the major problems of hydro power is its dependence upon variations in rainfall and streamflow. Seasonal, daily, and hourly variations in the demand for power have their own pattern, of course, independent of variation in water supply. In periods of strong river flow, excess water is released over the spillways, rather than through the generators. On the other hand, in periods of water shortage, streamflow is not great enough to meet the capacity of the plant or of demand. Both shortage and excess of water, then, mean wasted capacity in a hydro plant—the unused capacity of the generators during shortage, and the unused potential of the spilled water during excess.

Thermal produces power as it is needed. The power that can be generated is a direct function of installed capacity, rather than of installed capacity *and* variations in supply of the major input. If there are shortages of power in a thermal plant, they are due to inadequate capacity in the *system*, not to inadequate supply of the major input. Moreover, shortages of power from a thermal plant imply full-capacity operation of the plant—and hence no loss of revenue. Shortages

[6] Tippetts-Abbett-McCarthy-Stratton, and Kennedy & Donkin, *Study of Argentine Power Problems* (New York and London, 1960), 2. Italics mine.

in a hydro plant, on the other hand, mean *unused* capacity—due to inadequate riverflow—and therefore loss of revenue.

Excess capacity in a thermal plant is due only to the hourly, daily, or seasonal trough in demand. In a hydro plant, however, excess capacity means wasted potential power in the form of spilled water, as well as idle generators. Moreover, excess capacity is much more costly for a hydro plant than for a thermal plant, even without considering the spilled water. Hydro's "free" water generation pays back the high initial investment of the installation. Thus moments of idleness in a hydro plant delay the amortization of that initial investment, with no savings in operating costs, which are almost zero. Thermal, on the other hand, amortizes its lower initial investment more quickly and its idle capacity not only represents less revenue, it also means less cost—in the form of fuel that is not used. Idle capacity, therefore, is a much smaller drain on the profitability of a thermal plant.

Hydro's dependence on nature is not irremediable. There are ways of evening out the gluts and shortages of waterflow that not only help the system operate more efficiently, but increase the profitability of each plant. And because this uneven utilization of capacity is much more costly in a hydro plant, there is a stronger incentive to correct the difficulty.

In the jargon of the industry, correction takes the form of "firming up" the unreliable waterflow. A hydro system can sell only its "firm power"—the amount of power which could be produced in the lowest water year, and which the system can therefore guarantee to provide by contract. What is left over—secondary power—is usually substantial, since most years see more than a minimum waterflow. This secondary power, then, is lost revenue; as a Bonneville power administrator said, "When you see water cascading over the spillways of Grand Coulee . . . it may look pretty but those are dollars going over the dam."[7]

It might be argued that developing countries push their power systems to a greater extent because customers have to be content with buying unreliable power rather than no power at all. Hence the spur to improvement caused by revenue loss from the unused secondary power would not be

[7] U.S., Bonneville Power Administration, *The New Program of Bonneville . . .* (Portland, 1962), 7.

as great as in an industrial country with more rigorous standards as to what it can contract to sell. But this argument pertains only to possible loss of revenue during water excess. It does not account for the loss of revenue during shortage, when the system simply does not have *any* kind of power to sell to those who want to buy. It is clear, then, that hydro articulates a waste. This leads to improvements which expand and refine the already existing system:

(1) One of the methods of evening out the irregularities of water supply is to regularize the flow of a river by the use of artificial storage basins. Storage is very expensive in terms of the benefits it will confer on any single plant. But there is a strong interdependence between storage at one plant and the generating capacity of any other plant downstream. If downstream plants without storage are already installed, an upstream storage plant will be very desirable. It will regularize the streamflow to all downstream plants and thereby increase their capacity to generate firm power. In addition, the upstream storage plant may cross the threshold of economic feasibility if its benefits extend to several plants, rather than to the one plant associated with it. If the development of the river is in a downstream, rather than an upstream, direction, otherwise uneconomic downstream sites may be economic if considered as beneficiaries of an upstream storage plant.

Hydro, then, not only induces its managers to build one plant after another on the same river, it also encourages a development of the river which is planned and integrated from the start.

(2) Drought is the specter that haunts a hydro system. In the spring and summer of 1953, drought played havoc with the power supply of Rio and São Paulo, causing severe shortages and strict rationing of power consumption. American & Foreign Power, which supplied the interior of the two states, found its revenues sharply diminished. The rate increase it had finally been granted was suspended because of the necessary rationing.

Interconnection lessens these penalties of drought by making possible large transfers of power between systems, based on the diversity of their hydraulic regimes and the existence of large storage reservoirs. Brazil's recent three-year development plan (1963–65) gives priority to interconnection, in order, among other reasons, to obtain this insurance against drought.

Interconnection of isolated systems is of course desirable for both hydro and thermal in that it enables increased utilization of capacity through reduction of the required margin of generating units for reserve purposes. In addition, different districts can complement each other's power supply. When the load curve is at its trough in one area, the plant's idle capacity can be used to supplement the supply in another area, where, at the same time of the day, week, or season, the load curve is closer to its peak. Costs are thus reduced by keeping idle capacity at a minimum, and because the interchange of power between systems allows a smaller reserve capacity to be maintained for the contingency of peak loads.

The inducements toward interconnection, however, are greater in power systems that are predominantly hydraulic. Because interconnection in general increases the size of the area served, it also increases the diversity of demand. Greater diversity of demand tends to even out the variations in demand, an improvement which is more urgently needed in a hydro system.

Interconnection can also smooth the jerky nature of hydro growth, as pointed out in Brazil's Electrification Plan of 1954.[8] The interchange of power between systems that is facilitated by interconnection can help to prevent the shortages that may arise while a system is waiting for the completion of a major hydro installation, and preventing the waste of power from a plant whose installed capacity is beyond the needs of consumers in its immediate area. Since thermal's growth proceeds in much smaller steps, there is no such problem to overcome. That hydro poses the problem makes interconnection desirable.

Interconnection, no doubt, is an expensive and complex task. The hydro system, however, by its very nature, is better adapted to take the step. Hydro is accustomed to spanning distances, to spinning out expensive transmission lines. As the power supply of an area develops, the transmission lines of separate plants are likely to cross or pass near each other

8 Brasil, Presidência da República, *Plano Nacional de Electrificação . . .* (Rio de Janeiro, 1954), 57.

on their way to the consuming centers. The lines and their plants, located as they are between centers, create a natural hub for interconnection of isolated systems. Thermal plants, next to consuming centers rather than between them, have little contact with other centers and their power systems.

The Furnas hydroelectric plant in the state of Minas Gerais is a good example of the locational inducements of hydro toward interconnection. Furnas, whose first stage was completed in 1963, was to be the key project in an integral development of the Rio Grande, which is approximately equidistant from the three major centers of the industrial southeast—São Paulo, Rio de Janeiro, and Belo Horizonte. Before Furnas, these centers and their surrounding areas were supplied by three separate systems. Now, Furnas and several other large hydro plants envisioned for the Rio Grande will provide the hub for an interconnection of these previously separate systems.

Developing countries, by the way, find a political virtue in hydro's expensive transmission lines. One of the arguments justifying state intervention in electric power throughout Brazil was the political necessity of industrial decentralization. Hydro's transmission lines provide a path for such decentralization.

Hydro, in sum, offers attractions and exerts pressures toward interconnection. Interconnection, in turn, has a considerable effect on hydro projects. Like the upstream storage plant, it brings many potential sites within the realm of economic feasibility.

(3) The pressures of drought and variations in demand are as influential in promoting the integration of thermal plants into existing hydro systems as they are in bringing about interconnection. Hydropower needs complementary thermal power because a pure hydro system is completely at the mercy of rainfall and river variations. After a certain point, the cost of overbuilding necessary to insure year-round coverage of peak loads is excessive. The majority of new thermal power stations in Brazil are therefore complementary parts of hydro systems.

There is, then, a kind of technological linkage from hydro to thermal. The severe penalties of a hydro system without complementary thermal facilities—as was the case in Brazil

Standardization of power equipment which makes large-scale or economic local production feasible is characteristically absent in developing countries. Hydro can facilitate standardization—and, thus, growth of local industry—through interconnection of systems.

There is another strong link between a hydro system and the development of the local equipment industry. If, as I have argued, hydro leads to a more planned development of the power system, then the demand for equipment several years into the future is visible to potential or existing local suppliers. Argentina provides the perfect example of this process in reverse. The growth of the local equipment industry has been hindered precisely because of the nature of the power enterprises' demand for equipment:

> The leading [electrical equipment] customers—national and provincial electricity enterprises and [the mixed private-public enterprise] SEGBA—do not space out their orders in such a way that manufacturing plans can be drawn up and efficient plant utilization ensured. The erratic nature of this demand is attributable to the fact that hitherto no long-term plans have existed, and when medium-term plans have been formulated, financial difficulties have prevented their implementation. Consequently, there are sporadic bursts of demand for large quantities of equipment to deal with emergencies, and long periods when no tenders are invited.[9]

The investment in hydro, then, is also an investment in the production of conditions favoring the growth of the local equipment industry.

V

A hydroelectric project is fine political capital. The politician looking for a good public works project is much more likely to select power if it is hydro. The hydro complex has drama and style, and there is an air of extravagance in its hugeness and grace which is awesome in a country trying to mobilize scarce resources for development. Though hydro supplies a basic necessity, it creates the aura of a country which no longer has to scrimp and save, but can spend with largesse. Its hugeness and its taming of a wild river bespeak a technological victory, and it imparts dignity to the people and the country who conceived it.[10]

[9] United Nations, Economic Commission for Latin America, "Generation and Transmission of Electric Power," *The Manufacture of Basic Industrial Equipment in Argentina*, Part III, E/CN.12/629/Add.2 (Mexico, July 13, 1962), 23–24.

Only hydro could produce rhetoric such as that of Juscelino Kubitschek of Brazil, when he described the hydroelectric plants he initiated as Governor of the state of Minas Gerais and as President of Brazil:

> I left an example of daring and an affirmation of national capability—as well as teams of Brazilian technicians trained in hydroelectric works of great size. . . . Twice we broke the barrier of a million kilowatts (the Furnas and Três Marias projects), and Brazil dared to undertake the construction of plants truly huge. . . . No more does any Brazilian have the right to hesitate before works of great size. For it has been exuberantly proved that we have the capability, that we have the courage, and that we lack neither the resources nor the possibilities for confronting the challenge of the scarcity of electricity . . . .[11]

The thermal plant, in contrast, is another industrial installation at the edge of the city. It is no political eyecatcher, though electricity supplied during a shortage will certainly produce grateful voters, no matter how it was generated. A dam simply doubles the political appeal. It puts electricity in the home and the factory, and imposes a magnificent symbol of strength upon the countryside.

A country whose electric power production is mainly hydro, like Brazil, will have experience with it and talent to create it. Power thus comes within closer reach of the politician looking for an impressive public works project. In a country with thermal, like Argentina, both types of power generation are further from the politician's reach. He would be more likely to select another type of public works project just as impressive as a hydro plant, but more technologically and financially feasible.

[10] The government of a certain developing country once requested a power loan from one of the international lending institutions for a large hydro project. The government had recently replaced a dictatorship which was replete with white elephants and corruption. One of the reasons the new government wanted to build the hydro complex was so that it could "do something big and honest" in order to impress upon the country that it was different.

[11] Juscelino Kubitschek, *A Marcha do Amanhecer* (São Paulo, n.d.), 135–36.

The political appeal of hydro, of course, is partially due to the mystique of hydropower. Hydropower, according to the mystique, is the free water that flows through the pen-stock gates. It costs almost nothing. The initial thermal installation may be less costly, but the power it generates costs money; it feeds on expensive fuel rather than free water. The people ask, therefore, why their government does not harness its rivers. Why not capture this precious resource, running wild and free? To let it flow into the sea, they say, is extravagant waste. Why not simply let it turn a wheel, and produce power that costs nothing?

The mystique, of course, is a gross exaggeration of the comparative costs of hydro and thermal. It simply fails to spread the initial cost of the installation on top of the almost-free kilowatt hours of hydropower. In so doing, it appeals for a spectacular expenditure on the grounds of preventing an intolerable waste. It can even enlist the support of thrift-minded holders of government purse strings, whose parsimony can be touched with the spectacle of precious waters extravagantly wasted in the sea.

The mystique, however, is not only a thing of the people. It has crept into the imagination of engineers and planners, and produces a kind of forgetfulness about the pain of the heavy initial investment. It has its rhetoric, too, as witness the words of Isaac F. Rojas:

> Water is our first and foremost unexploited potential. With heavy heart, I have looked at the lazy rivers in every part of our country. To take advantage of these waters is to create wealth. Just let a wheel catch the flow of a stream, and its wealth-giving power will be with us forever. . . . Our rivers remain untouched, when only a little effort would be sufficient to change their courses—be it to irrigate, or to fall mightily from the mountaintops.[12]

In contrast to hydro, thermal power is bare of mystique. If there are any sentiments about thermal, they are usually hostile. Thermal, after all, is the hungry giant who demands to be fed constantly with nothing but the best; fuel purchased with precious foreign exchange. Such feelings about thermal, of course, are based on the hydro mystique. If only

[12] Argentina, Comisión Asesora de Planificación Hidroeléctrica, *Una Solución Nacional—Agua—Electricidad—Economia* (Buenos Aires, 1958), viii.

cheap hydroelectricity would be developed, according to the mystique, the expensive grip of thermal could then be avoided, and scarce resources could be devoted to other matters.

The mystique—regardless of its validity—describes an affinity for hydro, as opposed to thermal, on the part of layman, politician, and power manager. It is, therefore, a source of strength for a government-sponsored power program. It recruits sponsors dedicated to the realization of certain projects, it eases the process of budgetary appropriation for power, and it attracts managerial talent to the field of power development.

CONCLUSION

Government operation of the power sector in developing countries—like any long-run government undertaking—is subject to many tests of endurance. It must compete with other necessary projects for scarce talent and funds. It must rapidly take its own roots, so that it can outlive the attention span of its original supporters. It must have its own inner logic of growth which reveals to its managers the next step, and both lures and impels them to take it. The writer suggests that hydropower is more able to meet these requirements than is thermal. These particular qualities of hydro might be designated, in hydro-thermal cost comparisons, as the benefits of survival, of success, or of training for planning.

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papers

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