A Simulated Field Trip: "The Visual Aspects of Power Plant Sitings[1]"

Bill Bottom [2]
Alex Young[3]

Abstract: The growth of our economy is demanding construction of a variety of power plants to generate electricity which is having a significant impact on the visual environment. These power plants will consist of conventional thermal (fossil fuel and nuclear), geothermal, wind and solar power plants. There are several areas where solutions to the visual impacts of these power plants can be effectively addressed - site selection, site planning, and cooperative research towards alternative design. In resolving the visual impacts of power plants and the visual resource, we as professionals and managers must be prepared to evaluate a variety of power plant types and a multitude of conflicts which will exist between the visual resource and other resource concerns.

INTRODUCTION

The growth of the American economy is resulting in the increased consumption of energy, particularly electric energy. This is demanding construction of increased numbers and varieties of power plants to generate electrical energy which is having a significant impact on the environment and the visual resource.

In sorting out our energy needs and their effect on the visual environment we must look at the short term and long term options. For the near future we will still be dependent on conventional thermal power plants to generate electricity. These power plants are powered by a variety of fuels which include coal, gas, oil, nuclear and synthetic fuel combinations. A dependence on "conventional" power plants will exist even if we are successful in conserving energy and developing alternative energy sources today.

Long term projections are varied for supplying electric energy by the year 2000. Some estimates indicate we could still be generating up to 80% of the electric needs of this nation by conventional thermal plants, which will be dependent on a variety of complex factors:

- fuel availability and production
- economic factors or demand levels
- current events
- environmental issues
- energy policy and regulations
- technology development
- public acceptability of alternative energy sources.

The prospects for satisfying a major share of total electric demands by alternative energy or power plant sources by the year 2000 are clouded. The most likely future alternatives for electric energy generation are geothermal, wind and solar power plants. The basic technology for solar and wind power plants exists today and is being tested in prototype or demonstration situations. Geothermal energy is being utilized on a limited regional basis where these power plant complexes can economically supplement existing power grids. Substantial improvements in technology and economics may be available in the near future and influence the implementation of these or other alternative energy sources.

[1/] Presented at the National Conference on Applied Techniques for Analysis and Management of the Visual Resource, Incline Village, Nevada, April 23-25, 1979.

[2/] Bill Bottomly, Landscape Architect, Bureau of Land Management, Denver, Colorado.

[3/] Alex Young, Landscape. Architect, Bureau of Land Management, Sacramento, California.

Projections after the year 2000 are difficult to predict although we know that alternative sources and their associated power plants will play a more important role in supplying electric energy (Moon 1979 EPRI 1978, CDWR 1978).

VISUAL IMPACTS

Let us examine the visual impacts of plants, both for conventional and alternative energy sources.

Conventional Thermal Power Plants - For as long as man has been involved with the industrial age he has depended on centralized production of energy, particularly electric energy to power his machines and light his homes. Traditionally, these power plants have been constructed near population centers. However, as the demand for electricity increases, public concern and environmental controls have forced the siting of a new breed of power plants in areas that are environmentally and visually more sensitive (CAI 1974).

Many of these power plants are "mega colossal engineering masterpieces" and among the largest power plants in the world, creating a visual impact not found anywhere in the natural landscape (fig. 1). These plants could require a minimum site of 1,000 acres for nuclear power plants up to several square miles for coal fired plants to accommodate the generation complex, fuel storage, fuel handling and preparation facilities, cooling structures, support facilities, transportation networks and waste disposal (EDAW 1978).

The visual impact of these facilities is particularly acute in the west - "the last of the blue sky areas." One major regional power plant complex - "Four Corners" - is near some of the most popular visual attractions in the nation (Craig 1971). However, this is not the end. Many multiple power plant complexes have been planned or are being proposed in other parts of the country. A southern utility has begun planning for several such facilities that would require a minimum site of 20,000 plus acres or 30 square miles (Jopling 1976).

Geothermal - Geothermal energy is directly related to the tremendous heat reserves from the earth's subsurface and one of the oldest sources of energy known to man. Current new techniques are exploring and utilizing this heat contained (natural steam and hot water), in impervious dry rock and geopressure formations for electric power generation. Only a small fraction of the gross potential of these sources of energy can be economically used for power generation in the western United States (USDI 1975). The process and equipment used to develop the geothermal resource are similar to oil and gas resources. The final development consists of well heads, pipe line collection systems, power plants and electric transmission facilities. There is much unused land that exists within a geothermal complex. In fact, the space occupied by the physical plant is only a fraction of the total land area committed in a typical geothermal development (fig. 2).

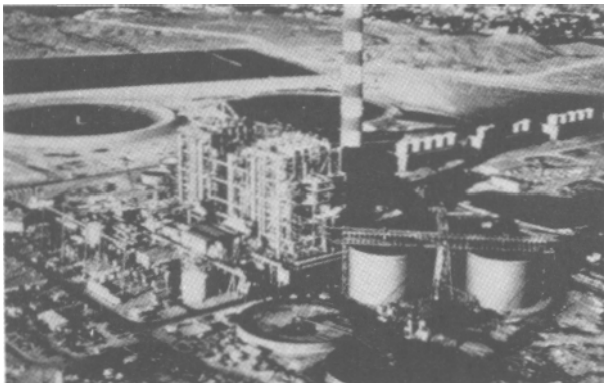

Figure 1--A new generation of power plants is typified by this fossil fueled thermal power plant, courtesy TVA.

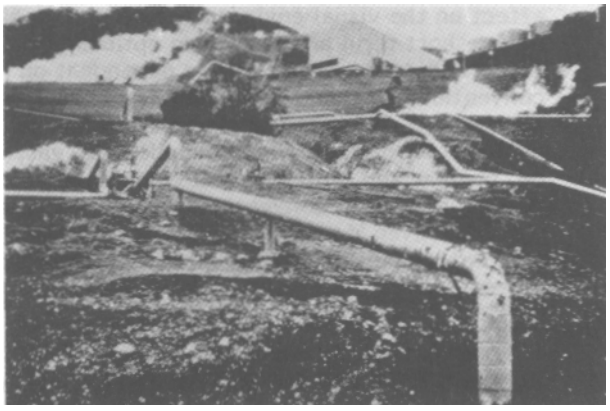

Figure 2--This is an example of a typical geothermal facility in the "Geysers," California.

Wind power plants - Wind has been used to provide a multitude of uses. But with the search for alternative energy sources, wind power is becoming a more attractive energy source. At its optimum wind power could generate only a small percentage of the national energy needs by the end of the century (EPRI 1979).

Typically wind power plants will consist of towers with massive blades and generators, a collection network, and support facilities which will require extensive land areas (fig. 3).

One of the wind power's major drawbacks is energy storage when there is no wind. Additional visual impacts would be associated in solving the base loading problem with pumped water storage or other alternatives.

Favorable sites for these facilities are difficult to predict at this time, since very little reliable data exist concerning suitable wind sites in the United States. A recent study in California indicates that mountainous areas, coastal zones and portions of the more open desert areas are most suitable. A high percentage of these sites is located in areas considered for their natural visual quality, or in highly visual areas close to population centers or travel routes (Hamilton 1975, Hohenemser 1977, Inglis 1977, Lockheed, 1976, Putman 1948).

Solar Power Plants - The technology to utilize the vast energy potential of the sun has existed for some time, yet until recently application of centralized electric generation from solar power plants has not been pursued.

Even though the sun radiates enormous amounts of energy, oily the sunbelt regions afford economical utilization of this energy for major power plant sites, while areas of frequent cloud cover would be excluded. This places regional siting limitations upon solar power plants.

To recover this energy economically will require large expanses of solar collectors to convert the solar energy into electrical energy. At this time solar thermal conversion power plants offer the best promise since they utilize present thermal power plant technology. Future solar plants could require over one square mile of generally level land with as many as 10,000 highly reflective surfaces or heliotats (Caputo 1977, Metz 1976, Mayer 1976).

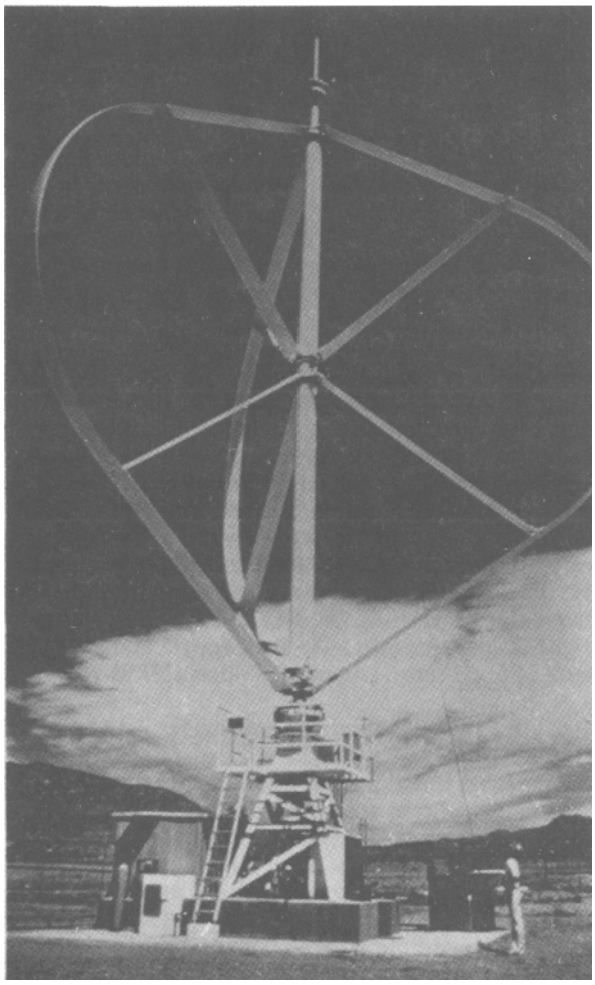

Figure 3--Prototype wind power plant site in Puerto Rico, courtesy EPA.

POWER PLANT CHARACTERISTICS

Now that we have examined the general characteristics of the major power plant types in our future, let us examine the physical components that will affect the visual resources. We must keep in mind that each power plant is unique unto itself and the surrounding characteristic landscape. However, we can make certain assumptions about the visual impacts of power plant components which can be categorized as follows: (EDAW 1978).

1. Fuel storage, energy collection systems or towers,
2. generation complex,
3. stacks,
4. cooling structures,
5. support and transmission facilities,
6. emissions and waste disposal.

Fuel Storage and Energy Collection Systems or Towers - A very significant portion of power sites is consumed by fuel storage and/or collection systems.

Coal fired power plants require large stockpiles of coal and handling equipment whether the coal is found "on-site" or is imported by unit trains, barges or slurry pipelines. This equipment can consume hundreds of acres for "mega" power plants. Other fossil fueled power plants also require storage tank farms of similar size (Craig 1971, Jones/Jones 1979).

The alternative power plant types afford certain advantages of utilizing renewable energy which appear at this time to be environmentally more acceptable. However, these plants require extensive collection systems or structures. Geothermal power plants must rely on deep well fields with collector pipeline systems which can be as much as one mile from the generating facility to supply a typical 100 MW power plant. An average of 500 acres could be affected per plant (Moon 1979).

A "typical" wind generating facility could occupy several square miles to provide economical electric energy. Solar thermal generation plants are being proposed that could cover up to one square mile per plant.

Generation Complex - Another significant visual impact of power plants is the generation complex. This is particularly significant for "mega" thermal power plants with massive boilers and generating rooms. These structures can be as tall as a 10-20 story building and could occupy several hundred to several thousand acres for a multiple plant site. These visual impacts are almost impossible to mitigate totally.

There is some reduction in the size of the structures for alternative energy sources. Geothermal energy plants are generally smaller but require an extensive network of on-site power plants to exploit the geothermal resource economically. This is also true of wi [sic] power plant sites which will require a large number of generating powers over an extensive area to generate electricity economically.

Stack Structures - Another major visual impact is tall stacks of fossil fueled power plants which can be 600-700-feet tall. The visual impact of these structures speaks for itself. In many cases, these stacks are painted in contrasting colors or adorned with lights "for air safety reasons" which makes the structures highly visible. Additional attention is brought to the stacks by the plume smoke (fig. 4).

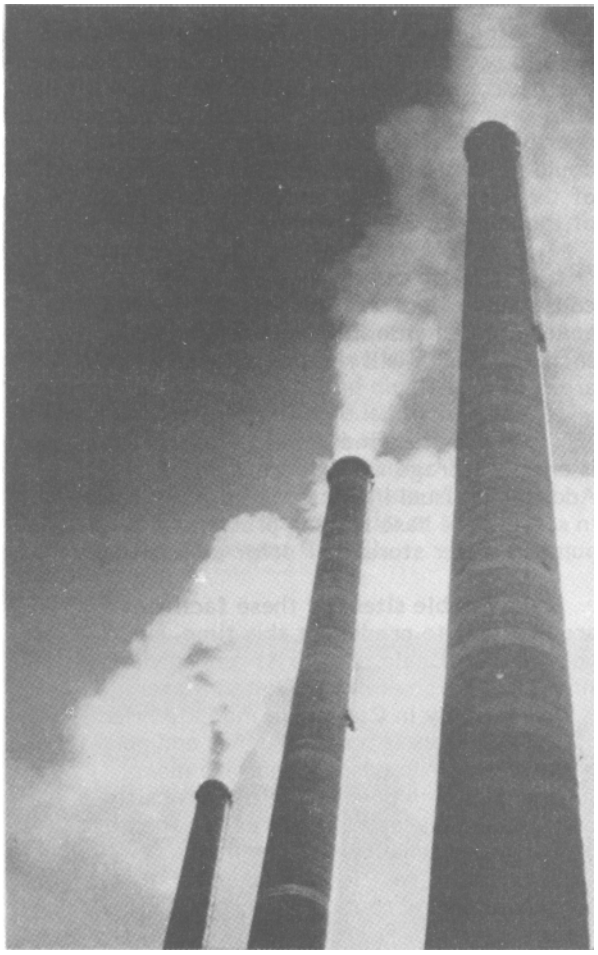

Figure 4--Typical stack at coal-fired power plant.

Cooling Structures - Cooling structures take on a variety of forms and functional aspects. Direct cooling systems are generally associated with sites with abundant water supply along major rivers, estuaries and oceans. The intake and discharge structures usually consist of head walls, channels and/or low dikes while mechanical coolers are low, massive structures and natural draft towers can rise 40-50 stories above the surrounding landscape. The total number and size of units will vary with the size and type of power plant. In the case of cooling towers and mechanical coolers water vapor brings additional attention to and accentuates the physical structure (Jones/Jones 1979).

Cooling ponds and lakes or lagoons are generally not associated with major physical structures but impact significant total areas. In more arid climates dry power plant sites may need to import water by aqueducts or open channels which create additional visual impacts.

Figure 5--Stack emissions from Four Corners power plant.

Support/Transmission Facilities - Major power plants regardless of the type of energy source will require additional structures to house control rooms, store equipment and for electric transmission (switch yards). These facilities are generally low profile structures but add to the total site impact.

Other visual impacts are associated with transportation systems or service roads, which will vary with the energy source and terrain. Extensive transportation systems are generally associated with fossil fueled power plants which must continually import coal or other fossil fuels on a daily basis. These facilities consist of rail yards, docks or pipeline systems. The visual impact of service roads is particularly acute for alternative energy power plant sites which cover extensive areas to service the energy collection systems (EDAW 1978).

Emissions - The impact of power plant structures and support facilities is obvious. However, there are less obvious visual impacts associated with other resource concerns - air quality and waste disposal!

If there is a return to reliance on coal powered electric generation, tons of fine particulate matter and gaseous pollutants will be pumped out at a high rate impairing the distant scenic views. In the Four Corners example, the "plume smoke" can be detected 200 miles or more from the point source. Newer technology for cleaning up the air could reduce the problem but never completely cure it.

Recent amendments to the Clean Air Act require visibility be protected on the same level as health hazards (fig. 5) (Smardon 1978). However, the law does not provide guidelines for assessing the scientific aspects of visibility deterioration. Studies have been conducted that obtain related measurements via Nephelometer and photographic, techniques or methodologies. There are also several visibility models related to particulate concentrations to visual range (Ziler and Wagner 1979).

Large quantities of waste material are also generated in energy production, particularly fossil fueled thermal plants which create tons of fly ash and scrubber sludge which must be disposed of on site or transported to dumps or utilized in construction materials.

MITIGATION OF VISUAL IMPACTS FOR POWER PLANT SITES

In assessing the visual impacts of major power plants we must remember that the impacts will vary within the landscape, depending on the specific power plant configuration and the characteristic landscape. It is difficult to address specific solutions; however, we can point out several general areas of concern where the visual impact of plants can be effectively mitigated.

Site Selection - We must look at site selection as a primary mitigation for visual resource management regardless of the number or configuration of the components or energy source. Because of the size of power plants architectual or engineering solutions do little to improve the appearance of large scale engineering marvels and usually come off as "decorative" statements with little relation to the visual environment. More attention should be made in selection of sites with higher visual absorption capacity and lower visual sensitivity.

In the past ecological and engineering concerns took precedence over visual resource values. Times are changing however. Many models have been developed to aid in site selection which consider all factors including the visual resource.

More recently the U.S. Nuclear Regulatory Commission denied the permit for construction of a nuclear power plant in Green County, New York, based on a number of factors of which the visual resource was a primary consideration (NRC 1979).

Site Planning - Even after the site is selected proper attention to site planning is essential. Site planning techniques are most effective in mitigating the visual impacts of arrangement and screening of low level components.

This is particularly true for centralized facilities such as conventional, thermal and solar power plants. However, the diverse

site requirements of wind and geothermal power plants will require development of innovative site planning techniques to reduce visual impacts.

Total site dedication to energy supply can lessen total acreage required, and be a deliberate design alternative to minimizing individual impact of dispersed sites.

Alternative Design - Alternative physical design of power plants is another effective tool in mitigating the visual impacts and could offer structural architectural and/or engineering efficiency. Therefore, cooperative research is needed for design concepts, particularly for newer technologies, otherwise we will be confronted with visual impacts equal to or exceeding those of conventional thermal power plants of today.

Conflicts and Consideration - In resolving visual impacts of power plant sites there is a multitude of conflicts which exist between visual resource values and other resources. These conflicts must be recognized if visual resource management is to be an effective management force. For example, large cooling towers add high contrast forms to the environment and bring added attention to themselves with large plumes of water vapor. Direct cooling would eliminate these structures but the solution may conflict with public concern for other resource values.

In the Geysers geothermal area of California, plants are located on more prominent visible sites to increase air circulation and reduce potentially toxic gases that accumulate at lower less visible sites. Other conflicts arise from the specific nature or location of the energy source-solar, wind, and geothermal which restricts the options in site selection and site planning.

IN SUMMARY

We can assume that for the foreseeable future the major visual impacts of power plants will be associated with thermal power plant complexes on a national level and with a variety of alternative energy power plants on a regional level. In addition to the fundamental socioeconomic and environmental problems of siting power plants, visual resource management is becoming a more critical issue as suitable sites with minimum environmental impacts are becoming scarce. We, as professionals and managers, must be prepared to evaluate and deal with visual impacts for a variety of power plant alternatives.

LITERATURE CITED

California Department of Water Resources (CDWR)
1973. Energy Dilemma - California 20-year Power Plant Siting Plan.

Caputo, R.S.
1975. Solar Power Plants. Bull Atom sci. 33:46-8.

Commonwealth Associates, Inc. (CAI)
1974. Nuclear Power Plant Siting A generalized Process. Atomic Industrial Forum, Inc., New York.

Craig, Roy
1971. Desert. Environment, 13 (6). pp. 21-34.

EDAW, IN'L.
1978. Visual Sensitivity of River Recreation to Power Plants. Minnesota Environmental Quality Board. pp. 515.

EPRI
1979. Staff Interview, Palo Alto, California.

Hamilton, Roger
1975. Can We Harness the Wind. National Biographical Magazine. December. pp. 812-829.

Hohenemser, K.H.
1977. Wind Power Update. Environment. 19:5.

Inglis, D.R.
1977. Answer is Blowing in the Wind. Progressive. 41:43-6.

Jones and Jones
1979. Staff Interview, Seattle, Washington.

Jopling, D.G.
1976. Large Capacity Plant Sites: Problems and Opportunities. Power Engineering. pp. 36-43.

Lockheed, Inc.
1976. Wind Mission Energy Analysis. A Study for the Energy Research and Development Administration.

Mayu, A.J.
1976. All About Solar Power. Newsweek. 87:68.

Metz, W.D.
1977. Solar Thermal Electricity Power Tower. Science. 197:353-6

Moon, John
1979. Lands and Minerals Staff, Interview, Bureau of Land Management, Sacramento, California.

Putman, Palmer Crosslett
1948. Power From the Wind. Van Norstrand Reinhold and Co. New York.

Smardon, R.
1978. Law and Aesthetics or When is the Pig in the Parlor? - A legal overview of legal factors influence on visual landscape. Policy. Berkeley, California.

U.S. Department of Interior (USDI)
1975. Final Environmental Statement for the Geothermal Leasing Program.

U.S. Nuclear Regulatory Commission (NRC)
1979. Environmental Statement - Greene County Nuclear Power Plant, National Technical Information Service, Springfield, Virginia.

Zeller, K. and W. Wagner
1978. Bureau of Land Management Visibility.