J. ENVIRONMENTAL SYSTEMS, Vol. 5(4), 1975

TRANSFERRING INFORMATION ON A REGIONAL ENVIRONMENTAL ISSUE: A HYBRID INFORMATION SYSTEM*

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ABSTRACT

The transfer of environmental information on an issue of regional extent presents several informational problems to those groups and individuals involved with the issue. For an issue like coal-fired energy development in the Colorado River Basin, members of the interested public have difficulties in acquiring factual material on power plants, while electric utilities and government agencies have other problems related to the communication of information. The Hybrid Information System was conceived as a method of facilitating the flow of impact information among the parties concerned with the effects of eight power plants in the Southwest. It is a computerized system that uses stored material, simulation models, and computational routines to describe impacts. An evaluation of the system by thirty-five prospective users from Arizona found it to be a viable way of transmitting environmental information.

Introduction

A fundamental requirement of individuals and groups involved in an environmental issue is a knowledge of the impacts associated

* Research was conducted under a grant from the Ford Foundation to the Civil Decision Quantification program in the Department of Hydrology and Water Resources, The University of Arizona.

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doi: 10.2190/T194-NPH9-LAGD-D048
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with alternative decisions. Since the interested public does not normally acquire this knowledge by producing its own environmental information, the appropriate material must be obtained from existing information sources. Traditionally the sources have included environmental reports and impact statements, periodicals, other printed documents, the mass media, public meetings, and personal contacts [1, 2]. For environmental issues in general such sources usually meet the information needs of the public [3]; however, for an issue composed of many decisions and resultant impacts, the use of existing sources poses problems of sufficiency, convenience, and credibility [4, 5]. In addition, present sources are unable to selectively transfer information to persons having specific needs, and they cannot quickly communicate information on the cumulative impacts caused by a series of decisions.

Deficiencies in the methods currently used to transmit information on environmental topics have prompted the development of new techniques designed to inform members of the public about decisions and impacts affecting the environment [6]. This paper presents an improved method of communicating information on a complex environmental issue. The methodology involves an interactive computer technology termed a Hybrid Information System (HIS) that utilizes simulation models and stored material in order to describe the environmental, economic, and social impacts of eight coal-fired power plants sited in the Colorado River Basin of the southwestern United States.

The Controversy

The production of electricity from large scale coal-fired power plants began in the Southwest during the years of 1962 and 1963 when the Cholla and Four Corners plants went into operation. Now there are six plants in operation with two planned that will eventually produce over 13,000 megawatts of electricity for places like Las Vegas, Los Angeles, Phoenix, and Tucson (Figure 1). Until about 1970 the unhindered construction and operation of the power projects seemed assured. A growing regional demand for energy provided the impetus for a rapid expansion of generating capacities, while the availability of both coal and water made the expansion possible. Then, a combination of forces acted to create opposition to the projects.

Foremost among those forces was an increase in public awareness and concern over environmental matters. Emerging out of the new interest in the environment were many individuals and several

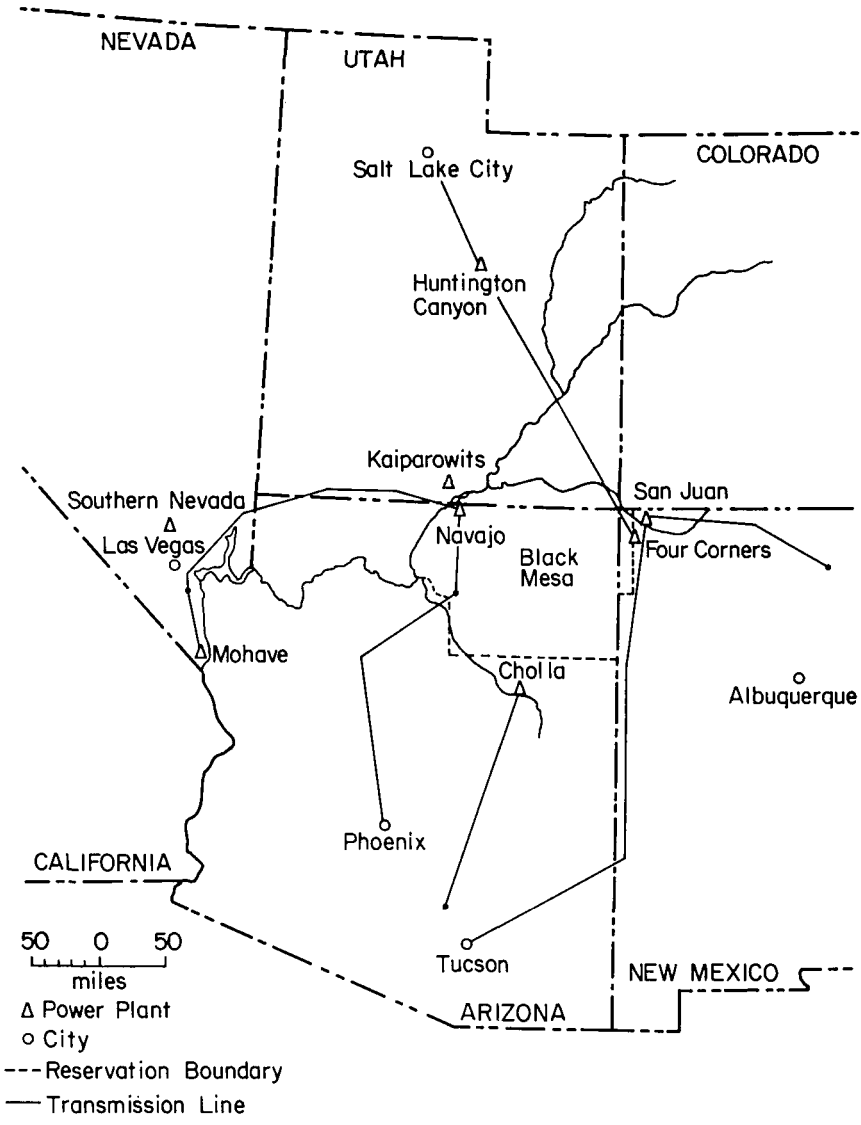

Figure 1. Power plant locations.

groups critical of the power developments. Their opposition to the plants was strengthened by the appearance of federal legislation comprised of the Clean Air Amendments of 1970 and the National Environmental Policy Act of 1969 (NEPA). These pieces of legislation helped focus attention on environmental impacts and in the

case of NEPA, actually allowed interested persons to participate in the federal process of reviewing the estimated impacts of a proposed power plant [7]. Another source of resistance, at least to some of the power projects, were certain members of the Hopi and Navajo Indian tribes who became concerned about the destruction of sacred lands due to strip mining [8].

The negative reactions of various parties to the impacts of the initial projects, nevertheless, were not always based on factual material. Indeed, little information was to be found on the impacts of existing power facilities and there was even less on those proposed. The paucity of impact information prompted the U.S. Department of the Interior to begin a comprehensive study of all operating and proposed coal-fired power stations. That project culminated in a 14 volume report known as the *Southwest Energy Study* [9]. With the implementation of NEPA, environmental impact statements became an important source of information on new plants coming under federal jurisdiction. Environmental reports of the electric utilities [10, 11] have also contributed to the impact information produced by federal agencies.

What was once a meager amount of information, has now grown into a large volume characterized by thousands of pages of text found in reports, periodicals, and studies. Unfortunately, neither these nor other sources of information have been able to significantly alter the public's knowledge of impacts. The reason for this resides with difficulties in acquiring, developing, and communicating impact information.

Informational Problems

The unrestricted flow of environmental information from the electric utilities and government agencies involved with power projects to the interested public is necessary for the formation of an *informed* public. Two activities determine to what degree the public receives the information it needs; the first consists of the efforts made by concerned individuals and groups to obtain relevant material, the second consists of the efforts made by government agencies and the electric utilities to transfer information to the public.

In acquiring impact information on power plants, members of the interested public have access to several sources of information, but often only a couple of sources are actually used. When just one or two sources are used, the kinds of information obtainable from them are limited. For example, the mass media may successfully outline the important features of power developments, but

they are not likely to provide the specific information needed to analyze the effects of individual projects [1]. Similarly, a reliance on impact statements, which provide detailed material on individual projects, may result in a lack of knowledge on the cumulative impacts of multiple power plants. The tendency to use a limited number of information sources is due in part to the inconveniences of searching for and then reviewing reports, publications, and periodicals pertaining to the projects being studied. Most of the difficulties in collecting information are caused by the geographic distribution of sources, that is, they are scattered throughout the Southwest. As a result, the costs in time and money of locating relevant sources prevent all but a dedicated few from attaining a comprehensive knowledge of the effects of energy development.

Further inhibiting the movement of factual material to the interested public is the credibility of the sources. Credibility interferes with the communication of information when the objectivity of a source is questionable [12, 13]. And since most of the information on power plants is produced by the supporters of the projects (i.e., power companies and some federal agencies), it is not strange that concerned individuals have at times suspected the accuracy of the material they acquire [4, 14].

Problems of communicating information needed to meet specific needs dealing with individual as well as multiple plants add to the acquisitional problems already mentioned. In particular, none of the available sources can quickly provide information on the cumulative impacts of many alternative sets of power plants. To illustrate, an analysis of the cumulative impacts caused by various levels of energy development, as defined by different subsets of the fourteen power plants and additions found in Table 1, could involve up to 16,369 combinations consisting of two or more plants. In report form the display of so many combinations for analysis purposes would be prohibitive.

A second important drawback of existing sources is their inability to selectively transfer information to a person having a specific requirement. In other words, they provide irrelevant material along with the material related to an information need. The greater the amount of irrelevant material, the greater the danger of individuals becoming "overloaded" with information—a condition that hinders the assessment of impacts [15].

The Hybrid Information System

A solution to the informational problems facing groups and individuals seeking environmental facts related to power plants is

Table 1. Power Plants by Generating Units

	Megawatt capacity	*Date of operation*
(Existing Plants)		
1. Four Corners (1-5)[a]	2162	1963
2. Mohave (1-2)	1580	1971
3. Cholla (1)	120	1962
4. San Juan (2)	345	1973
(Plants Under Construction)		
5. Huntington Canyon (1)	430	1974
6. Huntington Canyon (2)	430	1977
7. Navajo (1-3)	2310	1974-76
8. San Juan (1)	345	1976
9. Cholla (2-3)	500	1976-77
(Proposed Plants)[b]		
10. San Juan (3)	500	1980
11. Southern Nevada	1600	1980
12. Kaiparowits (1)	1000	1980
13. Kaiparowits (2)	1000	1980
14. Kaiparowits (3)	1000	1980

[a] Plant consists of five generating units of varying megawatt capacity.
[b] Plant capacities and dates are tentative.

an information system utilizing the storage and computational abilities of an interactive computer. The hybrid system considered here is an interactive system specifically designed to communicate information on coal-fired power plants and their impacts. It is a hybrid of: management information systems that use predictive models to provide input to managerial decision-making [16]; environmental information systems that retrieve and process bibliographic or environmental data [17, 18]; and finally, an issue-oriented system developed at the University of Illinois that uses a special teaching computer [19].

The principal components of the HIS are an information base, interactive computer software, a hardware configuration, an information specialist, and supporting documentation [20]. The information base is the source of the system's environmental information and consists of stored material, mathematical models, and computational routines. Impacts on the natural and human environments of the region (see Table 2) are either described qualitatively by stored textual material or quantitatively by models

Table 2. Impact Categories

Natural Environment	
Air	*Water*
Sulfur dioxide	(Groundwater)
Nitrogen dioxide	Groundwater consumption
Particulates	Drawdown changes
Visibility	Groundwater quality
Land	Groundwater legal aspects
Land uses	(Surface water)
Chemical-physical factors	Surface water consumption
Reclamation	Colorado River water quality
Coal consumption	Local water quality
Biota	Surface water legal aspects
Vegetation	
Fish and wildlife	
Human Environment	
Economics	*Human Interest*
Local economics	(Archaeology, aesthetics, historic, recreation)
Regional economics	
Native Americans	
(Acculturation, individual stress, population, health, etc.)	

and routines. The models simulate the impacts of power plants on air quality, visibility, water quality of the Colorado River, groundwater in the Navajo Sandstone on Black Mesa (see Figure 1), regional economics, and Indian social systems [21]. The routines perform computations on such things as resource consumption and cumulative air quality changes. Access to the information base is accomplished through the use of the storage and control programs that make up the interactive software. The storage program creates as well as edits a file containing textual descriptions of impacts and any data needed by the computational routines; the control program retrieves selected information from the storage file or executes subprograms which represent the models and routines. Information is processed, stored in, and displayed by a hardware configuration composed of an interactive computer, random access storage devices, and a remote cathode ray tube (CRT) terminal.

Interfacing the user with the hardware and software of the system is an information specialist who helps users retrieve and analyze impacts. Also assisting the user is a pamphlet that presents

an overview of the system and its operation together with descriptions of the models. The process of acquiring information from the HIS is outlined in Figure 2. At first the user studies the pamphlet and then selects one or more power plants plus an impact. Next the specialist enters commands at the terminal that correspond to the user's decision so that the control program can obtain the relevant information. Once an impact is displayed and analyzed, additional options are available should the user elect to consider other sets of power plants or impacts.

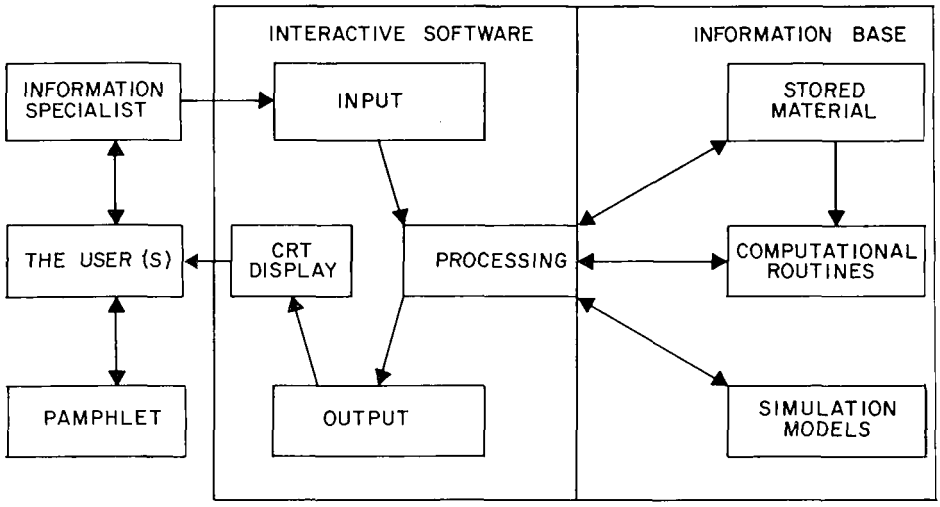

Figure 2. System operation.

System Evaluation

Evaluation of the HIS was carried out by demonstrating it to thirty-five prospective users who were drawn from electric utilities, government agencies, and the interested public in Arizona. A profile of the users' backgrounds is shown in Table 3. Users became familiar with the operation of the system through a series of interactions in which they were free to select and analyze any of the available impacts. Their reaction to the HIS was recorded directly by a questionnaire and indirectly by the control program which monitored the interactions. The questionnaire asked the users to rate the information system, along with other sources, according to their usefulness, convenience, credibility, and accuracy. It also gathered user feedback on advantages, disadvantages, and

Table 3. Profile of User Backgrounds

	Electric utilities	*Government agencies*	*Interested public*
A. Degree of Interest		(frequency)	
1. highly	9	3	6
2. moderately	2	9	4
3. mildly	1	0	0
4. uninterested	0	1	0
B. Type of Involvement			
1. with an electric utility	12	0	0
2. in a public hearing	7	1	2
3. provided comments to reports	5	3	1
4. in an organization	4	6	7
5. sending letters	1	3	4
6. a concerned citizen	3	7	5
7. other	2	4	2
C. Experience with a Computer			
1. yes	9	13	5
2. no	3	0	5
D. Importance of Sources		(median ranks)[a]	
1. newspapers or television	5	4	3.5
2. impact statements	1.5	1.5	2.5
3. environmental publications	3.5	3	2
4. public hearings	3.5	3.5	4
5. personal contacts	2	3	3

[a] One is most important.

improvements of the system. Interactions were monitored by recording the impacts selected and the time spent on each impact.

The effects which the group classifications and information sources had on the ratings were evaluated by analyses of variance. Those analyses revealed that the group classifications had a statistically insignificant ($p > .05$) effect on the source ratings for usefulness, convenience, credibility, and accuracy. This means the users' ratings of the information sources were unaffected by their group association. Significant effects ($p < .001$), though, were produced by differences in the information sources. Ratings given the sources (Table 4) were compared by Tukey's "honestly significant difference" procedure, and from the comparisons, it was found that the information system was judged to be:

1. more useful than public hearings and the mass media;
2. more convenient than impact statements, public hearings, and personal contacts;

Table 4. Ratings of the Information Sources

Sources	Mean Ratings from all Groups[a]			
	Usefulness	*Convenience*	*Credibility*	*Accuracy*
Impact Statements	77.17	56.50	74.83	76.33
Environmental periodicals	58.00	60.17	61.17	62.17
The information system	72.17	78.83	72.67	72.37
Newspapers and television	40.00	63.33	43.00	54.00
Public hearings	46.00	39.00	55.17	54.00
Personal contacts	65.27	53.00	66.40	68.57

[a] *Scales:* Usefulness—0 points (useless) to 100 points (extremely useful).
Convenience—0 points (inconvenient) to 100 points (highly convenient).
Credibility—0 points (no credibility) to 100 points (full credibility).
Accuracy—0 points (inaccurate) to 100 points (extremely accurate).

3. just as credible as the primary sources of information (i.e., impact statements, environmental periodicals, and personal contacts), yet more credible than the mass media; and
4. more accurate than the mass media or public hearings.

Completing the evaluation of the ratings was a regression analysis of the relationship between the usefulness ratings and those of convenience, credibility, and accuracy. That analysis ($F(3, 187) = 103.16$, $R^2 = .62$, $p < .001$) showed credibility to be the main source of variation in the ratings of usefulness.

Advantages of the system, as stated by the users, dealt mainly with the convenience of having a large amount of information in one place that can be quickly accessed for specific facts. Disadvantages stressed the expense of the system, a lack of material on the models and their inputs, and difficulties in interpreting some of the displays on the computer terminal. The users suggested that the HIS could be improved by displaying the data and assumptions used in the models and modifying displays of cumulative impacts to make them clearer.

Measurement of the users' responses to the information they examined was accomplished by having them rate the bias, clarity, and completeness of the information displayed on each impact category. Comparisons of the ratings by Scheffé's method indicated that the models were able to describe impacts as well as textual material since there were no significant differences between ratings given the categories covered by text and those covered by models. Moreover, monitoring of the user interactions with the system (Table 5) revealed a distinct preference to review impacts simulated by models.

Table 5. Interactions with the System

Impact categories and origins of information	*Frequency*	*Total time (minutes)*	*Time per display (minutes)*
Natural Environment			
Air			
(simulation)	59	249	4.22
Biota			
(documents)	27	73	2.70
Land			
(documents)	19	63	3.32
Water			
(documents)	23	76	3.32
(simulation)	19	84	4.42
Human Environment			
Native Americans			
(simulation)	20	289	14.45
Local economics			
(documents)	1	4	4.00
Regional economics			
(simulation)	18	159	8.83
Human interest			
(documents)	6	35	5.83

Conclusions

The evaluation of the hybrid system revealed it to be a viable way of communicating information to individuals involved with a regional environmental issue. With respect to other sources of information, the system is just as valuable as environmental impact statements, environmental periodicals, and personal contacts as a means of acquiring information, and more valuable than the mass media or public hearings. The evaluation also indicated that the usefulness of an information source is most likely to depend on its credibility—not its convenience. Supporting the use of models to simulate impacts were their ability to describe cumulative impacts and the users' interest in interacting with them.

The favorable response given the HIS—all but two of the users indicated they would be willing to use the system again on another subject—suggests that there are other issues to which it could be applied. The successful application of the information system to other environmental issues, however, will depend a lot on the method of implementation. One way of implementing the system

would be to use it as a primary source of information at a workshop dealing with a particular issue. By using the system in this way, a number of people directly concerned with a controversy could be quickly informed of needed facts. Future applications will also depend on the organization operating and maintaining it. If the group applying it to an issue is closely associated with a certain position with regards to that issue, then credibility problems may detract from the system's usefulness to others. Furthermore, if models are used to simulate impacts, they must be carefully documented or they too will suffer credibility problems.

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