



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D. C. 20555

AUG 25 1980

MEMORANDUM FOR: Harold R. Denton, Director  
Office of Nuclear Reactor Regulation

FROM: Thomas E. Murley, Acting Director  
Office of Nuclear Regulatory Research

SUBJECT: RESEARCH INFORMATION LETTER # 100 - "THE VISUAL AESTHETIC  
IMPACT OF ALTERNATIVE CLOSED CYCLE COOLING SYSTEMS"

Introduction and Summary

This memorandum transmits the results of completed research to develop a method for assessing the visual aesthetic impact of alternative closed cycle cooling systems of nuclear power plants. This work was performed by Pacific Northwest Laboratories under the direction of the Environmental Effects Research Branch of the Office of Nuclear Regulatory Research (RES) in response to a request from your office (NRR-76-14).

The interpretation of NEPA which has evolved in the licensing process requires that NRC make an evaluation of the deterioration of aesthetic and scenic values which would result from the construction and operation of nuclear power plants. A particularly important issue has been the relative aesthetic impact of mechanical draft cooling towers and the much larger natural draft cooling towers. In the past, these evaluations have relied heavily on unquantified assessments provided by authorities in the fields of architecture and aesthetics. It is difficult to include this type of information in a cost-benefit framework as required in the licensing process. The objective of this research effort was to develop a method to allow the NRC staff to predict the cost, in actual dollars, of the relative visual aesthetic deterioration due to mechanical draft cooling towers and natural draft cooling towers and the plumes associated with each type of system.

Methodology

Obtaining quantitative estimates of visual aesthetic impact is a difficult task. However, the response of individuals to visual aesthetic effects can theoretically be measured by using tradeoffs; i.e. how much of other goods and services would be required to compensate an individual for what that individual perceives as a negative visual aesthetic impact with no change in the individual's overall well-being. This is best done by using dollars (which represent command over other goods and services) vs. visual aesthetic impact. There are two obvious approaches to obtaining dollar estimates of visual aesthetic impact of alternative closed cycle cooling

systems. Estimates derived from differences in residential property values due to visual aesthetic impacts could be used. Differences in market values of properties with similar characteristics except for a significant visual aesthetic impact could be measured (for example, two similar houses in similar locations, one with a view of mechanical draft cooling towers and one with a view of natural draft cooling towers). Lack of sufficient data and the difficulty of isolating the visual aesthetic impact, as opposed to other effects such as a perceived risk, precluded using this approach. The other approach is to use personal estimates through a process known as bidding games. The bidding game approach attempts to measure intended market behavior, rather than actual market behavior. It attempts to estimate the tradeoffs individuals would be willing to make rather than those which they actually have made. The bidding game methodology used here consisted of the following steps: A comprehensive and quantifiable visual aesthetic impact measure was defined as willingness-to-pay (the maximum amount individuals would be willing to pay for visual aesthetic changes on landscapes including nuclear plants), or willingness-to-accept compensation (the minimum amount individuals would be willing to accept in compensation for visual aesthetic changes on landscapes including nuclear plants).

Responses were elicited from individuals faced with a pair of landscapes (photographs of actual landscapes with natural draft or mechanical draft towers and a variety of plume types airbrushed in were used to represent these) to a series of questions designed to measure willingness-to-pay (WTP) and willingness-to-accept compensation (WTA) for changes in visual quality. WTP and WTA for each individual were related to a series of other variables such as family income, distance from residence to plant site, and attitude toward control of pollution.

Data collection was aimed at obtaining a range of information on variables in a variety of locations in the United States. Two locations with an existing nuclear power plant, two locations with a proposed nuclear plant, and two locations with neither a proposed nor existing nuclear plant were selected.

TABLE 1. Sampling Sites Chosen

Site	Power Plant	Cooling System
Rancho Seco, California	Nuclear Existing	Natural Draft Towers
Prairie Island, Minnesota	Nuclear Existing	Mechanical Draft Towers
Black Fox, Oklahoma	Nuclear Proposed	Mechanical Draft Towers
Perkins, North Carolina	Nuclear Proposed	Mechanical Draft Towers
Bangor-Augusta, Maine	None Nor Any Proposed	---
Puyallup, Washington	None Nor Any Proposed	---

The bidding game methodology described above was utilized with samples of individuals at each location.

### Results

It was found that visual aesthetic impact measured in terms of dollars per household per month depends on:

- a) the difference between the visual aesthetic scores of two landscape scenes including nuclear power plants,
- b) pollution control attitude,
- c) family income, and
- d) distance from residence to nuclear power station site.


The visual aesthetic impact, measured as the willingness-to-pay or willingness-to-be compensated for changes between landscapes, increased as the difference between the visual aesthetic scores of the two landscapes increased. Visual aesthetic impact was greater the more pro-pollution control were attitudes. Visual aesthetic impact was greater the higher was family income, and visual aesthetic impact was lower, the greater the distance from the residence of the respondent was from the nuclear power station site.

The results indicated that on average, a natural draft cooling tower will cause a statistically significant negative visual aesthetic impact on a community, compared with using a mechanical draft cooling tower. Willingness-to-pay for a mechanical draft tower as opposed to a natural draft tower ranged from 0 to \$10 per month for an average household, depending on site-specific conditions such as meteorology, topography, and demographic characteristics. Predictive models resulting from this analysis can be applied to any existing or proposed nuclear station site, using readily available data sources.

### Recommendations

Many of the wide variety of types of environmental impacts which must be considered in evaluating the overall environmental impact of a nuclear power plant have proven to be extremely difficult to incorporate in a cost/benefit framework, as required by NEPA. The visual aesthetic impact of different types of cooling systems is an excellent example of the type of environmental impact most difficult to place on a cost/benefit basis. We regard this study as a pioneering effort to render an environmental impact not readily quantifiable into a form suitable for inclusion in a cost/benefit framework. It should be useful to your staff in evaluating the visual aesthetic impact of alternative types of closed cycle cooling systems and serves as a useful test of the bidding game methodology in quantitatively assessing previously difficult-to-quantify environmental impacts.

For further information on this study, please contact Dr. Clark Prichard (427-4358).



Thomas E. Murley, Acting Director  
Office of Nuclear Regulatory Research

The bidding game methodology described above was utilized with samples of individuals at each location.

**Results**

It was found that visual aesthetic impact measured in terms of dollars per household per month depends on:

- a) the difference between the visual aesthetic scores of two landscape scenes including nuclear power plants,
- b) pollution control attitude,
- c) family income, and
- d) distance from residence to nuclear power station site.

The visual aesthetic impact, measured as the willingness-to-pay or willingness-to-be compensated for changes between landscapes, increased as the difference between the visual aesthetic scores of the two landscapes increased. Visual aesthetic impact was greater the more pro-pollution control were attitudes. Visual aesthetic impact was greater the higher was family income, and visual aesthetic impact was lower, the greater the distance from the residence of the respondent was from the nuclear power station site.

The results indicated that on average, a natural draft cooling tower will cause a statistically significant negative visual aesthetic impact on a community, compared with using a mechanical draft cooling tower. Willingness-to-pay for a mechanical draft tower as opposed to a natural draft tower ranged from 0 to \$10 per month for an average household, depending on site-specific conditions such as meteorology, topography, and demographic characteristics. Predictive models resulting from this analysis can be applied to any existing or proposed nuclear station site, using readily available data sources.

**Recommendations**

Many of the wide variety of types of environmental impacts which must be considered in evaluating the overall environmental impact of a nuclear power plant have proven to be extremely difficult to incorporate in a cost/benefit framework, as required by NEPA. The visual aesthetic impact of different types of cooling systems is an excellent example of the type of environmental impact most difficult to place on a cost/benefit basis. We regard this study as a pioneering effort to render an environmental impact not readily quantifiable into a form suitable for inclusion in a cost/benefit framework. It should be useful to your staff in evaluating the visual aesthetic impact of alternative types of closed cycle cooling systems and serves as a useful test of the bidding game methodology in quantitatively assessing previously difficult-to-quantify environmental impacts.

For further information on this study, please contact Dr. Clark Prichard (427-4358).

**DISTRIBUTION:**  
 Subject File FSwanberg, Jr.  
 CHRONO JDavis  
 CIRC OBassett  
 CPrichard FArsenault  
 JLarkins

Original Signed by T. E. Murley  
 Dir, DST, NRR  
 GKnight  
 T. E. Murley  
**Thomas E. Murley, Acting Director**  
 Office of Nuclear Regulatory Research

Record Note: Meeting was held with user office.

add record note re coordination - see outside slip

OFFICE	SAFER:RES	SAFER:RES	SAFER:RES	SAFER:RES	RES	RES
Enclosure	NUREG/CR-0988					
SURNAME	CPrichard: fkm	FSwanberg	JDavis	Bassett/Arsenault	JLarkins	TMurley
DATE	8/8/80	8/5/80	8/1/80	8/13/80 8/13/80	8/21/80	8/27/80