Interim Report

**A Documentation of Bidding
Games Used in Measuring Social
Value**

Excerpt from NUREG/CR-0989, PNL-2952,
Vol. II Appendix C

J. W. Currie
J. Kidd

September 1980

Prepared for
the U.S. Nuclear Regulatory Commission

Pacific Northwest Laboratory
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FOREWORD

This report results from a Nuclear Regulatory Commission sponsored project to determine the socioeconomic consequences from people viewing alternative closed cycle cooling systems on nuclear power plant landscapes. This was accomplished by measuring individual perceptions of visual aesthetic differences among alternative cooling systems and relating the perceived differences to individual willingness to pay and be compensated for the differences.

The contents of this report are contained in Appendix C of the following two-volume final report.

Currie, J. W. 1979. The Visual Impact of Alternative Closed Cycle Cooling Systems, Executive Summary. NUREG/CR-0989, PNL-2952, Pacific Northwest Laboratory, Richland, Washington.

Adams, R. C. et al. 1979. The Visual Impact of Alternative Closed Cycle Cooling Systems, Main Report. NUREG/CR-0989, PNL-2952, Pacific Northwest Laboratory, Richland, Washington.

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Project Manager

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SUMMARY

This paper reviews the bidding game literature describing strategies used to measure the social value of various impacts resulting from environment-altering projects. The theoretical measures of social value are presented, followed by a discussion of their relationship to different types of bidding games. Previous bidding game studies are documented. The important elements of bidding games and their relationship to the theoretical measures of social value are discussed. Finally, elements of the bidding games designed for a Pacific Northwest Laboratory project are compared with those of the studies reviewed.

A DOCUMENTATION OF BIDDING GAMES USED IN MEASURING SOCIAL VALUE

INTRODUCTION

This report results from a Pacific Northwest Laboratory (PNL) research project designed to quantify the visual aesthetic impact of alternative closed cycle cooling systems on nuclear power plant landscapes.⁽¹⁾ In the project, sponsored by the Nuclear Regulatory Commission, PNL researchers used bidding games to measure respondents' willingness to pay and to accept compensation for visual aesthetic changes resulting from alternative mechanical and natural draft tower and plume configurations. A necessary early task in the research was to review the bidding game literature and to collect, catalog, and document past bidding game questionnaires. These instruments were then intensely reviewed to determine precisely what each study was attempting to measure, the problems encountered, and the extent to which the respective researchers met their objectives. It was believed that this process would help ensure the best possible research design for the PNL project.

This report presents the results of the bidding games review. The different theoretical measures of social value are presented. Their relationship to different types of bidding games is shown. Major bidding game studies are documented in tabular form. The important elements of bidding games and their relationship to the theoretical measures of social value are discussed. Elements and results of the bidding games designed and used in the PNL project are presented along with the studies reviewed.

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DEFINITION AND DERIVATION OF SOCIAL VALUE

One of the most important concepts used by welfare economists in assessing the comprehensive benefits and costs of an environmental change is the Pareto principle. This states that the change is desirable if it makes at least one person better off without making anyone worse off. However, in practice, it is virtually impossible to have any change within a social system without some people feeling that they are being made worse off. This has led to the development of the benefit-cost criterion for deciding if a change is desirable. The criterion states that accepting the existing distribution of income, wealth, and rights, if total benefits exceed total costs a "potential" Pareto improvement exists. "Potential" means that conditions exist for the gainers to compensate the losers such that no one would be worse off.^(a) It is within this benefit-cost framework that social value is defined and measured.

Four major contributions to defining and deriving social value are of vital importance to understanding and designing bidding games. The initial contribution by Marshall can be interpreted as defining social value within a willingness to pay framework.⁽²⁾ Hicks subsequently proved there are actually four measures of social value: two willingness to pay (WTP) and two willingness to accept compensation (WTA) measures.⁽³⁾ He also showed that the four measures are not necessarily equal. The final two contributions are more recent. Willig has rigorously demonstrated that, with certain information,^(b) the welfare impact of changes in prices can be derived for each of the four measures.⁽⁴⁾ Finally, Randall and Stoll have shown how to 1) derive the welfare impact of quantity changes for each of the four measures and 2) select the correct measure of social value for any valuation problem.⁽⁵⁾

(a) Whether or not compensation should be made is generally argued to be an equity question not part of economic efficiency considerations. Thus, distributional consequences of policies are usually made explicit in the benefit-cost analysis but do not enter the benefit-cost criterion.

(b) The required information is estimates of one social value measure, the income elasticity of demand, the income of the consumer, and the proportion of income spent on the relevant good.

The four possible measures of social value appear in Table 1. The correct measure depends on whether or not the individual has rights to his preferred state and whether he views his current state as being better or worse than the proposed alternative state. The superscripts B and G in Table 1 are meant to be relative measures of preference and stand for "bad" and "good" as viewed by an individual or group. The WTP measures are the maximum amount the individual or group is willing to pay to avoid a "bad" (WTP^B) or acquire a "good" (WTP^G). The WTA measures are the minimum amount of compensation the individual or group is willing to accept to incur a "bad" (WTA^B) or forego a "good" (WTA^G).

For goods and services traded in the marketplace, "state" in Table 1 refers to the set of prices facing the individual or group. Here the issue of rights is usually well-defined. The individual is a price-taker and has no designated right to any particular set of prices. For example, if a price rise were about to occur, the correct measure of value would be the maximum amount the consumer would be willing to pay to avoid this price increase (WTP^B). The value of a potential fall in price would be measured by WTA^G , the minimum amount the individual would accept to forego the fall in price.

TABLE 1. The Four Measures of Social Value(a)

	<u>Individual or Group Has Rights To Preferred State</u>	<u>Individual or Group Has No Rights To Preferred State</u>
Individual or Group Views Proposed State Less Desirable Than Current State	WTA^B	WTP^B
Individual or Group Views Proposed State More Desirable Than Current State	WTA^G	WTP^G

(a) Hicks referred to WTP^G and WTA^B as Compensating Measures and WTP^B and WTA^G as Equivalent Measures.

In some market situations, society has decided that certain consumer groups have rights to a particular set of prices. For example, in some cities senior citizens pay a lower fare for public transit than does the rest of society. In this situation, with an impending price rise, the value of the public transit fare price rise to senior citizens would be WTA^B . Senior citizens have a right to their preferred state (the lower price) and they would view the change to the higher price as less desirable than their current state.

The concept of different prices to define current and impending states has little meaning when the goods in question are not exchanged in the marketplace. For example, consumption of environmental goods such as visual aesthetics does not take place by consumers purchasing as many units as they desire. A change in visual aesthetics is a quantity (quality) change on the community as a whole. All the individuals are faced with the change and each adjusts to it in his own way. Thus, with nonmarketed goods, quantity (quality), not price, defines the current and impending states in Table 1.

While the rights issue is usually clearly defined for market goods and services, rights are usually ill-defined for nonmarketed goods. For example, much of the controversy in siting power plants is over which group--the advocates or the dissenters--has the right to its preferred position. It is important to emphasize that the social value of the change may differ, depending on the assignment of rights.^(a) The problem of power plant siting offers a good example. First, assume that individuals who would be impacted by the plant can be divided into two groups: dissenters and advocates. Considering all market and nonmarket impacts, the aggregate benefits and costs of siting the power plant would then be estimated. In making these estimates it could first be assumed that the dissenters have rights to their preferred state. The relevant measure of the perceived power plant impacts for the dissenters would then be WTA^B , the minimum amount of compensation they would accept to incur a bad.

(a) In many cases the assignment of rights and implicit assessment of social value are made as a joint decision by some judiciary. Part of the reason for this is that social value is neither rigorously defined nor measured in most impact studies.

The relevant measure for the advocates would be WTP^G . The difference between WTA^B and WTP^G would be the appropriate measure of social value, assuming the dissenters have rights to their preferred position. If WTP^G were greater than WTA^B (benefits greater than costs), the advocates would be willing to completely compensate the dissenters, and overall social welfare would be increased by building the plant at the site in question.

Assigning preferred rights to the advocates would require measuring and comparing WTA^G for the advocates and WTP^B for the dissenters. If WTP^B were greater than WTA^G , the dissenters would be willing to completely compensate the advocates, and overall social welfare would be increased by not building the plant at the site in question.

For a particular valuation problem, it is necessary to not only identify the relevant measure(s) of social value, but also to select an approach for estimating this measure(s). Significant improvements in estimating social value have been made over the last decade. The development and use of bidding games constitutes one of the most important advancements. Bidding games employ techniques that attempt to effectively persuade people to reveal their true values. A typical game presents people with choices between alternative situations in which they are encouraged to state the amount of money they are willing to pay to acquire, or to accept in compensation to forego, their preferred choices. Appreciation of how this can be accomplished was one of the most important elements of this review.

The four theoretical measures of social value have been presented. It was shown how these measures relate to individual and group preferences and the assignment of rights. An example was presented to illustrate how to determine the theoretically correct measure of social value. Finally, the empirical measurement of social value using bidding games was discussed. A review of bidding game designs and how these have been used is presented in the next section.

REVIEW OF PREVIOUS STUDIES

This section reviews 18 different bidding game studies, conducted between 1972 and 1980. The studies are reviewed in two parts. The first part documents the survey instruments and sample while the second focuses on the specific bids. In documenting the bidding game elements, rigorous definitions of the elements were not developed. Therefore, it may not be appropriate to compare results across the 18 studies for some of the bidding game elements.

Theoretical and empirical issues regarding the design and results of bidding games are intentionally omitted here. Several sources of information on these topics are available elsewhere.⁽⁶⁻⁸⁾

SURVEY INSTRUMENTS AND SAMPLE

Table 2 provides detail on four important elements: instrument type, sample size, total questions asked, and stimuli used. These will be discussed in turn.

Type

Three types of survey instruments have been used: personal interviews, guided interviews, and questionnaires. In the personal interviews, each respondent is questioned individually by the interviewer. Guided interviews involve one or more subjects who read and answer some of the questions on their own, in the interviewer's presence. Questionnaires are usually completed by the subject alone.

There are situations in which any one of the three instrument types will be preferred over the other two. If the bidding game were relatively complex and utilized costly stimuli then personal interviews could have an advantage. If the bidding game were straightforward and utilized verbal stimuli, mail questionnaires could have the advantage. If probability sampling were not required and the bidding game were straightforward then group administration of guided interviews may be the preferred choice.

More than one instrument type was used in several of the studies. The most popular was personal interviews, used in at least 13 of the 18 studies.

TABLE 2. Bidding Game Instruments and Samples

Study	Type	n	Sample Return/Usable	Total Questions	Stimuli
Mulligan(9) Risk, Nuclear Power Plant Accidents	Personal interview	Data not available	82	36	Verbal
Franke(10) Risk, Hazard and Valuation of Life	Guided interview	245	169 69%	54	Verbal
Hammack and Brown(11) Waterfowl Hunting	Mail-in questionnaire	4,900	2455/1692 50%/35%	13	Verbal
Bohm(12) Television Demand	Guided interview	605 (invited)	211/211 35%/35%	Not Available	Verbal
Hall(13) Environmental Quality	Personal interview	Data not available	162	37	Verbal
Thorpe and Holmes(14) Welfare Impacts of Urban Noise	Personal interview	60 (pre- test only)	60	100	Verbal
Gramlich(15) Charles River Cleanup	Personal interview Questionnaire	832	165 20%	25	Verbal
Acton(16) Public Programs to Save Lives	Personal interview Guided interview Questionnaire	36 21 160	Entire Sample 93/50 43%/23%	43	Verbal

TABLE 2. (contd)

Study	Type	n	Sample Return/Usable	Total Questions	Stimuli
Randall(17) Fish and Wildlife Resources	Personal interview	160	138 86%	~60 per game	Pictures (3) of different wilderness scenes
Randall et al.(18) Strip Mining Impact	Personal interview	240	216/204 90%/85%	75	Pictures (4) A-Worst Mine B- Intermediate Mine C-Best Mine D-No Mine
Sublette and Martin(19) Recreation Area Valuation	Mail-in questionnaire	5,298	2695/2400 51%/45%	50	Verbal
ω Randall, Ives and Eastman(7) Coal Mine/Power Plant Impact Abatement	Personal interview	1,099	747 69%		Picture Sets (3) A-Worst B-Intermediate C-Best
Brookshire, Ives and Schulze(8) Aesthetic Damages of Coal-Electric Plant	Personal interview	104	82 79%	9	Picture Sets (3) A-No Plant B-Plant C-Plant, heavy plume

TABLE 2. (contd)

<u>Study</u>	<u>Type</u>	<u>n</u>	<u>Sample Return/Usable</u>	<u>Total Questions</u>	<u>Stimuli</u>
Loehman(20) Health Value of Air Pollution	Mail-in questionnaire	Data not available	Data not available	44	Verbal
Blank et al.(21) Economic Value of Visibility	Personal interview	130	119 92%	49	Picture Sets (4) A-Best B-Medium C-Poor D-Worst
Ben-David et al.(22) Geothermal Visual Impact	Personal interview	Data not available	81	17	Picture Sets (2) A-W/O Plant B-With Plant
Oster(23) Water Pollution Abatement	Personal interview (telephone)	~400	200 ~50%	7	Verbal
Currie(1) Cooling Tower Visual Aesthetic Impacts	Guided interview	501	506/434 100%/86%	65-77	14 Photograph Sets, 7 each from two dif- ferent sites
	Personal interview	285	285/240 100%/84%	39	

The guided interview was the least popular instrument, and was used in only four studies.

The PNL study⁽¹⁾ used two types of survey instruments; guided and personal interviews. Guided interviews were used to assure coverage of the full range of nuclear power attitude and as a data base for an econometric model to explain and predict visual aesthetic impact (social value). Data from the personal interviews were used to validate the model.

Sample

In Table 2, "n" represents the total number of people sampled. The next column shows the number and percent of the sample returned (i.e., questionnaires returned or interviews completed) and usable. The questionnaire return rate was generally lower than that of the other instruments.

Results presented for the PNL study indicated all the survey instruments were returned. Approximately 15 percent of these did not contain enough information to be deemed potentially useable.

Total Questions

Information in the Total Questions column is included as a rough indication of instrument length. The number of questions ranged from 7 to 100 with a mean of 44 for 15 different studies. There are no obvious relationships between total questions and instrument type, or total questions and return rate.

The total number of questions used in the guided interviews of the PNL study ranged from 65 to 77. This approached the upper limit of previous studies. The total number of bidding games played in each personal interview was one-half the number played in each guided interview. This resulted in only 39 questions for each personal interview, which is close to the mean for previous studies.

Stimuli

Stimuli refers to how the bid situations were presented to the respondents. "Verbal" means that the situations were described orally or in writing. Some situations (e.g., the loss of a season's hunting rights) can be

realistically visualized in response to verbal stimuli, whereas others (e.g., air pollution reducing visibility) cannot. For topics such as air pollution, pictures of the different scenes can evoke a more uniform perception of the situation among the subjects. A third stimulus, for studies involving environmental change, is to take the subjects "on site" and ask them how they would respond to various changes in the site. None of the studies employed this stimulus. This may be appropriate for some studies, but the day-to-day variance in weather and environmental conditions make it difficult to present representative and uniform stimuli to all subjects. Pictures, on the other hand, are uniform, and can be retouched to be representative of specific weather and environmental conditions. Eleven of the 18 studies used verbal stimuli while seven used pictures or photographs.

BID ELEMENTS

Table 3 provides detail on several important elements of the bid: scale, vehicle, protest, type, and comparisons of observed WTA responses to WTP responses.

Scale

Bid scale is the means by which the data are recorded. The most complex scale is incremental. For example, an interviewer asks the subject if he would be willing to pay X (a small amount) for reducing pollution. If the subject says "yes", the question is repeated for a slightly higher sum (e.g., \$2 more). This procedure is repeated with progressively higher sums until the subject says "no". At the point of a "no" bid, the interviewer reduces the bid by a smaller increment (e.g., 25¢) and continues to reduce the bid until the subject responds in the affirmative. In this way, the subject's bid is determined. This scaling process cannot be done by questionnaire, but it does have the advantage of producing specific bids.

Open-ended bids are without scale. The subject is asked the amount he is willing to pay or be compensated and this amount is recorded in a blank below the question.

TABLE 3. Elements of the Bid in Bidding Games

Study	Scale	Vehicle	Bid Type	Observed WTA WTP	Protest Bids As % of Total Bids
Mulligan(9) Risk, Nuclear Power Plant Accidents	Open-ended	Monthly energy bill	3 WTPG 3 WTAB	1 to 12	Not available
Frankel(10) Risk, Hazard and Valuation of Life	Open-ended	Automobile price Life guaranteeing permit	2 WTPG 3 WTAB	Not available	Not available
Hammack and Brown(11) Waterfowl Hunting	Category	Out-of-pocket hunting costs Sale of hunting rights	1 WTPB 1 WTAB	4	~14%
Bohm(12) Television Demand	Open-ended	Out-of-pocket payments	1 WTPG	Not applicable	Not available
Hall(13) Environmental Quality	Category	Beach use permit Taxes Sale of beach rights	5 WTPG 4 WTPB 6 WTAB	12	WTAB = 28%
Thorpe and Holmes(14) Welfare Impacts of Urban Noise	Open-ended	Taxes and/or out-of-pocket purchase of service	6 WTPG	Not applicable	Not available
Gramlich(15) Charles River Cleanup	Open-ended	Taxes	2 WTPG	Not applicable	Not available
Acton(16) Public Programs to Save Lives	Open-ended	Taxes	10 WTPG	Not applicable	Not available

TABLE 3. (contd)

Study	Scale	Vehicle	Bid Type	Observed WTA WTP	Protest Bids As % of Total Bids
Randall(17) Fish and Wildlife Resources	Incremental	Taxes Hunting license Entrance fee Environmental fund payment Utility bill	20 WTPB 8 WTPG 16 WTAB	7 to 10	WTPB = 8% WTPG = 13% WTAB = 50% Total = 21%
Randall et al.(18) Strip Mining Impact	Incremental	Coal price Electric bill Environmental fund payment	9 WTPG	Not applicable	8%
Sublette and Martin(19) Recreation Area Valuation	Category	Park entrance fees	1 WTPB	Not applicable	Not available
Randall, Ives and Eastman(7) Coal Mine/Power Plant Impact Abatement	Incremental	User fees Electricity bill Sales Tax	8 WTPG 2 WTAB	10	WTPG Utility bills = 11% Sales Tax = 32% General fund with Indians = 49% WTAB = 52%
Brookshire, Ives and Schulze(8) Aesthetic Damages of Coal-Electric Plant	Incremental	Daily user fees	2 WTPB	Not applicable	21%

TABLE 3. (contd)

Study	Scale	Vehicle	Bid Type	Observed WTA WTP	Protest Bids As % of Total Bids
Loehman(20) Health Value of Air Pollution	Category	Out-of-pocket payment to avoid unpleasant medical symptoms	24 WTP ^B	Not applicable	Not available
Blank et al.(21) Economic Value of Visibility	Incremental	Utility bill User fee	8 WTP ^B 10 WTA ^B	4 to 14	Not available
Ben-David et al.(22) Geothermal Visual Impact	Incremental	Park daily entrance fee	1 WTP ^B	Not applicable	Not available
Oster(23) Water Pollution Abatement	Open-ended	Taxes or out- of-pocket payment	1 WTP ^G	Not applicable	Not available
Currie(1) Cooling Tower Visual Aesthetic Impact	Open-ended	Utility bill Trust Fund	5 WTP ^G 5 WTP ^B 2 WTA ^G 2 WTA ^B	3 to 6	WTP = 23% to 65% WTA = 35% to 71%

Category scales consist simply of different amounts of money arrayed along a line (e.g., \$0-2, \$3-5, \$6-10). Bidding by category is less exact, but can lend itself to easier coding.

Of the studies reviewed, eight used an open-ended scale, six used an incremental scale, and four used a category scale. Personal interview instruments were employed for all games using the incremental scale. There were no other obvious relationships.

Vehicle

The vehicle is the means by which the bid payment or compensation is transacted. It is important to select a vehicle that will either not bias the subject's response or will allow statistical testing for the influence of bias. The three most commonly used vehicles found were user fees, general taxes, and utility bills.

Bid Type

The bid type is delineated by one of the four measures of social value. It implies two things: the subject views the proposed state as either good or bad, and the subject does or does not have a right to his preferred state.

Thirteen studies asked questions on the willingness to pay to get a "good" (WTP^G). Most of these studies considered a public action program such as environmental cleanup. Nine studies asked questions on the willingness to pay or accept compensation to avoid or incur a "bad" (WTP^B and WTA^B). These studies considered states that are less desirable than the current state. An example of this would be a reduction in the size of an elk herd. Only in the PNL study did subjects play all four WTP and WTA games.

Comparison of WTA and WTP Bids

The next column compares WTA and WTP bids for the same item. For example, Mulligan⁽⁹⁾ asked one set of subjects how much they would be willing to pay to reduce the risks of nuclear power station accidents over a specific range. She also asked another set of subjects how much they would have to be compensated to accept increased risks of accidents over the identical range. The ratio of WTA to WTP for her study varied from 1 to 12. The range of the ratio WTA to WTP for all studies investigated was 1 to 14. The ratio for the

PNL study ranged from 3 to 6. Although WTP should be less than WTA because of individual income constraints, this does not explain the degree of difference between measured WTP and WTA for the studies reviewed.

Protest Bids

The last column in Table 3 shows estimates of protest bids from the different studies. A protest bid occurs when a respondent intentionally states a bid which he knows does not represent his valuation of the good in question. This could result from the vehicle used, rights implicit in the questions, use of dollars as a metric, strategic behavior in an attempt to impact the aggregate value, or something else.

Protest bid is seldom rigorously defined. Infinite and near infinite bids are usually considered protest bids; however, the definition can be much broader than this. For example, in some studies subjects have been asked to explain reasons for unusually high or zero bids. In the studies reviewed, reports of 20% protest bids on WTP questions were not uncommon. Protest bids on WTA questions ranged to 50%.

In Table 3, ranges of protest bids are listed for the PNL study of estimating visual aesthetic impacts of alternative closed cycle cooling systems on nuclear power plant landscapes. The smaller numbers resulted from applying similar criteria used in other studies to identify protest bids. The larger protest bid numbers resulted from applying more rigorous data selection criteria than was used in other studies. This was primarily due to the nature of the problem faced by PNL. Visual aesthetics is a relatively minor attribute of nuclear power when compared to perceived health and safety risks and growth and employment benefits. Recognizing this, the PNL study team implemented a research design and data selection criteria in anticipation of a relatively high number of protest bids.

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