World Resources Institute

Sustainable Enterprise Program
A program of the World Resources Institute

The AES Corporation (A)

For more than a decade, WRI's Sustainable Enterprise Program (SEP) has harnessed the power of business to create profitable solutions to environment and development challenges. BELL, a project of SEP, is focused on working with managers and academics to make companies more competitive by approaching social and environmental challenges as unmet market needs that provide business growth opportunities through entrepreneurship, innovation, and organizational change.

On an afternoon in mid-1987, Roger W. Sant was in a rush to get back to his office. As Chairman of the Board and CEO of the AES Corporation, and a board member of several environmental organizations, Sant felt the company ought to assume more accountability for its contribution to the build-up of greenhouse gases in the atmosphere. He had just spent another day as a member of a World Resources Institute global warming panel where he had become more convinced than ever that excessive carbon dioxide in the lower layer of the earth's atmosphere would be one of the main causes of global warming, should global warming occur.

As one of the nation's leading independent power producers, AES had a commitment to meeting the energy needs of its customers at the lowest possible costs, a strategy which Sant and his colleagues had developed and written about while with the Mellon Institute ten years previously. Although they had successfully operationalized their mission on "least-cost," they felt a competing responsibility to minimize the company's impact on the environment. This accountability for social costs was integral to AES's value system, which put social responsibility as the first, and conditional order of business. Unfortunately, the least cost option for power

This case was prepared by Marcy Trent of the Sustainable Enterprise Program and reviewed by James E. Post, Professor of Boston University School of Management; Forest Reinhardt, assistant Professor of Harvard Business School; and Walter D. Scott, Professor of Kellogg School at Northwestern University to stimulate class discussion rather than to document effective or ineffective management strategies.

generation in the U.S. does not have the lowest environmental impact. Coal-fired co-generation plants are significant emitters of carbon dioxide, a gas which is not regulated by law, but which is the key greenhouse gas. As soon as he arrived at the office, Sant called Roger Naill, Vice President of Planning Services, and Sheryl Sturges, Director of Strategic Planning, to discuss the problem of how to offset these carbon dioxide emissions so that AES could bring its cost strategy in line with its value system.

The Company

The AES Corporation was co-founded in 1981 by Roger W. Sant and Dennis W. Bakke to capitalize on the market potential for cogeneration (the sequential generation of steam for industrial uses and electricity for sale to utilities). The company entered the business of developing, owning and operating independent (i.e., non-utility) cogeneration facilities in 1981, and in 1983 began the construction of its first plant. By 1987, AES had grown to 215 employees with annual revenues of over $40 million (see **Exhibit 1**) and two operating cogeneration facilities: AES Deepwater, a 140-megawatt petroleum coke-fired facility and AES Beaver Valley, a 120-megawatt coal-fired cogeneration facility (see **Exhibits 2 and 3**).

AES's primary objective in 1987 was to meet the growing need for electricity by being a safe, reliable and efficient power supplier in the independent power market. AES used a six-part strategy to develop its core cogeneration business and maintained a critical corporate value system to achieve this objective. The six-part strategy was as follows:

- *Project Size*: AES typically focused on larger projects, generally greater than 100-megawatts in size and $100 million in construction costs. The customer base for the electricity produced from these projects was electric utilities.

- *Least Cost*: AES offered its customers the "least cost" supply of energy. In the company's judgment, coal generally provided the best alternative to meeting this criteria. Coal is expected to be abundant and available from U.S. reserves for over 200 years. Also, prices for coal are less likely to rise than those of other fuels due to threatened shortages or political disruptions, enabling the company to obtain long-term coal supply contracts at competitive rates.

- *Long-term Contracts*: AES entered into long-term power sales contracts with electric utilities (i.e., 30 years) at a set electric rate with escalators that match those of the projected fixed and variable costs of operating the plant.

- *Careful Site Selection*: The company attempted to find appropriate facility sites before extensive capital commitment by optimizing the following variables: access to fuel and waste transportation, water availability, potential steam or thermal markets, and local government and community acceptance.

- *Stand-alone Financing*: Each project, to the maximum extent possible, was financed without recourse to the Company or to other projects.

- *Commitment to Operations*: Because of the Company's commitment to the electric utility customer, it emphasized excellence in operations and believed strongly that it should operate all projects which it developed or acquired.

Apart from the above six-part strategy, maintaining a strong corporate value system integral to all operating decisions was seen as key to AES's ability to meet their stated objectives. The four shared corporate values at AES Included:

Integrity: To act with integrity and honor its commitments
Fairness: To treat fairly its employees, customers, suppliers and the governments and communities in which it operates

Fun: To create and maintain an atmosphere where employees can advance in their skills while enjoying their time at work

Social Responsibility: To undertake projects that provide social benefits, such as lower costs to customers, a high degree of safety and reliability, increased employment, and a cleaner environment.

This value system was created by and represented the personal values of Roger Sant and Dennis Bakke. They were of such importance to the founding members of AES that the company would adhere to these values even at the cost of a lost profit opportunity.

The Thames Plant

During 1987, the company competed in and won the bidding competition to furnish Connecticut Power & Light 181-megawatts of base load power on an annual basis. Montville, Connecticut on the Thames River was chosen as the site for the new "Thames" coal-fired cogeneration plant that was expected to begin commercial operation in 1990.

The 181-megawatts to be furnished under the 25 year contract was enough poiwer to provide electricity to over 100,000 homes. The Thames plant would also supply up to 100,000 pounds per hour of steam to Stone Container Corporation's Uncasville paper recycling plant under a 15 year contract.

The fuel course for the plant was planned to be West Virginia coal, supplied by CSX Transportation, Inc. under a 15 year contract. The coal would be burned in two state-of-the-art circulating fluidized bed boilers, which produce lower stack emissions than conventional boilers, and are significantly cleaner than all current and proposed federal, state, and local standards (see section "Coal Technology").

The forecasted capital investment of the project was $275 million, with AES holding 100% of the economic interest. By the end of 1987, the project was beyond the planning state and under construction. However, limiting carbon dioxide emissions had not been incorporated into the project planning or original cost estimates. AES estimated that the Thames plant would emit over 15 million tons of carbon over its expected 40 year life.

The Independent Power Industry

Historically, electricity generating plants were constructed almost exclusively by regulated utilities, municipalities and rural electric cooperatives. In 1978, Congress passed the Public Utility Regulatory Policies Act of 1978 (PURPA) that fostered a new market of electricity generation produced by independent producers (IPPs) at a price at or below the utilities' "avoided" or incremental supply cost. By the late 1980's competition for these supply contracts was driving down the prices for electricity, making it difficult for small IPPs to compete. AES relied on its proactive environmental position as a means of setting it apart from its competitors.

In the *1987 AES Strategic Outlook*, the following statement summed up the state of competition in the independent power industry:

> Our best guess is that over the long-term, the utility industry will restructure towards competitive (deregulated) generation… When this happens we want to be the least-cost (and most reliable) producers of electricity in order to survive in a deregulated market. Even in the near term, we are facing stiff competition from utilities and other IPPs in our bids to obtain electric contracts and maintain all of our plants profitably.

Coal Technology

Since World War I, over half of the electricity in the U.S. has been generated by coal-fired power plants. With the uncertainty of nuclear power and oil supply, coal-fired power plants in 1987 were expected to contribute up to 70 percent of electric power in the U.S. by the end of the century.[1]

The U.S. is estimated to have coal reserves for over 200 years, and long-term contracts can be arranged with coal producers. This economic advantage of locking in a low-cost fuel supply as an offset to fixed price electricity contracts has been a leading cause for U.S. power producers to continue building coal-fired power plants.

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[1] Balzhiser, R.E. and Yeager, K.E., "Coal-fired Power Plants for the Future," *Scientific American,* vol. 257 (September 1987), pp. 100-107.

Most coal-fired power plants are used for larger "base load" facilities, rather than "peak load" facilities. Base load power plants are used 24 hours a day, and shut down for maintenance only about every two years. Peak load facilities run during intervals of high usage, such as mid-day during the summer months when air conditioning loads are high. The variable operating costs drive the profitability of a base load plant; coal and nuclear power are the most common base load fuel because they fuel costs are so low.

Despite the fact that coal has long been a major course of U.S. electricity, coal has never been considered a very efficient fuel for power plants. Coal contains less energy per unit of weight than natural gas or oil; it is expensive to transport; and there are many hidden environmental costs to using it. Coal-burning plants generate emissions of sulfur dioxide, oxides of nitroguen, and carbon dioxide, gases which may fall back to earth as acid rain or contribute to global warming. Of the various sources of air pollution in the U.S., coal-fired power plants account for about 70% of all sulfur dioxide emissions, 30% of all oxides of nitrogen emissions, and 35% of all carbon dioxide emissions.[2]

Development of new technologies for burning coal cleanly was a key issue during the 1980's for the utility industry and AES. Congress created a national initiative to demonstrate and deploy clean coal technologies to industry. Emissions control systems accounted for as much as 40 percent of the capital cost of a new plant, and 35 percent of its operational costs. [3] Maintaining the lead in clean coal technology was inherent to AES's commitment to social responsibility. Creating the most energy efficient and low cost pollution controlled plants was also critical to maintaining their competitive advantage in the bidding process to win new electric contracts.

AES used a circulating fluidized bed (CFB) combustion technology to capture 90 percent or more of the sulfur released from coal during combustion while minimizing the formation of oxides of nitrogen by operating at a lower temperature. The advantages of this technology are its energy efficiencies and the flexibility for AES to purchase a range of coal qualitieis in the marketplace, reducing operating costs. In 1987, 78% of utilities were considering implementing the CFB combustion technology, making the technology less unique to AES and threatening their competitive cost advantage. [4] Thirty-six coal-fired cogeneration plants out of a total of 78 power plants were either under construction or planned through the year 2000 (see **Exhibit 4**) to satisfy a 1.5% to 3.6% forecasted growth in electricity demand (see **Exhibit 5**).

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[2] Corcoran, E. "Cleaning up Coal," *Scientific American*, May 1991, pp. 107-116.
[3] Balzhiser, R.E. and Yeager, K.E., supra note 1.
[4] "*1987 AES Strategic Plan*: Background Data and Issues," 1987.

Global Climate Change

The earth's temperature is a function of the rate at which the sun's rays reach the earth's surface and the rate at which the warmed earth sends infrared radiation back into the atmosphere. "Greenhouse" gases such as carbon dioxide and methane trap this infrared radiation in the lower atmosphere, resulting in warmer temperatures (see **Exhibit 6**). Human activities during the last century have increased the concentrations of these naturally occurring greenhouse gases primarily through the burning of fossil fuels. Powerful new gases such as chlorofluorocarbons (CFCs) that are released through chemical processes have also intensified the "greenhouse effect" of the earth's lower atmosphere.

In 1987, the link between growing atmospheric concentrations of greenhouse gases and eventual global warming was becoming of greater interest world-wide to scientists and policy-makers. The Environmental and Energy Study Institute, established by Congress and chaired by Roger Sant of AES, published a Special Report in 1987 summarizing the state of the global warming controversy:

> Recent studies support projections that the earth's surface temperature will climb in the next century by several degrees – to a level never experienced by humans. For virtually every effect, the amplitude, timing, and, in some cases, even direction of the projected changes are uncertain.[5]

Since scientists began measuring the mean global temperature over a hundred years ago, 1987 was the warmest year on record, and the 1980's the warmest decade on record.[6] Nevertheless, there were questions about the cause of leveling and slight downward trend of temperatures between 1940 and 1965, and the reliability of earlier measurements. Some scientists were also skeptical that these temperature trends represented simply a normal fluctuation from the thirty-year climate average rather than any link to the greenhouse effect.

The Department of Energy created climate models that estimated a 1.5 to 4.5 degreed Celsius (3 to 8 degrees Fahrenheit) increase in average global temperatures over the next 75 to 150 years using current carbon dioxide emissions rates, and potentially double that increase with the other greenhouse gases included.[7] However, both the magnitude and the timing of global warming remain uncertain, and many related determinants of future climate change are still inadequately understood. For instance, climate models cannot predict how the thermal inertia of oceans may slow any temperature changes caused by increased greenhouse gases over the next several decades.

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[5] Robock, A., "The Greenhouse Effect: Global Warming Raises Fundamental Issues

[6] "The Global Greenhouse Finally has Leaders Sweating," *Business Week*, Aug. 1, 1988, p 74.

[7] Robock, A., supra note 5.

Roger Sant at AES thought the linkage between greenhouse gas buildup and global climate change was plausible. He also knew that carbon dioxide in 1987 contributed to 57% of all greenhouse gas emissions. His research showed that the United States annually generated approximately 23% of global carbon dioxide emissions, and that U.S. energy producing plants alone generated over 6%.[8]

Although carbon dioxide emissions can be tied directly to industry smoke stacks, they are also an integral part of virtually all natural and combustion processes (see **Exhibit 7**). There is no single, identifiable source of carbon dioxide emissions, making the control of carbon dioxide through legislation particularly difficult.[9] Due to this fact, the Clean Air Act and its amendments never have included regulation of carbon dioxide emissions. By 1987 no legislation had been proposed to control carbon dioxide emissions, nor was there any expected to be considered in the near future.

Offsetting the Thames Plant Carbon Dioxide Emission

Roger Sant presented the problem of carbon dioxide emissions from the Thames power plant and their possible relationship to global warming to Naill and Sturges. He asked them both to come up with some options to offset the carbon dioxide emissions for the next operating committee meeting in two weeks.

Neither Naill nor Sturges had a great deal of background knowledge on greenhouse gases nor the natural carbon cycle process. They did, however, know what kind of project would meet AES operational needs. Sitting in Naill's office, they developed the following criteria to evaluate the various alternatives.

a) **Cost of the alternative must not exceed 1% of capital cost of project (approximately $275 million).** If greater than this amount, the pool of investors would need to be advised and the electric sales contract would need to be modified. Such action would undermine AES's credibility and competitiveness.

b) **Carbon dioxide must be disposed of permanently.** For example, selling it to beverage companies to enhance the carbonation in their drinks would not permanently remove the carbon dioxide from the atmosphere.

[8] "The Looming Crisis in Electric Power Generation" April 4, 1989, Dennis P. Meany, Booz-Allen & Hamilton Inc.

[9] Peters, M.B. "An International Approach to the Greenhouse Effect: the Problem of Increased Atmospheric Carbon Dioxide Can Be Approached by an Innovative International Agreement," *California Western International Law Journal,* Winter 1989, pp. 67-89.

c) **The alternative must be technologically feasible.** A solution is needed that solves the problem but maintains the viability of AES as a business.

d) **The alternative preferably has other positive social benefits aside from carbon sequestration.** The project itself is assured greater sustainability over the long-term and can be enhanced by financial leverage from other investor-related parties if it has further humanistic value than simply carbon sequestration.

The Alternatives

After developing these criteria, Naill passed the problem onto Sturges. After extensive investigation into the issue, Sturges came up with the following alternatives. The first three could be implemented for the Thames plant specifically, and then repeated for other coal-fired power plants. The last dealt with a strategy shift for AES, that would not only affect the carbon dioxide emissions but would drastically change the way AES does business.

1) Promote energy conservation of 180-megawatts per annum to offset the carbon dioxide emissions from the Thames plant.

The Electric Power Research Institute estimated in 1986 that a 50,000-megawatt reduction in energy use was achievable during peak hours through industrial, commercial, and residential conservation and load management.[10] However, at that time, only a handful of utilities were focused on demand side energy conservation. Part of the problem of energy conservation programs was that, to assure project conservation goals were achieved, each individual consumer's old and new electricity utilization rates needed to be measured and aggregated. This made monitoring costs extremely high in relation to total conservation program costs.

Because utility companies had direct access to the residential market, their incremental cost of conservation marketing was minimal. AES did not have this access, so the company was limited to commercial and industrial sectors to target energy conservation. These sectors represented over 70% of all electricity and use in 1986 (see **Exhibit 8**).

A means of promoting conservation in these sectors was through "lighting retrofits." On everage, one-third of commercial/industrial electricity costs were attributed to lighting. Lighting retrofits replaced short-lived fluorescent lights with longer life fluorescents that lasted up to ten years. The customer would not only save on operation costs for replacement of the lights, they would also save 30 to 40 percent on their electricity bills. In order to obtain 180 megawatts of

[10] Keelin, T.W. and Gellings, C.W. *Impact of Demand-Side Management on Future Customer Electricity Demand,* Electric Power Research Institute Report EM-4815-SR, October 1986.

conservation, AES would need to form partnerships with several utility and industrial companies to establish in excess of 100 lighting retrofit contracts with individual end-users. Additionally, a monitoring system would need to be implemented to guarantee that the end-users remain faithful to the lighting retrofits, the cost of which at this point was unknown, but thought to be very expensive.

2) Employ a technology that scrubs carbon dioxide from plant exhaust gases. Find a means to permanently remove them from the atmosphere.

Carbon dioxide can be removed from smokestack emissions using liquid solvents or solid absorbents and converted to gas, liquid or solid blocks. A variety of new systems were available, at a very high cost, to perform this task. For instance, the Brookhaven National Laboratory uses the chemical solvent monoethanolamine to separate the carbon dioxide. The system, however, costs $50-300 million per plant in 1980 dollars. Also, extra energy capacity would be needed to run the removal system, lowering the overall efficiency of the plant. At the Shady Point plant currently operated by AES, the capital cost of 4% carbon dioxide removal was approximately $10 million.

A secondary market for carbon dioxide existed; however, the price of purified carbon dioxide kept the market small. The only potential market for captured carbon dioxide emissions that would not cause the emissions to be re-released into the atmosphere was enhanced oil recovery (EOR). This process injected carbon dioxide into rock formations during exploration and production of crude oil, pushing out the excess crude otherwise unattailable. The carbon dioxide was then recycled by the company.

According to the authors of EPRI 4631 *Chemistry and Uses of Carbon Dioxide*:

> The [EOR] activitiy is intense; probably the only reason that more projects are not in place is the shortage of Carbon Dioxide. This has been a problem for years and awaits a solution.[11]

In developing a market for carbon dioxide, AES has three major considerations:

- The volume of carbon dioxide it would capture and resell could exceed the market demand.
- A sudden increase in carbon dioxide supply could drive current inflated prices down.

[11] *Chemistry and Uses of Carbon Dioxide*, Electric Power Research Institute Paper 4631, 1987.

- The company had to be sure that the carbon dioxide would not be re-released into the atmosphere (criterion b).

An alternative to selling the carbon dioxide in the EOR market would be to store the gas deep in the bottom of the ocean so that it could never be re-released. The cost of this process, in addition to the carbon capturing technology installed in the plant, would be considerable.

3) Halt deforestation or encourage reforestation to increase amount of carbon removed from atmosphere by trees.

AES determined that the Thames plant would emit 15.5 million tons of carbon over the plant's 40 year life. Rather than attempting to capture or conserve the carbon dioxide using man-made processes, this third option utilizes the natural carbon cycle to absorb or "sequestrate" the carbon dioxide emissions. The natural carbon cycle consists of plants/forests and oceans absorbing and emitting carbon particles as part of a natural process (see **Exhibit 7**). The man-made portion (combustion processes, deforestation, etc.) represents only a small fraction of the carbon flows moving through this cycle. However, this intervention permanently affects the magnitude of the total process. By planting more trees or minimizing deforestation, for instance, the influence of the coal-fired combustion process can be minimized, returning the carbon process back to its more natural order.

Sturges came up with the following table to determine how many trees would need to be planted to offset the 15.5 million tons of carbon from the Thames plant. The numbers vary based on the type of tree (planting density and growth rates are critical factors), and the health of the soil being planted.

	Area per 180-megawatt plant
Acres	32,400 to 127, 800
Hectares	12,960 to 51,120
Square miles	54 to 200

This table compares to nearly 410 million hectares (1 billion acres) of land that is currently recovering from "clash and burn" agricultural techniques in developing countries which could greatly benefit from reforestation work. Sturges also learned that trees in tropical areas grow more quickly thereby absorbing carbon more rabidly in the earlier years. Based on these figures, and discussions with various international development agencies, Sturges determined that the cost of such a project would be between $1.5 to $8.0 million in a tropical developing country, assuming that the reforested land would not need to be purchased. The development agencies believed that AES could leverage its financial input by collaborating with local groups that may provide cheap sources of labor or contribute to the funding of the reforestation project. The company could find land for reforestation near Connecticut, where the plant was to be located; however, the costs of the labor would be prohibitive. As it was, labor costs were projected to be 50% to 75% of the total project cost.

4) Reevaluate current strategy of coal-fired power plants as least cost technology. What are other-long-term strategic options open to AES that may represent a least "social" cost?

Natural Gas
The most efficient technology for the natural gas fuel source in 1987 was combined natural gas, distillate, and residential oils allowing the risk of shortage or price variations to be spread across three products. The combustion turbines produced few or no sulfur dioxide emissions if the quality of the fuels burned is controlled. Nitrogen oxides are emitted, but could be mitigated through a secondary process of injecting water or steam into the system. Still, the amount of nitrogen oxide produced by natural gas is, per unit of energy, equal to or greater than that of coal. Carbon dioxide emissions from natural gas plants are approximately two-thirds that of coal.

Capital costs were approximately $600 per kilowatt for a combined cycle plant, as compared to $1000 per kilowatt for a coal-fired plant with CFB technology. However, fuel for the combined cycle technology was very expensive comparatively and subject to price swings; operating costs for natural gas ranged two to three times greater than that of coal. Also, plant profitability was at risk because the cost of the natural gas fuel could exceed the fixed price electric power sales contract developed by an independent power producer. Conservatively, the combined cycle option might ass as much as 15% to AES real economic cost of doing business if gas price forecasts were to be realized.[12]

Renewables: Biomass, Wind, Hydro and Solar
Biomass refers to energy stored in plant and animal organic matter. The primary resources of biomass energy include wood wastes, agricultural residues, animal manures, the organic portions of municipal solid waste, landfill gas and sewage. Utilization of available biomass for energy production was estimated at only 25% in 1985[13]. However, biomass primarily provides energy for individual use rather

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[12] *1987 AES Strategic Plan:* Background Data and Issues.
[13] Fenn S., Williams S. and Cogan D., Power Plays: Profiles of America's Leading Renewable Electricity Developers, Washington DC: Investor Responsibility Research Center Inc. (1986).

than electricity sales. For instance, the lumber industry derives almost 75% of its energy from direct wood combustion and the pulp and paper industry derives 51% of its energy needs from wood.

The most promising biomass technology is waste-to-energy, which converts solid waste into saleable energy through incineration. Capacities of these plants are typically only 1 to 80-megawatts, with capital costs ranging from $500-$1600 per kilowatt. Most waste-to-energy projects must be developed through an alliance between developer and municipality. The plants must also be located close to waste centers and to population centers, raising environmental concerns. Pollution from waste-to-energy plants varies based on the combustion method of the plant and the composition of the waste. However, little data exists as to the danger of the pollutants produced, and few regulatory standards have been established to monitor the emissions.

Wind energy is one of the fastest growing renewable technologies in the 1980's due to tax incentives passed in the Wind Energy Systems Act of 1980. However, these tax incentives expired during 1985, making wind energy production less appealing to investors. Over 95% of the U.S. development in wind energy production has been in California, in part due to state incentives. Wind is a clean, free and renewable source of energy with short lead times and few off-site environmental impacts. Major disadvantages are that wind is an intermittent energy source subject to unforeseen variations; it requires extensive land use potentially leading to land erosion, generates noise pollution for nearby home dwellers, and interrupts bird and wildlife migrations. The capital costs for wind technology range from $900 to $1200 per kilowatt, with most projects under 20-megawatts.

Hydropower harnesses the kinetic energy in falling water to produce electricity. The total capacity in the United States in 1985 was 79,000-megawatts or one-eighth of the nation's total generating supply. Because of the competing uses of rivers as water sources, and the depletion of available rivers for damming, most domestic development would need to be concentrated at existing dam sites with generating potential of 25-megawatts or less. In comparison with other renewable energy sources, hydropower's potential is limited due to its past high exploitation. A primary environmental advantage of hydropower is that is does not require combustion, therefore limiting any damage to air quality. However, the dams can have negative effects on wildlife, scenic river valleys and recreational uses of rivers, inhibiting future growth of hydropower. The process of obtaining a hydropower license has therefore become extremely expensive, arduous and time consuming.

Solar energy refers to technologies that convert energy from sunlight into thermal energy, which eventually becomes electricity. With tax incentives expiring year-end 1985, the solar industry could not maintain the financial support to continue growing as did the other renewables. As a result, capital costs of solar are higher than other renewable alternatives ($2000 to $3000 per kilowatt) and operating costs are burdensome. Most solar projects are under 30-megawatts of power.

The Operating Committee Meeting

Roger Sant had asked Naill and Sturges to present their recommendations in two week's time at an upcoming operating committee meeting. Sturges knew that the operating committee members would be receptive to creative solutions that enhanced the company's commitment to social responsibility. She also realized that the fourth option, changing the long-term strategy of AES from coal-fired power plants to natural gas or renewable energy, could not be applied to the Thames plant which was already under construction. For the board meeting, she needed to present one of the first three options as a means to offset the carbon dioxide emissions.

Understanding the value structure at AES, she knew that eventually the company would need to reevaluate its least-cost strategy of coal-fired power plants to incorporate environmental externalities and generate a "total cost" strategy. For right now, she would have to leave that to later strategic planning meetings. Sturges turned to her computer and started working on the presentation of the alternative she knew was the right choice for the Thames plant and for AES.

Exhibit 1: Projected AES Net Income

	($ millions)			
	1987	**1988**	**1989**	**1990**
OPERATING REVENUES				
Steam and Electricity Sales	40.8	80.5	125.8	220.3
OPERATING EXPENSES				
Costs of Production	24.1	44.0	68.4	112.6
Other Expenses	14.1	25.7	39.9	65.6
Total Expenses	38.2	69.7	108.3	178.3
INCOME BEFORE TAX	2.6	10.8	17.5	42.1
Taxes	1.0	4.2	6.4	16.1
NET INCOME AFTER TAX	1.6	6.6	11.1	26.0
MEMO:				
Earnings Per Share	1.1	4.6	7.7	18.1
Projected Cash Generation	5.7	10.0	10.0	27.7
Projected Cash Cumulative	6.1	16.1	30.5	58.2

(*Source: 1987 AES Strategic Plan: Background Data and Issues*)

Exhibit 2: Plant Descriptions

	Utility Customer	Fuel	Electricity (Megawatts)	Capital Costs ($MM)	AES Interest
In Operation					
Deepwater	Houston Lighting & Power	Petroleum Coke	140.0	275	(1)
Beaver Valley	West Penn Power Co.	Coal	120	120	80%
Under Construction					
Placerita	Southern California Edison Co.	Natural Gas	99	140	97.5%
Thames	Connecticut Light & Power Co.	Coal	181	275	100%

(1) Operated under management agreement

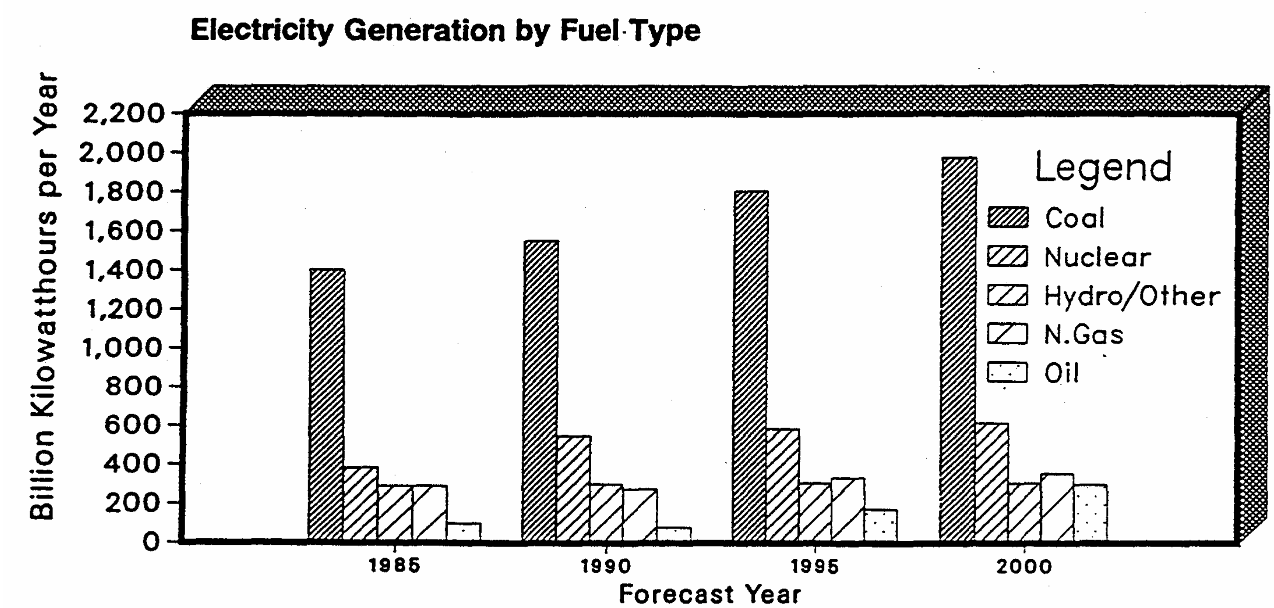
(*Source: 1991 Prospectus for the AES Corporation Common Stock*)

Exhibit 3: Operation Goals and Results

AES Plants in Operation	**1988 Goal**	**1988 Actual**
Deepwater		
Capacity Factor	90%	100.2%
Operations & Maintenance Costs	$15.7 MM	$15.7 MM
Total Cost/ kilowatt hour	4.7 cents/kwh	4.7 cents
Beaver Valley		
Capacity Factor	87%	84.2%
Operations & Maintenance Costs	$35 MM	$35 MM
Total Cost/ kilowatt hour	5.3 cents/kwh	5.3 cents

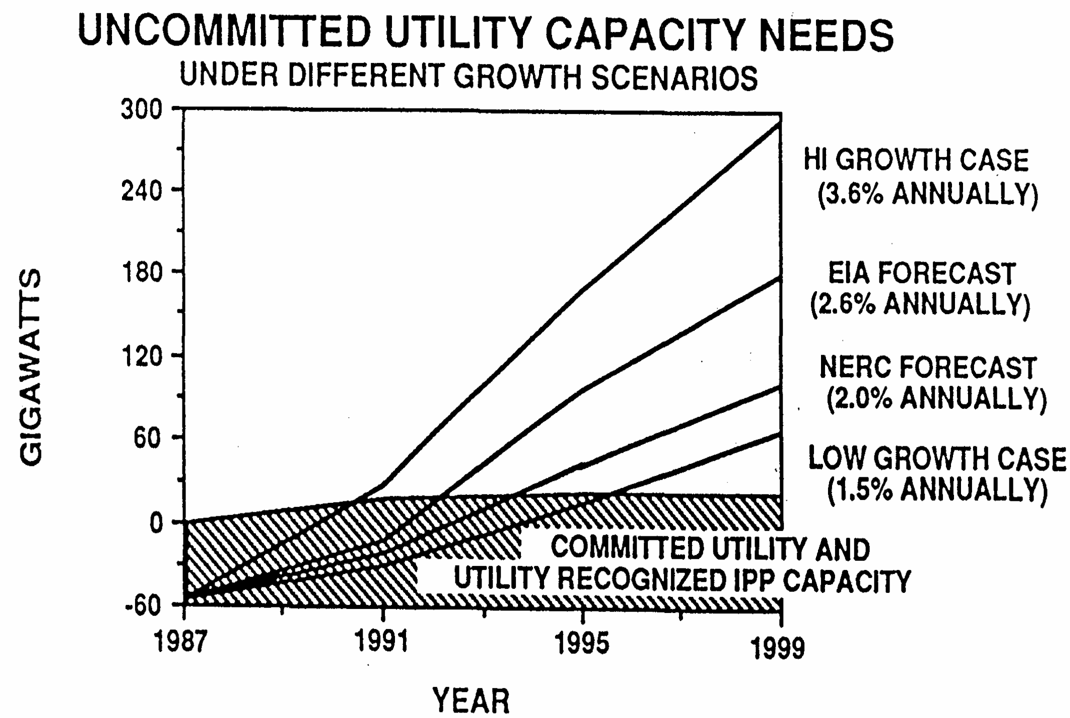
(*Source: 1988 AES Strategic Plan: Background Data and Issues*)

Exhibit 4: Existing Capacity and Projected Expansion by Fuel Type



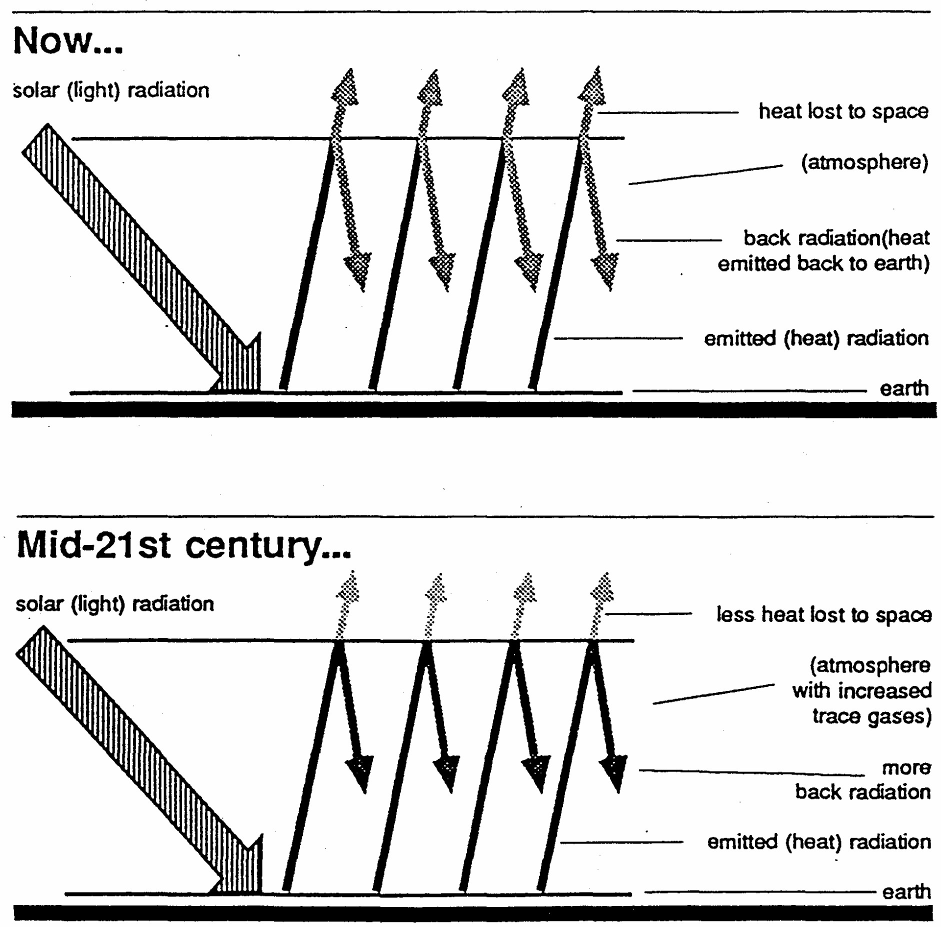
(Source: Energy Information Administration: Annual Energy Outlook 1986, February 1987)

Exhibit 5: Uncommitted Utility Capacity Needs



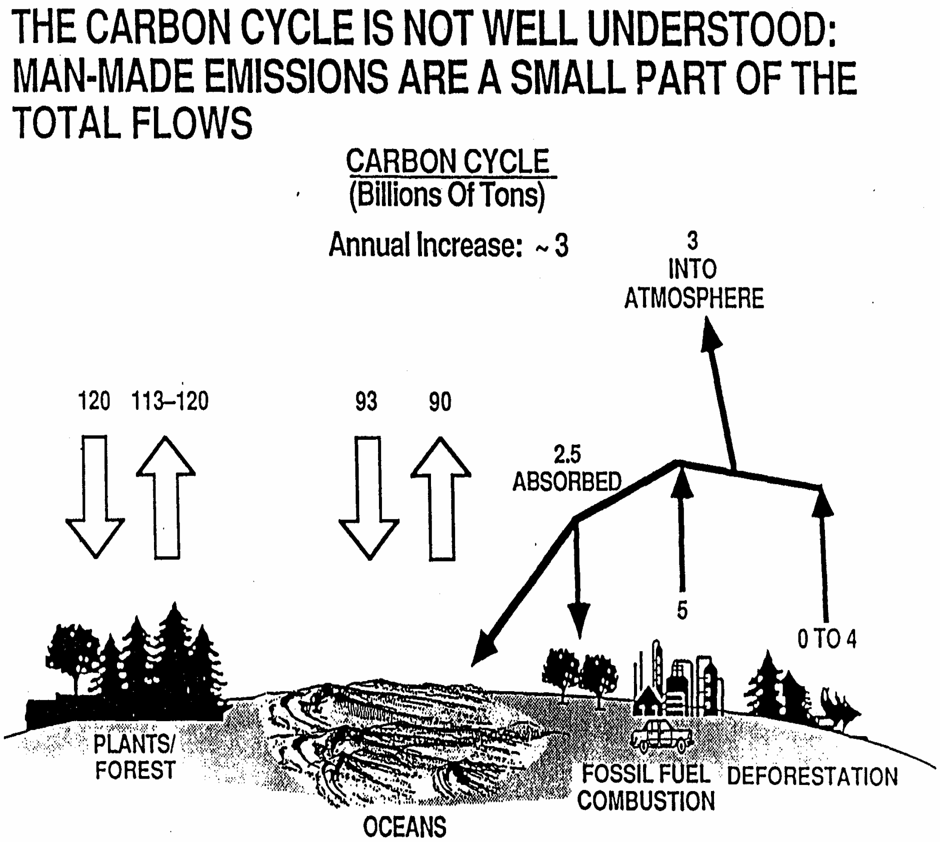
(Source: 1987 AES Strategic Plan: Background Data and Issues)

Exhibit 6: Greenhouse Effect



(Source: Environmental and Energy Study Institute, Special Report: The Greenhouse Effect, September 1987)

Exhibit 7: Carbon Cycle



(Source: Warwick and Jager cited in presentation by Dennis P. Meany, Booz, Allen & Hamilton Inc., "The Looming Crisis in Electric Power Generation" at the Energy Bureau Conference, 1989)

Exhibit 8: Electricity and Total Energy End Use

Table 4: Electricity and Total Energy End Use, 1986, 1985, and 1980, and Selected Growth Rates (Quadrillion Btu)

Sector	1986	1985[a]	1980	Growth Rate 1985-1986 (percent)	Growth Rate 1980 – 1985 (percent)
Residential End Use					
Electricity	2.8	2.7	2.4	4.0	2.0
Total Energy	9.0	8.9	9.1	0.8	-0.5
Commercial/Other End Use					
Electricity [b]	2.5	2.4	1.9	5.2	4.4
Total Energy	6.1	6.0	6.0	0.7	0.3
Industrial End Use					
Electricity	2.8	2.9	2.8	-2.1	0.5
Total Energy	19.6	20.4	23.9	-4.2	-3.1
Total Electricity End Use [b]	8.1	7.9	7.1	2.2	2.1
Total Energy End Use [c]	55.2	55.4	58.6	-0.3	-1.1

[a] 1985 data for electricity demand are collected from all U.S. electric utilities and published in the January 1987 *Electric Power Monthly*. The 1985 data for electricity demand used for projections in Chapter 2 are consistent with earlier data published in the *Annual Energy Outlook 1986*, based on data for sales of electricity collected from a sample of utilities.
[b] Includes electricity use in the transportation sector
[c] Includes end-use energy in the transportation sector.

Note: Data include energy loss in electricity production.

Note: Totals may not equal sum of components because of independent rounding. Growth rates are calculated before rounding.

Sources: Energy Information Administration, 1986 and 1980 data: *Monthly Energy Review,* December 1986 and preceding issues: 1985 data: Estimates prepared by the Electric Power Division.

(*Source: Energy Information Administration: Annual Energy Outlook for U.S. Electric Power 1987*)