THE CHALLENGE OF IMPLEMENTING AN IRP PROCESS IN ASIA: THE CASE OF HAINAN PROVINCE, CHINA

Lawrence J. Hill

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
managed by
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Lawrence J. Hill
Oak Ridge National Laboratory

INTRODUCTION

Developing a modern electric power sector is necessary for economic growth and development to proceed.[1] Power development is complicated because electric power industries are among the most capital-intensive in an economy. Developing these industries is a serious drain on scarce financial resources. And, for countries lacking indigenous energy forms, imports of energy are also a serious drain on foreign exchange reserves. This is particularly true during periods of rapid increases in energy prices such as those experienced in the 1970s or, just as important, during periods in which a country's currency is depreciating on foreign exchange markets.

The capital and foreign exchange required to develop modern electric power sectors, of course, compete with those same requirements in other sectors. That is, the electric power sector's drain on scarce capital and foreign exchange is exacerbated by the process of economic development itself: the transition from a self-sufficient, agriculturally based economy to a more specialized urban orientation, requiring capital and foreign exchange. Electric power is an important input in this development process, fueling urbanization of an economy, its industrial growth, and rising standards of living.

Besides being capital-intensive and using foreign exchange, investments in electric power have long gestation periods with paybacks over many years. In many countries, the planning horizon is much shorter, oftentimes dominated by socio-political considerations such as health and survival, education, and equity.

[1]Although economic growth and development are sometimes used interchangeably, there is a fundamental distinction between the two. The former implies a simple increase in per-capita income; the latter implies not only higher levels of income, but also a structural change in the economy. Therefore, an economy can grow without developing.

This is the dilemma confronting many countries. That is, the opportunity cost of investing in electric power plants is high, with scarce funds competing for alternative uses in social and industrial sectors to improve prospects for economic growth. Yet, the opportunity cost of not investing is high also because investment in electric power is required for growth to proceed. The relationships between electric power infrastructural development (and electricity consumption), industrialization, and economic growth are highly correlated.

China is an example of a country undergoing such change. Although expected to decline to 10.0 percent in 1994, China's GNP grew at rates exceeding 13 percent in both 1992 and 1993. Industrial output grew at rates of 27.5 and 23.6 percent in 1992 and 1993, respectively. Growth in electricity demand and generating capacity requirements mirror the growth in the overall economy. This growth and, yet for austerity purposes, the government plans to cut expenditures on capital construction by 14.2 percent in 1994. (1)

Integrated resource planning (IRP) is a management paradigm that can be used in the electric power sector to help China reconcile the power-sector capital investment needs with the capital needs of the general economy. Concisely, IRP is a management tool that allows firms (we concentrate here on electric firms) to compare consistently the cost-effectiveness of all their resource alternatives--those on both the demand and supply side--taking into account the different economic and reliability characteristics of these alternatives. Simply put, the IRP process increases the choices available to an electric firm in meeting its demand. If applied properly, it leads to the most cost-effective electric-power resource mix. It is especially useful in growing economies with growing electric-generating capacity needs and, consequently, high avoided costs of power.

Because of China's size, however, it is impractical to initiate an IRP process on a national scale. The ideal approach would be to select a city or province as an IRP test-bed and use the experiences as a model for other Chinese cities or provinces. That is the case with Hainan Province, China, an island off the Southeast coast of China's mainland and the largest of China's five special economic zones. A prefeasibility study of implementing an IRP process in Hainan was conducted, (2) and one of the recommendations was to use a full-scale IRP process in Hainan as a "laboratory" for the Chinese mainland. We discuss the Hainan experience in this paper.

Specifically, we address three areas. First, we discuss the relationship between demand-side planning and IRP, emphasizing that the two are not equivalent. The former is one part of the latter. We place IRP in the context of a dynamic process: (1) the motivation for utilities to engage in IRP, (2) the IRP process itself, and (3) evaluation of the performance of resources selected in the IRP process.

Second, we discuss the situation in Hainan, first providing an overview of Hainan's energy economy and then discussing the results of the aforementioned prefeasibility study. The study showed that, by the year 2000, the Hainan Electric Power Company (HEPCO), the island of Hainan's electric firm, can cost-effectively reduce annual electricity demand by as much as 20 percent or more by setting cost-based prices, introducing energy conservation standards for buildings, and running technical demand-side management (DSM) programs.

Third, we discuss the difficulties of implementing an IRP process in an economy that does not have regulatory and incentive mechanisms similar to those in countries where IRP is widely practiced. We emphasize the necessity of creating an organizational mechanism for implementing and sustaining an IRP process and the necessity of creating financial incentives for electric firms to adopt alternatives to conventional generating plants in their planning processes.

WHAT IS IRP?

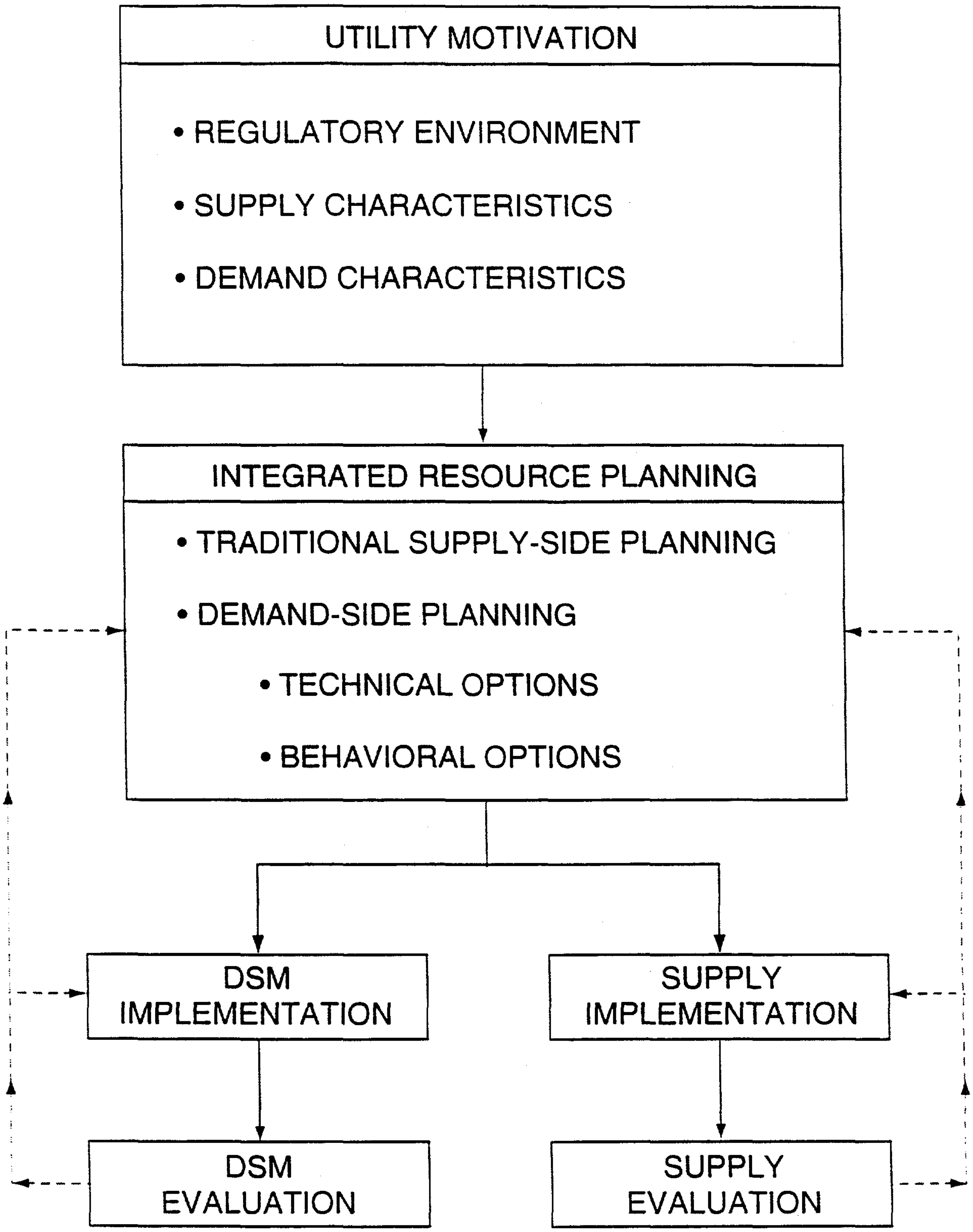
The process of selecting an electric resource mix on the basis of comparing the benefits and costs of demand and supply resources is referred to as IRP. In the IRP process, changing the pattern and level of electricity demand and considering nonconventional generating sources are weighed as resource options on an equal footing with traditional supply resources (e.g., building conventional generating stations, extending the life of old ones). The IRP process is a combination of (1) traditional least-cost planning, a process by which utilities minimized the cost of generating a given amount of electricity and (2) demand-side planning. Its goal is to provide electricity at the lowest possible economic, social, and environmental cost.

In Figure 1, DSM planning is placed in the context of a dynamic electric utility planning framework, including (1) factors that motivate utilities to consider IRP, (2) the relationship between demand-side planning and the IRP process, and (3) implementation and evaluation of both demand- and supply-side options. The process is dynamic not only because planning by its very nature is evolutionary but also, as we show in Figure 1, because the performance of DSM programs and supply alternatives has feedback effects on both the process of selecting the programs and the way in which they are implemented.

Besides regulatory factors, characteristics of both the power delivery system and customer demand influence the decision to engage in IRP. For example, the types of generating units used by electric utilities can be a motivating force to engage in IRP. Reliance on fossil-fuel units in periods of rising energy costs is an important motivating factor. On the demand side, utilities with low load factors are more likely to seek ways to shave peak load and forego the need to build peaking capacity. There are several powerful tools to accomplish this, including setting cost-based electricity prices. The goal in all cases is to find the mix of supply and demand resources that lowers present and future costs and, therefore, increases the amount of capital available for reinvestment.

When comparing resource alternatives in the IRP process, different dimensions of resources complicate the process (3). That is, although DSM programs and supply resources have the common characteristic of meeting future energy and capacity requirements, they typically differ along three dimensions: (1) financial, (2) economic, including externality and value of service considerations, and (3) reliability. Also, an integrating method must be chosen. Three methods can be used to integrate DSM and supply resources: (1) a sequential approach in which DSM resources are selected first; (2) a sequential approach in which supply resources are selected first; and (3) a simultaneous approach in which resources are selected jointly using some measure of cost-effectiveness as a guide. (4)

Figure 1. Integrated Resource Planning as Part of a Dynamic Process



The final two sets of blocks on implementation and evaluation are important. DSM programs are implemented and evaluated in the same way that supply resources are. That is, DSM programs are treated parallel to the manner in which a utility chooses to (1) build a power plant, (2) construct it, and (3) evaluate its performance. The problem that many utilities confront in treating DSM and supply resources in a parallel manner is the lack of data on running DSM programs. The technical savings of these programs are generally well known. It is the marketing side where utilities are deficient. They need better information on:

- the number of customers using different types of electricity-using durables and, therefore, the total amount of savings available from a program;
- the possible market penetration of energy-efficient durables;
- trade-offs between marketing and penetration;
- the most effective financing mechanisms for different programs;
- customer response to DSM pricing strategies.

There are two important conclusions obtained from the discussion surrounding Figure 1. First, demand-side planning is not equivalent to IRP. The development of DSM programs that are compared with other resource alternatives is only one portion of the IRP process. Second, the success or effectiveness of an IRP process is in no way related to the resource mix that results from the process. IRP relates to the process of comparing and evaluating resource alternatives--not to the mix of cost-effective resources obtained from the process. Therefore, simply because utility A's resource mix obtained from an IRP process contains more DSM programs and renewables on a percentage basis than utility B's does not necessarily mean that utility A's IRP process is in some sense "better" than utility B's.

AN OVERVIEW OF HAINAN AND ENERGY

From 1979 to 1982, the Chinese government created four special economic zones (SEZs) on the Southeastern coast of China: Xiamen, Shantou, Shenzen, and Zhuhai. An SEZ is an area designated to carry out the export-development portion of China's mixed development strategy. That strategy includes both import substitution and export-oriented development: inland areas generally are assigned import-substitution activities, while the SEZs are engaged in export-related activities.

In 1988, Hainan Island off the southeast coast of China was separated from Guangdong Province, organized as a separate Province, and designated China's fifth--and largest--SEZ. Hainan has a long history of commercial and industrial contacts outside of China. Also, much of the overseas Chinese population comes from southeastern China, providing linkages with this region to the rest of the world.

Hainan's economic development strategy is export-oriented, loosely modeled after those of South Korea, Taiwan, and Hong Kong. The success of that strategy and economic development depend on Hainan's ability to harness domestic savings and attract foreign investment. The effective functioning of stock, bond, and foreign exchange markets is crucial to this process. The government has made a special effort to attract foreign investment, especially in Yang Pu, a port region on the Western coast of Hainan, where it created a 30-square kilometer "special" special economic zone. For the first time in China, enterprises in that zone will be permitted to issue bonds and equity shares using fixed assets as security to raise funds from foreign investors.

To date, the economic reforms have been fairly successful. From 1990-1995, government planners project the economy to grow at the rate of 16 percent per year, and to increase six-fold by the year 2000 (Table 1). GDP per-capita will nearly triple over the same time period, from $268 in 1990 to $734 in 2000.

Table 1. Actual and Projected Population and GDP in Hainan, China for the Years 1990, 1995, and 2000

Year	GDP[a]	GDP per Capita[b]	Population[c]
1990	1.8	272	6.6
1995	3.6	486	7.4
2000	5.9	740	8.1

SOURCE: Hainan Electricity Bureau.

[a]In billions of U.S. dollars; based on an exchange rate of 5.3 Yuan per U.S. dollar.

[b]In U.S. dollars; based on an exchange rate of 5.3 Yuan per U.S. dollar.

[c]In millions.

Historically, Hainan has imported most of its energy requirements--primarily from the mainland. Its major imports include coal, diesel, gasoline and charcoal. It has no known reserves of crude oil. Hainan's major energy resources include oil shale, a low-grade brown lignite, and some off-shore natural gas. Much of the gas production, however, is destined for Hong Kong, based on an agreement signed in March 1992.

The island also has some potentially cost-effective renewable energy forms, including the sun, wind, and biomass. The exact amounts of these resources await in-depth studies.

In Table 2, we show the electric generating capacity of the Hainan provincial grid. As footnote "a" indicates, the total grid capacity of 626 MW understates the total amount on the island by 160 MW. That amount is owned by self-generators such as sugar mills, small, isolated hydropower stations, and the like. Generating capacity is expected to increase to 866 MW by 1995 with completion of a 240-MW hydropower station at Da Guang Ba. Capacity is then expected to increase to 1,590 by 2000, reflecting in large measure 600 MW of new coal-fired capacity at Basao. This 600 MW was initially designed to be gas-fired, with the gas obtained from the off-shore gas discoveries. However, as just noted, much of the natural gas is now scheduled to be exported to Hong Kong. If more gas is discovered--and there are indications that it may be--the 600 MW of capacity at Basao could be converted to natural gas.

Table 2. Actual and Projected Growth of Generating Capacity in the Hainan, China Provincial Grid for the Years 1992, 1995, and 2000
(In Megawatts)

Year	Coal	Hydro	Total
1992[a]	439	187	626
1995	439	427	866
2000[b]	1,039	551	1,590

SOURCE: Hainan Electricity Bureau.

[a]Capacity of the provincial grid only; does not include 160 MW of off-grid capacity.

[b]Does not include 1,300 MW of planned capacity in Yang Pu which will be built by private interests.

As Footnote "b" in Table 2 indicates, total generating capacity in the year 2000 would be almost doubled if the 1,300 MW, coal-fired units at Yang Pu were included in the total. This capacity is to be built in three phases (2X100 MW, 2X200 MW, and 2X350 MW). Present plans are that these facilities will be constructed and operated by private interests as part of the development strategy of the "special" SEZ in Yang Pu and semi-isolated from the provincial grid.

This marked growth in electric generating capacity, of course, mirrors the projected growth in electricity demand. Electricity demand is expected to grow by five-fold over the 1990-2000 period, reflecting in large part the growth in industrial use of electricity from 6 tWh in 1990 to 44 tWh in 2000.

POTENTIAL FOR ALTERNATIVES TO FOSSIL-FUEL PLANTS

Using IRP principles, we identified potentially attractive, environmentally benign, energy resource options for Hainan in a prefeasibility study. (2) The options are potentially attractive because they were not identified on the basis of rigorous analysis, but rather estimated based on the experiences of the authors with integrated planning in other economies. The results indicate that estimated electricity savings from implementing DSM programs are substantial. We estimate conservatively that Hainan could save as much as 80 percent of its 1992 peak electricity demand by the year 2000. Although we considered a range of resource alternatives to constructing conventional generating plants, we discuss the most promising below.

Electricity pricing as a DSM strategy is an important option for HEPCO. The philosophy behind the tariff in Hainan is to encourage electricity consumption because of excess generating capacity. Hainan's generating capacity is very lumpy with over-sized units not allowing load to be followed very easily. Because of the lumpy excess capacity, far-sighted price incentives are not in place to encourage electricity conservation over the longer-term. That is, HEPCO faces the classic short run-long run pricing problem confronting many other electric firms throughout the world: pricing for excess capacity in the short run, but distorting incentives for the longer term because economic development is promoting electricity demand growth rates so large that the utility will be experiencing capacity shortages in the longer term. And, making up that electricity generation capacity deficit is very costly because of the capital intensity of electric generating systems.

Electricity pricing can be used both by itself and as a complement to other demand-side measures in Hainan (5). A recent study showed that cost-based pricing compares favorably with other technical DSM programs as an alternative to constructing generating plants. (6)

More stringent energy conservation building standards in the three rapidly growing cities of Haikou, Sanya, and Yang Pu in Hainan could also save significant amounts of energy. These cities are currently experiencing a construction boom and every indication is that they will continue to do so in the future. Therefore, this is a particularly favorable time to implement more stringent conservation standards for new commercial construction. Currently, Chinese national standards are used. These standards are not as stringent as those used in the West.

Hainan appears to have the climate to support a cost-effective residential solar water heating program. These programs have been shown to be cost-effective in regions with similar climates such as Jamaica (7) and the U.S. Virgin Islands (8). The most effective types of programs are based on point of sale. That is, the program targets customers who are replacing old water heaters or are purchasing ones for the first time.

A program to increase the penetration of efficient lighting in Hainan could also achieve rapid and significant demand-side electricity savings for HEPCO while lowering energy costs for household customers.

IMPEDIMENTS TO ACHIEVING THE POTENTIAL

Reduced to its fundamental level, effectively evaluating and implementing cost-effective alternatives to constructing conventional electric power plants--i.e., engaging in an IRP process--hinges on a system of incentives, provided to both electric utilities and their customers. Attempts to create an effective IRP process without understanding the underlying incentive mechanisms probably will be futile. It may be helpful at this point to disaggregate the incentive structure of a typical U.S. IRP process to see what drives the process, looking at (1) the motivation for IRP, (2) the incentives provided the utility, and (3) the incentives provided the customer.

First, as discussed above, there are compelling business reasons for an electric utility to seek alternatives to constructing generating plants--i.e., to engage in IRP without government or regulatory intervention. A good example of such sound business practice is a utility with a low load factor, seeking to reduce peaking requirements with a load management program instead of constructing a combustion turbine. However, the primary impetus to develop a formal integrated plan--and implement it--for U.S. utilities is generally not self-motivation, but regulation, either state law or administrative order. These legal/regulatory requirements do not necessarily chracterize the electric power sectors of other countries throughout the world.

Second, incentives to adopt alternatives to constructing generating plants are provided to many utilities in their IRP processes. Various incentives for running DSM programs are good examples. They take several forms. In some jurisdictions, revenue decoupling is used to segregate the utility's allowed revenues from its kWh sales, thereby increasing the incentive to reduce kWh consumption. Rate-basing of DSM program costs is another common incentive provided to utilities. Under rate-basing, DSM program costs are capitalized in the rate base and amortized over periods typically ranging from three to ten years, allowing the utility to earn a steady return on DSM program investments. In some jurisdictions, rate-base returns in excess of those allowed conventional generating plants are also provided as an incentive to run DSM programs. Still another incentive is a performance bonus for DSM programs that save kW or kWh in excess of a prespecified goal. Of course, when evaluating resource alternatives in an IRP process, these incentives improve the financial attractiveness of DSM programs in comparison with other alternatives considered in the process.

Alternatively, disincentives may be provided certain resource alternatives in an IRP process, decreasing their financial attractiveness. An example is a requirement to internalize the environmental costs of using fossil fuels used to generate electricity, thereby increasing the unit kWh cost of electricity produced from these fuels.[2] Effectively, this procedure makes the cost of electricity produced from fossil-fuel generating plants more expensive relative to other resource alternatives compared with them in an IRP process.

The problem is that, in most countries, these types of regulatory institutions do not exist and, therefore, incentive mechanisms for adopting resource alternatives to fossil-fuel generating plants are not available. In many countries, the incentives are to construct electric generating plants to service load requirements, not save kW or kWh. And, because of foreign exchange considerations, the incentives are to construct fossil-fuel generating plants in countries possessing coal, petroleum, or gas reserves.

Third, incentives are oftentimes provided to electricity customers to adopt energy-efficiency measures for utility-run DSM programs. Typically, a cash payment is made to a customer as an incentive to purchase a more efficient durables such as refrigerators, lights, air conditioners, and the like.

However, the strongest incentives for energy conservation on the customer's side of the meter--i.e., cost-based electricity prices--do not exist in most countries. In fact, for a variety of social, political, and economic reasons, many governments subsidize the price of electricity. This not only serves to distort conservation incentives for electricity consumption by time of day, but also subsidizes customers' total electricity bills. The subsidy, of course, provides a disincentive for adopting energy-efficiency measures. For utilities in these countries, the process of determining what electricity prices should be is an issue separate from the political reality of actually raising them--i.e., the implementation problem. If the goal of public policy is to set electricity rates at cost-based levels and rates have been subsidized for long periods of time, the key political issue may be the process of getting rates to cost-based levels, rather than calculating what correct rates should be.

CONCLUSIONS

The institutions to implement an IRP process do not exist in many countries. In these countries, incentive mechanisms are not in place to transfer a market-based IRP process to an economy that does not have similar institutions. Therefore, the challenge for those attempting to tranfer these concepts and this process is to develop appropriate incentive and institutional mechanisms for electric firms--and their regulators--that afford consideration of resource alternatives other than fossil-fuel generating units.

In developing these institutions and incentive mechansims, it is important to realize that DSM is not equivalent to IRP, either conceptually or in practice. This observation is especially important for those who (1) collect data on electricity consumption, (2) estimate the technical and engineering potential of efficiency improvements, (3) are enamored with the magnitude of potential savings, and (4) mask these activities as an IRP process. These

[2]In real-world settings, the costs are typically internalized in one of three ways: (1) qualitative, (2) percentage adder, or (3) monetization. The most difficult to estimate is the latter.

four activities are an important part of an IRP process--but clearly do not constitute an effective IRP process.

Other than its importance as a "laboratory" for the rest of China, the attractiveness of creating an IRP process in Hainan has several roots. First, Hainan's economy is growing rapidly with a concomitant increase in electricity demand. Therefore, the avoided cost of power is high even though Hainan had excess generating capacity when the prefeasibility study was conducted. Despite this excess, this is an ideal time in Hainan's development to implement an IRP process. For one thing, some of the resource alternatives to fossil-fuel plants such as DSM programs have long lead times before reaching maximum penetration into the market.

Second, regional and global environmental concerns about generating electricity from coal focus special attention on Hainan's power sector. Because Hainan's hydroelectric resource base is nearly exhausted, its avoided power source is coal. Therefore, any reduction in electricity demand in Hainan will serve to reduce emissions from coal-burning power plants.

Third, Hainan's current low level of income implies modest penetration of the most electricity-intensive durables. Economic development implies higher income levels and the penetration of new and different types of electricity-using durables such as water heaters, air conditioners, refrigerators, and lighting. The ability of HEPCO and the government to promote the use of energy-efficient durables is much greater before those types of products have had much time to penetrate Hainan's markets. There is inertia in an existing stock of electricity-using durables, implying that they will not be readily traded for more efficient new ones in the short term even if better means of meeting needs exist. The longer the delay in implementing an IRP process, the greater the sacrifice in Hainan's future well-being.

One formidable challenge for realizing the potential efficiencies that an IRP process can foster in Hainan is collecting relevant information and data on resource alternatives to fossil-fuel generating plants. However, an even greater challenge for Hainan in the short term is to develop institutions and incentive mechanisms for HEPCO to (1) adopt cost-based pricing, (2) run cost-effective DSM programs, (3) construct renewable generating plants, or (4) improve the efficiency of its existing power delivery system. For the longer term, the challenge is to sustain the IRP process: continually re-evaluating short- and long-term plans for resource acquisition.

One proposal for developing these mechanisms is to create a Hainan government-wide IRP committee chaired by the Vice-Governor for Science and Technology, providing a forum for relevant stakeholders to share ideas, gather information, and make decisions on aspects of the current system that are impediments to IRP. This committee would be the institutional mechanism for HEPCO to overcome the obstacles that now exist for implementing an effective IRP process in Hainan. HEPCO and representatives of ministries such as science and technology, planning, finance, and industry would sit as equal partners on the committee. HEPCO, in turn, would organize three "research groups" of its staff to accommodate the Hainan-wide IRP effort. The research groups are organized around (1) generation alternatives, including conventional and renewable, (2) DSM activities, and (3) integration/coordination of the two.

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