IMPLICATIONS OF A NUCLEAR FACILITY IN SOUTH COUNTY RHODE ISLAND

VOLUME 4

ECONOMIC IMPACT DYNAMICS

IMPLICATIONS OF A NUCLEAR FACILITY IN SOUTH COUNTY RHODE ISLAND

Volume 4

ECONOMIC IMPACT DYNAMICS

Eliahu Romanoff and Stephen H. Levine

prepared for

REGIONAL COASTAL ENERGY IMPACT PROGRAM

WAKEFIELD, RHODE ISLAND

The preparation of this report was financed in part by funds from the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, administered by the ENERGY OFFICE, EXECUTIVE DEPARTMENT, GOVERNOR'S OFFICE, STATE OF RHODE ISLAND.

June, 1980

PREFACE

A dynamic framework is presented for analyzing the impact resulting from the construction and operation of a nuclear power plant in South County, Rhode Island. The novel approach to the impact analysis is introduced in non-technical form in Chapter 2. The evaluation of the project's impact dynamics is presented in Chapters 3 and 4. The use of simulations in this report is mainly to introduce the impact dynamic processes and develop scenarios with which essential impact features can be examined and mitigation strategies can be outlined.

We are indebted to the many individuals who broadened our understanding and who responded to our queries, thereby making this study possible. We are particularly indebted to Dr. David Durand for his stimulating discussions in the early stages of the project, and to Dr. S. Basheer Ahmed for his comments on an early draft of this report. However, the responsibility for this report rests with the authors. The assistance of Mark Brody in the preparation of data is greatfully acknowledged.

We would like to express our appreciation to Jonathan Feinstein, former Director, and to Cynthia G. Collins, Acting Director, and to their staff at the Regional Energy Impact Program for their assistance in this undertaking.

E.R. and S.H.L.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

1.1 Purpose

The purpose of this report is to present the results of the examination of the dynamic economic impact of the Charlestown Nuclear Power Plant on the coastal communities of South County, Rhode Island, shown in Figure 1. Because the original application for the Charlestown Nuclear Power Plant was tentatively withdrawn, and is expected to be resubmitted around 1995, and because of the present uncertainty as to where the plant is to be built--in Charlestown or Westerly--the evaluation is presented in terms of scenarios focusing on two fundamental issues which are of particular interest to South County.

The two fundamental issues are: (a) employment, and specifically the potential for job creation, and (b) the seasonality of the coastal economy. Their implications on the growth prospects of South County raise the issues that ought to be addressed by the State and the local governments charged with the provision of services and facilities in the Region. In this way, advance mitigation strategies can be formulated and accommodation plans can be developed in an orderly and timely manner.

Power plant construction has usually been favored because of the stability it brings to the labor market by the provision of long-term construction jobs. The case study examination of the Millstone Nuclear Power Plant in Waterbury, Connecticut by Grant and Cameron (1980), attests to this attitude. Similar interest was expressed in the proposed Charlestown Nuclear Power Plant by Providence labor, Callaghan and Comerford (1978).

However, in past examinations and assessments employment was measured in labor-years. This measure does not furnish the number of employees that are expected to be employed by the project. One hundred labor years may mean 100 jobs for employees working one year each, or 20 jobs for employees working five years each, or any of many other combinations. This measurement ambiguity was recognized by Callaghan and Comerford (1978,

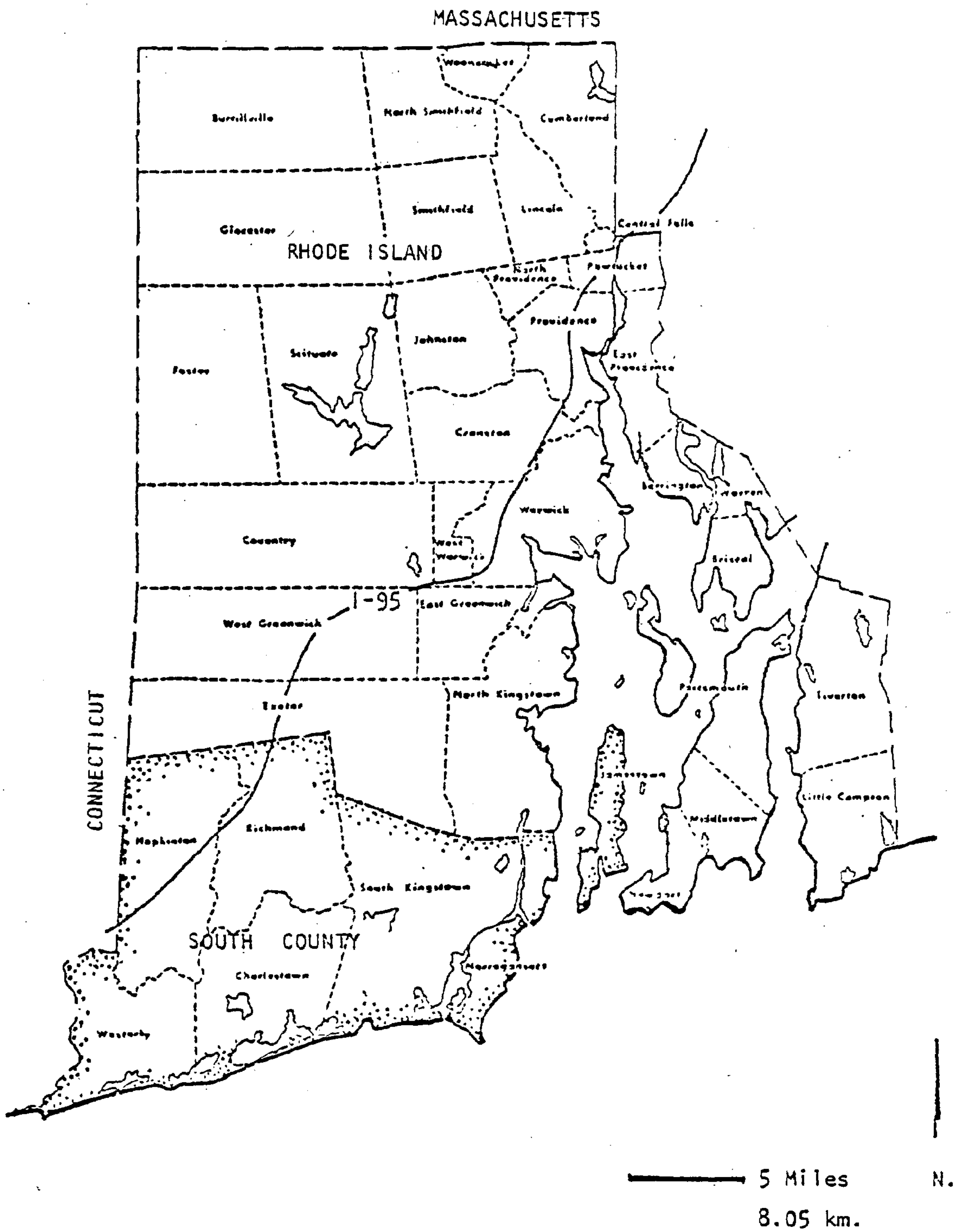


FIGURE 1-1, THE SOUTH COUNTY REGION

p. 29), who noted the error of equating a work-year with an employee-per-year in computing the number of employees as a function of work-years. Their examination revealed this type of error in manpower estimates for the Charlestown Plant made both by NEPCO and by the Construction Manpower Demand System, CMDS, of the TVA.

The present study addresses this problem by examining the impact dynamics of the plant construction. The analysis furnishes information not only on the potential for job creation, but also on job duration.

Seasonality was found to be an important economic characteristic of the coastal communities in South County, see Romanoff (1980) and the main report of the South County Regional Impact Program. Agriculture, fishing and their related industries are seasonal. Tourist trade and summer homes, and their supporting industries are most active during the summer months. The temporal and seasonal conflict between the economic activity of the South County economy which peaks during the summer months, and power plant construction which usually peaks during the non-winter months, raises an important issue for impact mitigation--namely, how to reconcile the temporal competition for the various resources in the Region. The identification of this important issue is achieved by the use of scenarios in which the power plant construction schedule is modified in order to accommodate the South County economy. The analysis introduces some of the dynamic impact characteristics relevant to this issue.

1.2 Planning, Construction and Operations

The main benefits from building a power plant accrue to the users of energy; the benefits to construction are secondary. This distinction originates with benefit-cost analysis which was developed in response to a congressional mandate to evaluate the worthiness of federal water resource developments. As originally formulated in benefit-cost analysis, secondary benefits fall on the construction industry, which builds a dam designed to control floods and provide irrigation. These benefits must be distinguished from the project's intended, or primary, benefits designed to be bestowed upon the farmers of the area. Similarly with power plant construction, secondary benefits fall on the construction industry building the plant, while primary benefits accrue to the public by the provision of electricity.

A distinction must also be drawn between power plant construction and operation with regard to the dynamics of impact. Once the plant is built, its operation is more or less stable and continuous over its lifetime, with periodic shutdowns for refueling. By contrast, power plant construction is a transient, relatively short-term event, lasting only several years, and the economic impulses generated are usually not uniformly distributed over that period. As will be shown, the duration of the overall economic impact of power plant construction is longer than the construction period itself. This temporal distinction is due to the transient nature of the construction process, which imposes unique dynamic characteristics on the resulting impact. In addition to power plant construction and operation, where each generates its unique repercussions on the economy, the power plant planning and review process also generates its own unique impact on the economy.

Of these three periods--planning and review, construction, and operation--this study focuses on the latter two, emphasizing construction.

Finally, an important note on terminology is in order. Primary and secondary benefits stemming from benefit-cost analysis must be distinguished from direct and indirect effects and first, second, and subsequent round effects, all originating with input-output analysis. As will be shown, secondary benefits (and costs) of power plant construction can also be divided into direct and indirect effects. With the proliferation of impact studies of power plants in Rhode Island and elsewhere, these terms are used interchangeably and thus blur the analysis; in this study we adhere to the distinctions noted.

1.3 Outline of Study

The examination is undertaken by the simulation of future scenarios aimed at a broad brush sketching, as it were, of the dynamic impact in order to introduce and describe the two key issues noted earlier. Because of the broad scope of the subject matter and the desire to present the material in non-technical form, further detailed information, such as employment breakdowns by occupational detail and other issues, are excluded at this time. Technical detail can be filled in at a later date and the analysis can be deepened if undertaken nearer the dates at which the utility will be granted hearings on its renewed application, and after the specific construction site in South County has been determined.

The study is in three parts. In Chapter 2, the economic impact characteristics of nuclear power plant construction are described, indicating their causes and effects and leading to the dynamic consideration of impacts.

In Chapter 3, the simulation of two simplified scenarios is presented, the impact of plant construction on the potential for job creation and job duration are evaluated and the effects on the coastal seasonal economy indicated. The impact of plant operation is also presented in that chapter.

Finally, in Chapter 4, some of the implications for South County are indicated and policy issues requiring resolution are discussed with some paths to their solution noted.

2. ECONOMIC IMPACT CHARACTERISTICS

2.1 General Framework

2.1.1 The Construction Project and the Regional Economy

The purpose of this chapter is to present a framework for examining the dynamic impact of the power plant construction on the economy. This introductory framework can then serve as a guide to the impact evaluations presented in the following chapter. To understand the overall process, we must consider, (a) some of the characteristics of the triggering event, the construction of a nuclear power plant, and (b) the characteristics of the responding State economy. It is the interaction of nuclear power plant construction with the operations of the Rhode Island economy, including the economy of South County, that determines the economic repercussions. The process is viewed in its dynamic settings.

2.1.2 Direct and Indirect Effects

Consider briefly the economic impact of power plant construction. Its direct effects are on the construction industries engaged in constructing the plant, and the indirect effects spill from the construction industries to all other industries in the economy. Once plans are developed, reviewed and approved, and financing is secured, the project is ready for execution. The construction firm which is selected to construct the plant must employ labor and purchase materials and services and must complete its tasks within a specified time. The purchased materials and services place their own demand for labor and for materials and services on many other additional industries. Thus, the total effect consists of both direct and indirect effects. To these, induced effects ought to be added to measure the direct and indirect-like effects caused by the hiring of labor which, with increase in income, is able to spend more on consumer items, thereby further stimulating the economy. Thus, in considering the overall impact, one must count both direct and indirect effects and, if possible, also the induced effects. This study examines the total effect, consisting of the direct and indirect effects.

2.2 Construction Technology and Configurations

2.2.1 Construction Technology

Power plant construction processes have unique technologies. The simplest distinction is among the building of structures, the erection and assembly of the mechanical equipment, and installation of the electrical and electronic systems. The construction technologies may be further modified by the unique design configurations which alter the resource requirements for each site. These may be further influenced by special institutional considerations unique to each region, such as union rules affecting hiring practices.

Construction projects usually require the use of several technologies which are represented by specific construction industries or subindustries. These may be undertaken by one or more construction contracts. Each of the technologies draws on different combinations of labor skills and materials. For example, structures require significant quantities of reinforcing steel and concrete while the fabrication and installation of plants' turbines require other kinds of steel and, instead of concrete, require other products.

The distinctions among the construction technologies are important to impact analysis, for each tends to generate its unique impact on the economy. The magnitude and the relative representation of each of the construction technologies contribute to the characteristics of impact.

The direct plant construction costs for the Charlestown plant shown in Table 2-1 suggest the construction technologies involved, i.e.:

	Million $
General and Structural Work	386.6
Mechanical Work	577.3
Electrical Work	141.9
Direct Construction Costs	1,106.0

Each of these technologies primarily uses the services of civil, mechanical and electrical engineers.

The indirect plant construction costs of 260 million dollars shown in Table 2-1 generate their own impacts; these impacts usually are not as great as those due to direct costs. For simplicity these indirect

TABLE 2-1

CHARLESTOWN NUCLEAR POWER PLANT CAPITAL INVESTMENT SUMMARY

	1978 Million Dollars
Direct Plant Construction Costs	
Structures and site facilities	342
Reactor plant equipment	358
Turbine plant equipment	145
Electric plant equipment	120
Misc. plant equipment	11
Spare parts allowance	2
Contingency allowance	128
Subtotal	1,106
Indirect Plant Construction Costs	
Construction facilities, equip. and services	38
Engineering and const. management services	137
Other costs	85
Subtotal	260
Total Construction Cost	1,366
Other Costs	
Interest during construction	905
Cost at start of construction	2,011
Escalation during const. (at 6%/yr.)	620
Total power plant capital investment	2,631

Source: NEPCO Response to NRC request for additional information, April 13, 1978.

construction costs are allocated among the three construction technologies to obtain the costs which are likely to generate the economic impact, and specifically, the demand for labor.

The total construction cost of 1,366 million dollars accounts for only about 52 percent of the total plant capital investment of 2,631 million dollars. The other costs shown in the table ought to be excluded because interest on borrowed funds and the escalation adjustment for inflation are fiscal factors which do not generate a unique impact on the State economy. Since inflation and funds borrowed on national financial markets have nationwide effects, the Other Costs shown in Table 2-1 must be separately treated and analyzed within a different framework. They are excluded from the study.

2.2.2 <u>The Estimated Construction Cost Schedule</u>

In order to gain an insight into the dynamics of the impact of power plant construction, one ought to consider not only the total construction cost estimated for the project, but also how it is distributed over time. This is because the construction process itself is a complex, sequential operation. As with ordinary buildings, where a trench must be dug and foundations built before walls can be erected and a roof spanned, so it is with power plant construction. Sites are first prepared, including access roads and support facilities; then trenches are dug and foundations are built over which the required structures are erected. Plant equipment and control and safety systems are installed, and facilities are completed and furnished. Each operation requires its complement of labor skills, specialized equipment, and a unique combination of materials. Because power plant construction requires particular attention to safety, the timing and duration of each operation must be carefully orchestrated in order to provide for the testing of components and subsystems of the plant. Because of the required synchronization of the construction schedule, the builder must carefully schedule the delivery of his supplies to fit his pace of construction.

The data for the then-proposed Charlestown plant show an eleven-year estimated total construction cost schedule, with completion of the first plant scheduled for 1986 and of the second plant for 1988, for a total of

1,564 million 1978 dollars.* See Table 2-2. The construction cost schedule shows a gradual increase in the pace of construction in the first five years in the life of the project, an accelerated pace of construction for three years when each year accounts for about one-fifth of the total cost, and then a three-year period of decline in the pace of construction as the project nears completion. If this eleven-year construction cost schedule were realized, the costs as they are distributed over time imply that inflationary effects since 1978 would drastically alter the total cost of the project and may raise the question of its profitability. Changes in electric rates would be required to absorb these added costs.

2.2.3 The Realized Construction Cost Schedule

The distinction between estimated and the actual or realized construction cost schedules is important, for although past impact studies were based on the estimated cost, it is important to recognize that the estimated cost is associated with a schedule and that both will be modified during construction. Delays and added cost will be seen to have unique impacts on the economy; they may differ significantly from those based on the originally estimated construction cost schedule.

The increasing extent and complexity of regulations required of nuclear power plants lengthened the duration of the construction period during the past two decades. Crowley (1976, p. 32) shows the lengthening trend in nuclear power plant construction schedules:

Year	Construction (months)	Total from Early Planning and Preparation Through Pre-Testing and Start-Up (months)
1967	42	63 - 66
1969	46	70 - 73
1974	60	96 -105

The construction period was lengthened from 42 months (3.5 years) in 1967

* The revised cost estimate of 1,546 million dollars, shown in Table 2-2, is larger than the 1,366 million dollars shown in Table 2-1. The revision includes an estimate of 154 million dollars for fuel costs, which accounts for most of the difference.

TABLE 2-2

ESTIMATED TOTAL CONSTRUCTION COST SCHEDULE NEPCO 1 & 2, EXCLUDING ESCALATION

(1978 1000 Dollars)

Year	Total Cost (1978 1000 Dollars)	Percent of Total
1978	3,695	.2
1979	13,455	.9
1980	26,590	1.7
1981	77,745	5.0
1982	137,475	8.9
1983	332,470	21.5
1984	319,370	20.7
1985	319,980	20.7
1986	167,870	10.9
1987	113,250	7.3
1988	34,065	2.2
	1,545,965	100.0

Source: NEPCO 1 & 2, Revision 2, Schedule 2, Costs Currently Estimated, June, 1978.

to 60 months (5 years) in 1974, with the trend apparently continuing since that time.

The process of constructing a nuclear power plant requires continuous attention to safety requirements, which are themselves continually changing. Design modifications are usually required. These modifications and the ensuing delays increase the cost of construction and lengthen the construction schedule. Delays in delivery are also not uncommon.* The comparison of estimated cost trends with actual experience in the nuclear industry is shown in Figure 2-1. The lower curve shows the costs estimated at project initiation. The top curve represents the actual experience to the end of 1975; the dotted line is the projection of past experience. Although delays and added costs are common and ought to be expected, estimating the relationship between delays and added costs is not a simple task.

Nor are these delays and added cost unique to the construction of nuclear power plants. They are common to most large and complex construction projects, e.g., mass transit construction; see Romanoff and Levine (1979b).

2.2.4 Impact of Construction on Supplying Industries

The impact of the construction technologies on the supplying industries generates the indirect effects noted earlier. The dynamic characteristics of this process are now discussed. Procurement for a construction project generally does not start until the construction firm determines the equipment and materials needed at the site. The resulting technical requisitions for such goods enable the purchasing department of the firm to develop its procurement program involving bids, actual purchases and inspection of shipped goods which ought to arrive at predetermined dates consistent with the construction schedule. Included

---

* Crowley (1976, p. 31) notes that it is not uncommon for equipment to be delivered more than 12 months later than promised by suppliers, and that suppliers will not contract for firm delivery dates with penalty provisions. Changes in NRC standards also contribute to delay in delivery. Crowley estimates that a one-year extension in schedule for a two-unit nuclear power plant adds more than 170 million dollars in escalation and interest cost during construction.

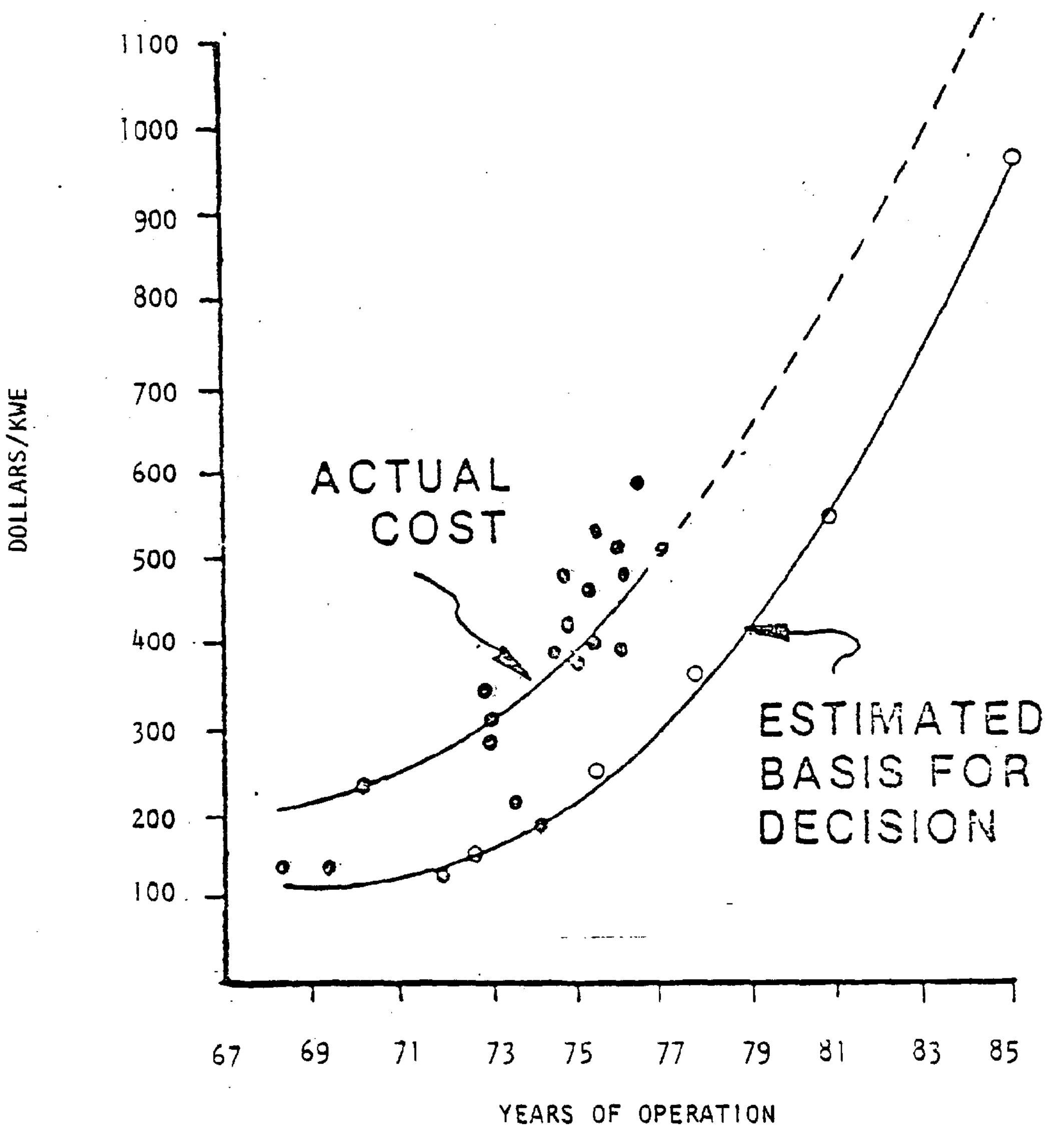


FIGURE 2-1: TRENDS OF NUCLEAR POWER PLANT COST (Dollars/KWE)

Source: Crowley (1976, fig. 16).

also are subcontracts to be awarded to the special trade contractors and fabricators. While some goods, such as cement, steel bars, and lumber can be supplied from inventories of wholesalers or of the respective producers, others cannot be so obtained. By contrast with standard items, materials and components which must be fabricated to special specifications to suit a particular construction job must be ordered well in advance of acquisition. This lead time implies that for these products, such as steel-fabricated plate girders, reactor vessels, or electronic safety and control equipment, fabrication and assembly must precede the delivery which is to be made sometime in the future.

Consider the economic repercussions of the process just described. With the issuance of the construction contract, the construction firm starts employing its off-site labor for the project; these include its office and yard personnel. Once the requirements for equipment and materials are determined, they are ordered. In the meantime, the construction firm can also start on the preliminary work such as site preparation, and then excavation. The cement needed for structural work is delivered at specific periods. Girders requiring lead time for fabrication arrive later for installation.

This simple example suggests the dynamics of impact. The purchase of standard items which are withdrawn from inventories implies that cement, steel bars and lumber, in our example, are produced in part <u>before</u> the construction contract has been awarded and construction starts, and are produced in part <u>during</u> a construction period for delivery during the later phases of the project. The production of the plate girders fabricated to special specification, on the other hand, occurs <u>during</u> the construction period of that project. However, the steel shapes required for the fabrication of the girders may have also been produced before the start of construction. This is schematically illustrated in Figure 2-2. The figure shows that the production period for all construction materials was initiated ahead of the construction start and may also terminate prior to construction completion, with the total period being perhaps longer than that of construction.* Production during the construction supply period

---

* The production supply period includes the building up of inventories to desired levels after the completion of production to satisfy construction demand.

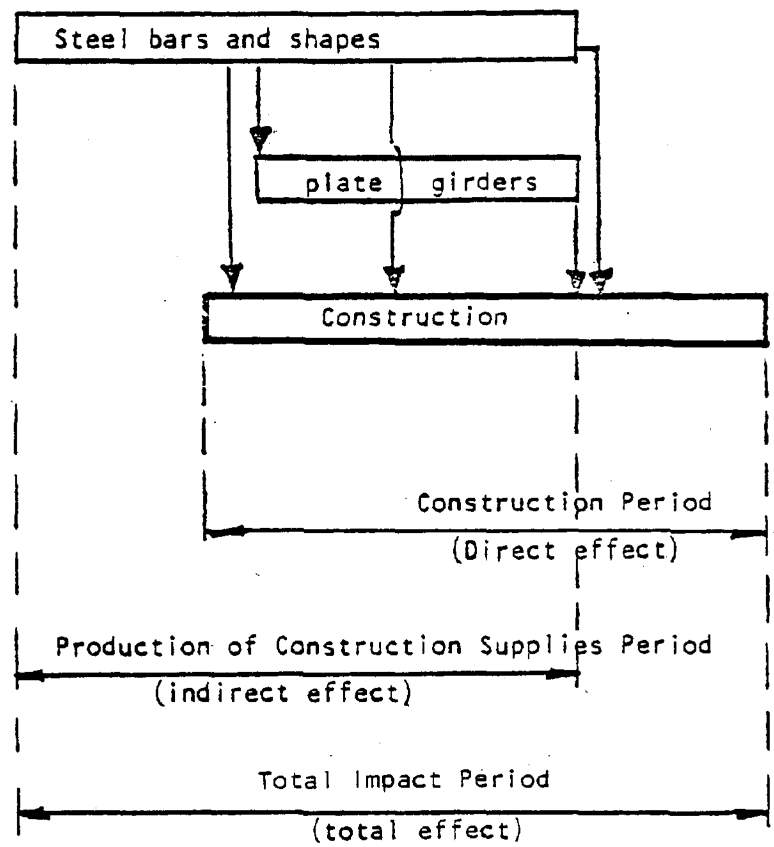


FIGURE 2-2: SCHEMATIC PRODUCTION SCHEDULE OF POWER PLANT CONSTRUCTION

represents the duration of indirect effects. Thus, the total effect of both direct and indirect effects is represented by the total impact period and is initiated with the production of materials to be supplied to construction and usually terminates with the end of the construction period. The duration of the total impact period is thus longer than that of the construction period.

2.3 The Regional Economy

2.3.1 The Structure of Production

Following the discussion of the triggering event of the impact, namely, power plant construction, attention is now directed to the characteristics of the local--State--economy, for it is the interaction of power plant construction with the local economy which generates the economic consequences to be examined. The most important characteristics of the local economy pertain to its structure of production, to the composition of local industries, and to the economic linkages among them. For impact assessment, the list of the industries in the State of Rhode Island can provide the information on particular products which can be supplied by local production. For example, states like Rhode Island in which there is no cement industry, must import that product and the impact on that industry will be felt in another state. In an interindustry matrix of the input-output model, the economic linkages among the industries indicate the magnitude of the impact transmitted among industries. However, if there is no local cement industry, the transmission of economic repercussions for that industry and its suppliers are excluded from the total local effect on the State. The example suggests that, generally, the larger and more diversified the State economy, the larger the regional economic impact is likely to be.

Industry production characteristics tend to vary among states, as was shown in several studies, recently in Romanoff, Ahmed and Davis (1978), which compared Kentucky with Massachusetts. Among the reasons for the variations in industry regional production characteristics are differences in price, in proximity to sources of supply and markets, in energy costs, and in labor costs. These differences will affect the magnitude of the economic transmission among industries, thereby affecting the distrubutive characteristics of the impact and its total effect on the economy.

Production characteristics are also known to change with time. Consequently, changes in the regional economy will affect production characteristics and the structure of production, implying that impacts measured for one period (decade) are not likely to be replicated in another.

2.3.2 The State and the South County Economies

Although the local economy responding to the power plant construction project is that of the State, interest focuses on the impact generated in the South County economy. The State was selected as the local responding economic area because it is large enough to contain inter-industry linkages which, by contrast, are barely represented within South County. Most local production is concentrated in and around Providence, the central city of the metropolitan area (SMSA). For example, the Rhode Island part of the SMSA includes most of the State manufacturers. The relevant data from the latest U.S. Census of Manufacturers, for 1977, are shown in the tabulation below:

	Rhode Island	R.I. Part of SMSA	Part of SMSA as % of State
Establishments	3,103	2,969	95.7
Employees (000)	125.7	119.1	94.7
Value of Shipments (millions of dollars)	5,410.5	5,135.2	94.9

By contrast, South County manufacturing employment accounted for about three percent of the State, in 1977. Further, not all Rhode Island industries are represented in South County.*

For these reasons, the local structure of production represents the Rhode Island economy, and the measures derived are allocated to the South County Region.

For purposes of analysis, the structure of production of the Rhode Island economy is classified into 28 industries, i.e.:

---

* Part of South County is included in the Providence SMSA. For further detail on the South County economy and its growth prospects, see the main report.

2	extractive industries
14	manufacturing industries
4	transportation, trade and service industries
2	subcontractors and fabricators
6	construction industries
28	total, Rhode Island economy

Further detail on the Rhode Island economy as used in the model is given in the Appendix.

2.4 Dynamic Considerations

2.4.1 Temporal Effects

The temporal characteristics of the power plant construction project were discussed in terms of their direct and indirect effects. It was suggested that some of the indirect effects on production and the use of labor may actually occur ahead of the construction project. In order to gain an insight into this phenomenon, consider briefly some production characteristics in their dynamic setting. Some industries produce ahead of demand by building up inventories. When orders arrive, goods are withdrawn from inventories for shipment. Most agricultural and mining industries, as well as many manufacturing industries, produce in this manner. Their products are usually standardized and are demanded by many other industries. On the other hand, some industries produce only in response to an order, and hence do not carry inventories of their products (e.g., the construction industry, metal fabricators of plate girders, precast concrete producers). Their products are generally specialized and they also produce customized items. There are also industries which produce in both modes, in anticipation and in response to demand; see Romanoff and Levine (1976).

To the extent that the construction industry operates in a responsive manner (in response to an order) and since power plant construction represents a highly specialized technology, many of the construction supplying industries (in the building material industries and equipment producers) also operate responsively. The suppliers to the building material industries, supplying the construction industries, usually operate in anticipation of an order by building up inventories of steel, cement, wire and similar products. However, because of the unique technology of nuclear power plant construction, requiring, say, steel beams of extra large size (to produce the plate girders of our example), and because only a few projects are undertaken at a time, and the technology itself is not fully standardized, there is no incentive to build up inventories for an uncertain market. As a result, heavier reliance is placed on responsive production, and because items may have to be specially ordered, their price may be higher than if they were standardized.

Further, inventory levels tend to fluctuate with the business cycle. At particular phases of the cycle, a sudden surge in the demand for products necessary for power plant construction projects may place an undue pressure on inventories, resulting in higher prices. Temporary shortages for specific products may also occur until producers operating in an anticipatory manner have had a chance to catch up with the backlog of orders by shifting to responsive production. Consequently, the dynamics of the impact may vary during the phases of the business cycle.

2.4.2 Dynamics of Impact

The above discussion suggests that because of the various temporal effects of power plant construction and its impact on the economy, the dynamics of impact will generate unique production chronologies for the affected industries and thus also employment chronologies. In measuring these effects, it must be underscored that the initial effects on the construction industries tend to generate their own distributional repercussions which cannot be directly estimated; for, as with many interdependent elements of complex systems, such as the industrialized economy of Rhode Island, indirect effects may have unforeseen consequences unless considered within the context of the entire system. The dynamic aspects of impact add further to this complexity.

To gain an insight into the dynamics of impact and the impact chronologies thus generated, consider the manner in which the economy responds to the stimulus of power plant construction. Here the production characteristics of industries operating in anticipation of demand are important, for they are responding to information on what this future demand is expected to be. Their production chronologies make it possible to gauge the duration of the lead time necessary to accommodate the construction demand of the project. The critical question is whether the information lead time about the project is of sufficient duration so that the economic system will be able to make the adjustments to the new levels of demand when they actually occur. Clearly, this depends on the various response times of the economic system, as well as the information lead time and involves not only the construction project of our concern here, but also other markets and the phase of the business cycle.

The above portrayed the economic system as an aggregate entity. A more detailed analysis would indicate that each industry must be so considered, and that some will have longer lead times than others, and that in some situations, production shortages may be found within the production network. See Appendix for further description of the model used in the analysis.

The total production chronology can be schematically depicted by building upon Figure 2-2. Summing up the production chronologies of these industries, the direct, indirect and total production chronologies are obtained. These are illustrated in Figure 2-3. The resulting production chronologies are influenced by the dynamics of the project construction cost schedule and the State structure of the production, and lead to the employment chronologies. These, in turn, determine the potential number of jobs that will be generated and their duration as shown in Chapter 3.

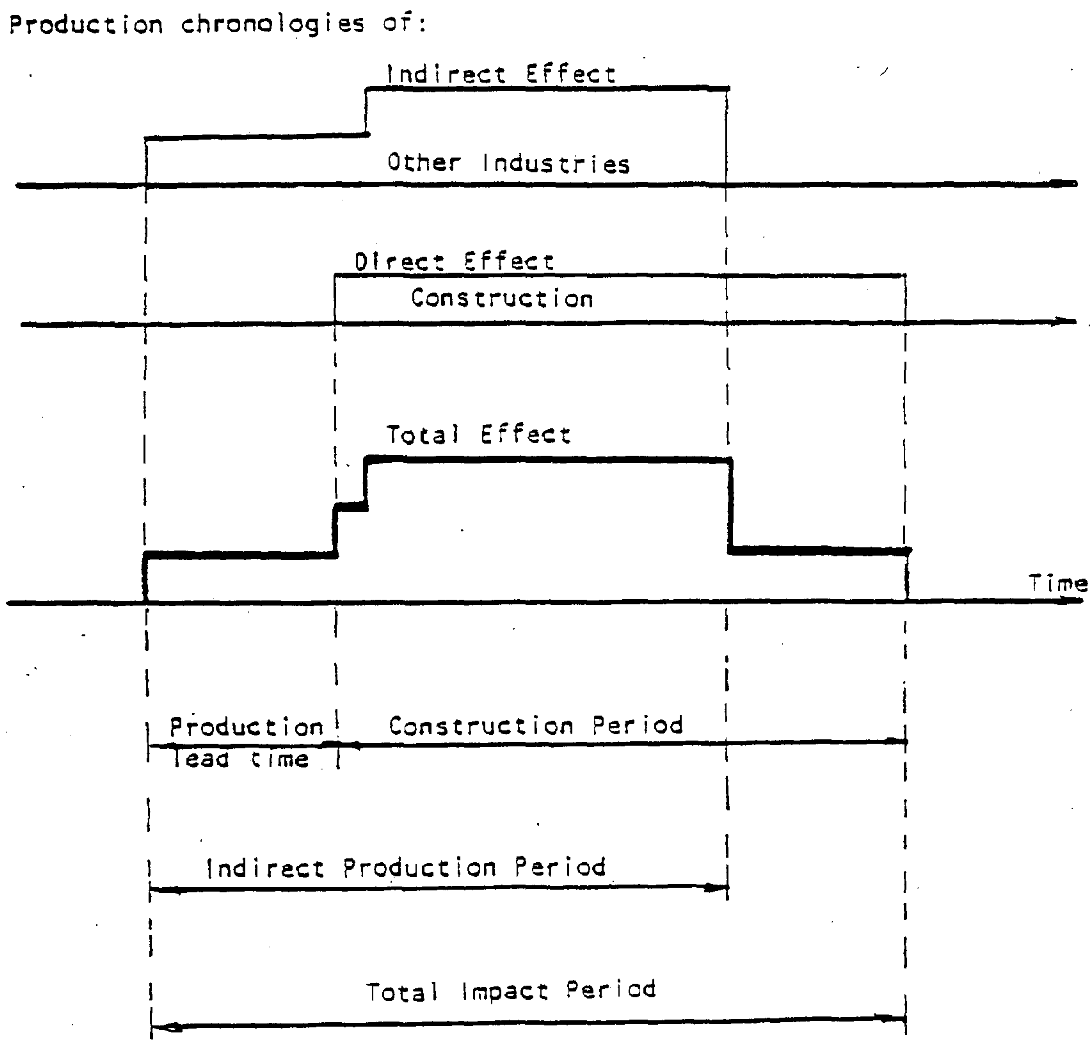


FIGURE 2-3: PRODUCTION CHRONOLOGIES AND IMPACT PERIODS OF DIRECT, INDIRECT AND TOTAL EFFECTS - SCHEMATIC ILLUSTRATION

3. SIMULATIONS OF IMPACT

3.1 Simulations of Some Important Features

3.1.1 Simulations

The simulations of the economic impact of the nuclear power plant are presented in this chapter in the context of scenarios in which the potentials for job creation and job duration are derived. The postponment in the construction of the power plant to 1995 requires the long-term estimation of events and their consequences which are expected to transpire 15 to 25 years from now. To do so, one must estimate the future characteristics of the construction project which will trigger the causal mechanisms to yield the impact, and the future characteristics of the structure of production of the Rhode Island economy which will generate the impact in response to the construction project. In order to achieve this task, use is made of simulations, which are sets of mathematical operations used to examine a series of situations which could well occur in practice. The use of simulations makes it possible to introduce and illustrate some of the impartant features of the economic impact dynamics as they may affect the South County Region.

3.1.2 Some Important Features

The simulations examine industry response to power plant construction. This involves both direct and indirect effects because of the interdependence of the Rhode Island economy. Because of the dynamic nature of the construction process and of the industries' adjustment to changes in demand, it is necessary to chart the chronology of the impact in terms of the fluctuations in industries' production which determine the demand for labor.

Such chronologies are generated in response to the Construction Cost Schedule (CCS), and imply adjustment paths which may be subject to several effects, including delays from the estimated to the actual or realized CCS. These chronologies suggest the use of simulations in the context of scenarios in which both the estimated CCS and the "realized" CCS are considered, and where component effects can be examined separately for each case.

The dynamically derived employment chronologies provide for the estimation of the impact of power plant construction on the employment potential in terms of:

(a) Job Creation, and

(b) Job Duration

Data of job creation by job duration when allocated to South County can thus be used to examine the implications of the dynamics of labor demand on the Region.

Accordingly, the simulations emphasize the impact on employment, involving the resulting employment chronologies and their implications in terms of job creation and job duration potentials, thereby indicating the ramifications of the impact on South County. Information on the project's impact on the seasonality of the Region is included. In this way, the issues raised by the proposed plant can be identified and their characteristics introduced; the issues involved in their solution can thus be examined in order to guide the coastal communities in the formulation of their timely policies by responding in advance of the hearings on the proposed project.

3.2 Scenarios

3.2.1 Simple Scenarios

Simple scenarios are presented to introduce and illustrate some of the key features of dynamic impact characteristics and the emerging issues involved. The use of scenarios enables the generation of the impact stemming from future events where only some aspects of the events can be forecast reliably, yet the evaluation of all relevant parameters must be undertaken. Another objective is to facilitate the simulation by focusing only on the measures of interest to this study. An important feature of the present scenarios is the incorporation of the dynamics of possible future events; they provide for the introduction and the examination of the two key issues noted earlier. It should be noted that scenarios are perceptions of possible future events.

Two scenarios are presented: Scenario A pertains to the estimated construction cost schedule to build the plant, as may be prepared by the utility. Scenario B pertains to the "realized" construction cost schedule, as may evolve during construction, and includes delay and added costs. As will be seen, the distinction between the impacts generated by these two construction cost schedules underscores one of the most important issues in this evaluation.

In the scenario, NEPCO 1 & 2 are scheduled for construction in 1995 or a few years later. Although originally the construction cost schedule, Table 2-2, was estimated at eleven years, in Scenario A the estimated construction cost schedule is set at eight years. The rationale for the shorter period stems mainly from two reasons. The first reason is based on the experience of the Three Mile Island episode, and the resulting inquiry; it may be reasonably expected that future NRC regulations and standards will be tightened and streamlined. In addition to improving on the safety of plants, the streamlining ought also enable the nuclear industry to shorten its construction period.

The other reason stems from foreseeable demographic trends, suggesting that, because of the decline in birth rates in the sixties and seventies, the population in working age groups is not likely to increase in the nineties as they did in the past few decades. Labor shortages may prevail, leading to increased automation in order to raise productivity. As a result, the demand for capital may continue the inflationary pressere, although not as severe as in the current experience. These inflationary pressures and the competition for scarce labor are likely to modify the technology of construction and shorten the construction period.

The scenario implies the possibility that, whereas currently the larger the number of employees required of a power plant construction project the more desirable it may be considered, by the turn of the century the reverse may hold. Projects requiring the least number of employees may be preferred.

3.2.2 Construction Cost Schedules

The Estimated Construction Cost Schedule, Scenario A. The Total estimated construction cost of the project is set at 1,546 million 1978 dollars, as shown in Table 2-2. By holding to this figure, it is possible

to approximate the future expected impact in terms best u
basis of current information. The total construction cos
among the three construction technologies in a manner desc
Section 2.2, i.e.:

	Million $
General and Structural Work	549
Mechanical Work	720
Electrical Work	277
Total Construction Cost	1,546

The estimated construction cost schedule for these three tech shown in Figure 3-1, where quarterly expenditure levels are i In order to clearly identify the seasonality issues, the proje at the beginning of the year so that the third quarter of each the life of the project represents the summer months.**

Consider the timing and duration of the three estimated te schedules shown in Figure 3-1. Construction starts with Genera Structural Work which lasts 32 quarters (eight years) to project tion. Mechanical Work starts four quarters (one year) after the of General and Structural Work, and terminates in the 28th quarte quarters ahead of project completion. Electrical Work starts at eighth quarter and terminates at the 30th quarter, two quarters ah estimated project completion.

In the scenario, the estimated CCS is designed to accommodate compensate for the seasonality of the South County economy. Seasc employment in South County for the 1976-1977 period yields the fol lowing when converted to a quarterly employment index (1st quarter 1.00):

* The scenario schedules are designed in general conformity with t on relative duration and timing of specific tasks in the constru nuclear power plants, given in DOL/DOE (1973).

** Quarterly data are used because of the long-term forecast invol the analysis and because quarterly data are judged to be better than monthly data for introducing the issues involved, particula seasonality.

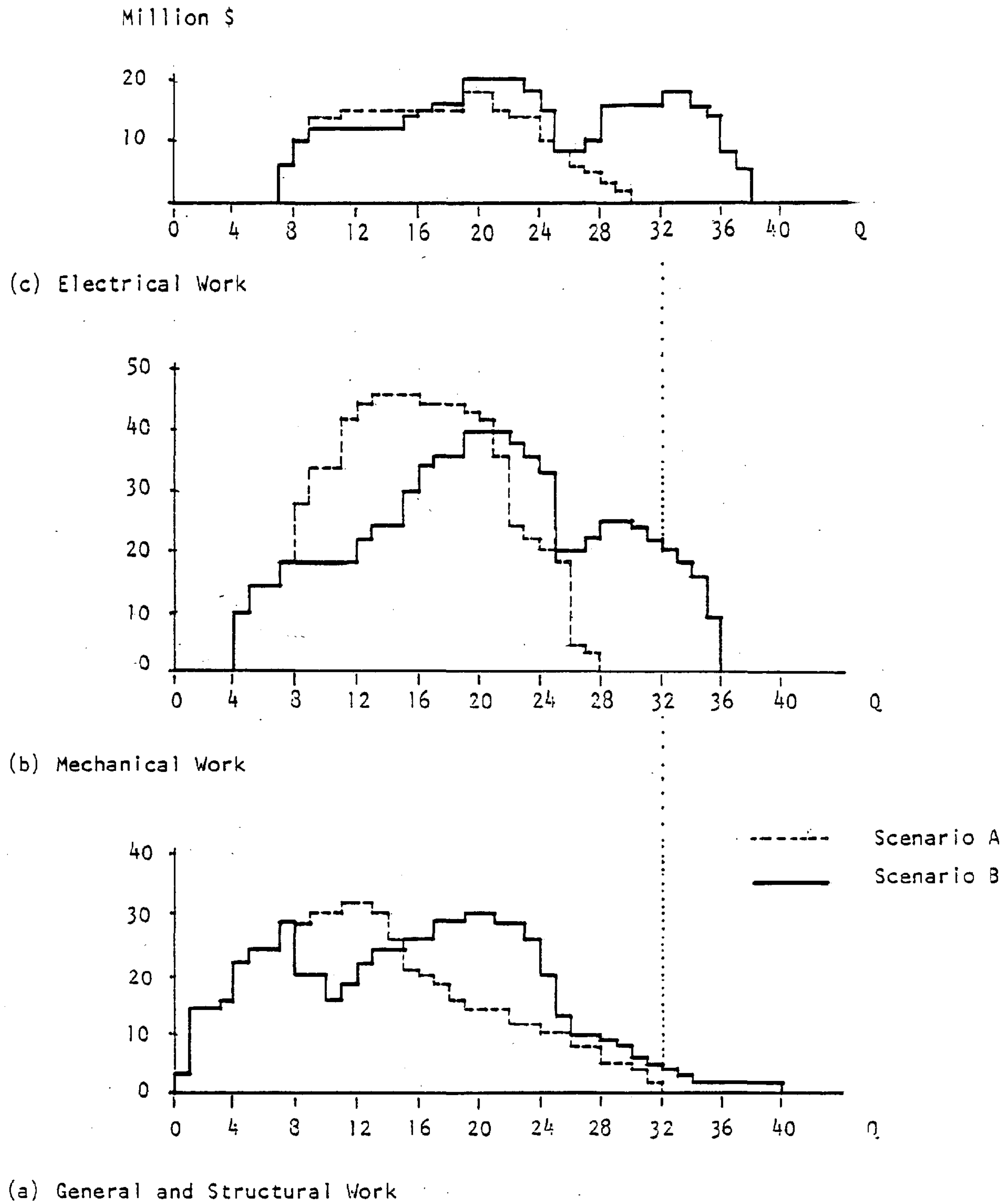


FIGURE 3-1 CONSTRUCTION COST SCHEDULES OF SCENARIOS A AND B

Quarter	Employment Index
First	1.00
Second	1.11
Third	1.24
Fourth	1.08

Accordingly, the estimated CCS is designed to compensate for the regional seasonality by using the following restrictions on the mean project quarterly expenditure levels (for the three technologies combined):

(a) Average of second and third quarter expenditure should be less than or equal to first quarter expenditure;

(b) Third quarter (summer) expenditure should be less than or at most equal to that of the second quarter;

(c) Fourth quarter expenditure may be larger than preceding first quarter expenditure (this is particularly important in the first few years of the project when construction accelerates);

(d) Restriction (b) should apply annually, as well as to the mean.

The resulting quarterly indices for the estimated CCS of Scenario A are:

Year	Q1	Q2	Q3	Q4
1	1.00	2.33	2.33	2.67
2	1.00	1.18	1.18	1.63
3	1.00	1.18	1.18	1.35
4	1.00	1.00	.96	.90
5	1.00	.97	.95	.95
6	1.00	.88	.66	.65
7	1.00	.90	.45	.40
8	1.00	.88	.50	.25
Project Mean	1.00	1.03	.92	.96
Mean Expenditure (1978 million dollars)	49.50	50.75	45.50	47.50

In this respect, the CCS is designed to accommodate the seasonality in the Region.

The Construction Cost Schedule of Scenario B. The use of scenarios makes it possible to simulate not only the impact resulting from the estimated construction cost schedule, but also from the "actual" or "realized" construction cost schedule. The latter evolves from the former because of delays and added costs. This "realized" CCS, which is described in Scenario B, is also shown in Figure 3-1.

The time-dependent ingredients of Scenario B are essential to impact analysis. Since delays and added costs are usually associated with the construction of nuclear power plants, the use of the estimated CCS will bias results. It is then necessary to estimate the impact resulting from the project "as built" rather than "as initially designed." This requirement adds further complexity to impact analysis, which must alter the initially estimated CCS by possible delays and added costs, which cannot be reliably forecast well ahead of construction at the time the impact study is undertaken and the project is evaluated. Scenarios are used to address this issue.

Out of many possible reasons for delays and added costs, one set is selected for representation in Scenario B. Two typical disturbances lead to the evolving CCS of Scenario B, consistent with the material presented in Chapter 2. One is the issuance of new federal regulations affecting the construction process; the other is a delay in delivery of supplies. The scenario thus foresees a set of fairly reasonable events. A more sophisticated evaluation will examine an array of such events for their possible implications.*

In Scenario B, the project begins and proceeds according to the estimated CCS of Scenario A for the first eight quarters. However, at the beginning of the ninth quarter, newly issued regulations affect the pace of construction of Mechanical Work. As a result, Mechanical Work cannot accelerate to the 28 million dollars originally estimated by beginning work on the second unit of the plant; it continues to operate for the next four quarters (the third year) at the level it did in the eighth quarter--18 million dollars. By that time, all necessary design modification, on-site corrections, and changes in orders to fabricators are

* In response to the announcement by the utility to withdraw its application, midcourse changes in study design necessitated the long-range evaluation; together with budget limitations, this precluded the more extensive examination.

accomplished so that by the 13th quarter, Mechanical Work begins to pick up the pace of construction.

This delay has its effects on the other two construction technologies. General and Structural Work is immediately affected; its pace of construction in the ninth quarter, which should have been at 28 million dollars, is dropped to 20 million, and by the summer of the eleventh quarter construction is decreased to 15 million dollars and then slowly picks up. The effect on Electrical Work is delayed by one quarter; in the tenth quarter its pace of construction is increased to 12 instead of 14 million dollars; this level is maintained for six quarters, and in the 16th quarter the pace of construction slowly begins to increase.

Another change in the construction cost schedule occurs on the 25th quarter in the life of the project. It affects first Electrical Work and involves delays in the delivery of modified equipment. Again, the other technologies are also affected, resulting in additional lengthening of schedule and in added costs.

As the result, the project schedule is lengthened by two years to ten years and the cost is increased by 310 million dollars to 1,856 million dollars. See Table 3-1 for the comparisons of costs and schedules between the CCSs of the three technologies in the scenarios.

The resulting quarterly indices for the CCS of Scenario B are:

Year	Q1	Q2	Q3	Q4
1	1.00	2.33	2.33	2.67
2	1.00	1.88	1.88	1.63
3	1.00	1.04	.96	1.00
4	1.00	1.07	1.07	1.25
5	1.00	1.07	1.07	1.20
6	1.00	.98	.96	.89
7	1.00	.60	.56	.62
8	1.00	.98	.92	.86
9	1.00	.93	.81	.60
10	1.00	.80	.20	.20
Project Mean	1.00	.98	.93	.98
Mean Expenditure (1978 million dollars)	4.77	46.70	44.40	46.80

TABLE 3-1

CONSTRUCTION COSTS AND SCHEDULES OF SCENARIOS A AND B COMPARED

Construction Technology	Scenario A	Scenario B	Percent Increase
	Cost (1978 Million Dollars)		
General and Structural	549	642	17
Mechanical	720	782	9
Electrical	277	432	56
Project, Total	1,546	1,856	20
	Schedule (Quarters)		
General and Structural	32	40	25
Mechanical	24	32	33
Electrical	23	31	35
Project, Total	32	40	25

The comparison of the project mean quarterly indices of the CCS shows that in both scenarios, the third quarter index is lower than for the first quarter, indicating the extent of accommodation of the project to the seasonality of the Region. Inspection of the mean third quarter expenditure for both scenarios shows that for Scenario B, the figure is lower by 1.1 million dollars than for Scenario A.

3.2.3 Third Quarter Project Cost and Regional Seasonal Construction

The organization of project cost on a quarterly basis also provides for a preliminary insight into the magnitude of the project relative to the regional seasonal economy. The measure is the increase in construction caused by the project relative to the level of construction the Region experienced in recent years. The level of construction expenditures in the Region during the summers of 1977 and 1978 is estimated at about 21 million dollars. By adding the project's yearly third quarter construction costs to the regional construction, and computing the percentages relative to the Regional level in the summers of 1977 and 1978, one can approximate the relative magnitude of the project's cost, and possible effect. The percentages for the CCS of both scenarios are presented in Table 3-2.

While doubling the regional summer construction expenditures may not cause excessive hardship, more than tripling that level is likely to affect the Region as discussed further in the text. These computations are based on the recent level of Regional construction; with growth and accelerated pace of Regional construction in the nineties, the Region is likely to experience severe strains for four or more summer seasons in the life of the project. This topic will be discussed again further in the text.

3.3 Impact Dynamics of the Power Plant Construction

3.3.1 Evaluation of Impacts

The results of the dynamic impact analysis are presented in this section. The analysis is based on the impact of the CCS in the scenarios on the Rhode Island economy. The resulting industry employment chronologies lead to the computations of the potentials of job creation and job duration, and to the repercussions on South County.

TABLE 3-2

PERCENT INCREASE IN SUMMER REGIONAL CONSTRUCTION EXPENDITURES RESULTING FROM THE PROJECT

Year	Scenario A	Scenario B
1	167	167
2	281	281
3	471	319
4	514	386
5	457	481
6	338	510
7	186	281
8	119	319
9	--	262
10	-	110
Mean	317	311

3.3.2 Comparison of Timing and Duration of Impacts

In order to bring into focus the dynamic impact characteristics expected by the project, the timing and duration of the impact resulting from the two CCS are presented in Figure 3-2 which shows the estimated schedule of Scenario A and the added time of Scenario B for each of the industries. The combined effects of the three construction technologies determine the timing and duration of impact on all Rhode Island producing industries and on the two subcontracting industries. Figure 3-2 complements the schematic illustration of Figure 2-2 and shows that a lead time of two quarters is required even though not all industries start production simultaneously.

Figure 3-2 also shows that the period of direct effects of construction is shorter than the period of indirect effects involving the other industries. The difference between these two periods is the production lead time. The corresponding periods for the two schedules are:

	Quarters of Impact	
	Scenario A	Scenario B
Direct Effects, Construction	32	40
Production Lead Time	2	2
Indirect Effects, R.I. Production	34	42
Total Impact Period	34	42

The production lead time means that the job creation process attributable to the nuclear power plant construction project begins two quarters ahead of construction. At that time, anticipatory producing industries in the State begin production to supply the project. In so doing, both anticipatory producers and their related service industries initiate the indirect demand for labor.

For both schedules the producing and service industries terminate production before or with the completion of the construction project. Toward the end of the project, producing industries engage in rebuilding their depleted inventories to desired levels. The schedules in Figure 3-2 help explain the employment chronologies involved.

3.3.3 Impact on Employment in Industry 9

In order to illustrate the dynamics of impact on a specific industry

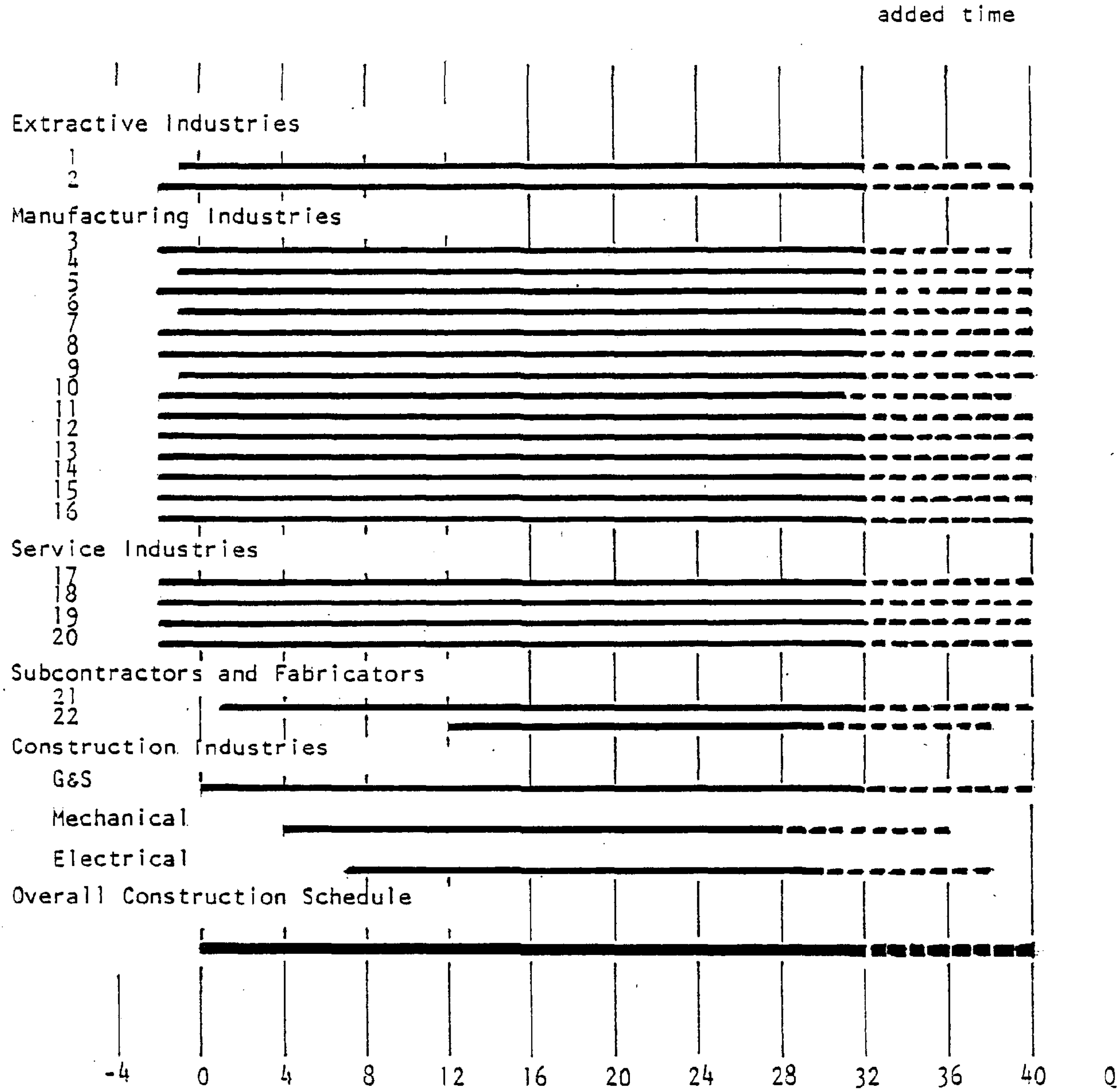


FIGURE 3-2 TIMING AND DURATION OF CONSTRUCTION SCHEDULES AND OF IMPACT.

demand for labor, consider Industry 9, Building Materials, group 2, and related products.* This industry was selected from among the manufacturing industries to underscore the importance of indirect effects and because it is greatly affected by the project. The production chronology for that industry generates its employment chronology; this, in turn, leads to the computations of the potentials for job creation and job duration. These computations are presented for both scenarios.

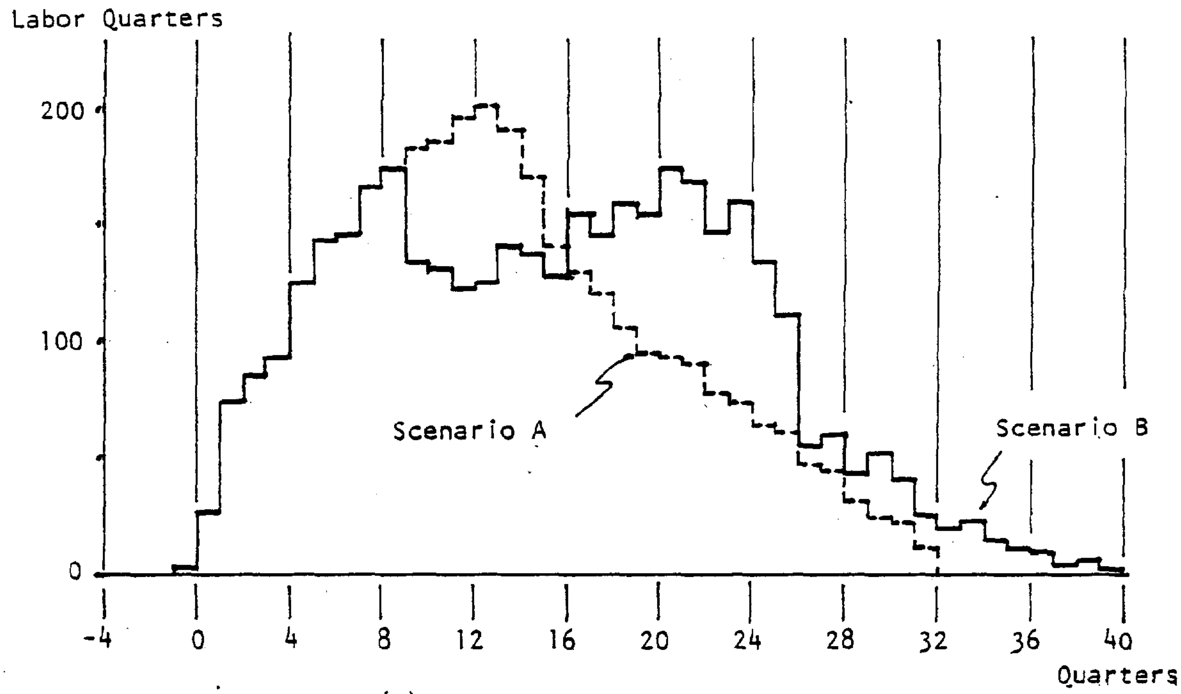
Industry 9 supplies mainly General and Structural Work and the subcontracting Industry 21. Its production for this project begins one quarter ahead of construction and terminates in Scenario A for the estimated CCS at the 32nd quarter, for a total of 33 quarters, or 8.25 years. In Scenario B, the industry terminates production in the 40th quarter, for a total of 41 quarters, or 10.25 years. In both scenarios, the industry supplies the project demand and rebuilds its inventories to desired levels at the end of the period. These schedules are shown in Figure 3-2. The industry employment chronologies are shown in Figure 3-3(a). The industry anticipatory production is shown in the figure; it produces and uses labor one quarter ahead of construction. In fact, the anticipatory behavior of that industry is exhibited even at the second quarter before construction starts. However, this initial demand can be met wholly from inventories, so that production is not required at that time. The industry production leadtime requires of it to accelerate production in the first two quarters of construction. Another large increase occurs in the fifth quarter in the life of the project with subsequent sporadic increases to the ninth quarter; this is when the schedule of Mechanical Work is affected according the Scenario B.

In Scenario A, Industry 9 peaks at the 13th quarter, even though the estimated CCS for General and Mechanical Work peaks at the 12th and 13th quarters (shown in Figure 3-1). This is because Industry 9 must also supply the subcontracting Industry 21 whose own production peaks at the 15th quarter, and it must have its inputs ahead of that time.

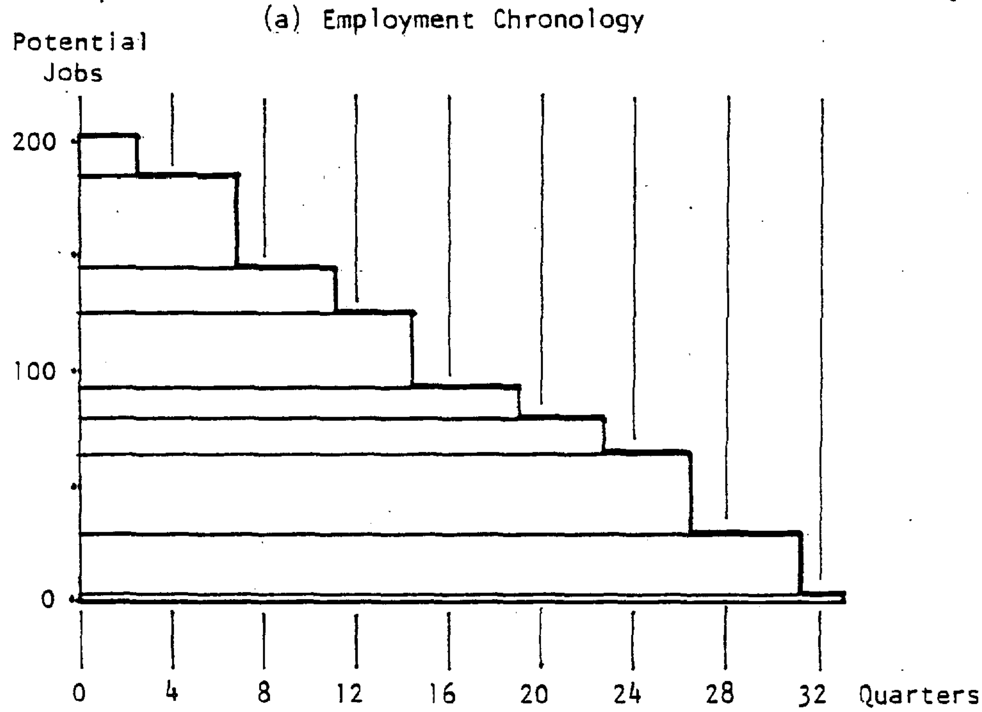
In Scenario B, the industry reaction to the change in pace of con-

---

* See Appendix for the description of industries used in the model.



(a) Employment Chronology



(b) Potential Jobs and Mean Job Duration, Scenario A

FIGURE 3-3 EMPLOYMENT CHRONOLOGY AND POTENTIAL JOBS
BY MEAN JOB DURATION, INDUSTRY 9

struction is delayed by one quarter. Although General and Structural Work curtails production simultaneously with Mechanical Work, Industry 9 responds to this change one quarter later, at the tenth quarter. At that time, it drastically curtails production and its demand for labor. Because of the subsequent revision in the CCS and the effort by General and Structural Work to catch up on lost time (which is also transmitted to Industry 21), the production chronology, and hence the employment chronology, of Industry 9 is fluctuating as it begins to increase production at the 13th quarter, peaking again at the 21st quarter. The second disturbance in Scenario B, occuring at the 25th quarter, affects Industry 9 at the 27th quarter, forcing it to reduce its production level more than it would otherwise do, to about one-half of the previous quarter. From there on, the industry decreases its production and the use of labor, since it must also reduce its excess inventory accumulated at the 26th quarter.

The two different employment chronologies shown in Figure 3-3(a) have their implications on the industry demand for labor for each scenario. The total labor demand by Industry 9 is:

Scenario	Labor-Quarters
A	3,460
B	3,880

Delays and added costs cause this industry to increase its demand for labor by 420 labor-quarters, or by about 12 percent. Yet, the potentials for job creation of both scenarios are not proportional to labor-quarters, for the demand varies during the construction period as depicted by the employment chronologies shown in Figure 3-3(a).

The number of potential jobs created by Industry 9 and their duration can be computed from the employment chronology ascribed to the project. For Scenario A, the employment chronology peaks at 202 labor-quarters during the 13th quarter, suggesting that the industry can employ 202 persons. However, in Scenario B, the employment chronology fluctuates, and although it peaks at 175 labor-quarters in the ninth quarter, it peaks again at 177 labor-quarters in the 21st quarter and also exhibits other minor peaks. Employment peaks are not a reliable measure to count potential jobs. A more careful evaluation of the potential for job creation exhibited by the employment chronologies must include the subtleties of fluctuation in production and by the various peaks. The evaluation must consider the shape of the employment chronologies which suggest the characteristics of the potential jobs. A simplifying assumption is made that the first hired is the last fired, according to the seniority principle. With this assumption, the distribution of job creation by job duration can be computed.

Using the information generated by Scenario A, the employment chronology shows that the industry peaks for one quarter at 202 man-quarters during the 13th quarter from the 198 man-quarters of the earlier quarter. This suggests the potential for (202-198) four one-quarter-long jobs. In similar fashion, the other short-term jobs are computed to yield:

Potential Jobs	Job Duration (Quarters)	Opening on (Quarter)	Labor Quarters
4	1	13	4
5	2	12	10
5	3	12	15
3	4	11	12
17	2.5		41

Thus, there are 17 potential jobs lasting up to one year with a mean job duration of 2.4 quarters for a total of 41 labor-quarters. The results of these computations are presented in Table 3-3, and shown in Figure 3-3(b).

For Scenario B, the computations are more complex, for they must include all short-term jobs offered throughout the production period. Because of the industry's fluctuating production in this scenario, the industry demand is for 105 jobs lasting up to one year; see Table 3-3.

The comparison between the potential jobs generated for the two scenarios shown in Table 3-3 reveals a difference of 63 jobs, or 31 percent more in Scenario B than in Scenario A. In this example, the percentage increase in potential jobs is larger than the 12 percent increase in labor-quarters shown earlier. In other industries these relationships may be different. Because of the different distribution of jobs by job duration obtained for the two scenarios, the 63 net additional jobs represent

TABLE 3-3

POTENTIAL JOB CREATION BY JOB DURATION IN INDUSTRY 9, SCENARIOS A AND B COMPARED

Duration Class (Quarters)	Scenario A Potential Jobs No.	Scenario A Potential Jobs %	Scenario A Mean Job Duration (Quarters)	Scenario B Potential Jobs No.	Scenario B Potential Jobs %	Scenario B Mean Job Duration (Quarters)
to 4.0	17	8.4	2.4	105	39.5	2.1
4.1 - 8.0	39	19.4	6.9	24	9.1	7.1
8.1 - 12.0	20	9.9	11.0	9	3.4	9.9
12.1 - 16.0	32	15.8	14.5	6	2.3	13.5
16.1 - 20.0	14	6.9	19.0	-	-	-
20.1 - 24.0	16	7.9	22.7	46	17.4	22.3
24.1 - 28.0	34	16.8	26.4	27	10.2	25.8
28.1 - 32.0	28	13.9	31.1	24	9.1	30.3
32.1 - 36.0	2	1.0	33.0	11	4.1	35.1
36.1 - 40.0				11	4.1	37.8
40.1 - 44.0				2	0.8	41.0
Total	202	100.0	17.1	265	100.0	14.6

gains and losses as shown in the following tabulation:

Job Duration Class (Quarters)	Difference in Number of Potential Jobs
to 4.0	+ 88
4.1 - 8.0	- 15
8.1 - 12.0	- 11
12.1 - 16.0	- 26
16.1 - 20.0	- 14
20.1 - 24.0	+ 30
24.1 - 28.0	- 7
28.1 - 32.0	- 4
32.0 - 36.0	+ 9
36.0 - 40.0	+ 11
40.1 - 44.0	+ 2
Total	+ 63

Although in Scenario B the industry demand for labor is higher than in Scenario A, and it offers more jobs, the change in the distribution of jobs by job duration means that the overall industry mean job duration decreases in Scenario B to 14.6 quarters (3.65 years) from the 17.1 quarters (4.28 years) of Scenario A.

3.3.4 The Impact on Employment Compared

The comparison between the impacts on employment generated by the two scenarios is presented in this subsection. While the impact on industry 9 was presented in some detail in order to introduce the reader to this method of evaluation, the impact on all other industries can be summarized. Although identical analysis are applied to each industry, it is the comparison between the data obtained by summarizing the results for each industry in each scenario which is impartant for the purpose of this study, particulary as applies to South County. Moreover, because of the long-range forecast embedded in the scenarios, the relationship between the magnitudes are more meaningful for policy analysis than the magnitudes themselves.

In the comparison, first, project aggregate quarterly employment multipliers are presented for each scenario. Next, direct effects on the potential for construction jobs are compared. Finally, the total effects are compared and the information is summarized for the evaluation of this impact on South County.

3.3.4.1 Aggregate Quarterly Employment Multipliers

Because of the dynamic fluctuations in employment chronologies, the static aggregate employment multiplier is inappropriate. Instead, aggregate quarterly employment multipliers are used. They indicate the ratio of total to direct labor-quarters at each quarter in the life of the project. The following tabulation shows the demand for aggregate direct, indirect and total manpower (in labor-quarters) during the first two years of construction, i.e.:

Season	Quarter	Labor-Quarters Direct (Construction)	Labor-Quarters Indirect (Other Industries)	Total	Aggregate Quarterly Employment Multiplier
Summer	-2		18	18	
	-1		111	111	
Winter	1	96	257	353	3.68
	2	310	329	639	2.06
Summer	3	448	364	812	1.81
	4	481	571	1052	2.18
Winter	5	763	776	1539	2.02
	6	1151	864	2015	1.75
Summer	7	1308	997	2305	1.76
	8	1535	1272	2807	1.83

These quarterly employment multipliers fluctuate with time; however, they are undefined for the two quarters of lead time before construction starts. Because the CCS were designed to accommodate the seasonality of South County, the interest is in the winter and summer multipliers; they are shown for both scenarios in Figure 3-4. The different dynamic characteristics of these scenarios can be observed in the figure, which also indicates the timing of the distrubances in Scenario B and the effect of these disturbances on production and hence on the multipliers.

3.3.4.2 Direct Effects Compared

For each scenario, the total manpower demand for the three construction technologies (industries) combined is:

Scenario	Labor-Quarters
A	58,100
B	69,600

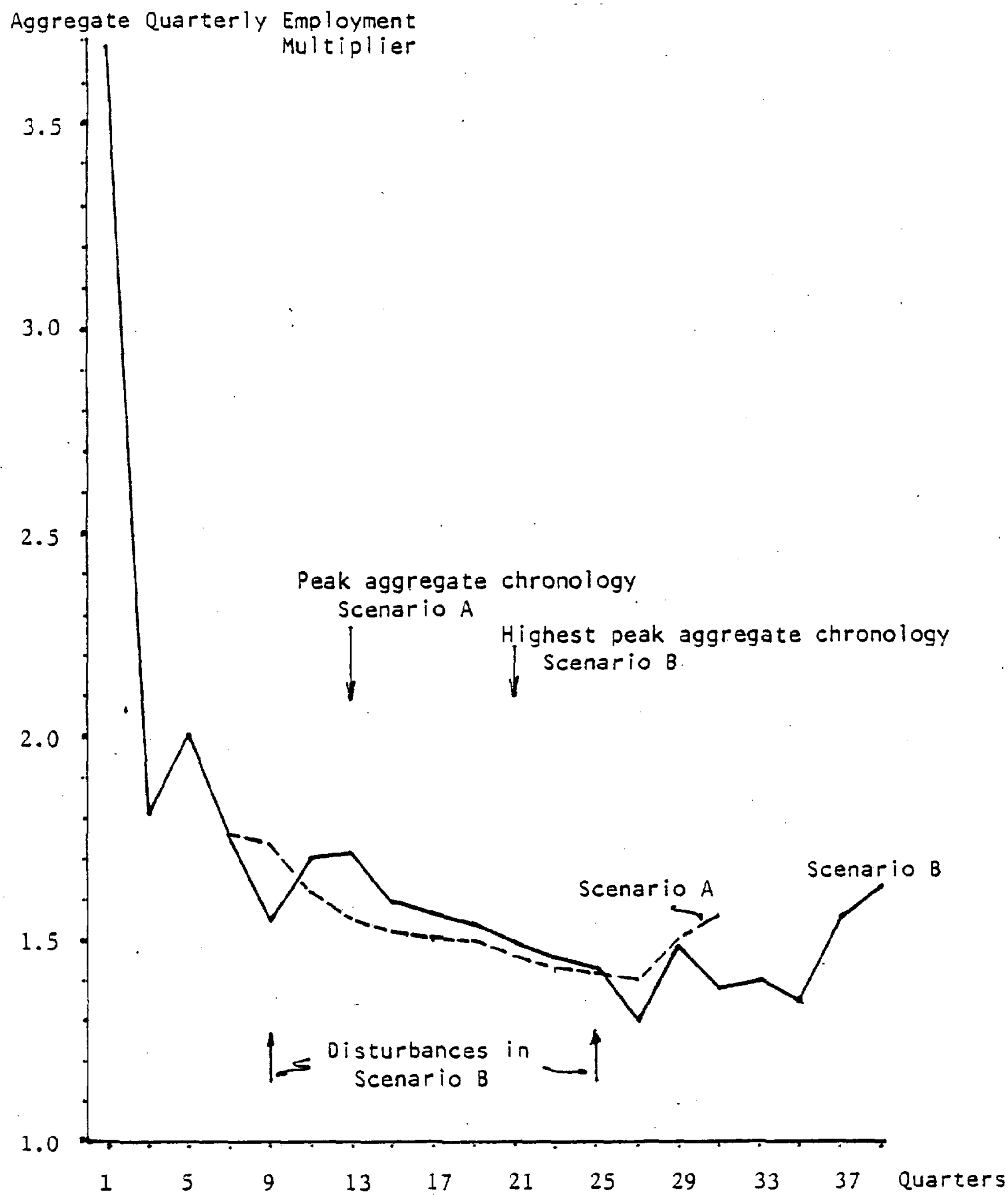


FIGURE 3-4, AGGREGATE QUARTERLY EMPLOYMENT MULTIPLIERS; WINTERS AND SUMMERS, SCENARIOS A AND B

That is, in Scenario B, the added time and cost generate 11,500 additional labor quarters, or an increase of 19.8 percent over Scenario A. The total labor demand per dollar construction cost for the two scenarios is:

Scenario	Labor-Quarter/Million 1978 Construction Dollar		
A	58,100/1,546	=	37.58
B	69,600/1,856	=	36.50

These figures suggest that, all other things being equal, Scenario A is slightly more labor intensive than Scenario B.

However, this partial and static evaluation neglects the dynamics of impact in terms of the implications of the changes in the construction cost schedule on the potential jobs generated and on job duration. These are shown in Table 3-4, suggesting that, although Scenario B contains more potential jobs when compared with Scenario A, the added costs and delays significantly alter the distribution of potential jobs by job duration. For both scenarios, the overall measure of mean job duration is 15.9 quarters, or almost four years, suggesting for Scenario A, where the project is to last eight years, that the project mean job duration is about half as long as the construction project itself. For Scenario B, where, because of delays and added costs the construction project is lengthened to ten years, the mean job duration is only about four-tenths as long as the construction project.

Because many ordinary construction projects last up to two years and they employ many of the occupations associated with this project, it is worthwhile to single out jobs lasting up to two years in the evaluation. Indeed, inspection of the percentages shown in Table 3-4 raveals that short-term jobs lasting up to two years accounted for 14.5 and 36.3 respectively in the scenarios, suggesting the more than doubling of the proportion of such short-term jobs in Scenario B. These added 1,057 short-term jobs for the total of 1,590, do not appear to add to the stability of the construction job market. The project demand for these jobs may compete with and distort the construction labor market for the other ordinary construction projects throughout the state, including South County, for six to seven central years of the construction period of Scenario B.

TABLE 3-4

POTENTIAL JOB CREATION AND MEAN JOB DURATION IN CONSTRUCTION:
SCENARIOS A AND B COMPARED
(DIRECT EFFECTS)

Duration Class (Quarters)	Scenario A Potential Jobs (No.)	(%)	Mean Job Duration (Quarters)	Scenario B Potential Jobs (No.)	(%)	Mean Job Duration (Quarters)	Difference B-A (Jobs)
to 4.0	298	8.1	2.3	820	18.7	2.7	+ 522
4.1 - 8.0	235	6.4	6.9	770	17.6	6.7	+ 535
8.1 - 12.0	680	18.6	10.4	724	16.5	10.2	+ 44
12.1 - 16.0	729	19.9	14.2	228	5.2	13.1	- 501
16.1 - 20.0	578	15.8	18.2	177	4.0	18.0	- 401
20.1 - 24.0	789	21.6	22.1	231	5.3	22.5	- 558
24.1 - 28.0	124	3.4	26.4	300	6.9	26.7	+ 176
28.1 - 32.0	227	6.2	31.2	1,010	23.1	30.4	+ 783
32.1 - 36.0				53	1.2	32.4	+ 53
36.1 - 40.0				67	1.5	39.5	+ 67
Total	3,660	100.0	15.9	4,380	100.0	15.9	+ 720

3.3.4.3 <u>Total Effects Compared</u>

Because the concern of this study is with the effects of the project on South County, the information generated by the analytical model can be further summarized for the purpose of the evaluation at hand. For this purpose, distinctions are made among three kinds of potential jobs classified by job duration. Short-term jobs are those lasting up to two years. As earlier indicated, these jobs do not add to the long-term stability of the construction job market, they may compete with other construction projects, and their relative short term may either accentuate or smooth the employment fluctuations associated with the business cycle. Intermediate-length jobs are those lasting for more than two and up to six years (from nine to 24 quarters). Long-term jobs are those lasting more than six years (25 or more quarters). The six-year cut-off was selected for two reasons. The schedule of many of the large and complex construction projects is usually more than six years. These projects are traditionally considered as bringing stability to the construction labor market. More importantly for this study, the six-year limit is the time required for a pupil to pass through an elementary or secondary school. Because of these considerations, an assumption is made that some of those employed in jobs of more than six years may wish to locate in South County.

The distinction among short-, intermediate- and long-term jobs is also useful to the understanding of the impact of construction delays. For the data presented for the two scenarios in Table 3-4 suggest that the net 720 additional construction jobs of Scenario B appear to be approximately equally divided between short-term jobs (lasting up to two years) and long-term jobs (of more than six years). The reallocation of jobs may differ for other scenarios involving delays and added cost. Generally, however, it is reasonable to expect project delays and added cost to affect labor unequally: some potential jobs are lengthened and others shortened while in the aggregage, more jobs are offered suggesting, perhaps, employment opportunities to more persons.

For industry 9, the data presented earlier suggest the following reallocation of jobs because of delays and added costs:

Job Duration (Years)	Scenario A	Scenario B	Difference
Short (up to 2)	56	129	+ 73
Intermediate (3-6)	82	61	- 21
Long (more than 6)	64	75	+ 11
Total	202	265	+ 63

The relevant data for the total effect on long-term jobs distinguishing between direct and indirect effects in both scenarios are shown in Table 3-5. Inspection of the table suggests that the project may generate between 351 and 1,430 long-term construction jobs, representing the direct effects, and between 306 and 544 long-term jobs in the other industries, representing indirect effects. These are the relevant data for subsequent evaluation of the impact on South County.

3.3.5 The Potential for Job Creation and Actual Employment

A note on the interpretation of the results presented is in order. Not all of the many potential short-term jobs are likely to be realized, for two reasons. First, to the extent that the impact analysis estimates the demand created in order for an industry to supply the project, the estimates represent only a portion of each industry total production at each quarter, for the industry also produces to supply other markets. Thus, the estimated demand attributable to the project must be combined by the industry with the demand originating with these other markets. The industry can then combine some of the short-term jobs for the project with others to obtain longer-term jobs. Second, for a variety of reasons producers are often reluctant to hire many employees for short-term periods. Instead, they may opt for overtime work with their current workforce during periods of peak production. In this way, the effective number of short-term job openings may also be reduced.*

In turn, these considerations lead to the broader question of reconciling labor supply with demand. The possible scarcity of labor foreseen for the nineties may mean that some delays may occur in filling positions, and that not all potential job openings may be filled. These, too, may have their repercussions on the number of persons employed, on their overtime load, on wage rates, and on related manpower issues. In extreme

* The analysis presented may suggest the extent of possible overtime work.

TABLE 3-5

TOTAL EFFECT ON LONG-TERM JOBS COMPARED

Industry	24.1-28.0	28.1-32.0	32.1-36.0	36.1-40.0	40.1-44.0	Total 24.1-44.0
	Long-Term Duration Class (Quarters)					
Scenario A						
1 - 16	61	38	11	-	-	110
17 - 20	69	51	10	-	-	125
21 - 22	51	20	-	-	-	71
Indirect	181	104	21	-	-	306
Direct, const.	124	227	-	-	-	351
Total	305	331	21	-	-	657
Scenario B						
1 - 16	41	98	82	11	13	245
17 - 20	7	31	75	50	10	173
21 - 22	22	54	44	6	-	126
Indirect	70	183	201	67	23	544
Direct, const.	300	1,010	53	67	-	1,430
Total	370	1,193	254	134	23	1,974
Difference (B-A)						
Indirect	-111	+ 79	+180	+ 67	+ 23	+ 238
Direct, const.	+176	+783	+ 53	+ 67	-	+1,079
Total	+ 65	+862	+233	+134	+ 23	+1,317

situations, possible additional delays in construction may also occur.

Further, the reconciliation of labor demand and supply must distinguish among occupations, for the demand for welders cannot be met with carpenters. The evaluation must then consider the occupational composition of the potential for job creation, thereby adding another dimension to the measure of job creation, in addition to job duration and timing.

Finally, there remains the issue of accommodating specific groups among the unemployed: the unskilled, minorities, women and other segments of the labor force, for some of which specific legislation applies. The reconciliation of labor supply and demand, including these legislative requirements, state manpower policies with regard to the project and union rules, help determine the persons to be employed.* These issues should be re-examined nearer the date at which the utility is expected to resubmit its application.

3.4 Impact of Power Plant Operations on Employment

With the completion of construction and the interim period of plant pre-testing and start-up, the plant is ready for normal operation. The level of manpower demand is expected to stabilize in the requirements for normal plant operation and maintenance. These requirements are estimated to reach a stable level five years after completion of construction, or around the year 2010. Due to the long time interval imposed on the long-range forecasts, plant operation and maintenance personnel requirements may change from those estimated in the seventies. For purposes of this study, personnel requirements are estimated in the range of 200 - 250 jobs. These are the direct labor effects. The indirect labor effects for employees engaged in supplying the power plant with goods and services necessary for its operation are then added. With the continuing economic development of South County as further stimulated by the power plant, it is assumed that about one-third of the indirect manpower requirements will be in establishments located in the region, i.e., 20 - 33 jobs.

Thus, the total effect of the plant's operation on South County is summarized as follows:

---

* For a discussion of the Rhode Island manpower policies regarding the project, see Callaghan and Comerford (1978).

Effect	Jobs
Direct	200 - 250
Indirect	20 - 33
Total	220 - 283

These are expected to last for the useful life of the facility, originally estimated at 40 years. Most of the jobholders are expected to reside in South County.

4. IMPLICATIONS FOR SOUTH COUNTY

4.1 General Remarks

Several references have been made in this report concerning the impact of the power plant on South County. These will now be brought together in order to emphasize two of the facets of impact implications for the Region. These are:

a) the effects of the potential long-term jobs on migration of workers to South County, and

b) the effects of summer commuting to the construction site.

These, in turn, may suggest an insight into regional growth prospects as may be stimulated by the project. Finally, the examination of these ramifications can suggest the future options for the timely formulation of mitigation strategies and for the development of accommodations plans.

In developing the scenarios, a key assumption was made that the utility will mold its construction cost schedule to accommodate the seasonal economy of South County. This accommodation in the Construction Cost Schedule was shown to mitigate some of the adverse effects of the pressure of construction as may find their expression in the competition for the use of highways in the Region and in the demand for short-term construction jobs. In the main report of this study, Volume 2, Regional construction employment was shown to be linked with tourist trade. Because of the small construction labor pool in the Region, it is estimated that the demand for short-term construction jobs will be filled mostly from the labor force rolls in Providence, with only minor local recruiting. Even this minor recruiting may cause a local scarcity of construction labor and commensurately increased wage rates. These, in turn, may lead to difficulty in undertaking local new and repair construction catering to tourist trade and to difficulty in sustaining the development of the Region. This is one of the issues that must be addressed by the Region at the proper time.

4.2 Long-Term Jobs and Migration to South County

Some of those employed in the long-term jobs created by the project may locate in South County. Most of the construction employees are likely to be employed at the project site. For them, living in South County offers the advantage of a shorter work trip compared with a ride from the Providence area. The place of employment of those in the other industries supplying construction may be anywhere within Rhode Island; they are most likely to be concentrated within the inner part of Providence SMSA. However, among those employed in Providence and in the towns on the western side of Narragansett Bay with a job security of over six years, some may find it advantageous to move to South County. For these reasons, the percentage of long-term job holders likely to move to South County is estimated to be higher among construction employees (counted in the direct effects) than among those employed in the other industries and counted among the indirect effects. The percentages of long-term jobholders estimated to move to South County are as follows:

Effect	Percent of Long-Term Jobs
Direct	12 (range of 10 - 15)
Indirect	5 (range of 3 - 8)

These suggest that the number of jobholders moving to South County according to Scenario A are estimated as follows:

Effect	Total	Moving to South County
Direct	351	42
Indirect	306	15
Total	657	57

For Scenario B, the corresponding estimates are:

Effect	Total	Moving to South County
Direct	1,430	172
Indirect	544	27
Total	1,974	199, say 200

That is, Scenario B shows 143 more moving to South County than does Scenario A.

Because of the variations in job duration, the advantages of moving to South County will be greater during the early years in the life of the project. As the project accelerates in the first two years, those who may find moving advantageous will do well to move as soon as they can. In Scenario A, during the third year in the life of the project, only a few will still find it advantageous to move, since the six-year horizon extends beyond project completion. Thus, for Scenario A, the timing of the estimated number of long-term jobholders moving to South County is:

First Year	17
Second Year	29
Third Year	11
Total	57

Estimating the timing of the move to South County for Scenario B is much more complex. This is because the disturbance in Scenario B occurs at the ninth quarter by which time (17 + 29 =) 46 of those moving are already in South County. Yet, the interpretation of the event as it affects the lengthening of the project involves various subtleties in the way people perceive events (and specifically sudden events) and respond accordingly. While a much more sophisticated mode of analysis is required than falls within the confines of this study, a first approximation can be offered. For simplicity, it is assumed that the addition of 143 moving to South County in Scenario B exhibit similar propensities to move as do those in Scenario A, except that their timing is associated with the third, fourth and fifth years of the project. Accordingly, this simple first approximation suggests the following schedule of moves:

Project Year	Scenario A	Difference (B-A)	Scenario B	Percent of B
1	17		17	8.5
2	29		29	14.5
3	11	43	54	27.0
4		72	72	36.0
5		28	28	14.0
Total	57	143	200	100.0

Assuming each long-term moving jobholder requires a housing unit, the estimate shows a peak demand for 72 housing units during the fourth year of the project. For comparison, these 72 housing units represent 10.7 percent of the total number of housing units for which building permits were granted in 1978.

4.3 Summer Commuting to the Construction Site

The aggregate construction employment chronology suggests the number of construction workers commuting to the project site. These estimates are presented for the summer quarters, the most critical in view of the South County tourist season, when local traffic peaks with the arrival of tourists. The estimates pertain to construction workers commuting to the project site from outside of South County during the third quarter of each year, mostly from Providence and nearby towns. It has been estimated that most construction workers reside in Providence and nearby towns; see Callaghan and Comerford (1978).

The number of commuting construction workers are presented for both scenarios, estimated by subtracting from the total labor-quarters of each summer: (a) the estimated number of construction workers residing in South County at the time, and (b) the estimated number of off-site construction employees, adjusted for those residing in South County.* The

---

* Estimates of those residing in South County are computed as: number of those moving in the previous year or years plus one half of those moving in the current year, except for the last year where all those currently moving are included.

The estimated number of off-site construction workers adjusted for those residing in South County are computed as follows: for Scenario A, off-site construction workers are first estimated at 10% of the jobs lasting five and six years and 20% of the jobs lasting seven and eight years, for a rounded total of 210 jobs, accounting for 5.7 percent of total construction jobs and about 8.4 percent of total labor-quarters. Of these, those lasting more than six years are adjusted to exclude those moving to South County at the rates previously used. The non-moving off-site workers are assumed to be employed during the first year of the project and their number declines according to their job duration. The estimate of 210 off-site construction employees from Scenario A applies to Scenario B until the ninth quarter, at which time the first disturbance occurs. The new regulations of Scenario B require modification in specifications, plans, change orders and related work performed off site. Consequently, 40 additional off-site employees are hired for short-term assignments (mostly two years). The second disturbance in Scenario B does not involve additional off-site employees. The resulting off-site employment chronology which is modified by lengthening job duration, is then adjusted to exclude those moving to South County at the rates assumed. For example, during the first summer season there are a total of 448 labor quarters from which: (a) 17/2 = 9 are deducted to exclude those moving, and (b) 65 are deducted to exclude off-site employees who do not move to South County; i.e., 448 - 9 - 64 = 375. The resulting figures are then rounded to the nearest ten, or 380 in this example.

number of construction workers commuting daily from outside South County to the project during the summer quarters is shown for both scenarios in Table 4-1.

These data suggest that commuting by car is likely to seriously affect the traffic flow in the Region. Alternatively, special bus commuting can be initiated, associated with parking restrictions at the site for those living outside the Region. The corresponding estimate of required buses are also presented in Table 4-1.*

The estimates presented in Table 4-1 suggest the extent of traffic problems that may be encountered in South County. Because construction workers commute in the direction reverse to the normal commuting traffic in South County, it is roughly estimated that a load of less than 30 buses may not cause significant traffic hardship. However, in seasons when 30 or more buses are expected to roll each morning and evening during the summer months, the Region may experience difficulties in handling the spurts of traffic flow.

For Scenario A, traffic pressures may be felt during four of the summers, while for Scenario B, the difficulties may be expected for three of the summers.

These estimates pertain only to traffic loads of commuting workers from outside the Region. In addition, traffic ought to be added resulting from the delivery of construction materials, supplies and machinery, the delivery and return of construction equipment, and the flow of vehicles used by maintenance inspection and management personnel. Although the model may be used to estimate the quantity of materials required at the site, the corresponding additional traffic estimates will have to be undertaken at a later date, closer to project permit application. Because of the changing structure of energy prices, the mix in the type of vehicles used in construction may change during the coming decades.

The data presented in Table 4-1 outline the extent of the traffic

* The number of buses was estimated using a 50-person/bus load factor, rounded to the next full number. These are based on the foreseeable bus capacity of 45-55 persons/bus in the eighties. Improved bus designs for the nineties may increase capacity.

TABLE 4-1

ESTIMATED DAILY NUMBER OF CONSTRUCTION WORKERS
COMMUTING TO THE PROJECT DURING SUMMER QUARTERS

Year	Summer Quarter	Scenario A Persons	Scenario A Buses	Scenario B Persons	Scenario B Buses
1	3	380	8	380	8
2	7	1,220	25	1,220	25
3	11	2,620	53	1,360	28
4	15	3,050	61	3,720	35
5	19	2,620	53	2,420	49
6	23	1,980	40	2,680	54
7	27	920	19	2,290	24
8	31	70	2	2,360	28
9	35			2,030	21
10	39			(a)	2

(a) Number of those moving and off-site construction workers approximately equals the total number of workers that season.

problems which can be expected because of the project. Here, several mitigation strategies can reduce the severity of the problem. One is the reliance on rail transportation. Because of the need to deliver supplies to the project, the construction of a railroad spur to the site will alleviate most of the traffic problems associated with the delivery of goods and can partly alleviate the problem of transporting workers. A four-car commuting train can transport about 400 workers.

Another mitigation strategy is the staggering of working hours and the use of flexi-time work policies. These tend to lengthen the daily period during which commuters arrive at the site, and thereby lessen traffic congestion and possible hazards. A combination of both strategies ought to be employed as another alternative.

The delivery of materials and supplies carried on the Region's highways, as distinguished from those delivered on a railroad spur, need to be addressed. At least some of the summertime deliveries can be scheduled for earlier shipment. Included are the bulky sand and gravel to be shipped from nearby quarries and the cement most likely to be shipped from outside New England, all required for the on-site mixing of concrete.*

4.4 Growth Propects

Regional growth prospects stimulated by the project may be characterized as those stemming from the plant construction and operation and those which may be influenced by the presence of the plant in South County. Growth stemming from plant construction and operation is primarily associated with employees locating in South County.** As noted earlier, some of those associated with plant construction were expected to move to the Region in the early years of construction; for Scenario B it was estimated that 200 would move during the first five years. In Section 3.4 it was

* Because of the project's size and duration, a concrete mixing plant is usually built on site, resulting in savings in construction cost. Similarly, temporary eating accommodations are installed, suggesting that only a few of the project employees will patronize the Region's restaurants and other eating and drinking places.

** Other growth effects such as some expansion in restaurant and lodging to accommodate visiting personnel are excluded at this time. These are estimated to exhibit lesser effects than those selected for examiniation.

estimated that 220 to 238 were associated with plant operations in South County. For simplicity, the mid-value of 252 persons is used. For Scenario B they can be expected to locate from the eighth to the 15th year, by which time the start-up phase is completed and the plant is settled into a stable level of operation. Thus, because of plant construction and operations, migration into the Region occurs in two phases: the first during the first five years, and the second starting the the eighth year and lasting perhaps eight years.

This slow, *pulsating migration* as it were, viewed in terms of Regional growth processes, represents the direct effect associated with the project. Growth due to the indirect effect ought to be added to account for the increase in the demand for various local services in the private and public sectors caused by those moving into the Region. The indirect growth component is to occur at the turn of the century and beyond, and ought to be viewed in a broader context of regional growth expected then. Since regional growth rates are less predictable as the time horizon increases, no estimate of indirect growth is provided at this time. It is noted here only for completeness.

Growth may also be influenced by the location of the power plant in South County. Because of the foreseeable rise in energy prices and the need for energy conservation, it appears that future industrial locational patterns may become more sensitive to the location of energy sources. This is because the transmission of electricity involves a power loss approximately as tabulated in Table 4-2. The power loss shown is approximate because it will vary with transmission line design and configurations. The location of energy-intensive manufacturing plants in the proximity of power plants reduces the system power loss, resulting on the one hand in overall energy savings and possible economies in the rate structure and in possible slowing of the pace of power plant additions as the demand for electricity grows with time. On the other hand, the reduction in systems power loss may offer the newly locating energy-intensive manufacturing plants discounts in the price of energy, thus making it possible for at least some of them to locate in Rhode Island.*

* For an examination of the decline of energy-intensive manufacturing in New England and the resulting effect on total manufacturing employemt, see Romanoff (1976), and for an interregional examination of energy costs in manufacturing production, see Romanoff, Ahmed and Davis (1978).

TABLE 4-2

APPROXIMATE TRANSMISSION POWER LOSS
WITH DISTANCE

Distance from Generator (miles)	Percent Power Loss Approx. Median[a]	Range
25	2.0	0.4 - 3.9
50	3.9	0.8 - 7.7
100	7.7	1.6 - 14.8
150	11.3	2.4 - 21.3

[a] 'Dove' bare aluminum steel-reinforced conductor

Source: Stevenson (1975)

These locational effects are likely to become even more critical if the outer continental shelf (OCS) explorations off New England waters are successful. For Rhode Island to capture its share of the anticipated growth in the processing of oil and gas and in the associated petrochemical manufacturing, the State will have to examine industrial location policies. These considerations suggest the preferable location of energy-intensive manufacturing plants in the proximity of the power plant, e.g., within a 25-mile radius. The foregoing together with the anticipated impact of outer continental shelf explorations still to be examined can be only briefly sketched out at this time. However, they suggest the prospect for industrial development in South County itself or in nearby towns with consequent additional population growth in the Region.

These growth prospects are schematically illustrated in Figure 4-1. The two phases of growth associated with plant construction and operations are shown in Figure 4-1(a), while the total growth discussed in this section is roughly shown in Figure 4-1(b). The figures show two growth waves in number of workers moving to South County and hence in the demand for housing units. Other future growth prospects will generate other growth waves. However, three common features appear to pertain independently of the scenario selected:

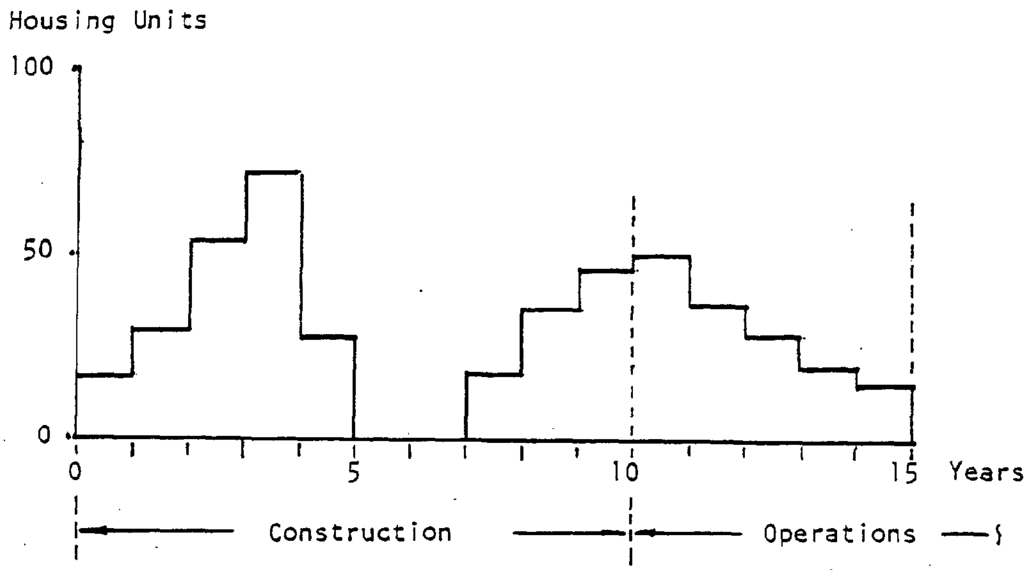
(a) The construction-related growth wave is likley to be distinguishable from those stemming from other effects.

(b) The duration of these growth waves may be similar to that of business cycles, may either accentuate or smooth the local effect of business cycles of that time, and may also be modified by the business cycles.

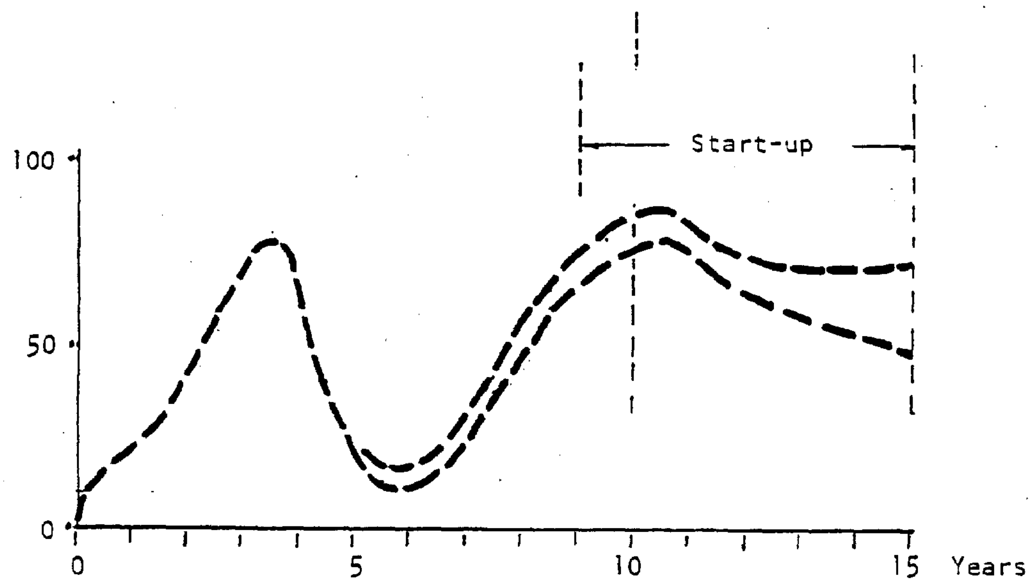
(c) Each of the waves is likely to contribute only a fraction of the total annual growth of the Region. The cumulative effect of the second wave appears to be larger than that of the first, and if industrial growth is to take place, it may continue well beyond the time shown.

Although the effects described may be quite small relative to the total annual growth of the Region it is important to recognize that their cumulative effects are likely to contribute measurably to the pressure for the urban transformation of South County by the next decade.

The growth described is not likely to be concentrated in the town in which the utility decides to build its plant. Rather, the growth is likely



(a) Construction and Operations



(b) Total Growth (Schematic)

FIGURE 4-1, REGIONAL GROWTH WAVES IN THE DEMAND FOR HOUSING UNITS to take place throughout the Region. Those employed at the power plant are likely to locate within a convenient commuting distance, in neighborhoods where affordable housing can be acquired and where the range of services offered is consistent with the expectation of the newly locating families (e.g., good schools, the variety in nearby shopping, access to various nearby services and recreation facilities, and proximity to public transportation). Should the plant be located in Westerly, it is reasonable to expect that part of the growth will be directed to the neighboring Connecticut towns.

4.5 Ramifications and Future Options

The dynamic impact analysis examined several facets of the implications of building a nuclear power plant in South County. The examination was undertaken from the vantage point of South County as distinguished from utility-sponsored impact analysis. Utility-sponsored impact analysis addresses mainly the effects generated by the proposed plant design options, and the material is organized with the aim of winning approval of the proposed project at public hearings held by regulatory agencies. By contrast, the objective of impact analysis under the Coastal Energy Impact Program is different: the purpose is to evaluate the effects of an energy-related proposal in terms of its repercussions on the coastal zone communities should the project be approved, rather than with the totality of the effects wherever they may fall. The evaluation of these effects ought then suggest the coordinating mechanism among the towns themselves and the various levels of government for the mitigation of adverse effects and the development of accommodation plans. The extra lead time afforded by the postponement in the application for plant construction provides South County with a unique opportunity other communities normally do not have: namely, time for advance preparation.

The Coastal Energy Impact Program stresses intergovernmental cooperation. Because of the complexity of the issues involved, the adversary proceedings embedded in past public hearings do not appear conducive to the effective resolution of issues of interest to South County. This suggests that the resolution of issues may be enhanced through a mechanism involving the utility. Indeed, some preliminary steps were initiated in this direction in the early phases of the Program.

It appears that in order to resolve the issues of impact mitigation in a mutually satisfactory manner, there is a need to develop a mechanism whereby both the Region and its member towns on the one hand, and the utility on the other hand can work toward mutual accommodation starting at the planning stage of the construction project. The mechanism to be developed can then, perhaps, supplement the public hearing proceedings.

The various assumptions embedded in the scenarios concerning impact mitigation imply additional costs to the New England Power Company. Their mitigating effects can best be developed at the planning stage before the construction cost schedule is set. However, the reconciliation at the planning stage requires that South County have its own information at hand on the issues involved and a timely understanding of the mitigation objectives. These can be furnished by the Regional Coastal Energy Impact Program of South County and its committees representing the member towns.

In the absence of an option for timely mutual accommodation, it is doubtful whether the complex issues of impact mitigation can be resolved in a satisfactory manner.

The dynamic impact analysis suggests that the project schedule from the planning phase through construction to operations imposes a particularly difficult task on the towns in the Region, namely to respond in a timely manner. That is, if the towns of the Region are to achieve the most by way of impact mitigation and accommodation plans, they will have to respond with (and initiate) actions at specific times. This requires advanced planning and preparation well ahead of the foreseeable event. Delays may mean lost opportunities and added costs.

Because of the importance of the seasonal economy to South County, an attempt was made in the development of the scenarios to introduce some simple feature of seasonal accommodation into the power plant construction cost schedule. Yet, as was shown, delays in the complex construction process are to be expected. One path toward the assurance that the pace of construction and changes in schedules will not conflict with the seasonal economy is by the issuance of conditional performance permits either at the State of Local level. The conditional performance permit can then specify the seasonal safeguards to be observed by the utility and its construction firm. Deviation from the specified performance can then result in fines, forfeit of performance bonds, or suspension of construction for the summer months. The legal procedures required to initiate the conditional performance permit ought to be examined.

These broad recommendations supplement the more detailed suggestions presented earlier. They are offered in order to safeguard the interests of South County and suggest approaches to impact mitigation. Should the power plant be built, it will be the largest construction undertaking in Rhode Island's history.

APPENDIX A
THE MODEL

The simulated dynamic impact analysis is undertaken by the use of a simplified version of the RSRC Sequential Interindustry Model (SIM), and modified for purposes of this evaluation.

Some of the main features of the workings of SIM are briefly described. SIM builds upon the static input-output model by the introduction of the chronology of industry production. Production is thus not undertaken simultaneously, as in the static input-output model, but rather in some sequence over a period of time. This approach enables the consideration of the role of each industry in the dynamic structure of production, recognizing that natural and cultivated resources flow through sequences of production to their final use.

Alternative modes of industry behavior are considered. They provide the means for gaining insight into the "black boxes" of production, beyond the mere concern with inputs and output. The model recognizes two simplified and pure production modes. In one, production is undertaken in anticipation of demand stimulus, leading to <u>anticipatory</u> production. In the other, production takes place after a known demand stimulus, leading to <u>responsive</u> production. The latter is typical of the construction industries and their sub-contractors. Both of the production modes are represented in the model, which depicts the dynamic linkage of production to demand.

Additional distinguishing features which are not available in the static input-output model are introduced. They are: the treatment of the industry interval, the handling of information, and the use of alternative inventory management policies. The latter two differ for anticipatory production and for responsive production. The model operates in response to final demand stimulus at each interval during the period under examination, as given by the construction cost schedules for each construction technology.

Because of the interdependence in production, levels of industry output are determined by the effects of both final and intermediate demand stimuli. The resulting pattern of fluctuating industry output for all intervals records industry production chronology and thus also employment chronology. The State level industry employment chronologies lead to the computation of the potential for job creation and job duration. These latter estimates are used to assess the impact on the Region.

A more detailed and mathematical presentation of the early version of the sequential interindustry model is given in Romanoff and Levine (1976, 1977a, 1977b). Some of the modifications leading to the current version of the model are presented in Romanoff and Levine (1979). The theoretical linkage between the Leontief static input-output model and the sequential interindustry model was shown in Romanoff and Levine (1977b).

Although in using SIM, the simulation modeling approach bears certain similarities to that developed by Forrester (1961), it differs in some key conceptual and operational features, particularly in the reliance on interindustry analysis and in the dynamic extension of the "static" input-output model. SIM also differs markedly from the sequential simulation model in Golloday and Haveman (1977), where the sequencing is mostly in data handling exogenous to the input-output model and in the use of the static input-output model, thereby ignoring production chronology (pp. 39-40).

A further description of the model applications to the evaluation of the impact dynamics of large construction projects can be found in Romanoff and Levine (1980).

APPENDIX B

THE STRUCTURE OF THE RHODE ISLAND ECONOMY

The structure of the Rhode Island economy is described by an interindustry matrix which identifies the industries in the State and the economic linkages among them, modified for the purpose of the model. The linkages are in terms of regional input-output coefficients. They specify the dollar value of an input from a supplying industry to a producing industry per dollar output of that Rhode Island producing industry.

The data for the interindustry matrix are mainly from two sources: the RSRC industry files and a special RSRC survey. These were augmented from other secondary sources, such as the U.S. industrial census, the R.I. Department of Employment Security (RIDES), and various publications. For this study, the RSRC Massachusetts industry production files were used in two ways: (a) data on firms reporting on branch plant R.I. operations were used, and (b) Massachusetts four-digit SIC production data were used for those industries where production difference between the two states is fairly small. These data were adjusted mostly for the difference in interregional trade and in size of establishment between the two states. The other source of information, the RSRC survey of local construction and construction-related establishments, was conducted in the Summer of 1979. With the withdrawal of the application by the utility and the subsequent redesign of the study to forecast the long-range impact, some of the R.I. survey data were not applicable to the new time horizon.

The study redesign required the forecast of future production technology. Some forecasts were based on industry production file data from 1965 to 1978, others were based on the use of foreseeable changes in relative prices for energy, transportation, and other key inputs. These were further modified, judgmentally, to account for likely material substitutions and other long-term effects, including some foreseeable changes in the composition of Rhode Island industries. These data were classified according to the specifically developed 54-industry Rhode Island Industrial Code (RIIC) in order to reduce error in the forecast and to make it consistent with RIDES data so classified for purposes of the employment study noted in Volume 2. These data were then aggregated for the purpose of the model. In the aggregations, particular care was excercised to preserve the properties of the dynamic structure of production in the reduced matrix.

For modeling requirements, a distinction is made between anticipatory and responsive production. There are 20 anticipatory industries in the sectoring plan. Of these, 14 are manufacturing, where because of the importance of durable goods production to the model, they were classified in greater detail. For durable goods, there are nine industries and one residual industry for a total of ten. For non-durable goods, there are three industries and a residual industry for a total of four.

While construction industries and special trade contractors and fabricators operate in a responsive mode, some of the fabricators belong to SIC industries which also operate in an anticipatory manner. In the sectoring plan, these are assigned to both production modes in order to preserve their representation in the dynamic structure of production.

Construction was classified into three groups, where each represents a *unique production technology*.* As noted in the text, the construction technologies (industries) order from their subcontractors and fabricators, who produce in response to these orders, and must await delivery of contracted items before they can be installed. That is, the completion of each construction component allows for the assembly of the subcontracted item and for its installation. In order to model this process in its simplest form, construction takes twice as long as in the case of other industries. Each of the three construction industries is partitioned into early and later phases of production, where the inputs of the subconstractors and fabricators are only in the later phase. Hence, there are six construction industries in this version of the model as well as two subcontracting and fabricating industries. Thus, the model utilizes eight responsive and 20 anticipatory industries, for a total of 28 industries which are represented in the Rhode Island interindustry matrix. The sectoring plan follows:

Industry	Name and Brief Description	Related SIC
1	Agriculture, forestry and fishing	013, 016, 018, 024, 025, 07, 081, 091, 092
2	Mining and quarrying of nonmetallic minerals, except fuels	14
3	Lumber and wood products	24
4	Furniture	25
5	Industrial chemicals Industrial inorganic and organic chemicals, plastic materials and synthetics	281, 282, 286
6	Chemical products Drugs, soap cleaners and toilet goods, paints and allied products, misc. chemical products, paving and roofing material and misc. petroleum and coal products.	283, 284, 285 289, 292, 299
7	Rubber and misc. plastic products	30
8	Building materials, group 1 Glass and glassware, products of purchased glass, structural clay products, pottery and related products	322, 323, 325

* The three construction technologies represent a simplified approach to the distinction among the technologies required of nuclear power plant construction in this first application to this topic. Based on our examination of mass transit construction, a greater modeling sensitivity is obtained if construction is further subdivided, Romanoff and Levine (1979b), which was far beyond the resources for this study.

Industry	Name and Brief Description	Related SIC
9	Building materials, group 2 & related Comps. Concrete gypsum and plastic products, cut stone and stone products, misc. nonmetallic mineral products, metal doors sash and trim, architectural and misc. metal work	327, 328, 329 3442, 3446, 3449
10	Primary metal industries	33
11	Fabricated metal products *	34
12	Non-electrical machinery *	35
13	Electrical equipment and apparatus and electronic components and supplies *	361, 362, 367
14	Electrical and electronic equipment * Electric lighting and wiring equipment, radio and TV receiving equipment, communication equipment, misc. electrical equipment and supplies, engineering and scientific instruments, measuring and controlling devices	364, 365, 366 369, 381, 382
15	Other durable manufacturing & construction M&R	
16	Other nondurable manufacturing	
17	Transportation	40 - 45, 47
18	Communications, electric gas and sanitary services	46, 48, 49
19	Trade, wholesale and retail	50 - 59
20	Finance insurance and real estate and services	60 - 89
21	Special trade contractors and building material fabricators Special trade contractors, other than plumbing and electrical work, concrete product fabricators	17, exc. 171 and 173, 327*
22	Metal fabricators, non-electrical machinery fabricators and specialized electrical and electronic fabricators	*
23	Construction, general and structural work, first phase	
24	Construction, general and structural work, second phase	
25	Construction, mechanical work, first phase	
26	Construction, mechanical work, second phase	
27	Construction, electrical work, first phase	
28	Construction, electrical work, second phase	

* Except as eleswhere specified

APPENDIX C

EMPLOYMENT CHRONOLOGY AND INDUSTRY AND AGGREGATE POTENTIAL JOB COUNTS

The purpose of this appendix is to distinguish between industry total and aggregate measures of jobs by job duration obtained from two employment chronologies. Consider two industries, (1) and (2), whose employment chronologies are shown below together with the aggregate employment chronology for (1&2). The employment chronologies represent four labor-quarters (LQ) for each of the industries and therefore eight LQ for the aggregate chronology (1&2). We wish to compute the number of jobs and their duration according to the hiring and firing rules described in the text. The LQ tabulations for the employment chronologies shown further below are:

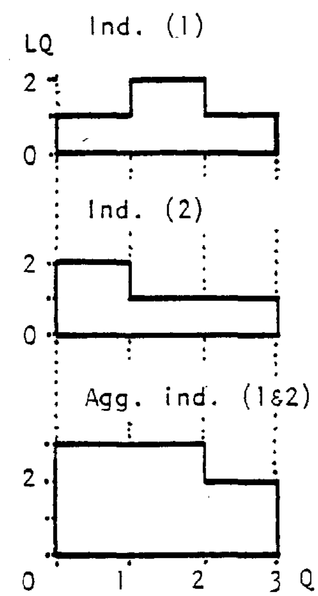
Quarter	Ind. (1)	Ind. (2)	Agg. (1&2)
1	1	2	3
2	2	1	3
3	1	1	2
Total	4	4	8

The job distributions by job duration are:

Ind. (1)			Ind. (2)			Ind. (1+2)		
Jobs	Duration	LQ	Jobs	Duration	LQ	Jobs	Duration	LQ
1	1	1	1	1	1	2	1	2
1	3	3	1	3	3	2	3	6
2		4	2		4	4		8

Each of the industries generates two jobs totaling four LQ and the total is four jobs totaling eight LQ. However, for the aggregate chronology (1&2), the job distribution is:

Agg. (1&2)		
Jobs	Duration	LQ
1	2	2
2	3	6
3		8



In this example, the total number of jobs shown for ind. (1+2) is not equal to that of agg. (1&2), even though their total LQ is identical. The two one-month long jobs obtained by summing the job distributions derived from each of the industry employment chronologies as given in ind. (1+2) differ from the one two-month long job obtained from the aggregate employment chronology of (1&2). This is because the two one-month long jobs of ind. (1+2) were aggregated into one two-month long job. To avoid aggregation bias, job counts ought be obtained from industry-level chronologies, not from the aggregate chronology.

The aggregation bias is magnified if the industry production chronologies are not simultanously initiated. The more disaggregate the industry chronologies, the lesser the bias in job counts.

REFERENCES AND BIBLIOGRAPHY

Ahmed, S. Basheer. (1979) Nuclear Fuel and Energy Policy. D.C. Heath & Co., Lexington, Massachusetts.

Balestra, Louis. (n.d.) "Charlestown Nuclear Power Plant: Construction and Operation Data." College of Engineering for Coastal Resources Center, University of Rhode Island, Kingston, Rhode Island.

Bella, David A. (1978) "Impact Assessment and Future Generations," Coastal Zone Management Journal, 4:3, 249-267.

Brody, Susan E. (1977) "Energy Impact Project--Federal Aid to Energy Impacted Communities, a Review of Related Progress and Legislative Proposals." Laboratory for Architecture and Planning, MIT, Cambridge, Massachusetts.

Callaghan, Dennis W. and Robert A. Comerford. (1978) Potential Employment of Rhode Island Labor in the Construction of the NEPCO 1 & 2 Nuclear Power Plants Proposed for Charlestown, Rhode Island. For the Governor's Energy Office. Callaghan and Comerford Associates, Wakefield, Rhode Island.

Crowley, John H. (1976) Testimony, United Engineers & Constructors Inc., New York Public Service Commission, case no. 2974. (Also in Nuclear Engineering International, July 1978).

Ditton, Robert B., John L. Seymour and Gerald C. Swanson. (1977) Coastal Resources Management. D.C. Heath & Co., Lexington, Massachusetts.

Forrester, Jay W. (1961) Industrial Dynamics. The MIT Press, Cambridge, Massachusetts.

General Services Administration. (1978) Naval Auxiliary Landing Field, Charlestown, Rhode Island, Final Environmental Impact Statement, vols. I-III. Boston.

Golloday, Fredrick L. and Robert H. Haveman. (1977) The Economic Impact of Tax Transfer Policy. Academic Press, New York, New York.

Grant, Malcolm J. and Francis Y. Cameron. (1980) Implication of a Nuclear Facility in South County, Rhode Island, Case Studies of Similar Facilities, vol. 3. Interface, Hope Valley, Rhode Island.

Isard, Walter, Thomas Reiner, Roger Van Zele and James Stratham. (1976) Regional Economic Impact of Nuclear Power Plants. Energy Policy Project, Regional Science Department, University of Pennsylvania and Policy Analysis Division, Brookhaven National Laboratory, BNL 50562/EY-76-C-02-0016.

National Oceanic and Atmospheric Administration, Office of Coastal Zone Management. (1976) Final Environmental Impact Statement: the Coastal Energy Impact Program. U.S. Department of Commerce, Washington D.C.

Romanoff, Eliahu. (1976) "A Characteristic of Growing and Declining Regional Manufacturing Employment Trends: New England and Other Geographic Divisions," Discussion Paper No. 76-4. Regional Science Research Center, Cambridge, Massachusetts.

Romanoff, Eliahu. (1980) "Coastal Zone Seasonality in Employment: the South County, Rhode Island Example," Discussion Paper No. 80-1. Regional Science Research Center, Cambridge, Massachusetts.

Romanoff, Eliahu, S. Basheer Ahmed and James L. Davis. (1978) "Energy Costs in Manufacturing Production: An Interregional and Intraregional Analysis," Discussion Paper No. 78-1. Regional Science Research Center, Cambridge, Massachusetts.

Romanoff, Eliahu and Stephen H. Levine. (1976) "Sequential Interindustry Models: Some Preliminary Results," Discussion Paper No. 76-2. Regional Science Research Center, Cambridge, Massachusetts.

Romanoff, Eliahu and Stephen H. Levine. (1977a) "Interregional Sequential Interindustry Modeling: A Preliminary Analysis of Regional Growth and Decline in a Two-Region Case," Northeast Regional Science Review, 7, 86-101.

Romanoff, Eliahu and Stephen H. Levine. (1977b) "Anticipatory and Responsive Sequential Interindustry Production," Discussion Paper No. 77-2. Regional Science Research Center, Cambridge, Massachusetts.

Romanoff, Eliahu and Stephen H. Levine. (1979a) "Sequential Interindustry Modeling: Information and Structure," Proceedings: International Conference on Cybernetics and Society, IEEE, SMC Society, October, Denver, Colorado.

Romanoff, Eliahu and Stephen H. Levine. (1979b) Impact Dynamics of Mass Transit Construction: the Potential for Job Creation, Regional Science Research Center, 422-3/DOT-TSC-1592. For Transportation Systems Center, U.S. Department of Transportation, Cambridge, Massachusetts.

Romanoff, Eliahu and Stephen H. Levine. (1980) "Impact Dynamics of Large Construction Projects: Simulations by the Sequential Interindustry Model," forthcoming.

Rorholm, Niels. (1960) "The University of Rhode Island as an Economic Factor in the Community," misc. pub. 56. Agricultural Experiment Station, University of Rhode Island, Kingston.

Rossin, A.D. and T.A. Rieck. (1978) "Economics of Nuclear Power," Science, 201:4356, 582-589.

Sparrow, Roy L. (1978) "Intergovernmental Complexity and Coastal Zone Management," Coastal Zone Management Journal, 4:4, 363-370.

Stevenson, William D. (1975) Elements of Power Systems Analysis. McGraw Hill, New York, New York.

United Engineers and Constructors Inc. (1972) 1000-MWTE Central Station Power Plant: Investment Cost Study. U.S. Atomic Energy Commission, Division of Reactor Development and Technology, Washington D.C.

U.S. Department of Labor. (1979) Projections of Cost, Duration, and On-Site Manual Labor Requirements for Constructing Electric Generating Plants, 1979-1983. Construction Labor Demand System.

U.S. Department of Labor, Bureau of Labor Statistics. (1979) Technological Change and its Impact in Five Energy Industries, Bulletin 2005.

U.S. Department of Labor, U.S. Department of Energy. (1978) "Labor and Capital Requirements for Constructing Electric Generating Power Plants."