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THE LOCATION OF ELECTRIC ENERGY FACILITIES: CONFLICT, COALITION AND POWER

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Introduction

Conflict, coalition formation and power appear to be key elements in contemporary locational problems. Location theorists recognize that real world locations are the result of compromises and as such do not depend solely upon simple economic or behavioral criteria. Although the literature details the importance of conflict, coalition and power [10, 14, 15, 19, 24], these factors have received little attention in the works of modern locational analysis. The works of Isard and Smith [11, 12], Wolpert [22], Wolpert and Ginsberg [23], Austin, Smith and Wolpert [1] and Cox [4] provide exceptions of note. For the most part, the above works tend to conceptualize rather than operationalize these elements in terms of their impact on the decision to locate. In short, there has been little attempt to incorporate the notions of conflict, coalition and power into the facility locational process. Consequently, this paper represents just such an attempt for the location of electric energy facilities.

The siting of electric energy facilities has all the factors present for conflict. For example, complications arise when public utility companies are faced with the allocation of scarce energy resources at competitive market prices as well as the necessity of developing an expensive environmental technology. In addition there has been an increase in pressure for the production of electricity, a decrease in the number of sites available for plant locations and, an increase in public concern for the maintenance of environmental quality. It is within this context that this paper examines the role played by conflicting pressure groups in the location of nuclear energy facilities in Ohio. Prior to examining the nature and impact of these roles, however, it is informative to discuss the trend in Ohio's energy development as it relates to the emergence of conflicting pressure groups.

The Energy Situation in Ohio

Historically Ohio's electric utility industry has encountered little, if any, opposition in the development and location of additional electrical capacity. A utility company simply projected electrical needs and then constructed new

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facilities to satisfy these needs. The late 1960s, however, witnessed a substantial increase in public awareness for preserving the environment. Many environmental organizations such as the Sierra Club, Friends of the Earth and the National Wildlife Federation became extremely active in national as well as local environmental issues for example, air pollution. One industry most often cited for high levels of air pollution was the electric utility industry, in general, and those utility companies that generated electricity from high-sulfur coal, in particular. Although Ohio is richly endowed with coal, the majority of deposits in the state contain high levels of sulfur. Since the environmental equipment required to clean and remove sulfur was expensive, the cost to produce coal-based electricity began to spiral upwards. As a consequence, Ohio's utility companies were forced to consider alternative nuclear energy-producing technologies.

During the period, 1969-73, there were nuclear facilities operating in the United States but for the most part, they were small and inconspicuously located. At this time, the production of nuclear energy was not perceived by the public to be an important issue and consequently the electric utility industry placed numerous orders for large nuclear facilities, Figure 1. Ohio's utility companies provided no exception to this national trend and began constructing and planning nine reactors, seven of which were to be situated on Lake Erie. These reactors are to become operational through the late 1980s, Figure 2. It is, in part, this planned large scale use of an experimental energy-producing technology that has led to a substantial increase in public awareness and involvement in the development and location of nuclear energy in Ohio. This ever increasing involvement culminated in three energy amendments being proposed by a group of concerned citizens for the Ohio elections in the Fall of 1976. The results of these proposed amendments provide a classic case study of the manifestations of conflict in public interest, coalition formation by various associations and the power of pressure groups seeking favorable decisions on controversial locational issues. It is informative, therefore, to discuss briefly the role each amendment played in Ohio's nuclear locational controversy.

The Emergence of Conflict and Coalitions in the Nuclear Locational Controversy in Ohio

The Element of Conflict. The energy amendments proposed by Ohio's most active citizen's group, the Coalition for Utility Reform (OUR), were designed to extend a lifeline rate to residential users, to establish a consumer action group, and to require legislative approval and sufficient indemnification prior to construction or expansion of a nuclear facility in Ohio. Although the last amendment forms the focus for the present study, the inclusion of all three energy amendments created an environment which led to conflicts of interest and the formation of opposing coalitions.

The first amendment required a utility company to charge a uniform rate to all customers regardless of volume consumed. Advocates claimed that the amendment provided incentive for energy conservation while opponents argued that instead of lowering rates for residential customers it would increase industrial and commercial rates. The second amendment proposed a consumer action group known as the Residential Utility Consumer Action Group (RUCAG), which guaranteed

FIGURE 1: Capacity of Nuclear Reactors on Order (1964-74) in the United States

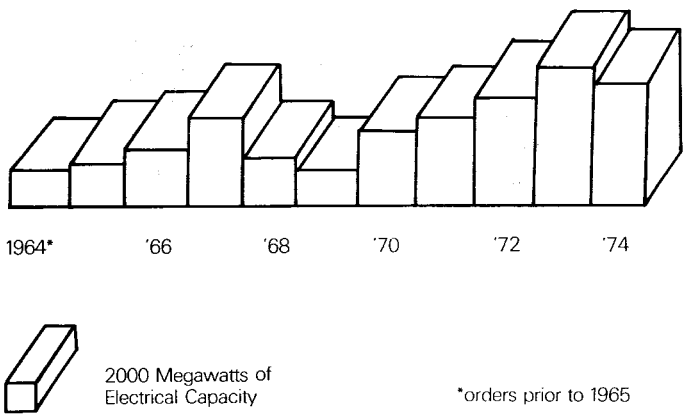
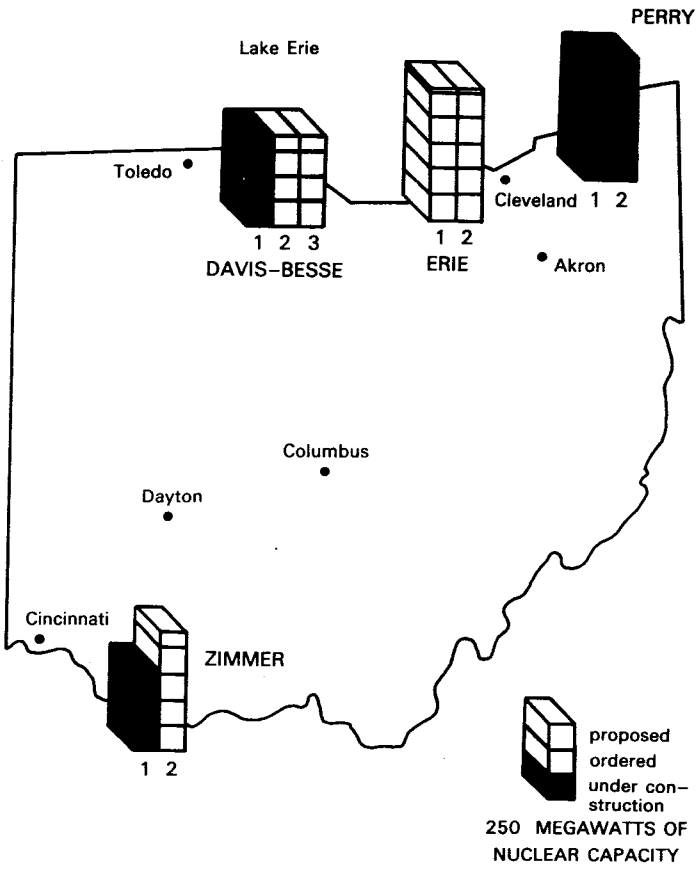


FIGURE 2: The Location of Nuclear Reactors in Ohio



the consumer expert representation at rate hearings. Proponents indicated that the major advantages of RUCAG was its ability to require investigatory information from a utility company and to provide expertise in technical matters concerning energy policy formulation. Opponents pointed out that RUCAG simply duplicated existing consumer action groups like the Utility Council. Finally, the third amendment reflected a growing concern for the safety and economics of nuclear energy. Individuals and groups in support of this issue questioned both the safety and economics of nuclear energy relative to coal-based energy. On the other hand, opponents reported that the proposed amendment would effectively halt nuclear development in Ohio and deny Ohioans a cheap source of energy [2]. Furthermore, it was felt that a curtailment in nuclear facility construction may jeopardize Ohio's economy and decrease the availability of electricity for employment and residences.

In sum, each amendment imposed additional constraints on the development and location of nuclear energy in Ohio, e.g., a uniform customer pricing policy, a lengthening of facility's lead time for on-line operation and the passage of ever more stringent environmental, safety and engineering standards. Together these amendments created a decision-making environment wherein conflicts of interest emerged resulting in the formation of opposing coalitions. The power of each coalition and the manner in which they presented their position was important to the energy campaign. Consequently, it is informative to identify the participants involved in the November 1976 energy issues and to summarize their position.

Coalition Formation. There were five identifiable participants in Ohio's energy campaign: (1) utility companies (UC); (2) engineering associations (EA); (3) industries in Ohio (INDO); (4) government (GOVT); and (5) environmental groups (ERG). The position of each participant is based on interviews, questionaires and existing literature. The major utility companies that participated in the energy campaign were Cincinnati Gas and Electric, Cleveland Electric Illuminating, Columbus and Southern Ohio, Dayton Power and Light, Duke Power, Duquesne Light, National Association of Electric Companies, New England Electric, New York State Electric and Gas, Ohio Edison, Ohio Power, Ohio Rural Electric Cooperatives and Toledo Edison. These companies opposed all three amendments arguing that they would effectively halt the development of nuclear energy in Ohio and as a consequence affect seriously the ability of utility companies to serve their customers reliably and at a reasonable cost [3]. In addition the major utility companies stated that nuclear energy meant more jobs for Ohio's citizens and would ensure continued industrial growth and economic expansion. The level of their concern was reflected by the size of their campaign contributions [21].

The National Society of Professional Engineers (NSPE), along with the Scientists and Engineers for Secure Energy (SESE), also opposed passage of the energy amendments pointing out that it would be a serious mistake to restrict the use of this available major source of electricity when it is most needed [20]. Both organizations emphasized the safety of nuclear energy and indicated that although nuclear power is not perfectly safe the overall risks are small and less than those of alternative energy-producing technologies.

Two other participants, Ohio industries and the government of Ohio, held

positions that were not strongly documented. Generally speaking, however, Ohio industries opposed the energy amendments on the basis that they would lead to a steadily decreasing supply of electricity which, in turn, would lead to increases in electrical rates [8]. They were also concerned with the prospects of growth in a state wherein the availability and cost of electrical energy may become uncertain. Industries with direct interests in the energy campaign and hence most active included Armco Steel, B. F. Goodrich, Firestone Tire and Rubber, General Motors, Republic Steel (high energy consumers); Babcock and Wilcox, General Electric, Westinghouse Electric (nuclear equipment suppliers); and Standard Oil of Ohio (nuclear research and development).

Government's interests throughout the energy campaign were twofold. On the one hand, certain governmental agencies such as the Energy Research and Development Agency and the Nuclear Regulatory Commission favored the development of nuclear energy in Ohio. On the other hand, the Department of Wildlife and Recreation and the Environmental Protection Agency opposed its development. It is noteworthy that government's role in Ohio's nuclear locational process was that of an intervener whereby it could have overruled certain environmental standards in favor of nuclear energy expansion or imposed stricter environmental guidelines in favor of environmental preservation.

The final participant, environmental groups, favored passage of all three amendments because they were designed to protect the consumer (amendments 1 and 2), and to preserve the environment (amendment 3). In short, these groups advocated that nuclear power was not economically competitive with existing energy alternatives and that nuclear facilities were technologically unsafe. As a result the energy consumer could expect higher electrical rates and the environment would continue to deteriorate. Environmental groups active in the campaign for utility reform included the Coalition for Safe Electric Power, Committee for a Nuclear Safe Ohio, Environmental Research and Action Group, Ohio Environmental Council and Ohioans for Utility Reform.

The preceding discussion outlined the participants' conflicting interests regarding nuclear energy in Ohio. Important issues that needed to be resolved were the safety of nuclear power, the economic competitiveness between nuclear and coal-based energy and, whether or not there existed a need to develop nuclear energy in a coal-rich state. Solutions to these issues varied among the participants which made for uncertainty and conflict in the development of nuclear power in Ohio and the related facility locational process. As a consequence, there existed incentives for some participants with similar interests to strengthen their bargaining position by cooperating in the formation of coalitions.[1] One such coalition was the Coalition for Nuclear Power (CNP), whose membership included utility companies, engineering organizations and industries in Ohio. Generally speaking, however, the participants may have partitioned themselves into a number of different coalitions. The analysis which follows hypothesizes two plausible scenarios that characterize possible coalition structures which may have formed

[1] A coalition is a set of individuals or groups which coordinate strategies to promote joint interests.

as well as illustrates why the Coalition for Nuclear Power ultimately formed and was so successful.

Ohio's Nuclear Locational Game

Scenario One. It may be hypothesized that utility companies, engineers and industry in Ohio form a coalition for nuclear power (CNP), and oppose those groups interested in preserving the environment (ERG). Namely, it is in the best interest for the Coalition for Nuclear Power to support nuclear energy in Ohio because it may stimulate industrial growth and economic expansion, generate employment with related economic spin-offs, provide research and development contracts and, insure an expanding long term supply of energy. On the other hand, environmental groups desire to control the development of nuclear power so as to protect both the consumer and the environment. The government would like to insure sufficient energy supplies for Ohio, attract future industrial development and create jobs but also require the installation of adequate safeguards to protect the consumer and preserve the environment. This dual position of government is significant for whichever side it favors may ultimately win the struggle to increase or decrease the rate of development of nuclear energy in Ohio. This scenario represents a simplified yet plausible situation in Ohio and may be represented by either a two-person constant or non-constant sum game [16].

Constant Sum Game. The structure of the two-person, constant sum, nuclear locational game is given below:

$$\begin{array}{ccc} & & \text{ERG} \\ & & [Y_1 \qquad\qquad Y_2] \\ \text{CNP} & \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} & \begin{bmatrix} a_{11},\ b_{11} & a_{12},\ b_{12} \\ a_{21},\ b_{21} & a_{22},\ b_{22} \end{bmatrix} = A \end{array}$$

where X_1 and X_2 represent strategies in which the Coalition for Nuclear Power should oppose environmentalists without and with government respectively as a joint member in a coalition;[2] stratgies Y_1 and Y_2 represent the proportion of the time in which the environmentalists should oppose the Coalition for Nuclear Power without and with government respectively and the matrix A is a gaming payoff matrix which contains all the payoffs a, b expressed in megawatts.[3] The payoff values used to determine both strategy sets $\bar{X}$ and $\bar{Y}$ are calculated by using survey

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[2] In gaming terms X_1 and X_2 are fractions or proportions whose sum is one. The same is true for Y_1 and Y_2.

[3] Entries in the gaming payoff matrix are expressed in megawatts of electrical capacity which reflect differences of power amongst participants. The unit of megwwatt represents a measure that may be interpreted for each participant. For example, the amount of electrical capacity eventually coming on-line may indicate the potential of nuclear development in Ohio while that electrical capacity eliminated may represent savings in environmental deterioration.

responses, coalition formation information, Table 1, the nuclear facilities construction timetable, Table 2 and, the financial contribution data, Table 3. In particular, the rationale for calculating as well as assigning megawatts of electrical capacity to the game's participants is twofold. On the one hand, the amount of megawatt capacity awarded to each participant directly relates to the power that participant wields. It is believed that both the financial contribution data and responses to the survey questions provide a suitable measure of power that may be assigned to participants. On the other hand, the megawatt values themselves derive from the facilities construction timetable. Specifically, the megawatt capacity of facilities scheduled to come on-line in the near future is assigned to participants favoring nuclear development. Facilities with later on-line dates possess a greater probability of risk for successful completion and as such their corresponding megawatt capacity is relegated to participants opposing nuclear development. Importantly, the specific values reflect relative differences in power between the participants. It is this rationale that underlies the calculation of the payoff values for each gaming situation developed in the paper. For example, it may be hypothesized that the following Ohio situation underlies the values in the nuclear locational game's payoff matrix.

If both the Coalition for Nuclear Power and the environmentalists enter into Ohio's nuclear locational game alone, the Coalition for Nuclear Power can expect to obtain 5920 megawatts of nuclear capacity. This amount corresponds to all facilities currently under construction and on order. The environmentalists should be able to eliminate 3714 megawatts of nuclear capacity which correspond to all proposed facilities.

If the Coalition for Nuclear Power joins in an enlarged coalition with government, 8352 megawatts of nuclear capacity should come on stream. This increase reflects the concern of governmental agencies, such as Ohio Energy Research and Development, for an adequate energy supply in Ohio. The figure 8352 assumes the on-line operation of all facilities under construction, on order and two proposed facilities that include Zimmer #2 and Erie #1. In this situation environmentalists may expect to prohibit only the 1282 megawatts of electrical capacity that correspond to one proposed facility to be known as Erie #2.

If only environmental groups join in an enlarged coalition with government, the Coalition for Nuclear Power should be able to secure 4108 megawatts of nuclear capacity which includes only those facilities currently under construction. The remaining 5526 megawatts should never come on-line. This amount includes those facilities on order and proposed.

Finally, if both the Coalition for Nuclear Power and the environmentalists enter into enlarged coalitions with appropriate governmental agencies, the coalition of utilities, engineers, industry and government may secure 7070 megawatts of capacity. This capacity corresponds to all facilities under construction, on order and one proposed facility which includes Zimmer #2. The remaining 2564 megawatts is held back by the environmental-government coalition. The payoffs assigned to the various coalitions corresponding to the preceding situation in Ohio are summarized in matrix B.

TABLE 1: Coalition Formation Information

Strategy	Coalition Members
X_1	Utility Companies, Engineering Organizations, Industry
X_2	Utility Companies, Engineering Organizations, Industry, Government
Y_1	Environmental Groups
Y_2	Environmental Groups, Government

TABLE 2: A Timetable for the Construction of Nuclear Energy Facilities in the State of Ohio

Nuclear Facility	Stage of Development	Date for On-Line Operation	Capacity (Mwe)
Davis-Besse #1	under construction	1977	906
Zimmer #1	under construction	1979	792
Perry #1	under construction	1981	1205
Perry #2	under construction	1983	1205
Davis-Besse #2	on order	1983	906
Davis-Besse #3	on order	1985	906
Erie #1	proposed	1984	1282
Erie #2	proposed	1986	1282
Zimmer #2	proposed	1986	1150

Table 3:* The Financial Contributions From Those Individuals and Groups Who Actively Participated in Ohio's November 1976 Energy Campaign.

I. Individuals and Groups in Favor of Nuclear Energy Development	Dollars Contributed
A. Major Utility Companies	
1. Atlantic City Electric Company	500.00
2. Cincinnati Gas and Electric	141,765.94
3. Cleveland Electric Illuminating	512,408.32
4. Columbus and Southern Ohio	147,951.35
5. Dayton Power and Light	173,594.78
6. Detroit Edison	263.00
7. Duke Power Company	10,000.00
8. Duquesne Light Company	6,805.00
9. National Association of Electric Companies	6,000.00
10. New England Electric System	6,000.00
11. New York State Electric And Gas	5,000.00
12. Ohio Edison	349,459.44
13. Ohio Power	215,365.00
14. Ohio Rural Electric Cooperatives, Inc.	37,323.14
15. Toledo Edison	118,971.00
B. Other Public Service Utilities	
1. Cincinnati Bell, Inc.	5,000.00
2. Columbia Gas of Ohio	37,398.93
3. East Ohio Gas Company	59,946.39
C. Private Industry	
1. Allied Chemical Corporation	3,313.12
2. Anderson Concrete Corporation	250.00
3. Armco Steel Corporation	35,114.00
4. Babcock and Wilcox Company	91,464.54
5. B.F. Goodrich Company	12,915.74
6. BIF	500.00
7. Blount Brothers Corporation	3,000.00
8. Buckeye International	2,000.00
9. Cincinnati Milacron, Inc.	5,000.00
10. Firestone Tire and Rubber Company	6,565.80
11. General Electric Company	57,560.67
12. General Motors Corporation	30,000.00
13. Republic Steel Corporation	26,073.71
14. Standard Oil (Ohio)	15,000.00
15. U.S. Steel	21,091.00
16. Westinghouse Electric	35,509.08
II. Individuals and Groups in Opposition to Nuclear Energy Development+	
A. Major Organizations	
1. Ohioans for Utility Reform	26,078.00
2. Committee for Socialist Alternatives	175.00
3. Committee for a Nuclear Safe Ohio	213.84

*This table presents only the financial contributions of those individuals and groups whose contributions exceeded two hundred dollars.

+Approximately ninety to ninety-five percent of the total campaign funds to oppose nuclear energy development were received from individual contributions ranging from five to fifteen dollars. For a complete list see Ohio State Secretary of Treasury.

Source: Secretary of Treasury, the Ohio State Government.

ERG

$$\text{CNP} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} \begin{bmatrix} Y_1 & Y_2 \\ 5920,\ 3714 & 4108,\ 5526 \\ 8352,\ 1282 & 7070,\ 2564 \end{bmatrix} = B$$

In order to determine whether or not the Coalition for Nuclear Power and the environmentalists should enter into the nuclear locational game alone or with government, it is necessary to partition matrix B into two sub-payoff matrices C and D.

CNP

$$\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} \begin{bmatrix} 5920 & 4108 \\ 8352 & 7070^* \end{bmatrix} = C$$

ERG

$$\begin{bmatrix} Y_1 & Y_2 \\ 3714 & 5526 \\ 1282 & 2564^* \end{bmatrix} = D$$

Matrix C represents the payoffs which the Coalition for Nuclear Power may expect regardless of the actions of the environmentalists and matrix D represents payoffs obtainable by the environmentalists independent of the behavior of the utilities, engineers and industry. The asterisk indicates that both matrices contain saddle point equilibrium outcomes. As a result the best each player can do, assuming both to be rational, is to assign a pure strategy to that row or column containing the saddle point value. Consequently, both the Coalition for Nuclear Power and the environmentalists should join with sympathetic governmental agencies in the nuclear locational game. Following this strategy 7070 megawatts of nuclear capacity will eventually become operational. This capacity corresponds to all facilities under construction, on order and one proposed facility which includes Zimmer #2.

The preceding constant sum game represents an oversimplification of the struggle which prevailed during the Fall of 1976. In short, this approach assumes that the interests between the two participants are exactly polarized and that the Ohio situation could be represented by either/or outcomes, in particular, either a facility eventually becomes operational or it is eliminated. In contrast, a somewhat more realistic portrayal of the 1976 energy campaign suggests that environmental groups, in addition to the elimination of nuclear projects, can delay the construction of any nuclear facility. Consequently, unlike the two-person constant sum game whereby cooperative strategies between the Coalition for Nuclear Power and environmentalists were not considered, frequently both participants can gain through cooperation. This situation reflecting non-polarized interests may be represented by a two-person non-constant sum game.

Non-Constant Sum Game. The game's payoff matrix E, given below, incorporates the notion of nonpolarized interests by deleting from the analysis the amount of nuclear megawatt capacity delayed. For example, it may be hypothesized that the following Ohio situation underlies the values in the payoff matrix E.

$$\text{CNP} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} \begin{bmatrix} Y_1 & Y_2 \\ 5920,\ 3714 & 4108,\ 1282 \\ 5014,\ 1282 & 7070,\ 2564 \end{bmatrix} = E$$

If both groups enter into the game alone, the Coalition for Nuclear Power may expect 5920 megawatts of nuclear capacity to become operational. This amount corresponds to all facilities currently under construction and on order. The remaining 3714 megawatts are eliminated which include all proposed facilities.

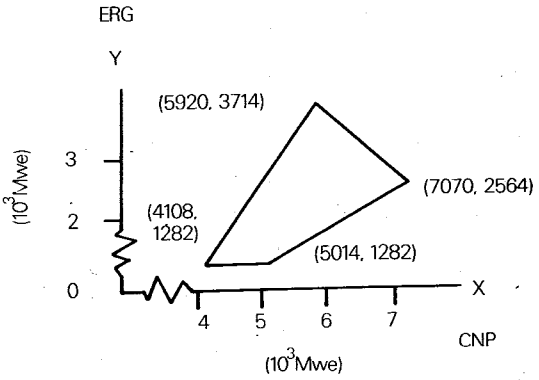
If only the Coalition for Nuclear Power joins in an enlarged coalition with government, 5014 megawatts of nuclear capacity eventually come on-line. The number 5014 assumes the construction of all facilities under construction and one on order, Davis-Besse #2. On the other hand, environmental groups are able to eliminate only 1282 megawatts, Erie #2, and to delay 3338 megawatts, Davis-Besse #3, Zimmer #2 and Erie #1. Government's role in this enlarged coalition is to reduce the amount of nuclear megawatt capacity which environmental groups eliminate.

If only environmental groups join in an enlarged coalition with government, they eliminate 1282 megawatts, Erie #2, and delay 4244 megawatts, Davis-Besse #2 and #3, Zimmer #2 and Erie #1. The remaining 4108 megawatts of nuclear capacity which includes all facilities under construction eventually will become operational. The role of government in this enlarged coalition is similar to that of the utilities, engineers, industry and government coalition. Namely, environmental groups, along with government, reduce the amount of nuclear capacity awarded to the Coalition for Nuclear Power. This strategy, however, is not without cost to environmental groups for they must be willing to transfer a share of eliminated capacity to that of delayed capacity. This transfer may occur in hopes that increasing support for the environment will prohibit the future construction of these delayed facilities.

Finally, if both groups form enlarged coalitions with government, the environment-government coalition eliminates 2564 megawatts of nuclear capacity. This capacity corresponds to two proposed facilities to be known as Erie #1 and #2. The remaining 7070 megawatts eventually become operational.

In order to calculate the strategy sets, $\bar{X}$ and $\bar{Y}$, for the Coalition for Nuclear Power and environmental groups respectively the non-constant sum, nuclear, locational game employs Shapley's negotiation procedure [16]. Given the game's payoff polygon Figure 3 which joins points in the game's payoff space it is necessary to calculate the status quo point of the game. This point is a reference point in the negotiation set whereby each participant is guaranteed this payoff regardless of his opponent's actions. Coordinates of this point, (x_o, y_o), correspond to the security levels calculated for each participant. For example, the status quo point for Ohio's nuclear locational game is obtained as follows: (1) calculate the security level for the Coalition for Nuclear Power by solving simultaneously the system of equations below:

FIGURE 3: The Payoff Polygon for the Two-Person, Non-Constant Sum, Nuclear Locational Game



$$(1)\quad 5920X_1 + 5014X_2 = V$$

$$(2)\quad 4108X_1 + 7070K_2 = V$$

$$(3)\quad X_1 + X_2 = 1.0$$

and (2) calculate the security level for the environmentalists by solving simultaneously the system of equations below:

$$(4)\quad 3714Y_1 + 1282Y_2 = V$$

$$(5)\quad 1282Y_1 + 2564Y_2 = V$$

$$(6)\quad Y_1 + Y_2 = 1.0$$

The resulting coordinates of the status quo point are (5494.18, 2108.88). Namely, the Coalition for Nuclear Power is able to operationalize 5494.18 megawatts of nuclear capacity regardless of the actions taken by environmental groups. On the other hand, environmentalists eliminate 2108.88 and delay 2030.94 megawatts of nuclear capacity independent of the actions taken by the Coalition for Nuclear Power.

Graphing the status quo point in the game's payoff space Figure 4 and constructing vertical and horizontal lines which intersect perpendicularly at this point the negotiation set for Ohio's nuclear locational game is defined. It is along the line defining the negotiation set on which the two participants cooperate so as to maximize their joint gain. The equation of the line, given below, that defines the negotiation set is one that passes through the two points (5920, 3714) and (7070, 2564).

$$(7)\quad y = -x + 9634.0$$

The point on the game's negotiation set that maximizes the participants' joint gain is given by:[4]

$$(8)\quad \text{Maximize } Z = (x - 5494.18)\ (9634.0 - x - 2108.88)$$

differentiating

$$(10)\quad \frac{dz}{dx} = -2x + 13019.3$$

and setting the right hand side of Equation (10) equal to zero, $x^* = 6509.65$.

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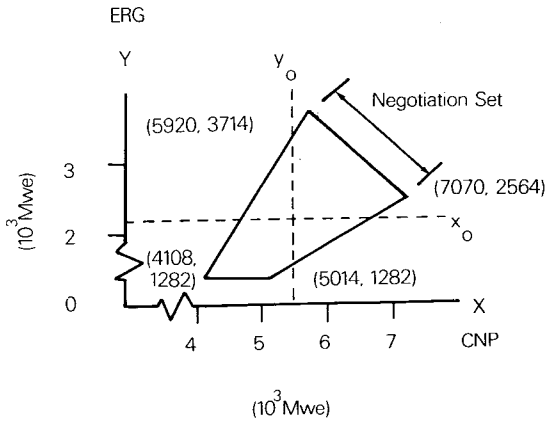
[4]Shapley's solution to the negotiated game assigns the security levels of the two participants as the status quo point of the game and solves the negotiation problem by maximizing Nash's general bargaining function [16].

$$(9)\quad \text{Maximize } Z = (x - x_o)\ (y - y_o)$$

FIGURE 4: The Negotiation Set for the Nuclear Locational Game



Substitute the value of x* into Equation (7) and solve for y*. Hence y* = 3124.35. In order to achieve this joint gain (x*, y*), however, both the Coalition for Nuclear Power and the environmentalists must follow a prescribed set of mixed strategies. These 'cooperative' strategy sets are calculated from a payoff matrix, given below, whose entries correspond to the pair of coordinates that define the negotiation set, i.e., the negotiated payoff matrix F. The cooperative strategy

ERG

$$\text{CNP} \quad \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} \quad \begin{matrix} [Y_1 & Y_2] \end{matrix}$$

$$\begin{bmatrix} 5920 & 3714 \\ 7070 & 2564 \end{bmatrix} = F$$

set for the Coalition for Nuclear Power may be calculated by solving the equation below:

$$(11) \quad 5920X_1 + 7070K_2 = 6509.65$$

Similarly the cooperative strategy set for the environmentalists may be calculated by solving the equation below:

$$(12) \quad 3714Y_1 + 2564Y_2 = 3124.35$$

The resulting cooperative strategy sets, $\bar{X}$, for the Coalition for Nuclear Power, and, $\bar{Y}$, for the environmental groups are (.49, .51) and (.49, .51) respectively. Therefore, if each participant adheres to his cooperative strategy set, together they will obtain the joint payoff (6509.65, 3124.35). Namely, 6509.65 megawatts eventually will come on-line while the remaining 3124.35 megawatts will be withheld.

Although the non-constant sum approach introduces complexities more characteristic of the energy struggle, it does not illustrate why in Ohio utilities, engineers and industry joined in coalition to oppose groups interested in controlling nuclear development. It is this latter issue which forms the focus for the second scenario.

Scenario Two. Generally speaking, two important decisions face all participants in a game. First, each participant must decide whether or not to enter the game as an individual or in a coalition representing a group of individuals. In terms of the present study since utilities, engineers and industry share similar interests, one would expect that they form a coalition. The forming of a coalition, however, is predicated on many other behavioral and economic goals particular to the individuals themselves. The second decision, therefore, concerns the fact that members of a coalition must decide whether or not to enter a game as an individual, a pressure group, or as a group of individuals, a coalition. For example, suppose a coalition S with s members can be partitioned in y(s) different ways. This implies that any counter coalition -S with n-s members can be partitioned in y(n-s) different ways. Depending upon the particular partition, the function $\theta(p)$, derived from a standard of fairness, may assign a payoff to each individual, pressure group and, coalition. Given the interests of each

participant as outlined in the section Coalition Formation, along with the information provided from survey responses and Tables 1 through 3, a more complicated yet plausible game may be developed.[5]

$$\begin{aligned} \text{INDO + EA} = v(\overline{1}) &= 0 \\ \text{UC} = v(\overline{2}) &= 0 \\ \text{GOVT} = v(\overline{3}) &= 0 \\ \text{ERG} = v(\overline{4}) &= 0 \\ v(\overline{34}) &= 0 \\ v(\overline{123}) &= 7070 \\ v(\overline{1234}) &= 9634 \end{aligned}$$

Essentially industry, professional engineering societies, along with sympathetic governmental agencies, joins with utility companies to form a coalition $(\overline{123})$. Other governmental agencies interested in environmental preservation form a counter coalition, $(\overline{34})$, with environmental groups. Each coalition may enter into Ohio's nuclear locational game either as one participant, a coalition, or as individual participants, pressure groups. In vector notation:

$$P_1 = (\overline{123});\ (\overline{34})$$
$$P_2 = (\overline{1}),\ (\overline{2}),\ (\overline{3});\ (\overline{34})$$
$$P_3 = (\overline{123});\ (\overline{3}),\ (\overline{4})$$
$$P_4 = (\overline{1}),\ (\overline{2}),\ (\overline{3});\ (\overline{3}),\ (\overline{4})$$

Furthermore, a standard of fairness fraction is assigned to each participating coalition and pressure group in the game. These fractions[6] which reflect questionnaire responses, information presented in Tables 1 through 3 and, experience with out-of-state situations approximate the share of nuclear capacity awarded to each coalition and pressure group. For example, the following standard of fairness fractions correspond to both the struggle that actually took place in the Fall of 1976 as well as reflect the distribution of power amongst the participants: (1) if p_1 occurs, coalition $(\overline{123})$ is entitled to 2/3 and $(\overline{34})$ receives 1/3 of the joint gain; (2) if p_2 occurs, individual 1 is entitled to 1/3, individuals 2 and 3 each receive 1/6 and $(\overline{34})$ receives 1/3 of the joint gain; (3) if p_3 occurs, individuals 3 and 4 each receive 1/8 and $(\overline{123})$ is entitled to 3/4 of the joint gain and, (4) if p_4 occurs, individual 1 is awarded 3/9, individuals 2 and 3 (governmental agencies in favor of nuclear development) each receive 2/9 while individual 3 (governmental agencies opposing nuclear development) and 4 each secure 1/9 of the total payoff. The standard of fairness values, expressed in megawatts, for the four proposed partitions are calculated below.

If p_1 occurs, members 1, 2 and 3 receive jointly:

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[5]In gaming theory games involving three or more active participants are expressed in characteristic vector form. This format provides insight into possible coalition structures and their expected payoffs.

[6]The importance attached to the standard of fairness fractions is not in the actual number per se but in their relative differences.

$$(13)\quad \phi_{123}(p_1) = v(\overline{123}) + 2/3\ [v(\overline{1234}) - v(\overline{123}) - v(\overline{34})]$$
$$= 8787.9 \text{ megawatts}$$
$$\phi_{34}(p_1) = v(\overline{1234}) - \phi_{123}(p_1)$$
$$= 846.1 \text{ megawatts}$$

If p_2 occurs, individuals 1, 2 and 3 obtain:

$$(14)\quad (\phi_1 + \phi_2 + \phi_3)(p_2) = v(\overline{1}) + 1/3\ [v(\overline{1234}) - v(\overline{34}) - v(\overline{1}) - v(\overline{2}) - v(\overline{3})]$$
$$+ v(\overline{2}) + 1/6\ [v(\overline{1234}) - v(\overline{34}) - v(\overline{1}) - v(\overline{2}) - v(\overline{3})]$$
$$+ v(\overline{3}) + 1/6\ [v(\overline{1234}) - v(\overline{34}) - v(\overline{1}) - v(\overline{2}) - v(\overline{3})]$$
$$= 3211.3 + 1605.6 + 1605.6$$
$$= 6422.5 \text{ megawatts}$$
$$\phi_{34}(p_2) = v(\overline{1234}) - (\phi_1 + \phi_2 + \phi_3)(p_2)$$
$$= 3211.5 \text{ megawatts}$$

If p_3 occurs, members 1, 2 and 3 receive jointly:

$$(15)\quad \phi_{123}(p_3) = v(\overline{123}) + 3/4\ [v(\overline{1234}) - v(\overline{123}) - v(\overline{3}) - v(\overline{4})]$$
$$= 8993.0 \text{ megawatts}$$
$$(\phi_3 + \phi_4)(p_3) = v(\overline{1234}) - \phi_{123}(p_3)$$
$$641.0 \text{ megawatts}$$

If p_4 occurs, individuals 1, 2 and 3 receive:

$$(16)\quad (\phi_1 + \phi_2 + \phi_3)(p_4) = v(\overline{1}) + 3/9\ [v(\overline{1234}) - v(\overline{2}) - v(\overline{3}) - v(\overline{4})]$$
$$+ v(\overline{2}) + 2/9\ [v(\overline{1234}) - v(\overline{2}) - v(\overline{3}) - v(\overline{4})]$$
$$+ v(\overline{3}) + 2/9\ [v(\overline{1234}) - v(\overline{2}) - v(\overline{3}) - v(\overline{4})]$$
$$= 3211.2 + 2140.8 + 2140.8$$
$$= 7492.8 \text{ megawatts}$$
$$(\phi_3 + \phi_4)(p_4) = v(\overline{1234}) - (\phi_1 + \phi_2 + \phi_3)(p_4)$$
$$= 2141.2 \text{ megawatts}$$

Let X_1 and X_2 represent the proportion of time in which $(\overline{123})$ enters into Ohio's nuclear locational game as a coalition and as a pressure group respectively. Similarly, let Y_1 and Y_2 represent the proportion of time in which $(\overline{34})$ enters the game as a coalition and as a pressure group respectively. The payoff values in matrix G, given below, correspond to $(\overline{123})$'s standard of fairness values.

Since the first row in the matrix

$$\begin{array}{lcc} & & \text{Coalition } (\overline{34}) \\ \text{Coalition} & & [Y_1 \quad Y_2] \\ (\overline{123}) & \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} & \begin{bmatrix} 8787.9 & 8993.0 \\ 6422.5 & 7492.8 \end{bmatrix} = G \end{array}$$

dominates the second row the game prescribes a pure strategy for both $(\overline{123})$, (1, 0), and $(\overline{34})$, (1, 0). As a result both $(\overline{123})$ and $(\overline{34})$ should enter into Ohio's nuclear locational game as a coalition and not pressure groups. In so doing the amount of nuclear capacity eventually coming on-line corresponds to all facilities under construction, proposed and one on order, Davis-Besse #2.

Summary and Conclusion

The study, focusing on Ohio's three energy amendments in the November 1976 election, develops two scenarios that characterize a number of strategic alternatives available to interested coalitions of utility companies, engineering organizations, industry, government and environmental groups. The first scenario examines Ohio's nuclear energy situation in terms of a simple two person constant and a more complex non-constant sum game. Essentially the Coalition for Nuclear Power and the environmentalists must decide whether or not to enter into an enlarged coalition with government in hopes of obtaining a larger megawatt payoff. The second scenario introduces complexities more characteristic of nuclear development and related facility locational problems in Ohio during the Fall of 1976. In particular, utility companies, engineers and industry were committed to economic growth for the state. This commitment meant a greater reliance in the future on nuclear-based electricity in spite of the possibility of some risk. It is to be remembered that Ohio lacks large quantities of cheap low-sulfur coal. Furthermore, the gaming analysis, focusing on the uneven distribution of power amongst the participants, suggested that utilities, engineers and industry join in coalition. By so doing environmental groups like the Ohioans for Utility Reform found themselves wielding little, if any, power with which to compete against a well financed, well organized and cohesive coalition for nuclear development. The end result was a resounding defeat for all three energy amendments.

Since many contemporary locational problems are increasingly subject to conflicting private as well as public interests, such as the siting of energy facilities, the use of traditional locational analytic techniques is difficult, if not impossible. It is hoped, therefore, that the present study provides a structured methodology for examining the impact of conflict and its related elements on the decision to locate.

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