THE TENNESSEE VALLEY AUTHORITY: A FIELD STUDY

H. Knop
Editor

RR-79-2
June 1979

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
Laxenburg, Austria

Research Reports provide the formal record of research conducted by the International Institute for Applied Systems Analysis. They are carefully reviewed before publication and represent, in the Institute's best judgment, competent scientific work. Views or opinions expressed therein, however, do not necessarily reflect those of the National Member Organizations supporting the Institute or of the Institute itself.

PREFACE

The Management and Technology Area of IIASA has carried out case studies of large-scale development programs since 1975. The purpose of these studies is to examine successful programs of regional development from an international perspective, with a multidisciplinary team of scientists skilled in the use of systems analysis.

The study of the Tennessee Valley Authority (TVA) is the first in this series of activities. The present report covers the field study of the TVA undertaken as a followup to the TVA conference held in 1974. Similarly, conferences and field studies have taken place on the Bratsk-Ilimsk Territorial Production Complex (BITPC) in the Soviet Union and on the Shinkansen Railroad Development Program in Japan.

The present report covers four major aspects of the TVA program: the systems approach to regional industrial development programs; the managerial structure of the TVA, including specific management case studies of several key departments; the application of models and computer techniques to management; and the integration of environmental factors into the TVA management and planning processes, including a case study dealing with the environmental decision-making process in the siting of a nuclear power plant.

This report on the planning, management, and organization of the TVA was accomplished with the support and assistance of the U.S. National Academy of Sciences, the General Manager of the TVA, and the organizational units of the TVA that were studied.

Drafts of this report were made available for outside review. The authors are grateful for the comments and suggestions received, many of which have been incorporated into the report.

Hans Knop
Editor

SUMMARY

This report on the Tennessee Valley Authority (TVA) is the combined effort of an international team of IIASA scientists and invited researchers with a broad range of experience and expertise. The team was composed of representatives from the USSR, the USA, the GDR, the FRG, the UK, and Poland.

The report follows from the results of the earlier IIASA conference on the TVA. It is divided into four main parts: the systems approach to regional industrial development programs; the managerial structure of the TVA, including specific management case studies of several major departments; the application of models and computer techniques to management; and the integration of environmental factors into the TVA management and planning processes, including a case study dealing with the environmental decision-making process in the siting of a nuclear power plant.

CONTENTS

Introduction

The study of the planning, management, and organization of the Tennessee Valley Authority (TVA) was a part of the 1975-1976 research program of the former IIASA Project on the Planning and Management of Large Organizations.* It was the final phase of the case study that began in October 1974 with the conference on "The Tennessee Valley Authority Experience".** The second case study was the Bratsk-Ilimsk Territorial Production Complex (BITPC) in the Soviet Union.***

Both the TVA and the Bratsk-Ilimsk studies deal with large-scale regional industrial complexes. Each complex covers about the same area and has several similarities with respect to the problem structure, including such tasks as flood control, power generation, development of transportation systems, industrial and agricultural development, development of settlements and services, recreational areas, environmental protection, and optimal use of resources. The purpose of the IIASA studies is fourfold: (1) to identify and systematically characterize the approaches, the methods, instruments, decision-making procedures, and organizational forms of regional industrial complexes; (2) to generalize and formalize the most advanced parts of the methodology; (3) to make these methodologies available for solving similar problems in other parts of the world; and (4) to compare the approaches, methodological solutions, and organizational forms under different social and political conditions.

The approach taken in the TVA study was that of retrospective case analysis. The main sources of information were:

- TVA Conference papers;

---

*Throughout the text wherever "the present time" is mentioned it refers to 1975/76, the year in which the TVA study was carried out.

**Knop, H., ed., *The Tennessee Valley Authority Experience*, 2 vols., CP-76-2, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1976.

***Knop, H., ed., *The Bratsk-Ilimsk Territorial Production Complex*, Proceedings of the Second IIASA Conference on Case Studies of Large-Scale Planning Projects, March 22-25, 1976, CP-77-3, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1977.
Knop, H. and A. Straszak, eds., Bratsk Field Study, RR-78-2, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1978.

- Presentations of representatives from the different departments of the TVA;

- Interviews with TVA personnel--the Chairman of the Board, the General Manager, and several members of the managerial staff;

- Documents, information, and films presented to the members of the study group;

- Publications on the TVA.*

During this study, and for the purpose of this publication, it was necessary to subdivide the integrated process of planning, management, and organization into four interrelated parts. Chapter 1 deals with the systems approach to regional industrial development programs. It contains a description of past and present characteristics of the TVA, the principal stages of development and the conceptual requirements for the study of planning, management, and organization with emphasis on managerial systems, structure and functions of comprehensive regional development. Chapter 2 is concerned with the TVA managerial structure and presents an analysis and several case studies. It deals with the planning and decision-making processes of the organization and focuses in particular on the functioning of organizational units and their internal and external interaction. Chapter 3 presents the results of a study of the application of models and computer techniques to management. Chapter 4 concentrates on the integration of environmental factors into TVA planning and management. Its purpose is to show how the different fields of resource conservation, environmental protection, hazard control, and industrial hygiene are managed and prepared by respective research activities. This chapter contains a case study on environmental decision making.

The study group was composed of members of the IIASA Planning and Management of Large Organizations Project and other scientists specifically invited for this study.** During the field study the IIASA team worked together and in separate working groups. These working groups are responsible for the different chapters of this report. The composition and responsibility of these groups was as follows:

- The TVA: Towards Complex Regional Planning and Management--A. Aganbegyan, H. Knop, and V. Tokhadze;

- Planning and Organization of the TVA--C. Davies, B. Milner, R. Ostrowski, J. Tomb, and R. Tomlinson;

- Models and Computer Application in the TVA--J. Owsinki and A. Straszak;

---

*See references at the end of Chapter 1.
**See List of Participants, Appendix 1.

- Integration of Environmental Factors into TVA Planning and Management--G. Popov, R. Tuch, and D.v. Winterfeldt.

The study of the TVA was the first of a case study series. This resulted in special working conditions and in certain weaknesses in the study. All the participants were aware of this. The weaknesses of the study are partially offset by its strengths, making the best use of IIASA's unique role. The study's strengths can be summarized as follows:

- The opportunity for gathering basic information on the TVA and the advance formulation of a questionnaire from the information gathered through the TVA Conference;

- The interdisciplinary and international (East-West) composition of the group;

- Direct interaction with TVA managerial staff and with many people living in the area who are directly affected by TVA activities;

- Cooperativeness and frankness of the TVA staff;

- The wide range of managerial units visited and interviewed.

The weaknesses included:

- The lack of IIASA experience, at that time, in field studies of this kind;

- The last-minute formation of the team and the high proportion of visiting scientists that it contained--both factors limited the opportunity for conceptual preparation and for a joint evaluation and systematization of results;

- The lack of contact with the social and political environment of the TVA (as governmental and local authorities), which could not be included in the study program.

Nevertheless, we decided to publish the Report for two reasons: firstly, in order to complete the information on this series of studies on large-scale programs, which has been undertaken in the past few years and, secondly, because the significance of our findings became more apparent after the completion of subsequent studies, the Bratsk-Ilimsk study in particular.

Chapter 1: The TVA: Towards Complex Regional Planning and Management

1.1 FACTS, FIGURES AND MANAGERIAL CHARACTERISTICS OF THE TVA

The TVA was established in 1933* as a part of President Roosevelt's New Deal Policy. Its establishment followed several years of discussion about the most effective use of the Muscle Shoals nitrate production facilities and the Wilson Dam, and about possible ways of overcoming the backwardness of the Tennessee Valley region. The TVA was created as a solution to both problems.

The activities of the TVA are concentrated in an area of about 100,000 km^2 within the Tennessee Valley watershed boundary (see Figure 1.1). The main goals of the project were to stop outmigration, to stabilize agricultural production and modernize agriculture, to prevent catastrophic floods, to stimulate

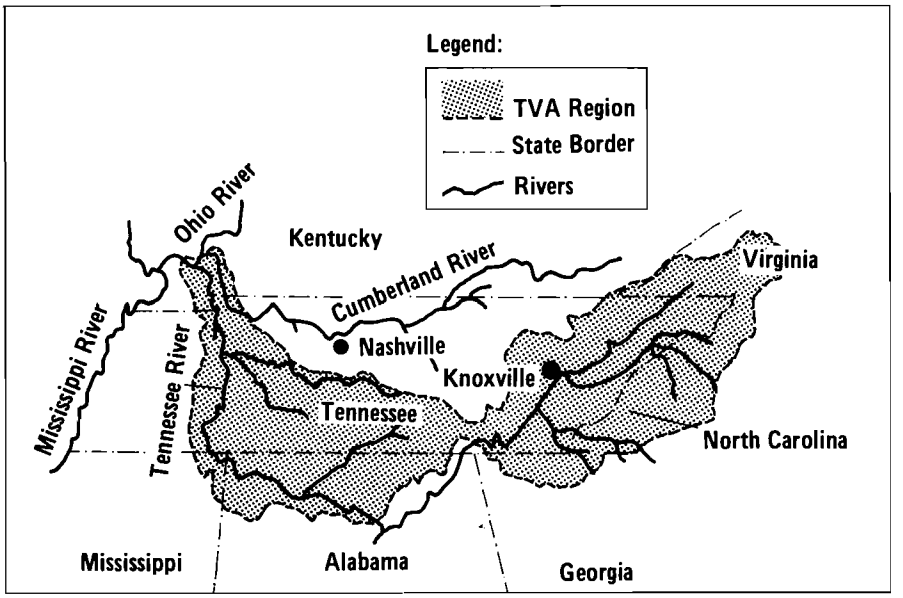


Figure 1.1. Tennessee Valley Authority region.

*The TVA Act of the U.S. Congress, May 18, 1933.

industrial development, to develop navigation systems, and to raise the general economic level of the region.

The TVA is a corporate agency of the Federal Government of the United States and operates to a reasonable degree with the autonomy and flexibility of a private corporation. It is an independent agency, not part of any federal cabinet department. All powers of the corporation are vested in its three-member Board of Directors, which reports to the President of the United States. The President, with the consent of the Senate, appoints the members of the Board to serve in nine-year overlapping terms of office. He designates one member as Chairman.

After 40 years the TVA's main goals have been achieved. The population increased slightly and then stabilized. The standard of living and per capita income increased significantly and, although still lower, approached the national average. Floods are under control. There has been a sharp increase in power generation; all water-power resources are used for power generation, providing a very cheap power source. At present, power is also generated by steam, gas turbine, and nuclear plants. A highly efficient navigation system was created, and production and productivity in agriculture and industry were significantly increased, due to cheap power, increased fertilizer supply, and scientific advances in agriculture. Recreational centers were created around the new water reservoirs, and the TVA initiated several federal laws on environmental protection.

The scale of TVA activities and the results of its development are reflected in the following figures:

Physical Characteristics

Area of Tennessee River Watershed	104,730 km^2	(40,910 mi^2)
Total length of shoreline	28,760 km	(17,870 mi)
Total area of water surface	155,383 ha	(383,959 acres)
Area served by TVA power system	204,800 km^2	(80,000 mi)
Total area of influence	235,520 km^2	(92,000 mi)
Total forest area	8.74×10^6 ha	(21.6×10^6 acres)
Total forest area in commercial use	8.49×10^6 ha	(21.0×10^6 acres)

TVA Power System

Circuit distance of TVA transmission lines (all voltages) 26,693 km (16,683.3 miles)

Installed rated capacity	1938	1960	1974
Hydro	420	3751	4472
Steam	-	7622	17,749
Gas turbine	-	-	1096
Total	420	11,373	23,317

Residential electric use (kWh/yr/capita)	TVA	USA	(1974)
	14,480	8019	
Rate per kWh	1.45¢	2.54¢	

TVA Budget

1933	1959	1974	
$50 × 10^6	$1.88 × 10^8	Power	$1.02 × 10^9
		Non-power	$1.29 × 10^9
		Total	$2.31 × 10^9

TVA Employees

1934	1954	1974
9173	23,933	23,446

Annual Average: 17,000

The main characteristics of the TVA from the viewpoint of the management, planning, and organization are:

(a) It is a federal corporation that was created for the development of the resources of a seven-state area. Its management is located entirely within the Tennessee River Valley. It is a program-oriented agency, including among its activities:

- Development, operation, and regulation of the river system control as well as the operation and partial construction of water resource projects, regulation of water flow, and provision of navigation facilities (the main responsibility for these activities lies with the Office of Engineering Design and Construction, and the Division of Navigation Development and Planning);

- Agricultural development based on research into and development of fertilizers; demonstration of fertilizer usage as an aid to soil conservation (the Office of Agricultural and Chemical Development);

- Development of power generation and transmission (the Office of Power);

- Improved conservation of the environment, including reforestation, fisheries and wildlife preservation, and the development of recreational zones (the Division of Environmental Planning, the Division of Forestry, Fisheries, and Wildlife Development, the Office of Tributary Area Development, and "Land between the Lakes");

- Urban and local development, including the planning and demonstration of urban development and the creation of industrial expansion opportunities, improvement of quality of life, etc. (the Division of Navigation Development and Regional studies).

(b) The TVA's power activities are financed by revenues from the sale of electricity, which must equal production costs. For some time, the TVA had been permitted to sell bonds in order to finance the expansion of its power facilities. In many respects

then, its power activities have become quite similar to those of a privately owned electric utility:

- Unlike other federal government agencies in the United States, the TVA is required to repay to the Federal Government the capital funds that were advanced between 1933 and 1959 to finance the construction of power generation and transmission facilities. Such payments currently approximate $100 million annually.

- Unlike a private utility enterprise, the TVA is not permitted to expand the geographic coverage of its power operations.

- Fertilizer production also is largely supported (97%) by revenues from fertilizer sales.

- Other TVA activities (including all of those related to regional development) are funded by federal appropriations, which exceed $100 million annually.

(c) Most TVA programs have been regional in scope; this is especially true of navigation and flood control. Some activities, however, have had national implications. One example is the development of experimental fertilizers and manufacturing processes at the National Fertilizer Research Center in Muscle Shoals, Alabama. Another is the leadership the TVA has provided in developing the fast breeder reactor for nuclear power generation; a third is the upgrading of strip mine reclamation standards.

(d) Unlike most other regional development programs outside the USA, the TVA operates within a basically private enterprise environment:

- Especially in its early years, private business interests strenuously opposed the TVA's programs for model housing, education, and health care as well as its large-scale land purchases and its regional planning and economic development efforts.

- Private enterprise opposition was so strong that Congress eventually limited the TVA's economic planning and development activities.

- More recently, however, the TVA has entered into joint ventures with private enterprise, e.g., one third of the Timberlake City program (urban development) is financed by the Boeing Corporation, while the Oak Ridge fast breeder reactor project is being undertaken with Commonwealth Edison, a Chicago-based electric utility.

(e) Although the TVA is a federal corporation with broad objectives, it has not been allowed to represent other agencies of the Federal Government that operate in the Tennessee Valley area. Its early leaders hoped that it would become the primary

vehicle for federal activity in the region, but other federal agencies insisted on maintaining their own separate programs.

(f) The TVA lacks the power to implement regional development programs, because it must operate within the existing framework of the roles and authority of state and local governments. Thus it is forced to rely heavily on persuasion and cooperation. This means that the TVA has to be flexible enough to adapt to the often conflicting positions taken by various government agencies, especially with respect to programs of regional scope.

(g) Under the continued influence of (d), (e), and (f), the TVA appears to have backed away from the aggressive approach to integrated regional development that characterized its early years and is now pursuing parallel but distinctly different courses of action:

- The Office of Power is characterized by strong and positive programs, e.g., the fast breeder reactor and the attempt to purchase Peabody Coal Company for $1 billion.

- In contrast, regional development activities take more of a low profile approach or are opportunistic and deal with separate and specific situations, characterized by: reliance on the "demonstration" approach to encourage new farming practices; insistence on local initiative for economic development programs; recreational areas, such as "Land between the Lakes"; and urban development, such as Timberlake.

1.2 THE OBJECTIVES OF THE TVA OVER 40 YEARS

The TVA Act of 1933 first established the specific goal structure of the organization. The ensuing 40-year period saw substantial changes in the political, economic, and social life of the United States. These changes influenced the original TVA goals, and led to the reallocation of priorities, and to the transformation and replacement of some objectives. This chapter takes a retrospective look at those changes and describes how they have led to the present TVA goal structure.

1.2.1 Historical Conditions Leading to the Creation of the TVA

At the beginning of the 1930s, the USA was suffering from an economic depression that affected all aspects of national life: political, economic, and social. Unemployment was widespread. The situation was aggravated by the many farmers who, having lost their property, migrated to the urban areas. Living conditions for a sizable proportion of the population were very poor. Even in such conditions, the Tennessee River Valley was one of the poorest regions from practically all economic and social aspects:

- The per capita income of the population in the region as a whole was only 45% of the national average ($168).

- More than half of the 3 million people were employed in farming, and farm incomes were low. Crops suffered from an uneven climate, endless rain alternating with extremely dry periods. Out of a total of 14 million acres of open land about one half was abandoned or severely damaged by erosion.

- Only 12% of the labor force were employed in manufacturing, as compared to the national average of 22%.

- Almost 8% of the population were illiterate and the labor force was generally unskilled or semiskilled. People suffered from malnutrition, pellagra and malaria.

- The Tennessee River, the fifth largest in the United States by flow, carried only 32,100,000 ton miles in 1933. The huge potential for hydroelectric power production was practically unused; the installed generating capacity was less than 500,000 kW.

- Frequent destructive floods were a disaster for the people and the region (the flood in 1967 at Chattanooga, Tennessee, caused damage amounting to approximately $500 million). In 1933, although the river provided the region's greatest opportunity, it was the scourge of the land.

The U.S. Federal Government had had the Tennessee Valley's problem under discussion since 1824. At that time, it was considered as part of a national program to connect the various parts of the country by roads, canals, and river channels. During the nineteenth century some attempts were made and several canals were built in the Muscle Shoals area in Alabama.

At the beginning of the twentieth century, when the country's demand for electric power was growing rapidly, the Tennessee Valley was attractive as a source of power. The potential of the river was fully recognized, but, because of differing opinions in the U.S. Congress, no serious steps forward in the development of the region were possible.

In 1916, during World War I, it became critically important to build up military strength. Therefore Congress passed the National Defense Act, authorizing the construction of nitrate plants, a process for which abundant electric power was essential. In 1917, President Wilson chose the site at Muscle Shoals for two nitrate plants, and a dam (Wilson Dam) to supply the hydroelectric power to operate them [1].

During the postwar period the struggle concerning the Tennessee River was resumed again, when the nitrate plants were scheduled to be sold to private companies. A progressive Republican from Nebraska, Senator George Norris, objected and sponsored several bills for federal maintenance and development of not only the nitrate plants and Wilson Dam, but of the entire Tennessee River Valley. Neither Presidents Coolidge nor Hoover accepted these proposals [2].

President Franklin D. Roosevelt, who was elected in 1933, strongly supported the idea of an increasing role for Federal Government in national development. The increased role of the government was an important part of the New Deal policy, which he introduced as a strategy for pulling the country out of its poor economic condition. His message to Congress on April 10, 1933, ran as follows:

> It is clear that the Muscle Shoals development is but a small part of the potential public usefulness of the entire Tennessee River. Such use, if envisioned in its entirety, transcends mere power development: it enters the wide fields of flood control, soil erosion, afforestation, elimination from agricultural use of marginal lands, and distribution and diversification of industry. In short, this power development of war days leads logically to national planning for a complete river watershed involving many states and the future lives and welfare of millions. It touches and gives life to all forms of human concern.
>
> I, therefore, suggest to the Congress legislation to create a Tennessee Valley Authority - a corporation clothed with the power of government but possessed of the flexibility and initiative of a private enterprise...[3].

On May 17, 1933 Congress passed the Bill. On May 18 the Tennessee Valley Authority Act was signed by the President and made law. The Act created the TVA as a nonprofit government corporation, whose Board of Directors was to be granted a reasonable degree of autonomy in the management of its operations.

1.2.2 Primary Goals and Objectives of the TVA

The TVA Act was the document that defined the principal objective for the newly established organization, i.e., the development of the Tennessee River and its tributaries in order to improve navigability and to control flooding. Flood control would be achieved by the construction of dams, water reservoirs, and channels. These facilities together with the construction of power stations, power structures, and transmission lines would be used to achieve hydroelectric power production. The development of the river itself was expected to provide the basis for achieving:

(a) The development of agriculture in the Valley, by water supply and the application of fertilizers;

(b) The development of fertilizer production in the Valley to supply local agricultural needs;

(c) Reforestation of the Valley and development of recreation facilities.

The combination of these objectives makes it clear that from the beginning the overall goal of the Tennessee Valley Authority was the unified, multiobjective development of the Tennessee River Valley.

We will consider the implementation of TVA objectives during the 40-year period of its existence within the political, social, and economic framework of the national and the local administration. The interests of these administrations often act as powerful constraints on original TVA goals. As a consequence these goals are often modified or changed. However the most natural reason for a change in goals arises after their complete or partial fulfillment.

The major factors that have influenced TVA development are:

(a) Interrelations with states, cities, and country authorities, private enterprises, and with the population of the region:

- Ownership of the land caused conflicts with local authorities and private landowners with respect to the location of dams, power plants, and enterprises.

- Problems of environmental pollution required negotiation with both the Federal Environmental Protection Agency, local pollution control organizations, and "environmentalists" in relation to the location of chemical enterprises, coal and nuclear power stations, and strip mines.

- Conflicts with TVA energy consumers arose frequently regarding both the distribution and price of electricity. Consumers include the Tennessee Valley Industrial Council, private companies, and private households.

(b) Political, economic, and social life within the nation:

- The economic crisis of the 1930s, which provided the impetus leading to the creation of the TVA;

- Participation in World War II, which greatly increased the need for electric power;

- Rapid postwar economic development, which stimulated demand for greater power production by the TVA;

- National trends in environmental control in the 1960s, which initiated the changes in TVA production facilities, and also strengthened trends within the TVA to develop recreation, demonstration and conservation facilities;

- Present energy crisis, which caused the TVA to greatly increase the energy production and to search for new energy options.

Looking at the TVA's history, one can roughly divide it into four periods during which substantial changes occurred. They will be analyzed in the following sections.

1.2.3 Harnessing the Tennessee River, 1930s to 1940s [1]

The period of the 1930s was characterized by intensive construction of storage reservoirs, channels, major dams, etc. The five largest dams (Norris Wheeler, Pickwick Landing, Guntersville, Chickamauja, and Kiwassee) were built at that time. The construction of multipurpose dams permitted, in an integrated way, the fulfillment of the three main objectives, navigation, flood control, and hydroelectric power production.

In addition to river channel control and the production of hydroelectric power, emphasis was placed on water control on the land to facilitate the development of agriculture and reforestation.

The existence of relatively cheap electric power encouraged industrial development, in particular fertilizer production. In 1934, the Muscle Shoals munitions complex started work on phosphorus and ammonia fertilizers, reaching an annual production of 36,000 tons of phosphorus and 75,000 tons of ammonia. Guided by TVA representatives, farmers of the Valley began to use phosphate and lime on their land and started to fight successfully against soil erosion and depletion.

The integrated control of the river system contributed to the success of measures taken against malaria, and made possible the construction of recreational facilities and artificial lakes.

In the 1930s the TVA's activities were aimed at the fulfillment of its main goal--the unified development of regional resources. The framework for this was established with the creation of the water control system. Table 1.1, which is based on the TVA organization chart for 1937, may serve as an illustration.

The 1940s may be characterized as a period of intensive hydroelectricity production development. US participation in World War II greatly increased power demand. The TVA's groundwork in resource development and organization allowed for a rapid shift to power production. By mid 1942, 12 dams and a steam plant were under construction; by 1945 power generation amounted to nearly 12 billion kWh, a sixfold increase on the 1939 total. Owing to increased postwar demand for power and rapid national economic development, power production remained one of the main TVA objectives.

Table 1.1. TVA organization units, 1937.

Source: [4]

DIVISIONS	DEPARTMENTS
Water Control in the River Channel	Water Control Planning
	Design
	Construction
Utilization of Hydroelectric Power	Power Planning
	Operations
Water Control on the Land	Agricultural Relations
	Forestry Relations
	Chemical Engineering

In order to describe the distribution of priorities among TVA objectives, the allocation of expenses (both operating and construction) has been observed between selected items of the TVA budget that roughly reflect the real situation.* For 1947, expenses were apportioned as shown in Figure 1.2.

The priority given to power production is obvious--an allocation of 57.8% of the total expenses ($44 million). The remaining sum was distributed almost equally between flood control and navigation, and chemical production (approximately 3%).

Although power production consumed more than one half of TVA expenses, this activity can be considered multiobjective, since the money spent, for example, on agricultural and chemical development in 1947 totalled $6.5 million. The heavy emphasis on electric power production during the war and postwar period reflected the governmental nature of the organization.

The increasing role of power production led to the formation of a separate Office of Power, including divisions for power use, operations, engineering, and construction (Table 1.2).

*This seems to be justified because any organization stresses the importance of a given item on considering the allocation of its budget. The allocation of money is the means for allocating priorities among the objectives of an organization, but budget documents are often inadequate representations of main fields of organizational activities.

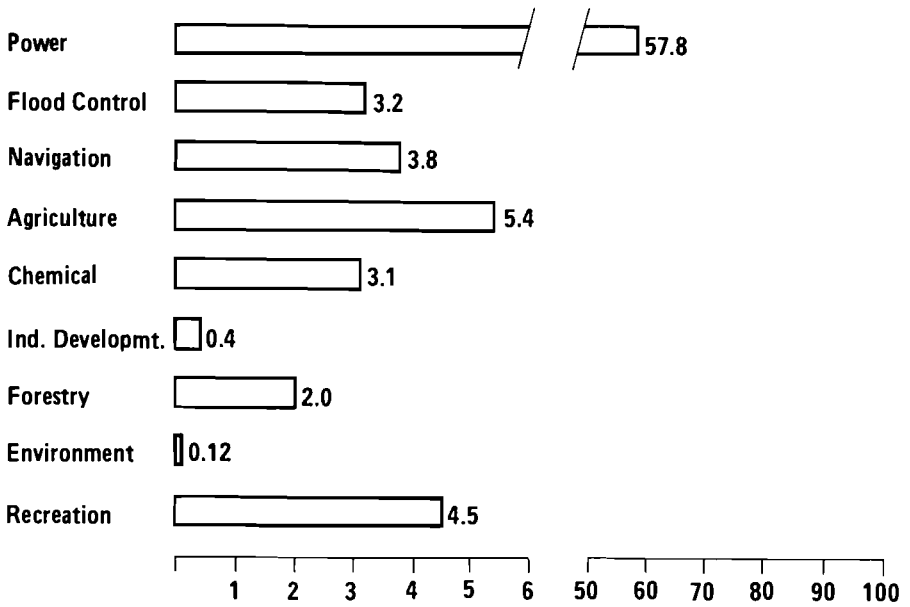


Figure 1.2. TVA budget allocations, 1947 (% of total budget). Figures given in this and following diagrams do not total 100%. The difference indicates expenses for some non-continuing programs, e.g., defense, which we do not consider in this chapter. In addition, figures are based on available data, which in most cases were incomplete; however there are instances where incomplete data required percentage calculations based on total available data. For details please refer to Appendix 2.

Source: [5].

1.2.4 Development of the TVA in the 1950s

During this period the TVA achieved one of its main objectives--integrated control of the river system.

(a) By 1952, TVA dams had created an unbroken chain of lakes, which formed an unbroken channel on the main river 650 miles long. This in turn, permitted rapid economic development of the region. In the 1950s private industry invested $669 million in more than a hundred waterfront plants and in expansion [6].

(b) Having built 20 major dams by 1958, the TVA achieved almost total flood control (by 1975 the TVA had constructed 23 major dams).

Table 1.2. TVA organization units, 1947.

Source: [5].

OFFICES*	DIVISIONS*
Chief Engineer	Water Control Planning
	Design
	Construction
Manager of Power	Power Utilization
	Power Operations
	Power Engineering and Construction
Chief Conservation Engineer	Chemical Engineering
	Agricultural Relations
	Forestry Relations

*In Table 1.2 Offices are analogous to Divisions in Table 1.1, and Divisions are analogous to Departments in Table 1.1.

(c) Since most of the dam construction on the river was completed, there were no more resources for producing hydroelectric power. Therefore, we may assume that the primary objective of hydroelectric power production had been achieved. However, the increasing postwar power demand forced the TVA to alter its policy. As cheap coal was available they began the construction of steam plants. Of the 14 steam plants that the TVA has at present, 11 were built during this period. The allocation of priorities within the TVA for operating and construction expenses for 1953 is shown in Figure 1.3.

Although investment in reforestation was also slightly reduced in 1953, it was still substantial ($640,000). The attention given to this problem during previous years made it possible to secure an 8% increase in growing stock during the 1950s. The forestry industry in the region had achieved an annual product value of half a billion dollars.

Investments in environmental protection increased from $90,000 in 1947 to $150,000 in 1953. This reflected increased demands for pollution control in coal steam plants.

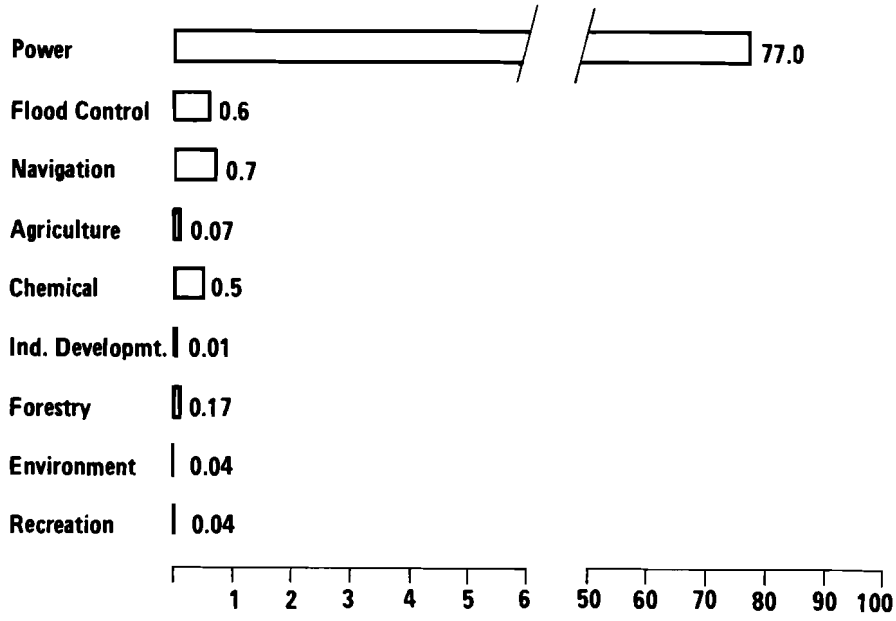


Figure 1.3. TVA budget allocations, 1953 (% of total budget).

Source: [7].

The organization structure in 1953 is shown in Table 1.3.

There has been a Division of Water Control Planning within the Office of Engineering for some time. The appearance of the Office of Chemical Engineering demonstrates the increasing attention given by the TVA Board to the changing production facilities for the new types of fertilizers.

1.2.5 Development of the TVA in the 1960s

The beginning of this period was followed by a continuous growth of power generating facilities. Power expenses reached 94.3% of the total TVA budget in 1960 ($308,100,000); one half of which was spent on the construction of generators. This has mainly been due to the rapid growth in the construction of thermal power stations. This situation is illustrated in Figure 1.4.

In the years that followed there were substantial increases in the TVA's budget (from $326.7 million in 1960 to $579.8 million in 1964). One of the reasons for this was the heavy investment in the construction of a large recreation center in western

Table 1.3. TVA organization units, 1953.

Source: [7].

OFFICES	DIVISIONS
Engineering	Water Control Planning
	Design
	Construction
Power	Power Utilization
	Power Supply
	Power Operations
	Power--Engineering and Construction
Chemical Engineering	Chemical Development
	Chemical Operations

SEPARATE DIVISIONS

Agricultural Relations
Forestry Relations
Navigation and Local Flood Relations

Kentucky. The construction started in 1964 and was finished in 1970, the area being called "Land Between the Lakes" [8].

Although accomplished with relatively small investment the development of this area was a key activity. Land conservation and education, and the development of recreational areas, became one of the major TVA goals.

Figure 1.5 illustrates TVA priorities for the year 1964.

The reduction in the allocation for power from 94.3% in 1960 to 83.3% in 1964 is mainly due to the increasing investment in recreational facilities, the construction of chemical plants producing new types of fertilizers (from $0.8 million to $8.6 million), and the building of additional multipurpose minor dams on the Tennessee River tributaries to improve navigation facilities (Appendix 2).

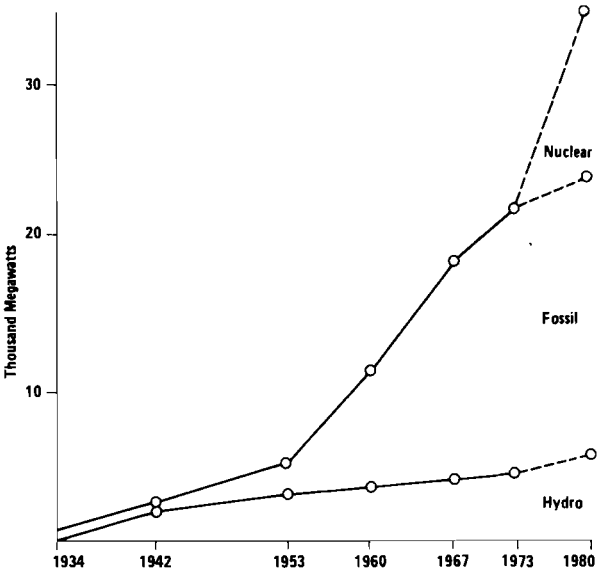


Figure 1.4. TVA thermal and hydroelectric power development 1934-1973 (output by 10^3 megawatts--MW).

Source: [9].

As Table 1.4 indicates, the organization structure conformed to the described objectives. Problems of water control planning have been separated from the Office of Engineering Design and Construction. Again, the expansion of the Office of Power is evident. Problems of agricultural and chemical development have been united under the Office of Agricultural and Chemical Development. The Division of Forestry Development has been kept separate [10].

1.2.6 Development of the TVA in the 1970s

Let us assess the present situation and try to give an evaluation of how previously stated TVA goals and objectives have been achieved and in what direction the TVA now moves.

If one looks at the budget allocation for 1973 (Figure 1.6) it is obvious that power production is the highest priority. This 94.4% represents $1897.4 million [11].

By June 1974, the TVA power system achieved a total generating capacity of 23,319,030 kW. In order to meet projected increases in the region's electric power requirements during the next few

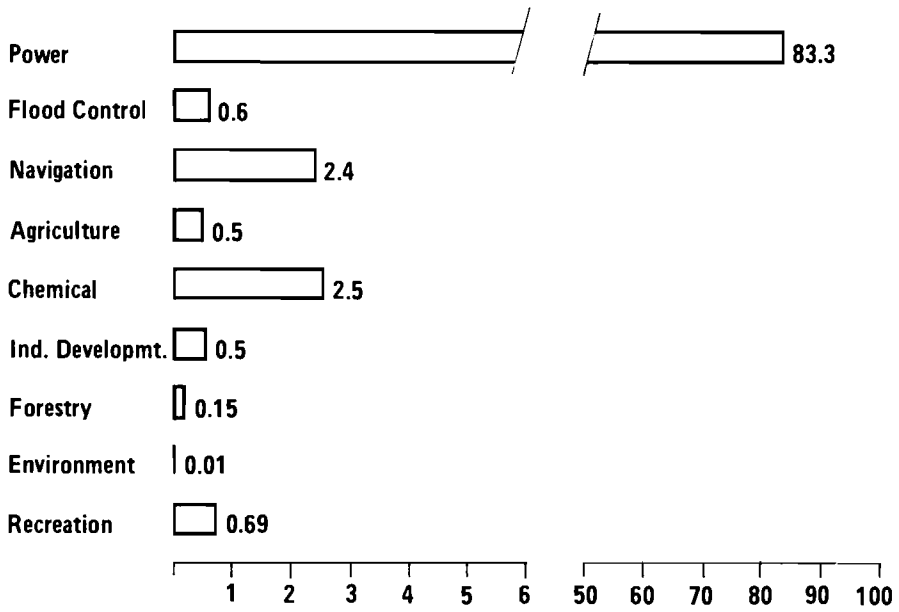


Figure 1.5. TVA budget allocations, 1964 (% of total budget).

Source: [10].

years, the TVA is planning to increase power production considerably, mostly through the construction of nuclear power plants. Five nuclear plants are scheduled for operation on the TVA system at intervals over the next eight years, three of them are under construction now and major equipment and fuel is on order for the other two.

In 1984 the planned proportion of nuclear power capacity will be 75% of the total generating capacity of the system. The planned increase is prompted by growing demands for fuel. Since the availability of uranium 235 is limited, the TVA, in collaboration with the U.S. Atomic Energy Commission and other organizations, is planning to build the power plant, using the breeder concept, on the Clinch River at Oak Ridge, Tennessee. The estimated cost of the whole project is about $1 billion and the TVA investment will be $22 million.

The increasing need for fuel forces the TVA to look for other options. Because of drastically reduced sources of oil and gas, it has acquired the coal mining rights within the region for 130,102 acres.

Bearing in mind the present budget allocation, the above mentioned figures and the fact that the TVA is increasing power sales

Table 1.4. TVA organization units, 1966.

OFFICES	DIVISIONS
Engineering Design and Construction	Engineering Design Construction
Power	Planning and Engineering
	Marketing
	Production
	System Operations
	Construction
Agricultural and Chemical Development	Agricultural Development
	Chemical Development
	Chemical Operations

SEPARATE DIVISIONS

Forestry Development
Water Control Planning
Navigation Development

not only to domestic users but also to organizations outside the region (it supplies an area having 6 million inhabitants), it may be concluded that the TVA is becoming a large governmental power producing and supplying organization. The organization structure in 1974, shown in Table 1.5, reflects the general development trends of the TVA. The Office of Power is being enlarged again at the expense of the Division of Resource Planning, and the Division of Planning and Engineering is being transformed into the Transmission Planning and Engineering Division. A separate Division of Environmental Planning has been created.

1.2.7 Summary and Comparison of the Different Periods of TVA Development

The preceding analysis of TVA goals and objectives, and the allocation of priorities in particular, have been based on the allocation of the TVA budget among items that were presumed to have matched specific objectives. Using the budget allocation also as a basis for comparison, we obtain the following results:

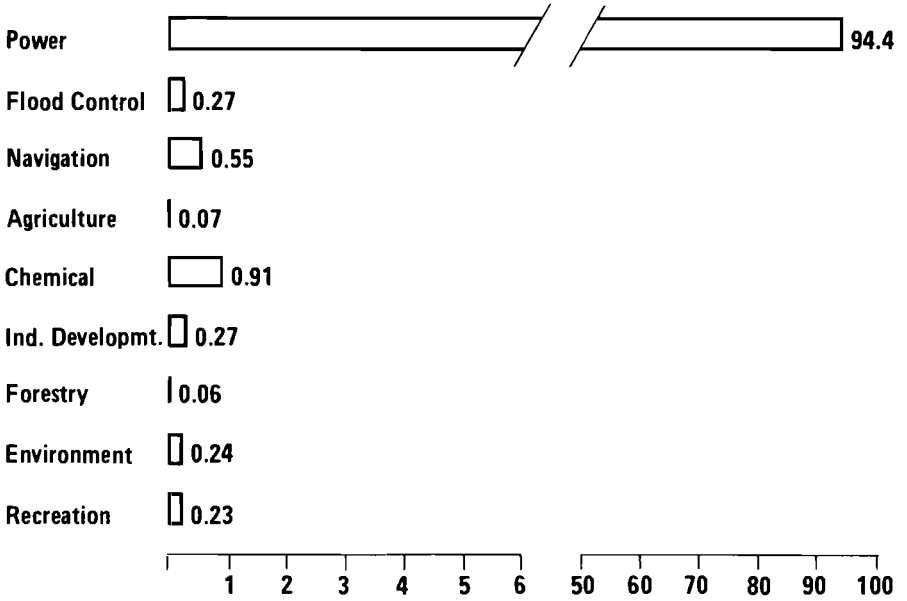


Figure 1.6. TVA budget allocations, 1973.

Source: [11].

since 1947, the share of power in the total budget has continuously increased, except for a period during the 1960s when large sums were allotted to the development of the "Land Between the Lakes" and fertilizer producing plants (Figure 1.7). While the proportion of expenses allotted to other TVA projects decreased, total dollars allocated for these other projects were increasing (Figure 1.8). For example, investments in reforestation, and environmental and recreation projects increased continuously and substantially during the same period.

Within the framework of this development many changes have occurred in the originally stated, primary objectives from 1933 until the present. The major characteristics of this change in goals over time are:

(a) Established in 1933 with the overall goal of unified development of the region, the TVA reflected the pressing need at that time for rapid economic and social innovations in the Valley. The high priority given to the development of the river made it possible to secure protection from destructive floods, develop navigation and power production. This provided the basis for industrial and agricultural development, reforestation, development

Table 1.5. TVA organization structure, 1974.

Source: [12].

OFFICES	DIVISIONS
Engineering Design and Construction	Engineering Design
	Construction
Power	Resource Planning
	Transmission Planning and Engineering
	Construction
	System Operations
	Marketing
Agricultural and Chemical Development	Agricultural Development
	Chemical Development
	Chemical Operations

SEPARATE DIVISIONS

Environmental Planning
Water Control Planning
Navigation Development Regional Studies
Forestry, Fisheries, and Wildlife Development, "Land Between the Lakes"

of recreational areas and improved social conditions. In this sense the TVA, having started from the development of the river, which might be called the core of valley development, contributed greatly to the achievement of the overall goal.

(b) Having fulfilled its function as a governmental organization and having shifted its policy in 1941 to the production of electricity, the TVA received larger appropriations from Congress and managed to increase the production of electricity and also, at its expense, to harness the river.

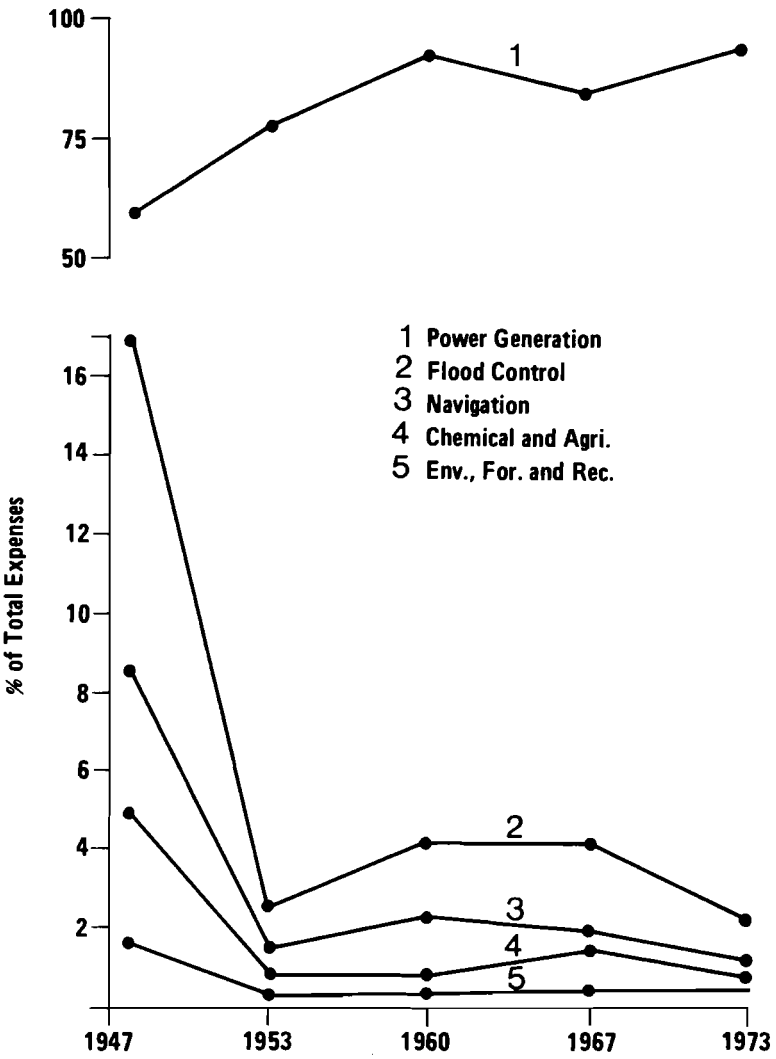


Figure 1.7. Share of TVA expenses (operating and construction) for selected purposes 1947-1973 (% of total budget).

Source: Compiled from [4,5,7,10,11,12].

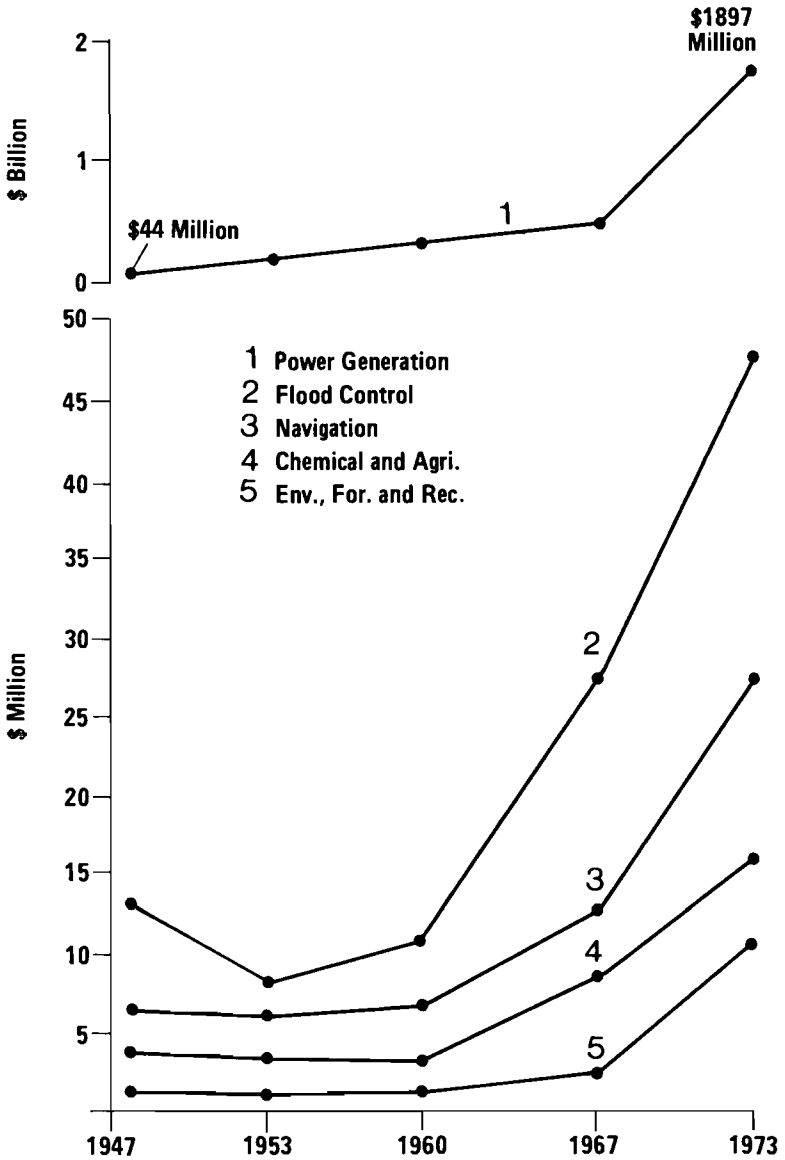


Figure 1.8. Allocation of TVA expenses (operation and construction) for selected items (in dollars) 1947-1973.

Source: Compiled from [4,5,7,10,11,12].

This was the first step, which led to the dependence of other TVA objectives on power production.

(c) The objectives of flood control and navigation were mainly achieved in the 1950s. The integrated river control system that already existed worked satisfactorily and required attention only for the solution of some local problems. The Tennessee River as a core of regional development no longer played the principal role. But at that time the TVA still possessed a very important tool for regional development--cheap electricity in combination with a waterways network and recreation facilities. This attracted private industry to the region, resulting in population immigration and the growth of new cities, etc. This led to the economic development of the region.

(d) In the 1960s there was an increasing demand for electricity. As the region afforded large reserves of cheap coal, the TVA switched its policy to the construction of coal (and later nuclear) power plants. Production costs were low, revenues were large, and in 1960 the TVA was allowed to treat its power operations as a separate entity. From this time, power was considered as a revenue producing branch with excess funds reinvested in power operations or distributed to other divisions.

(e) Since it had excellent research facilities, the TVA invested money in the pilot production of fertilizers, selling them to the farmers at a special low price. The purpose--demonstration activity and making agriculture more profitable--was an important factor in regional development. The TVA also invested money in recreation facilities, reforestation, wildlife, and fisheries to improve environmental conditions for residents and to educate them in nature conservation.

Another important TVA activity aimed at a unified development process--the development of tributary areas--is considered in section 1.3.4 of this chapter.

The TVA can no longer play the key role in the management of regional economic development. Today there are many different ways of influencing this development that are outside TVA control, for example, state taxation policy, credit policy of the banks, location of industrial enterprises. The most profitable branches of industry, such as light industry and machine building, are not a part of the TVA and TVA relations with the banks are weak.

1.3 COMPLEX REGIONAL PLANNING AND MANAGEMENT--GENERAL REQUIREMENTS AND ACHIEVEMENTS OF THE TVA

1.3.1 Systems Approach to Regional Management Complexity

The forms and methods of management of a social or economic system are always largely determined by the goals, structure, and functions of this system. The management system reflects the characteristics of the system to be managed and is itself an integral part of it (see Figure 1.9).

A regional system is characterized by the social and economic units acting as part of this system, their roles and interrelations. The main functions of a regional system occur in:

- Social services to provide health care, education and information;
- The circulation and distribution of goods and financial funds;
- The protection, conservation, and development of the natural environment and available natural resources.

These activities are performed in specialized units--factories and plants, transportation enterprises, social service utilities, institutes, and settlements.

A regional system is also characterized by a wide variety of social and political groups, whose nature varies in accordance with the national sociopolitical structure. Each group in any national setting, however, represents an individual set of social, economic, and political interests in the region. The interaction among these groups and their differing levels of influence determine the goal-setting process and priorities for the future development of that region.

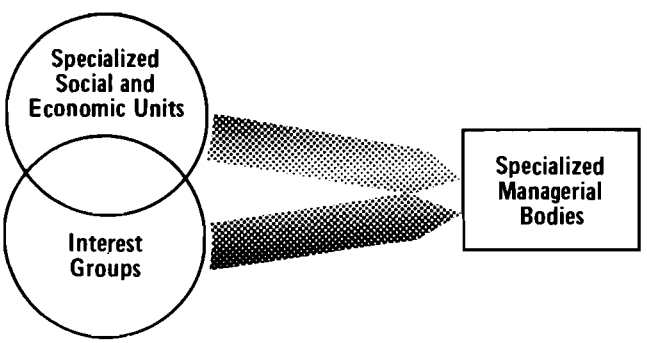


Figure 1.9. Systems elements of regional management.

Managerial bodies dealing with regional planning and management in the United States appear as:

- Federal, state, county, and city governing parliamentary bodies;
- Governing agencies;
- Management of nationalized enterprises;
- Management of cooperatives;
- Management of private enterprises;
- Management of social service units.

The management of regional development depends on the degree to which these managerial bodies interact and to which it can be guaranteed to streamline all activities in the direction of a complex, unified, and harmonious development of the region. This requires, in many cases, a certain centralization of regional management functions and the creation of specialized organizations to perform these functions.

Complex regional development has two aspects. One is the embedding of the region in national development. The objectives of regional development can only be determined if they are derived from the general objectives of nationwide socioeconomic development, and the internal proportionality is much influenced by the links between the individual region and the rest of the country. The other aspect of complex regional development is the guarantee of internal proportionality, harmony, and efficiency at all stages of development. This includes a determination of the objectives of regional development and their breakdown into related sets of subobjectives and operational activities for implementation and control.

These two aspects are reflected in the principal managerial functions related to a region, which have to be performed in interaction with all existing managerial units. They can be described as follows:

- The analysis of the economic and social conditions of the region at the beginning of the development process, including the position of the region within the national economy, the characteristics of the level of economic development, the demographic, climatic, and natural resource characteristics;
- The determination of objectives of regional development derived from national and regional, social and political interests;
- The decision making for the different areas of regional development on the basis of forecasts and programs, situation assessments, assumptions, and planning calculations;

- The implementation of the planned regional development by means of operational activities of all organizational units; based on information and incentives, directed to all groups and individuals involved, demonstration, training, etc.

When the TVA was founded, this was done with the intention of giving to it specialized responsibilities for the management and planning of the Tennessee Valley region development. The TVA was and is responsible for major development activities in the area of the Tennessee Valley (see Figure 1.1) and for a larger overlapping power supply area. The state of Tennessee only partly overlaps the TVA area. The same applied to the subregions. There are counties, as governmental units, within larger tributary areas, which are subunits of responsibility of the TVA and still larger development districts. In terms of managerial structure, in each administrative echelon there are at least two types of managerial unit responsible for regional development (Figure 1.10). For the Tennessee Valley region, these are the TVA, a federal agency, and the state governments of Tennessee, Kentucky, Alabama, Georgia, North Carolina, and Virginia. On the regional subsystems level, these are mainly the county and city administrations, and the TVA tributary area agencies. Regional development must be coordinated among these units and with many private enterprises that are not under the direct supervision of the regional management units. The regional coordination links are shown by the dotted lines in Figure 1.10.

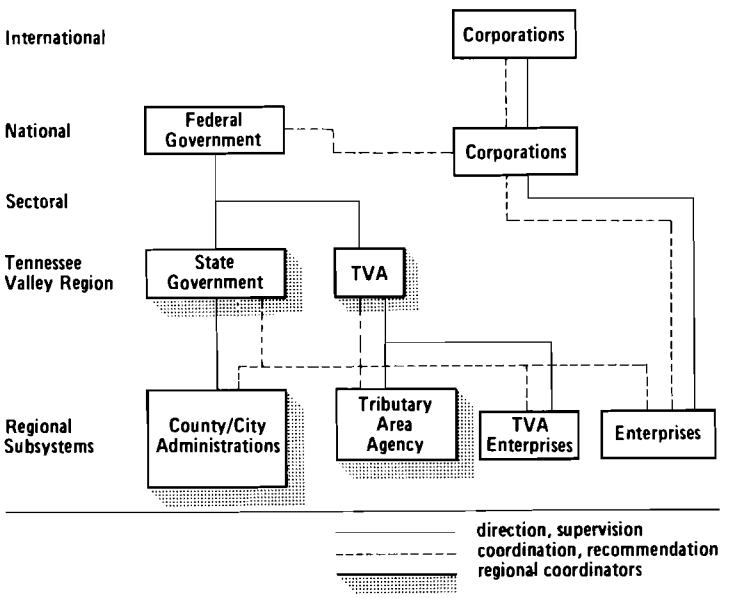


Figure 1.10. Management of the Tennessee Valley region.

The TVA's capacity to provide management for complex development of the region was and is quite limited, and it has altered during the course of time. During the 40-year period, TVA activity promoted more rapid development of the region than had been achieved elsewhere. In the first period it was achieved because the TVA had tackled the basic link on which the region's economic development depended--the integrated control of water resources in the Tennessee River basin.

As soon as the measures on water resource development had been accomplished, the TVA's influence on complex development of the region decreased considerably. Today it is mainly exercised in the area of electric power production and distribution, and the organization of demonstration programs. The important factors of regional development are now in the hands of private companies and state authorities.

Though TVA management still considers its main goal to be the complex development of the region, TVA activity is aimed only at solving specific problems of electric power production, water control, recreation activity, fertilizer development, the organization of demonstration farms, etc.

The three main areas in which the TVA has exerted considerable influence are: the industrial development of the region; the agricultural development of the region; and, more recently, the development of tributary areas of the river system.

1.3.2 Industrial Development

The primary influence exercised by the TVA on industrial development was through the development of a high capacity source of electric power, in combination with related water control activities (e.g., reservoirs, navigation channels).

The TVA's selling prices for electricity are lower than those in other regions, where electricity is produced largely by private companies.* The low prices have been made possible by (1) the availability of cheap hydropower, resulting in quite low production costs, and (2) the constraints dictated by the nonprofit nature of the TVA as a government-owned organization. The availability of abundant, low-cost electric power was clearly a major factor in attracting industry to the Tennessee region. Although the initial capital seemed rather large, over the long term it has shown a

*The average annual price of electricity for industry is 0.8-0.9 cents per kWh, which is much lower than the national average. Households in this region buy electricity for 1.8 cents per kWh, against 5.9 cents in New York, 4.2 in Boston, 3.4 in Washington, 2.9 in Los Angeles, 2.8 in Chicago. The average price for the USA is 2.8 cents (end of 1974).

significant return. However, it would be misleading to exaggerate the importance of this factor.

The production cost of electric power does not usually exceed 15% of industrial production expenditure. Under present circumstances in the United States, economic conditions determined by state regulations, e.g., credit terms, have a greater influence on economic development. This is one factor that is not influenced by the TVA, but upon which the TVA is itself dependent.

In addition to the provision of power and related water resource activities, the TVA exerts some more indirect influences on industrial development. A few of these are noted below:

(a) Recreation resources resulting from TVA development attract skilled specialists to the region;

(b) New enterprises seeking a riverside zone can be influenced by the TVA regarding the purification of waste water, because the TVA regulates these zones. On the whole, the TVA role of protecting the region's environment is not significant outside of its own activities.

(c) Providing information on the development conditions of industrial enterprises to regional chambers of commerce to pass on to interested companies;

(d) Informal influence on the activity of the state, and private companies;

(e) Development of regions situated on the Tennessee River tributaries.*

In addition to TVA-related activities, industrial development is influenced by a variety of factors. A summary of these is provided below:

Favorable Factors

- Availability of relatively cheap electric power (the results of TVA activity);
- Availability of reservoirs (TVA activity);
- Availability of cheap water transport (TVA activity);
- Availability of excessive and relatively cheap manpower and as compared with some other regions, greater diligence among the employees;
- Relatively low taxation and other stimulating measures on behalf of the states;

---

*To be discussed in detail in section 1.3.4.

- Availability of recreation resources which attract skilled specialists (TVA activity).

Negative Factors

- The presence of chemical enterprises, ferrous and non-ferrous metallurgy, coal-fired electric units, which pollute the environment;

- The relatively unskilled labor force, which prevents the development of highly skilled branches of the engineering industry.

However, the favorable factors greatly exceed the negative ones. Therefore industry in the Tennessee region is developing more rapidly than in the United States as a whole. Within 40 years the number of those employed in industry in the region had grown four times the national average at that time.

The decade from 1960 to 1970 is particularly significant [13]. Within this period the number of people involved in the manufacturing industry increased by 4.7% annually, while in the rest of the United States no growth was evident. In agricultural areas and small settlements (up to 10,000 people) this growth made up about 70%, in small towns (10,000-25,000 people) about 30%, but in the big cities it was less than 15%.

1.3.3 Agricultural Development

So far the question of TVA influence on the development of regional industrial production has been discussed. But, perhaps, it had an even greater impact on agricultural production development. Flood and soil erosion prevention (the development of about one million acres of land liable to erosion and previously unsown), efficiency in the manufacture and use of fertilizers, the establishment of demonstration farms, great organizational, educational, and informational activity--all these factors contributed substantially to the 25-fold increase in farm production over the 40-year period. The volume of farm production sales totalled $1.5 billion a year. The average land area of one farm has increased from 70 acres in 1933 to 120 acres at present, and the annual income of one farm, from $300 to $10,000.

The TVA experience in this field is an interesting example of how to achieve considerable results with relatively small funds. The National Fertilizer Development Center can serve as an example: it has a relatively small budget (nearly $14 million per year) and a limited number of personnel (about 800 employees including the personnel of a pilot plant).

The Center is important in determining the production structure and the efficiency of fertilizer use in US agriculture including the TVA region. This has been achieved by careful

choice in the directions of work and by the structure of its organization. The following factors can be singled out.

(a) Concentration of the Center's efforts on elaborating new kinds of fertilizers (there is a plant for their production on a relatively small scale--225,000 tons a year; 10-15 new units are put into operation every year, each costing from $20,000 to $200,000) and free provision of its production technology to industrial companies (the Center has contracts with 200 firms).

(b) An original approach to the testing and evaluation of the efficiency of fertilizers. For this purpose there are contracts with 46 US universities which carry on this experimental work. The Center also has representatives in 14 large universities throughout the country.

(c) Collaboration with farms and universities to test new fertilizers. In 1974 there were 886 demonstration farms in 35 states and more than 1100 farms were involved in testing fertilizer efficiency;

(d) Organization of a wide network of training courses and conferences, training of apprentices and publication of handbooks.

(e) Popularization of fertilizers by means of model farms, training courses, publication of handbooks, and farmers' organizations, etc.

A recent program, initiated in the late 1960s whose objective was to "increase farm income through the introduction of new technology and improvements of farm operator management ability", offers an example of the kind of improvement achieved by one of the TVA programs (Table 1.6).

The high degree of flexibility is also peculiar to the activity of the Agricultural Development Department, which has less than 140 employees but achieves considerable results in the

Table 1.6. Income statistics for 89 rapid adjustment farms (1967-1973, in thousands of dollars).

Source: [14].

	First Year	Closing Year
Gross profit per farm	22.3	40.0
Net profit per farm	5.6	10.6
Capital investment	61.6	84.8

TVA region. This activity will be considered, using the example of resources development in the valleys of the Tennessee River tributaries.

Among the methods of regional development applied by the TVA, the demonstration techniques with the subsequent activity involved in their dissemination are of great interest. Demonstration farms are examples where, in collaboration with the universities, the TVA elaborates recommendations on the ways to increase economic efficiency, and provides fertilizers on favorable terms, thus promoting the successful development of these farms. In 50 model farms, the gross profit increased by 93% and the net profit by 274% (from $1.3 million to $5 million).

In many ways, the TVA recreation activity also uses demonstration techniques. An interesting example is the development in 1964 of the "Land Between the Lakes", where over an area of 170,000 acres a recreation zone and a forest reserve have been created. There is also an environmental education center. At present, 2 million Americans visit this area every year and in the near future this number is expected to double.

The TVA Board of Directors attached great importance to the implementation of the Operation Townlife programs, among which is the program for establishing a model town--Timberlake on the Tellico Lake.

Stimulating the development of industrial and agricultural production resulted in a decrease in migration from the region. During the decades 1940-1950 and 1950-1960 the negative migration balance in the region was 600,000 people per decade, but during 1960-1970 it was 120,000 people and in recent years it did not take place at all. The annual income per capita has grown from $168 (45% of the average US level) to $3365 in 1972 (75% of the average US level), i.e., a 20-fold increase in comparison with a 12-fold increase for the whole country.

However, although the industrial and agricultural development rates in the TVA region were higher than in the whole country, the region's backwardness has not been completely overcome within 40 years of the TVA activity.

1.3.4 Development Programs of Tributary Areas

The implementation of tributary projects plays a key role in current TVA activity on regional development. Emphasis is placed on complex development of the regions situated on the Tennessee River tributaries. Since 1933 the TVA has implemented 18 such projects and several new projects are being realized. The Office of Tributary Area Development, consisting of 47 people and subordinated directly to the General Manager, was established to direct these activities.

First of all, a place has to be found among other regional organizations for the management of tributary areas. The state is the main regional unit of the United States with territory control. States are subdivided into counties, which are primary administrative units. Towns also have administrative management. In addition to this administrative division, which is quite stable, in the recent decade "development districts" have begun to appear. The Federal Government allocated funds for solving the problems related to their development. Funds are granted for specific tasks and after completion finance is discontinued. These districts are formed according to their goals, with no regard to existing administrative structures. They sometimes include several counties or a county and a town inside the state, or even adjoining regions of the neighboring states. Although development districts belong to the federal program of regional development, they are coordinated by local administrative authorities under US law. In development districts, regional planning commissions are being organized.

Tributary areas are of a different character. They are situated within the TVA region on the Tennessee River tributaries and thus partially cover the TVA region. Chronologically, they came into being together with the TVA, that is, before the development districts. The major difference between them and development districts lies in the fact that these tributary areas were established to provide complex rather than single specific development.

A state agency is being established to manage the tributary areas, the leaders of which are appointed by the state Governor. The state agency includes representatives of the state, local authorities and the TVA. In addition, local authorities organize voluntary Tributary Area Associations, which usually contain 20-50 people who elaborate the area development projects with the help of administrative bodies, private and public organizations.

In a number of cases, development districts and tributary areas overlap and, in order to coordinate the three organizations--Regional Planning Commission, Tributary Area Agency, and Tributary Area Association--a Board of Directors and a coordination group is being formed from these organizations.

The following are sources of funds for tributary area development:

(a) Allocations for the construction of dams and hydroelectric power stations on the Tennessee River tributaries obtained by selling bonds;

(b) TVA budget allocations;

(c) Funds of other federal agencies;

(d) State funds;

(e) Capital from private companies--attracted by offers of better economic conditions, etc.

Upper Duck River Valley, which is situated to the south of Nashville and includes four counties, is a typical example of a tributary area. It is an underdeveloped region where the major problems were river control and industrial production development. In 1964 an association was established to plan, promote, and sustain a program of complete land and water resources development. In 1965 the association submitted a complex report on the directions in which this region's resources should be used (about 300 pages [15]). It contained the following sections: human resources, business and industry, governmental services and finances, recreation and travel, water supply, water use, forests, minerals, and agriculture.

The development program includes research, demonstration, and development activity. Each section of the report ends in conclusions and recommendations, which unfortunately tend to be too general. The problem of water resources control was studied in greater detail and a special report was made.

The Elk River region may serve as an example of a tributary area with an agricultural bias. It borders on the Upper Duck River area in the south. A careful study of the soil was carried out in this region, and then the TVA completed a five-year contract with the University of Tennessee to carry on research and demonstration work on the agriculture of the region.

A peculiarity of this region was the fact that in spite of the surplus of labor, the region suffered a scarcity of skilled workers, job opportunities, and capital. A mechanism to motivate farmers was worked out in detail with the help of the University, farmers' organizations, crediting cooperatives, etc.

1.3.5 The TVA and Regional Policy of the U.S. Federal Government

The TVA is the only complex regional organization of the U.S. Federal Government. But even the TVA, as shown above, is limited in its authority to implement national economic development in the Tennessee River region.

This constraint is especially obvious when considering the interrelations between the TVA and the Federal Government.

The TVA budget is approved by Congress only as a part of the budget for the coming fiscal year. This presents difficulties in realizing long-term programs. In addition, according to the words of the Chairman of the TVA Board of Directors, Mr. A.J. Wagner, Congress takes a long time to solve regional development problems because of the bureaucratic procedures. Thus, for several years there has not been approval of the development of the TVA construction facilities, which would greatly influence the time required for putting new electric power units into operation.

The absence of any unity in planning between the federal departments and the TVA is also characteristic. The procedure of

"goal management" is widely used for those departments operating under the guidance of the Budget Bureau and the President's Management Department. However, this procedure of program planning is not used in the TVA, and, moreover, it is regarded by their management as "paper" planning.

In a number of cases, the TVA has close interrelations with many federal departments, in particular with the Agricultural Department, Environment Protection Agency, Department of Internal Affairs, and others. At the same time, there is not sufficient unity in this work; for example, there is no joint realization of unified development programs.

It should be noted that until recently, the Central Federal Authority was not involved with the problems of regional development, but relied solely upon the activity of the states. The TVA was the only exception. The first steps in this direction were taken in the 1960s. The original idea of providing assistance for the development of the Appalachian region, which is spread over 13 states, belonged to John F. Kennedy, but it was not until 1965 that a special office was established to allocate funds to this area. These funds are mainly for the development of the infrastructure.

Later, President Lyndon Johnson drew attention to the above mentioned development region for which special allocations were envisaged in the federal budget [16].

In 1969 President Richard Nixon reorganized the regional subdivisions in different state departments and formed 10 federal regions. In these regions, there are directors for some departments (health care, education, use of natural resources, environment protection, etc.) with their own staff and they are united into Committees of Regional Directors. Although the number of regional staff is fairly large (2000-3000 employees in one region, for example in Boston or New York) the influence of this apparatus upon the region's development is relatively small. Their principal purpose is to consider the proposals of local authorities for obtaining additional funds from the federal budget.

There is no doubt that against this background, the TVA stands out as a more efficient organization for regional development.

1.3.6 Conclusions

(a) During the first stage of the TVA's development the main efforts were concentrated on the multipurpose program of regulating and making use of the Tennessee River, its tributaries and adjoining land, which, as we have seen, is the core of the economic development of the region. Today these problems have to a great extent been solved. As a result the objectives of the TVA, as described in this chapter, have changed, and its capacity to influence regional development is more restricted. Now the major

influences on this development come from private companies and state authorities.

Although the TVA leaders still consider the main goal to be the complex development of the region, almost all TVA activity is directed towards solving specific rather than complex problems. There has been no complex program, general plan, or even a complex forecast of the development of the region for 10, 15, or 20 years. TVA activity in different directions is reflected in the availability of long-range forecasts and long-term plans for development of the power industry, fertilizer activity, recreation work, etc.

(b) There is no efficient regional policy on the part of the federal authority in the United States and there is a lack of unity in planning between the TVA and the federal departments.

REFERENCES

[1] TVA, *Tennessee Valley Authority: The First Twenty Years, A Staff Report*, Knoxville, 1974.

[2] U.S. Congress, *Muscle Shoals Development*, 73rd Congress, First Session, H. Doe, 15, 1933.

[3] Kyle, L.H., *The Building of TVA*, Louisiana State University Press, Baton Rouge, 1958.

[4] TVA, *Annual Report for the Year 1937*, Knoxville, 1938.

[5] TVA, *Annual Report for the Year 1947*, Knoxville, 1948.

[6] Clap, G.R., *The TVA: An Approach to the Development of a Region*, University of Chicago Press, Chicago, 1955.

[7] TVA, *Annual Report for the Year 1953*, Knoxville, 1954.

[8] Smith, F.E., *Land Between the Lakes: Experiment in Recreation*, University of Kentucky Press, Lexington, 1971.

[9] TVA, *Tennessee Valley Authority Handbook*, Knoxville, 1974.

[10] TVA, *Annual Report for the Year 1964*, Knoxville, 1965.

[11] TVA, *Annual Report for the Year 1973*, Knoxville, 1974.

[12] TVA, *Annual Report for the Year 1974*, Knoxville, 1975.

[13] Harrison, C.B., Industrial Growth in the Tennessee Valley Region, 1959 to 1968, *American Agricultural Economics*, February (1974).

[14] TVA, *Analysis and New Directions of the Valley Agricultural Resource Development Program*, Knoxville, 1975.

[15] TVA, *Upper Duck River Valley, Summary of Resources*, Knoxville, 1965.

[16] Derthick, M., *Between State and Nation: Regional Organization of the United States*, The Brookings Institution, Washington, D.D., 1974.

Chapter 2: Planning and Management in the TVA

2.1 INTRODUCTION

This chapter brings together some distinct but related approaches to the study of organizational aspects of the TVA--its structure, its methods of planning, and its means of implementation. In this introductory section we will briefly describe the interrelationships of the papers, and the general approach and limitations of the TVA study particularly as they affect organizational issues.

The study of the organization and management of the TVA is of potential interest in two different ways. Firstly as a particular organizational means of achieving the balanced development of a region which was, relative to the national average, underdeveloped; secondly as an internationally recognized example of a complex organization carrying out diverse programs. While the two approaches are related, the second does not include the specifically regional focus, but is more representative of the activities of the organizational study group, although not necessarily that of the other groups within the larger study team.

To look at the TVA as a particular mechanism for regional development would have involved concentrating not only on the TVA itself but on the many other organizations that relate to development activities in the Tennessee Valley. These include state and local governments, federal agencies, universities, and others. The TVA is the central agent in Tennessee Valley development, but it is certainly not the only one. To understand and evaluate the TVA as a particular regional mechanism, we would also have to take account of the specific factors and values operating within the United States more than 40 years ago, which through the formulation of the federal policy led to the creation of the TVA. The research reported here cannot and does not aim to be so comprehensive. We have some information on the network of organizations of which the TVA is today a part. However, the research was not designed to fully elaborate that network and we have no reason to believe that our information is complete--rather the opposite. From the historical standpoint we are not able to discern why a TVA-type agency seemed the appropriate organizational solution to policymakers, given the specific conditions of the 1930s. Some of those conditions have now changed and this may be one of the reasons why the TVA has not been imitated elsewhere. Under today's conditions policymakers may see more attractive ways of providing coordination between interconnected programs.

We focus, then, on the TVA as an example of a modern complex organization. No organization can be considered in a vacuum or

without regard for its evolution, so we will refer to this wider context on the basis of our own observations and literature reviews, including sections relating to TVA history. The special regional character of the TVA will not be lost in the following sections, but these sections will not amount to an evaluation of TVA strategy as a means of achieving regional development. This limited perspective is consistent with the circumstances under which the study was initially planned--as part of the IIASA Large Organizations Project, which had not at that time placed an emphasis on regional development.

In studying the TVA as an example of large and complex organization one can follow one of two primary and related modes. One is to look at the TVA as a repository of specific and sometimes novel management mechanisms. From this it should be possible to add to the battery of organizational forms or management techniques that have stood the test of time and may be applicable elsewhere. Hence the insight gained from the TVA experience can be very direct. The second is to compare or criticize the TVA against particular theories or organizational "solutions" which have been tested elsewhere. At its most simple this mode asks, "How does the TVA compare with, or add to, the state of the art of designing management systems?" Knowledge gained from empirical experience underlies this approach; consultancy activities and much organizational research follows it. As will be seen the TVA does partially fulfill the expectation of being a good means of observing novel methods.

It is reasonable to categorize the first three of the four sections in this chapter as broadly following the latter mode. They were written by three separate observers within the study team, who were able to draw on different experiences and who used different models or criteria. The first section describes, with some evaluation, TVA structure at the corporate level, and focuses on mechanisms used for integration and coordination (J.O. Tomb). The second concentrates on the TVA planning system (R.C. Tomlinson). The third details some of the rather special, indirect mechanisms used to achieve implementation in some of the TVA program areas (R. Owstrowski). Each section reflects the rather different perspective of the author.

The fourth section in this chapter considers TVA organization at the divisional rather than corporate level (C. Davies). This mode of study is rather different and the analysis has drawn upon a conceptual approach developed at IIASA in the 18 months following the field study.

Studies which seek to learn from particular mechanisms or procedures used in any organization, and attempt to apply that experience elsewhere must ultimately be limited by questions concerning the universality of that experience. Most students of organization would agree that ways of solving organizational problems are not infinitely transferable but are limited by the nature of the objectives of the organization and the setting in which it exists.

No doubt some mechanisms are more transferable than others, and some settings or purposes can in practice be regarded as sufficiently similar for at least a transfer attempt. The success of much work in the organization field demonstrates that a degree of transferability of direct organizational experience does exist. However, this mode of research does not itself help to define the boundaries of the process. An alternative approach to organizational study is to use cases to establish a theoretical framework for understanding the conditions under which particular structures or mechanisms are appropriate and can therefore be expected to be successful. This was not our central approach in the TVA case study, but we can nevertheless apply such ideas developed after the case to make additional use of the information collected.

The ideas we will use in the fourth section draw upon a conceptual approach developed at IIASA specifically to deal with cases in different settings where it was expected that experiences would not be directly transferable. It is an approach that was applied in a Soviet and also a UK case study. Because it was designed to address questions of large-scale program management involving many institutions rather than one, we are not able to apply all the ideas here. Nevertheless some of the basic concepts are presented and through them it is possible to make new interpretations of our TVA data.

This chapter will not end with an overall summary or with final conclusions about TVA management and organization. Each section presents its own insights and conclusions. Some of these (where they overlap) are on occasion at variance with one another; this reflects the initial viewpoint taken by the author. For this particular area of the study it would be wrong to try to create a unified view over the study team. We believe the different conclusions to be an inevitable reflection of the state of organizational research, especially as it affects studies carried out by international teams on a single organization and especially as it attempts to conduct research across national and cultural boundaries.

2.2 ANALYSIS OF CURRENT ORGANIZATIONAL STRUCTURE

This summary of the TVA organization structure discusses significant characteristics of the Board of Directors, the Office of the General Manager, the mainstream operating activities and the service and support units. It then examines the mechanisms for internal and external coordination with their emphasis on informality.

2.2.1 Board of Directors

The TVA has a Board of three members appointed by the President of the United States to serve full time (with no outside interests) for overlapping nine-year terms. The Chairman of the

Board is designated by the President; he serves as spokesman for the Board and often for the corporation and is thus the chief executive officer. Majority vote governs Board decisions.

The background and experience of the Board members covers a broad spectrum. The initial Board included an educator, a lawyer, and a specialist in construction. The present Board Chairman started with the TVA as a construction engineer in 1934. Later he became General Manager and in three years will complete his second nine-year term on the Board. The other Board member is a lawyer and a former Tennessee state legislator, who later served as a Commissioner of Conservation in the state. (One of the positions became vacant when the incumbent's term expired and the vacancy had not been filled in June 1975.)

The size of the Board is a rather unique feature. For an enterprise of the TVA's size one would expect it to be much larger.* The three-man Board avoids the problems that often stem from "one-man rule".** Overlapping terms provide continuity. At the same time, the Board is small enough to minimize communication and coordination problems.*** The TVA Act of 1933 defined the broad objectives of the TVA, but left it to the Board to determine the most appropriate internal arrangements. In addition, the TVA is independent of the Civil Service Commission in Washington, D.C.; it establishes its own organization structure and position classifications, determines its own pay scales (based on general practices in the Valley) and maintains its own retirement fund.

Figure 2.1 illustrates the structural relationship between the Board and the overall organization. The Board is empowered to "...direct the exercise of all the powers of the corporation". It establishes general policies and programs; reviews and appraises final results; evaluates projects and specific items, which are of major importance, involve important external relations, or otherwise require Board approval; approves the annual budget; and

---

*The TVA's annual operating expenditure approximates $1,000,000,000; its assets exceed $5 billion; its staff number over 10,000.

**In 1941, David Lilienthal, one of the original Board members and its second Chairman, was discussing the appropriateness of a three-man Board. Gordon Clapp, later General Manager, expressed "...a great deal of faith in the proposition that the public thinks that a three-man board is less arbitrary and is less subject to local special pressures than a single Administrator. Three men are almost invariably less arbitrary, in fact, than one man; there may be countervailing disadvantages, of course." [1, p. 281]

***An observer of the nationalization, then the partial denationalization and later the renationalization of the British Steel Industry between 1949 and 1966 has commented that for the sector that remained publicly owned throughout, a three-man Board of this type might have provided the considerable advantage of continuity with flexibility and quick response.

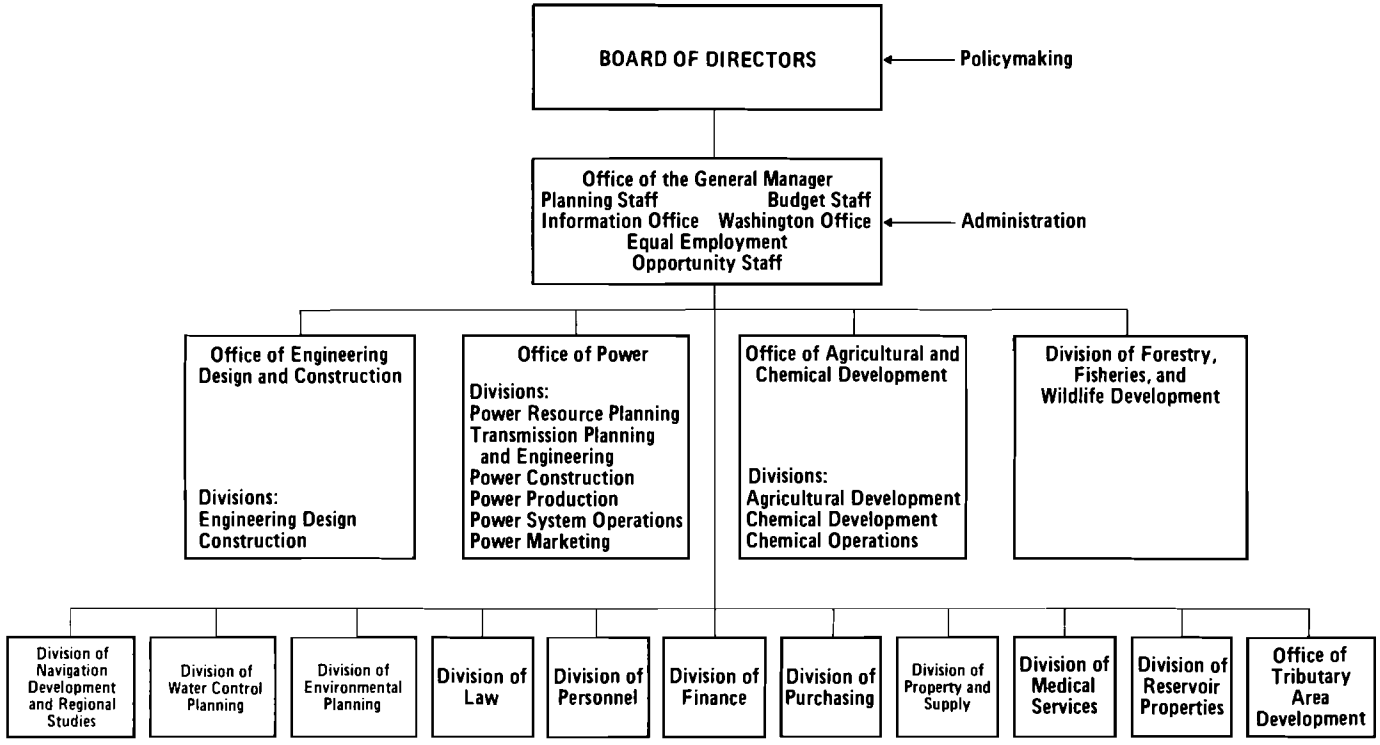


Figure 2.1. Organization of the Tennessee Valley Authority.

establishes the basic organization through which programs and policies are executed.

The preceding paragraph suggests that the Board is a strong policymaking and strategy-determining body. In the very narrow sense that formal Board action is required, this impression would be correct. In actual practice, however, the Board appears to have a more limited role. For example, we have been told that the General Manager screens or filters the issues presented to the Board, "so as to avoid conflict situations" and minimize confrontation. The June 12, 1975 Board meeting, attended by a member of our group, would support this view.*

The strategy and policymaking role of the Board can also be obstructed. This occurs because it is often presented with a single situation for decision rather than with alternatives; thus it is limited to a "yes or no" decision and cannot exercise judgement about the relative desirability of available alternatives. To some extent, therefore, the remainder of the organization has preempted the policy- and strategy-formulation role of the Board.

It is perhaps because of this situation that the Board finds it difficult to leave nonpolicy matters to others in the organization. We have been told that Board members are "unwilling to be isolated from operations". There are said to be times when the Board will "assert itself" with respect to the way its policy decisions are implemented.**

---

*At the June 12 meeting (one of the two monthly sessions that are open to the public) 6 representatives of the press (including a movie camera photographer) and 12 other individuals were present. After brief opening comments by the Chairman, the General Manager explained each of the 33 items of the agenda that required Board action (approximately one third had been informally approved prior to the meeting because of time limits relating to contract bids). From time to time, the Chairman and the other directors present asked questions or offered clarifying comments. Occasionally executives from various organizational units were asked to elaborate on the remarks of the General Manager. The session could be described as informal and the comments were usually noncontroversial.

**A recent example relates to a Board directive to reduce operating costs in the Office of Power by $10,000,000. Operating management decided to terminate a number of home economists as part of a broader program to eliminate the Power Marketing Division (a function that seemed redundant when the TVA was encouraging customers to reduce their use of electricity); once this decision became known, the Board member who "pushed the hardest" for the cost reduction policy is said to have insisted that the home economists be retained. While this action of the Board member may have been justified, this example is said to be an illustration of the difficulty executives have in understanding the role of the Board in relation to operation decisions.

The fact that the Board has no staff of its own, but relies on individuals throughout the TVA for information, opinion, and advice probably encourages an inclination to "reach down" into the organization on nonpolicy matters. This staff arrangement minimizes overhead expenses but the pattern of direct communication with the entire organization makes involvement in nonpolicy matters almost inevitable.

Board members devote about one half of their time to meetings, both formal and informal, with government officials. These sessions range from budget reviews with the Office of Management and Budget in Washington, and Congress, to less structured discussions of existing or prospective TVA activities.

The Board does not appear to have addressed itself specifically to the traditional responsibility of the policymaking body in a large-scale organization, i.e., the updating of goals and objectives. Board members continue to define the mission of the TVA in terms of its initial (1933) charter--to provide for the integrated development of the resources of the Valley. In actual practice today there is very little activity in the TVA that could be labelled "integrated regional resource development". Instead, each individual organization unit tends to focus on its own particular concerns, rather than on action that would optimize overall conditions throughout the Valley. (For example, Power is said to have strenuously opposed the efforts of other organization units to introduce more stringent strip mine rehabilitation standards, because such action would increase fuel and power costs. Likewise, Water Control objected to efforts to maintain higher water levels that would enhance recreation sites on the reservations up-river from TVA dams.) As a Brookings Institution report observed,

> ...TVA became a performer of specific tasks, not a comprehensive regional planner...Sections 22 and 23 of the act, the planning sections, have barely been used and a regional planning unit created at the outset was eliminated after 1938. Among specific tasks, TVA has concentrated heavily on the generation and sale of electric power. [2, p.2]

Furthermore, the history of the TVA includes many efforts at regional development that were abandoned due to public pressures:

- The use of dam construction sites to establish model housing, education, health care, and other social infrastructure mechanisms;
- Purchase of large land areas adjacent to new dams and power plant sites so that the TVA could carry out extensive programs of reforestation, soil erosion control, and farming practice improvements;
- Commerce Department program to attract industry to the TVA area;
- Plans for overall development of the Valley's resources.

Although the TVA can no longer be viewed as an integrated regional resources development agency, the Board seems to ignore this situation--at least in its public and published statements. One consequence of the discrepancy between formally stated objectives and the actual situation is the rather widespread concern about the TVA's future. Both internally and externally we heard comments about the "lack of direction". As often happens, a redefinition of the goals of the total enterprise appears much clearer in the lower echelons of the organization structure than in those higher up. The fact that power operations account for 94% of the TVA's operating budget leads to concern over the single-minded emphasis on power. People are said to be "scrambling to protect themselves" against the possibility (which some believe is very real) that in the future the TVA will be an electric power producer only.

The lack of a clearer sense of direction for the organization as a whole may stem, at least in part, from senior management's desire to "maintain a low profile". The TVA often has purposefully minimized its own role because of the importance attached to the philosophy of "helping people to help themselves". Management wanted others to get the credit for whatever was accomplished. The TVA's role was essentially considered to be that of a catalyst--an agency that would identify ways to improve the quality of life and provide information on the steps that should be taken, but not to effect the improvements. This action would be the responsibility of individuals or local governments.

Whatever the cause, the absence of a clearer sense of direction creates the impression of an enterprise that has informally and unofficially decided to confine itself to a far narrower role than was envisaged by its creators. The Authority has become largely opportunistic; activities that might come under the regional development category now tend to be ad hoc developments rather than an integral part of a regional development plan. The absence of formally expressed objectives (including the absence of any efforts to revise them to reflect changing conditions, both externally and internally) does not represent a model that other regional development enterprises shoudl emulate. As the enthusiastic sense of mission of the TVA's founding generation is no longer available to provide a forward thrust, the absence of a clear sense of direction would seem likely to breed a loss of confidence, slow down the Authority's momentum, and lead to internal confusion and conflict.

The author would also suggest that other regional development projects should make more of an effort than the TVA seems to have done to maintain its early innovative and pioneering spirit. Regional development should be viewed as a continuing cycle of new challenges, rather than as a finite task.* Dynamic leadership

---

*This philosophy was reflected in President Kennedy's comments in his speech at Muscle Shoals in May 1963: "The work of TVA will never be over. There will always be new positions for it to conquer."

that keeps pushing new targets out in front of both the enterprise and its environment is essential in order to prevent the enterprise from being overwhelmed and coopted by the environment.

2.2.2 Office of the General Manager

The General Manager is the Authority's chief adminstrative officer. One of his responsibilities is to ensure effective coordination of all operations within the policy framework established by the Board. He must also keep Board members informed. The General Manager is said to be "the boss on most operational problems".

The attempt that is made within the TVA to differentiate between the Board of Directors and the Office of the General Manager may be somewhat artificial. There is a high degree of interaction between these two organization units. The General Manager spends much of his time in informal discussions with Board members; as the comments about the Board of Directors indicated, the General Manager exerts a considerable influence over the matters brought to the Board as well as over the way in which they are presented. Conversely, the extent to which the Board becomes involved in "administrative" matters varies according to both the issue being considered and the management style of incumbents in both organizational units. (For example, the General Manager who preceded the present incumbent had been described as "weak" and "anxious to avoid problems"; in contrast, his predecessor was considered "strong".) Thus, we prefer to view the TVA's senior management as a single entity, as Figure 2.2 illustrates.

Figure 2.3 indicates the staff units that make up the Office of the General Manager. Considering the TVA's complexity and scope their small size is surprising. For example, Planning contains only two individuals. The Washington office is essentially a post office box, and contrary to some impressions, does not act as the clearinghouse and coordinator for relationships with federal agencies. The very limited role of the Washington office reflects the nonfulfillment of the hope of the TVA's early leaders that it would become the major vehicle for effecting federal programs in the Valley. For a variety of reasons, agencies such as the Departments of Agriculture, Commerce, and Interior perceived the TVA as a threat to their own existence; the net result was not only a refusal to turn over any of their own activities to the TVA but also the lobbying in Congress--often effectively--to take away programs that the TVA had initiated in its early years.

2.2.3 Operating Units

The mainstream operating activities of the TVA are carried out through four "program" units organized essentially around professional disciplines: Office of Engineering Design and Construction, Office of Power, Office of Agricultural and Chemical

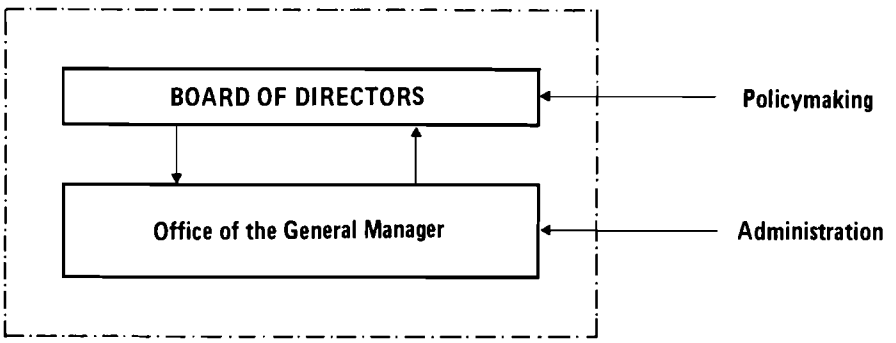


Figure 2.2. The TVA's senior management organization as it seems to function in practice.

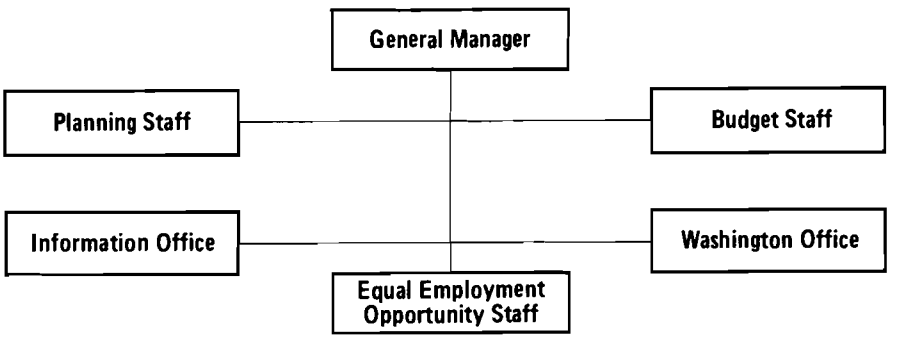


Figure 2.3. Office of the General Manager.

Development, and the Division of Forestry, Fisheries, and Wildlife Development.

Engineering Design and Construction is essentially a service unit that deals with the planning, engineering design, and construction of most permanent structures. The Office of Power is a more or less conventional "product" grouping concerned primarily with the generation and transmission of electric power. (Distribution is handled by some 160 local entities, often known as utility boards, which are generally publicly owned and completely separate from the TVA.) Power is a highly self-contained segment of the enterprise. For example, its finance division maintains direct contact with banks and other financial institutions and arranges for the sale of bonds or other debt instruments. Power is said to do its own program planning and resource allocation with only "general review". This situation causes concern about the adequacy and competence of the decisionmaking process.

The Division of Forestry, Fisheries, and Wildlife Development conducts investigative and development programs directed toward maximum sustained production, use, and enjoyment of resources within the TVA area.

The Office of Agricultural and Chemical Development is an outgrowth of the World War I nitrate plant in Muscle Shoals, Alabama, that served as the genesis of the TVA. It carries out research in and development and production of new and improved forms of fertilizers; much of the country's fertilizer production is manufactured under licenses granted by the TVA. It also tests and demonstrates methods of fertilizer use as an aid to soil and water conservation and to the improved use of agricultural resources.

An analogy is often drawn between the TVA's "program" Offices or divisions and the product divisions of a multidivision enterprise, but this does not adequately reflect the unusual diversity of activities carried out within the TVA. Unlike the relatively similar product divisions of many large-scale enterprises, in which product differences are greater than the variations in management functions, the TVA's "program" Offices and divisions contain a broad spectrum of dissimilar management activities. Engineering and Construction, as well as Power come the closest to the pattern of production and marketing (or delivery) activities found in a conventional product division of a multidivision enterprise. At the other end of the spectrum is the Office of Agricultural and Chemical Development, in which research and development, and farming practice activities predominate. Between these two extremes is the emphasis on education and demonstration in the Division of Forestry, Fisheries, and Wildlife Development.

The TVA often has been described as a "decentralized" enterprise. The phrase "decentralized" appears to have originated during the early days of the TVA when the decision was taken to locate its management in the Valley at a distance from the federal bureaucracy in Washington. In terms of its relationship to other

federal agencies, the TVA is decentralized. The early decision to base the entire management team within the Valley has facilitated what David Lilienthal, one of the original three directors and later the TVA's Chairman, has termed "region building at the grass roots" [3, p. XIV]:

> TVA is an effective effort to decentralize the functioning of the federal government, to reverse the trend toward decentralization of power in Washington, to delegate, dilute, and withdraw federal power out of Washington and back into the regions and states and localities, insofar as the development of natural resources is concerned. The majority of the original Board of Directors and succeeding Boards, with the approval of Congress, set out to provide a demonstration that greater and greater centralization in the Washington bureaus and departments was not inevitable; that a practical way could be worked out for regional decentralization that would work. That effort largely succeeded.*

However an examination of the TVA's organization structure reveals a mixture of centralization and decentralization with the degree of each differing by function and by activity. To take one example, Power wields a great deal of influence (partly because the head of the Office of Power has easy access to the Chairman of the Board, which permits him to bypass the General Manager); on the other hand, the negotiation of all contracts

---

*A recent study of regional organizations in the United States suggests that this grass roots doctrine is "suspect" because it grew out of the TVA's efforts in 1939 to avoid being placed under the jurisdiction of the federal Department of the Interior. Martha Derthick goes on to observe [2, p. 34-35]: "As a description of TVA's conduct, the doctrine also has the defect of being too general. This is the nature of such doctrine, but the defect is accentuated in TVA's case by the actual variety of organizational behavior. The fact is that how TVA has conducted relations with others has depended on which program TVA was conducting. Each has its own pattern of politics and administration."
Before the grass roots doctrine was enunciated in comprehensive terms, the Authority itself drew a clear distinction between the functions that were federal in nature, and therefore proper for it to execute, and those that were local in nature, and therefore properly left to the people of the Valley and their state and local governments. "Control of the Tennessee River is under the authority and direction of the Federal Government", the TVA's annual report stated in 1936, and "the planning of the river's future is entrusted to the TVA". On the other hand, the Authority had "no power or desire to impose from above a comprehensive plan for the social and economic life in the Valley. The planning of the Valley's future must be the democratic labor of many agencies and individuals."

for coal, which accounts for 60% of the total cost of electricity, is handled by the central Purchasing Division rather than by the Office of Power--an arrangement that divides accountability for power costs. The next section of this chapter provides a more detailed explanation of the mixture of centralization/decentralization within the TVA's mainstream operating units.

Thus, while there is no consistent pattern of decentralization, we believe it is correct to say that the organization structure is characterized by a high degree of compartmentalization and self-sufficiency. With some exceptions of a rather limited nature, the TVA functions with far less interaction than one might expect to find in an enterprise dedicated to a unified approach to resource development. Engineering, for example, only becomes formally involved in the planning of a new power generating facility after a project is well advanced. Compartmentalization has almost advanced to the stage where power or fertilizer production could be spun off as separate entities without having a significant impact on the TVA's other activities.

2.2.4 Service of Support Units

The Authority's organization structure includes the usual range of services or support units to be found in a large, multi-product enterprise: Finance, Law, Medical Services, Personnel, Property and Supply, and Purchasing. It should be noted that Finance is essentially a bookkeeping/accounting activity without responsibility for external financing--which lies with the Office of Power. It is also not responsible for planning or management information systems, which are handled by the Planning Staff in the Office of the General Manager.

In addition to these conventional service or support activities the TVA's organization structure includes several units that have a special content: Division of Environmental Planning, Division of Navigation Development and Regional Studies, Division of Reservoir Properties, Office of Tributary Area Development, and Division of Water Control Planning. Some of these units perform operational functions (e.g., Water Control Planning directs the release of water from the reservoir system), but the overall range of their activities appears to be more of a service or support nature. The rather special activities of these units are summarized below.

The Division of Environmental Planning is responsible for insuring that the ongoing or proposed activities of the TVA meet the environmental protection criteria established by government agencies or by the TVA itself (in those cases where the TVA chooses to set standards higher than governmental criteria).

The Division of Navigation Development and Regional Studies combines two separate categories of activities. The first relates to the further navigation engineering development of the Tennessee River system, and includes responsibility to maintain channel

markers on secondary channels. The second and potentially more significant, since the river system is essentially completed, relates to regional economic analysis and the preparation of plans for regional economic development. The latter role, however, is essentially advisory since the TVA has no authority to implement any regional development plans that its staff may prepare; it must rely on persuasion and the cooperative action by others.*

Reservoir Properties operates and maintains the parkland reservations adjacent to dams, provides property protection and law enforcement, and operates facilities for visitors.

Water Control Planning is responsible for determining the flow of water from reservoirs throughout the Valley so as to minimize flood damage and maximize hydroelectric power generation.

2.2.5 Mechanisms for Internal Coordination

The TVA has established a high level of technological coordination in its operating activities. Evidence of this can be seen in the close working relationships, with daily or even hourly contact, between the Division of Water Control (that determines

---

*Some pertinent observations can be found in [4, p. 122, 123, 128-129].

- "TVA has believed that these planning and implementing powers belong to the states and that TVA's responsibility is to help the states assume and use these powers. Over the years TVA has accepted the responsibility of helping states and local governments create the necessary planning and implementing organization and to assist in coordinating their activities in the region."
- "It is generally accepted that TVA has been a success in the development of a multi-unit, multipurpose river system. In this sense, TVA holds itself up as a model of orderly, integrated resource development for the rest of the world to follow. TVA has been less successful in the development of the land resources in its geographic area and still less so in bringing about the social and economic changes required for economic development."
- "All TVA policies and programs should be oriented to creating a desirable climate for growth. Much greater effort is required to get local government to accept its responsibility for creating this climate. Much greater emphasis on the role of urbanization in the region is required, as well as increased education on the requirements of continuous planning and the need for coordination of responsible state and local agencies."

the release of water from reservoirs) and the Office of Power (that operates the electricity generators). Another example is the collaboration between the Office of Power and the Division of Fisheries in determining the impact of water intake or exhaust systems at power plant locations on biological systems and developing technical designs to minimize unfavorable conditions. The steps taken in the TVA's early years to combine the construction of new dams (and their reservoirs) with a program to eliminate malaria-carrying mosquitoes is yet another illustration of successful technological coordination.

However, the managerial aspects of the Authority are characterized by the paucity of internal coordination and integrating mechanisms. The integrative organization units that were established during the early years of the TVA (i.e., Coordinating Division, Regional Planning Council, and Management Services Council) no longer exist.

The elimination of the Coordination Division followed by the planning councils meant that the Office of the General Manager became the focal position in the organization (other than the Board) at which a total enterprise viewpoint could be brought to bear. The need for the General Manager to "balance the activities of the operating units" was especially important since the operating units had been organized vertically around fields of technical specialization, e.g., design, construction, power generation, agricultural practices, rather than around programs that cut across these technical fields. The insistence of some General Managers that each Office or division should present its case independent of other organization units that might be affected added to the need for the Office of the General Manager to play an integrating role.

Two steps have been taken in recent years to improve coordination:

(a) To ease the integrating load the present General Manager decided to encourage "self coordination". This has been considered to be a relatively ineffective process that favors "bland generalizations" and tends to "bury conflicts".

(b) Much the same has happened to the "situation assessment" step in the planning process that was introduced when the Planning Division was established in the Office of the General Manager several years ago. In concept, this first step in the annual planning process includes an analysis of the working environment: (i) outside the TVA, (ii) within the TVA but outside the operating unit, and (iii) within the operating unit. The analysis is intended to identify "circumstances, trends and situations that may impact either favorably or unfavorably on the organization units' ability to achieve...goals.

> Particular emphasis is given...to problems that cannot be resolved without policy direction or guidance by the Board of the General Manager". If it worked as expected the situation assessment could provide the General Manager with some of the information that he needs to identify and resolve conflicts. However, it seems that the situation assessments are limited to "sanitary comments" and muted references to interunit conflicts. The lack of interunit discussion about problems has been described as the "greatest single weakness" in the Authority's planning process.

Unfortunately, these devices fall far short of the needs of a regional development enterprise with multipurpose, multiproduct activities organized in a largely vertical manner. In the words of one observer, "...The mode of coordination within TVA has not been integration through strong central direction. Friction among the parts has been reduced by giving freedom to each." [2, p.32]

Against these rather meager integrating efforts stands a rather impressive array of deficiencies.

First, there is no formal approach to regional resource development. Non-power projects are activated as separate undertakings rather than as part of a coordinated, long-range program.

Second, there is no mechanism for resource allocation between major organization units. Each Office or division determines its own resource needs. The situation is fragmented and organization units may even operate at cross purposes.

Third, the situation is compounded by the failure to inject an integrating device, such as a project team, in order to reduce the compartmentalization that characterizes the organization of mainstream activities. Even though the design, construction, and operation of a new power plant would appear to be ideally suited to the use of project teams (with members drawn from all organization units affected, including Finance and Personnel), the TVA has not adopted this organizational mechanism, which has been proven quite effective in integrating operations in capital intensive industries. Even so simple an agent as a one-man project coordinator is only now being introduced; it is so new that the position description had not been incorporated in the Administrative Guides as of June 1975.

In many large enterprises, the planning process--including the review of proposed plans by senior management and the subsequent assessment of group and individual performance--can be an effective integrating device.* When compared with general practice

---

*See for example Steiner's comments to the effect that planning "is an integrated framework within which each of the functional plans is interlinked and all are tied together..."; planning "provides a mechanism for the interrelated parts to be coordinated, thereby

in US industry, the TVA does not rate too highly. The present effort to use planning as an integrating device did not get under way until the 1970s--about 40 years after the TVA's inception. There appears to be limited support at some senior management levels, for a substantive planning system. Planning processes are best characterized as "loose and incomplete". Plans seldom include the formal considerations of alternatives or contingencies. One example cited was the failure to provide for an upward revision for electric power rates, although it was almost a certainty that such a change would take place at least once during the period of time covered by a recent plan. The informal "general" review of plans by senior management is defended on the grounds that greater emphasis "could be destructive of TVA's decentralized organization". Once the annual budget is approved, we understand there is little, if any, review of performance until the end of the year. A recent analysis of the TVA's management practices by the Controller General in Washington was highly critical of the "lack of planning".

One consequence of the absence of integrating mechanisms for mainstream activities is the reduced opportunity to consider the TVA as a unified system. Another result is an insularity of viewpoint, especially at lower organization levels. A third, which we have not yet assessed but for which we have gained some impressions, is the potential for less than efficient project effort on large capital expenditure projects.

Mainstream operations are not the only area in which integrating mechanisms are lacking. The same is true of research. This function is "fragmented by division" with a minimum of coordination. For example, hydraulics research is carried out in one division, fertilizer in another, nuclear power in a third, and solar energy in a fourth. Some of these fields are so sophisticated that an economy of scale approach rather than a decentralized approach would seem to be preferable.

One does not expect to find a lack of integration and coordination mechanisms in multipurpose organizations where the formal structure is largely vertical and where the predominant management style is extremely informal.

2.2.5.1 Reliance on "Informal" Structure

The TVA's organization is "informal" in two respects. First, it is an organization in which hierarchy plays less of a role than

---

(continued from previous page)
avoiding suboptimization of parts at the expense of the whole"; or planning "does not deal with each separate element of the business alone, by itself, but rather permits the manager to see things as parts of a whole...A well-developed plan naturally lays the basis for coordination, and effective control cannot be assured without planning and coordination." [5, pp. 7, 66, 67, 297]

in most enterprises of its size. This produces a flexibility which permits a response to external or internal changes without the need for official modification in organization structure that might be necessary in other large enterprises. The lack of emphasis on hierarchy also generates a more satisfying environment for those interested in a broader range of responsibilities. In this respect, the Authority has created an internal environment rather similar to that found in some unusually successful high technology organizations--e.g., Boeing, TRW, Xerox.

The second aspect of the TVA's informal structure is the extent to which people have developed relationships--often of a personal nature--that compensate for the absence of formal integrating mechanisms. As one person expressed it: "TVA functions in spite of its organization structure deficiencies".

These features help to create a third characteristic: the relatively undisciplined nature of the management processes. As noted earlier, there appears to be little inclination to take a strong-minded approach to the review of capital expenditure proposals or annual plans. Likewise, the control process and the relationships are characterized more by conflict avoidance than by conflict resolution.

These characteristics of informality could lead to an attractive work environment. At the same time, given the absence of formal integrating and coordinating devices, they may make the TVA a relatively inefficient enterprise. There are some indications that the latter is the case, for example, the apparent narrowing of the electric power rate gap that once separated the Authority from private electric utilities. However, if the TVA is an efficient enterprise, then its combination of informality, flexibility, and relaxed discipline would represent an unorthodox path to successful operation.

2.2.6 Mechanisms for External Coordination

At its inception in 1933, the TVA was literally superimposed on a complex structure of existing government agencies--federal, state, and local. In addition, many viewed it as an unwanted intrusion on a private enterprise economy. Thus, the steps taken by the Authority to coordinate its activities with the external environment required particular attention.

There are four aspects related to the TVA's external coordination:

- Interaction with the Federal Government;
- Relations with state and local governments;
- Cooperation with private industry;
- Overall effectiveness.

Each of these will be examined separately.

2.2.6.1 Interaction with the Federal Government

The creators of the TVA and its early leaders envisaged that the enterprise would play a broad role in the improvement of the area's economy. This is evident from the early attempts to use dam construction sites on models for housing, education, and health care.

From the beginning it established a Washington office to coordinate its activities with various federal agencies. The assumption was that the agencies would welcome a federal corporation within the Tennessee Valley that could, in effect, become their agent and even bear some of their responsibilities. This proved to be an erroneous premise. The federal agencies proved unresponsive; they were quite unwilling to relinquish any of their activities in the Valley area. Thus, the TVA gradually gave up its hope of becoming the key representative of the Federal Government in the region and switched its attention to the use of capital investment in navigation, flood control and power generation, and transmission.

More recently there was an attempt to use TVA facilities and personnel in the research activities of the nationally created Office of Health and Environmental Science. Once again, various federal agencies moved to preempt the field--this time environmental research. The result was much as before: the TVA pulled back from its ambitious beginnings and concentrated on dealing with its own environmental problems through the new Division of Environmental Planning.

One reason for the relative lack of success in its relationships with federal agencies may be the fact that there is no focal point of contact. Instead of a central coordinating unit with the responsibility to ensure that the various federal agencies are adequately informed about TVA plans, the Authority seems to be pursuing a policy that assumes government relations are everyone's business.

2.2.6.2 Relations with State and Local Governments

From the beginning TVA management knew that it would have to coexist with the seven state governments in its area. One practical reason for this was the variety in their governmental structures, pattern of existing legislation, etc.

Thus, the TVA has followed the practice of working with several states. One example would be its cooperative effort with the state agricultural colleges to start farm demonstrations introducing new fertilizers. Another would be cooperative efforts with state forestry agencies to introduce programs of reforestation, timber management, fire protection, wood utilization, and strip

mine reclamation. At the time of the TVA's creation, there were no state parks in the Valley. It established several demonstration parks and later transferred them to the respective states. State park departments were soon created, and state forest, fish, and wildlife agencies expanded their staff and activities.

Much the same happened with state planning agencies concerned with industrial development. The TVA has been instrumental in creating such agencies, which have been among the most active in the nation.

Since its inception, the Authority has stressed the importance of cooperation with local government. Initially, this included helping communities to organize their own electric power distribution system and providing preferential treatment in the purchase terms for TVA electricity, but it has also involved assisting in the selection of the best location within the community for an industrial park and then collaborating with local people in the design, financing arrangements, etc.

In David Lilienthal's words, the TVA "deliberately tried to 'start something' that local forces might later carry on, on their own". His description of the Authority's role in creating local libraries illustrates how this process works:

> The Authority wanted to provide library service for its thousands of employees building the Watts Bar Dam. But we did not want to set up an independent library that would be closed and disappear once the dam was built. So TVA contracted with the Tennessee Division of Libraries and the City Library Board of Knoxville, to provide this service at an expense to TVA that did not exceed what direct TVA library service would have cost. These two agencies knew the people of the localities, knew whom to turn to for local leadership. This contract then became the nucleus for the development of local interest in library service. Regional library service grew naturally out of this beginning. As TVA construction work moved up the river to other dams in countries near by, more and more local agencies and leaders joined, all contributing funds raised by local town councils or county governments, until the library project had expanded into thirteen counties of east Tennessee. In only one of these counties had there ever before been adequate public facilities for the reading of books. Mobile library units were going through the area, reaching TVA construction workers at their homes, and also, under the terms of the contract, non-employees living in the remote regions.
>
> By the autumn of 1942 the Watts Bar Dam was nearly completed. TVA's contributions of funds would therefore soon be terminated. Now came the real test of the methods that had been inaugurated. Had the roots sunk in deeply enough to sustain and continue what was now under way?

> A meeting was called to see what could be done to keep the regional library system operating. A dozen women and a half dozen men attended, representing the library boards of eleven out of thirteen of the counties, and one by one they rose to tell of their experience. Mrs. Willis Shadow of Meigis County began the discussion:
>
> *We have 6,000 people in Meigis County, and no railroad, no telephones, and no newspapers. The bookmobile and the grapevine are the only means of communication. If we lose the library bookmobile, how will we know what is going on in the world? What chance have we to improve standards of health or living except through reading? Talk about country people not reading! In Meigis County we read 4,000 books a month. There is not a family in the county that the library doesn't touch.*
>
> Many of these board members had been reluctant a year to two before to ask their county officers for a few hundred dollars contribution to the regional library. Yet before the meeting adjourned they had all agreed to ask the State Legislature for an annual appropriation of $25,000. They organized a legislative committee and mobilized state-wide support. On February 9, 1943, the Governor of Tennessee signed a measure setting up an east Tennessee regional library office, with an initial state appropriation of $20,000. [1, p. 128-129]

One of the more unique community activities of the TVA is the Tributary Area Development (TAD) program. This was initiated in 1961. It represents an effort to deal with resource development needs and opportunities in areas removed from urban centers and, usually, from the Tennessee River itself. Essentially, the TAD program is designed to foster cooperative effort between adjacent county units, each of which is too small or too economically impoverished to launch an improvement program on its own.

Through analyses of the local situation, informal discussion with local leaders and other means the TVA will identify the existence of some form of improvement opportunity. If the local community decides that action is needed and wanted, the TVA will provide a broad range of assistance, most of it in the form of technical advice from its trained personnel but sometimes also financial aid. The cooperative effort is carried out through such multicountry organizations as citizen associations, health districts, educational cooperatives, and others. The activities range from developing a common water supply and distribution system to upgrading educational opportunities, disposing of household refuse, collecting discarded automobiles for scrap metal processing, providing summer recreation for children, and so on. (The TVA publication, *Tributary Area Development 1970-1971* details many of these local community assistance projects.

Once local communities band together for one or more projects, they typically form a "development district" to direct the effort. These districts often have a Board of Directors that includes the county judges, community mayors, and selected citizens.

The TAD program also is moving into small-scale power projects that are too small to be of interest to the Office of Power. In addition, it is experimenting with solid waste disposal methods, use of wood waste as fuel, and solar energy generation.

More recently, the Boeing Company joined forces with the TVA in the urban planning for Timberlake--a new community. Commonwealth Edison, one of the nation's largest electric utility companies, participates jointly with the TVA in the faster utility reactor project that is underway at Oak Ridge.

2.2.6.3 Effectiveness of External Coordination

It is ironic that the TVA's energetic and varied efforts to integrate its activities with the external environment have not been more productive. This is most clearly seen in the TVA's inability to become the primary vehicle for representing the Federal Government within the Valley. It is also reflected in the failure to establish similar regional development agencies in other areas of the United States.

Even within the Valley one senses a rather grudging willingness to support the TVA. Certainly there is little evidence of a desire to expand its present activities. "It is far from clear whether the TVA provides a suitable model for emulation in much of the less developed world." [6, pp. 39-40]

2.2.6.4 Cooperation with Private Industry

Efforts to interact with the environment have not been limited to working with governmental units. The TVA has also attempted to "weld a union of the public interest and the private interests of business men". A dramatic example of this approach was the technical assistance provided to fertilizer manufacturers in installing the electric furnace process developed by the TVA for producing highly concentrated plant nutrient from low-grade deposits of rock phosphate. Likewise, the TVA made available to private industry its data on production processes for dicalcium phosphate--a cattle feed supplement. Today, its methods and equipment are used in the processing of three quarters of the US fertilizer production; and it is currently "the world's principal center for fertilizer research and development" [7, p. 13].

The lakes behind TVA dams have spawned private investment in recreational facilities that generate over a billion dollars a year in tourist trade. The Authority joined forces with the

world's largest aluminum company--Alcoa--by offering to integrate its own dams with those of this private enterprise. After extensive study, the TVA and Alcoa entered into a contract whereby

> ...the Aluminum Company agreed to turn over to the TVA indefinitely, the right to direct just how Alcoa's dams should function, that is, when water should be stored from hour to hour, and when released through power turbines or sluice gates. The contract's effect (without any change in Alcoa's title to its property) is to unify the control of water of the entire watershed, and thereby increase the public benefits accruing not only in power but also in flood control and navigation. The added power benefits created by the arrangements are divided between the parties to the contract by a formula which both sides believe advantageous. A strategic power site, long owned by the company, was also turned over to TVA, and upon it Fontana Dam in the high mountains of North Carolina was built [1, p. 116].

2.2.7 Conclusions

2.2.7.1 Effectiveness of the TVA

The TVA is one of several possible approaches to the management of large-scale regional programs. The analysis of its experience with all the strengths and weaknesses should be useful for the development of new and the improvement of existing program-oriented organizations in different countries.

On the basis of an organization study it seems difficult to arrive at a scientifically justified and quantified evaluation of the TVA's effectiveness. To do this it would be necessary to evaluate the TVA's contribution to the unified development of the Tennessee Valley and make a comparative study of other US regions similar in terms of initial situation and subsequent level of economic development. Given the lack of pertinent information, the TVA's effectiveness cannot be measured against alternative ways of managing a regional development program. However, the magnitude of its economic achievement in specific fields, which are discussed in other chapters of this report, should ensure that the particular observation of strengths and weaknesses will have a relevance for those concerned with the implementation of a regional development program.

2.2.7.2 The Strengths of the TVA as an Organization

As an organization the TVA has some strengths that favorably influence its activities.

- The program management team is based in the region, i.e., where practical problems arise; this represents a

decentralization of federal government activities to the regional level.

- The Board of Directors was granted broad discretion to determine the TVA's organization structure and management practices.

- It possesses a critical group of specialists conducting research of national significance. They are also capable of handling major problems in the field of industry, agriculture, and urban planning and development.

- A high level of technological coordination has been achieved in operating activity, e.g., in the multipurpose use of water flow--navigation, power generation, elimination of malaria-carrying mosquitoes, etc.

- A wide use of demonstration programs provides a means to introduce advanced methods in different fields of activity and conditions for their introduction on a national level.

- Corporate dedication and competence, informality in defining problems, developing and implementing the corresponding solutions gives the TVA flexibility.

- It strives to involve the local people in tackling regional problems; it acts in an advisory capacity when new programs are initiated in spheres where it has neither the funds nor the opportunity for realizing the programs. It selects local problems and encourages adjacent communities to establish development districts to help solve these problems; in such cases the TVA acts mainly as consultant.

The above strengths can be considered when implementing any model of management organization of large-scale regional programs.

2.2.7.3 The TVA's Weaknesses

In terms of its program orientation the TVA has organizational shortcomings:

- Poorly developed management objectives; top management has no explicit performance measurements nor does it exercise regular control of achievements; there is no direct relationship established between goal achievement and group or individual motivation;

- No organizational unit that devotes its attention to the overall development of regional resources: Office of Navigation Control and Regional Development Studies would seem from the title to have such a role, but in fact it does not. Regional Planning was an important formal activity in the early years, but it has been eliminated;

- Only limited organizational resources are devoted to the preparation of plans, and even more important to their review, analysis, coordination, or modification; the review process is relaxed and casual; the planning department in the Office of the General Manager has only two staff members. The Budget Department concentrates on transforming division plans into a budget for the Office of Management and Budget in Washington; there is no integrated information system;

- No integrated interorganizational mechanisms to coordinate and integrate its (originally defined) task. There is inadequate use of instruments such as lateral coordination, integrating units, formal project teams, project leadership, matrix organization, etc.;

- Few mechanisms to influence its environment; its influence on the implementation of many of the programs is only indirect;

- No well developed function for coordination with government bodies: the present staff and function of the Washington Office do not coordinate with the Office of the President and Congress.

While the actual role of the TVA has changed over time, this has not yet been recognized in formal expressions of goals and objectives. Regional development organizations need to recognize the importance of a periodic review and modification of their goals and objectives in order to avoid the loss of their dynamic character. When considering any organizational model for the management of regional development, the above mentioned shortcomings of the TVA experience should be especially noted.

2.3 PLANNING PROCEDURES AND THE PLANNING SYSTEM OF THE TVA

This section describes the TVA planning process, and comments on its effectiveness in achieving the goals and objectives of the TVA (see Figure 2.4 and Table 2.1).

2.3.1 The Planning Organization

Planning at headquarters is the responsibility of the Office of Plan and Budget, which consists of a director, two deputy directors and supporting finance staff. There are no professional staff under the deputy directors.

Program planning in the TVA's decentralized management system places responsibility on the operating Offices and divisions. Each Office or division maintains documented plans, which are continually updated to meet program needs. Plans of the Office or division are subject to review by the Board, the General Manager, and by the Office or division itself.

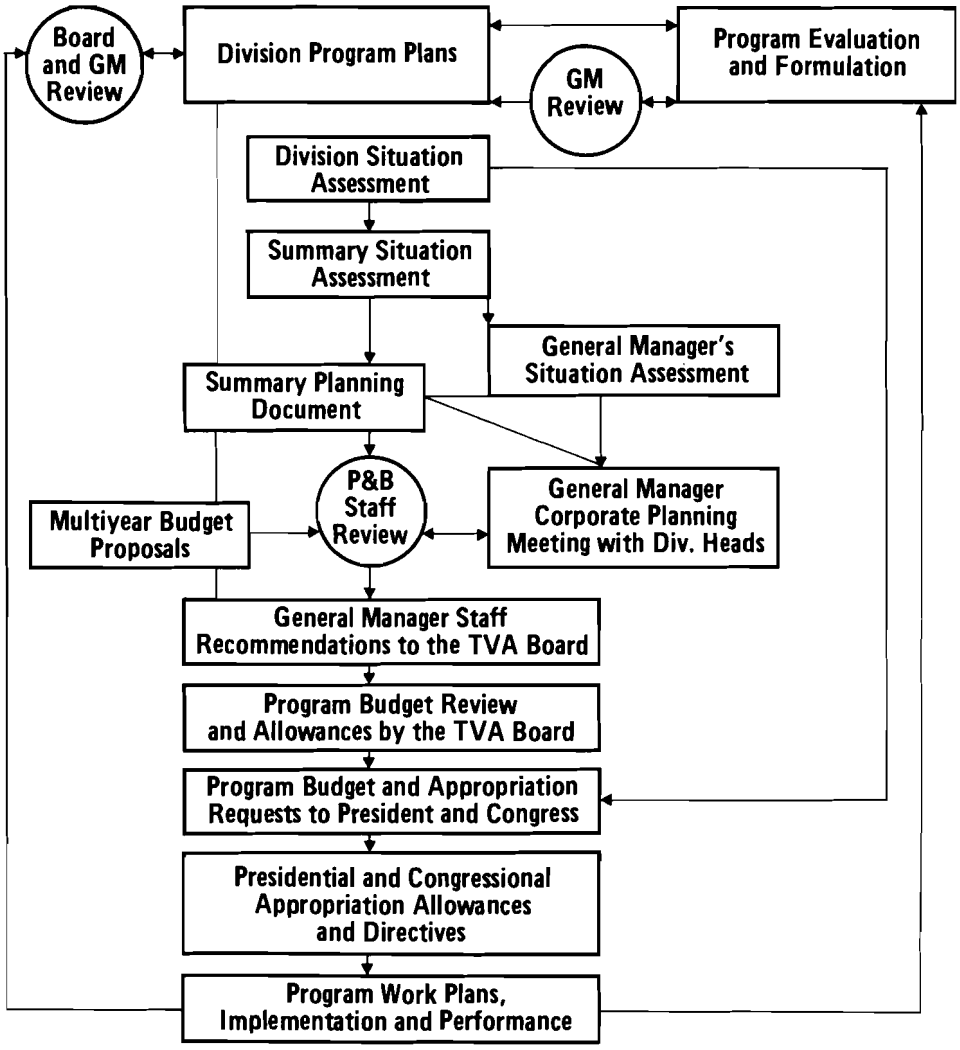


Figure 2.4. The TVA planning system.

Table 2.1. Responsibility in the planning process.

Level of Responsibility	Task	Identification of Needs, Opportunities, etc.	Project Formulation	Activity Formulation	Description & Justification Statements	Activity Statements
General Manager	Recommend & Concur	-	-	-	-	-
Director	Select & Approve	Approve Identify	Approve Select	Review Concur	Approve	Review Concur
Branch Chief	Recommend & Select	Identify	Select	Approve	Approve	Review Concur
Section Supervisor	Recommend	Identify	Recommend	Recommend Concur	Approve	Prepare Input or Concur
Project Supervisor	Recommend	Identify	Recommend	Select	Prepare Submit	Prepare Input or Approve
Resource Specialists	Recommend	Identify	Recommend	Recommend	Information Input	Prepare Input Information Input
Consultants	Information Input	Information Input	Recommend	Recommend	Information Input	Information Input

In the Offices and divisions there is no common organizational pattern, but in most there are no staff concerned with the overall coordination of plans. Thus planning is seen primarily as an ongoing function of management, rather than as a separate activity solely aimed at the production of "plans".

2.3.2 Continual Review Processes

The program performance of the Offices and divisions is continually being evaluated. The Board and General Manager review program performance through various formal and informal channels to determine whether objectives sought are being achieved and whether the level of achievement is of greater value than the resources expended. Changes in the level and/or direction of program activities may result from these reviews.

In addition, a formal process of program evaluation is conducted, which covers all programs or activities of operating Offices and divisions over a three- to five-year cycle. Here emphasis is placed on defining program needs, policies, and strategies for future programs. The results of these program evaluations, subject to approval by the General Manager, range from formal updatings to complete reformulations of Office and division plans.

2.3.3 The Situation Assessment

This section is the first of three that describe and analyze planning subprocesses. Each section is subdivided into a description of the process, a presentation of examples, and a commentary.

2.3.3.1 The Process

The situation assessment procedure takes place aobut three months ahead of the formal preparation of summary programs. It is described by the Planning Staff at Head Office as a "general program review of the present and the probable future circumstances that determine the relative success or failure of our program activities".

The assessments begin at the lower management levels and proceed by stages to a summary document prepared for the General Manager by the heads of Offices and divisions. The roles to be taken at various levels are set out below.

Each summary assessment includes:

(1) An assessment of the external situation facing the TVA; that is, an evaluation of the local, state, and national conditions that may be expected to influence the TVA positively or negatively.

(2) An assessment of the situation within the TVA as it may impinge on the ability of the Office or division to achieve its goals. Actual or potential conflicts should be brought out here.

(3) An assessment of the situation within the Office or division. This provides an opportunity for the program manager to evaluate the strength and weakness of his organization as they affect the Offices' or divisions' ability to achieve their goals. Changes in the scope or definition of goals should be considered at this time.

2.3.3.2 Examples

The assessments vary in length. The assessment for the National Fertilizer Development Program of the Office of Agricultural and Chemical Development (OACD), submitted in December 1974, was about 3000 words long and covered the following ground.

2.3.3.2.1 External to the TVA: Importance of fertilizers; the fertilizer industry; supply-demand situation; prices and profits; external relationships of OACD, industry R&D effort; fertilizer introduction program relationships.

2.3.3.2.2 Within the TVA: Power shortages--minority group recruiting; TVA purchasing.

2.3.3.2.3 Within OACD: Overall program costs; production; electric furnace operations and pollution control; natural gas supply; labor; trading versus purchase of new materials; reorientation of R&D programs.

In addition the assessment indicates the current high income from fertilizer sales and suggests that this can be used to supplement the research budget for the future.

This particular program is unique in the TVA in that it is a national program involving considerable expenditure--20 million dollars--a substantial part of which is funded from product sales. On the other hand, the agricultural resource development program, which is much smaller in the level of effort, though just as essential to the primary objective of the TVA, has a much less organized assessment of under 1000 words.

All the situation assessments are received by the Planning Staff in Knoxville, who are located in the General Manager's Office. After some discussions and calls for elucidation from the divisions concerned, an overall summary assessment is prepared for the General Manager. He then discusses the overall situation with the senior staff concerned.

These assessments are the agreed basis for the subsequent stages of the planning/budgeting process.

2.3.3.3 Commentary

The situation assessment is a device that in principle should overcome one of the most serious drawbacks to planning/budget systems in large organizations where the overall resources are limited, i.e., where the central policymakers have to decide between the conflicting demands of divisions or functions because the available resources are limited. (The resource may be in terms of finance, manpower, materials, or equipment.) Unless the lower echelon planners are given some prior idea of the desired level of activity for their echelon, or unless it is possible to evaluate the plans simply in cost-benefit terms, they find themselves in what is essentially a game situation, i.e., they find themselves making competitive bids against other echelons for the available resources. Even in organizations that are primarily production oriented, the quantitative definition of benefit can be difficult (a recent study of one large organization revealed that only 50% of major capital projects could be classed as having a quantifiable return). Moreover, advance estimates of performance in unknown situations are notoriously speculative.

Such game playing situations are very common in large organizations and a wide range of strategies is used by the planners and managers concerned. No great harm is done when the situation is relatively static. In such cases the rules of the game become well understood and the central planners can make reasonable judgements based on their experience from the previous year's figures. However, when the situation is changing rapidly, the whole procedure can become unstable and regulatory action may be necessary. The first step to improve the process is to ensure the correct flow of information. Herein lies the advantage of the situation assessments. These provide the Head Office management with a broad overall planning scenario, which enables them to calculate the desired balance of effort and, in particular, to identify those new projects or programs that will require detailed study.

A number of other features of the assessment procedure are worth noting. One is the way in which the attention of those concerned with individual programs is drawn to the overall goal and objectives of the organization. Since TVA employees, cooperatives, consultants, interested citizen and advisory groups are all brought into the process, it serves as a useful corrective mechanism when those involved in particular programs become diverted by purely local objectives.

Another important feature concerns the handling of organizational problems or other conflicts that cannot be resolved within the division or Office responsible for the assessment. Head Office issues specific instructions that these problems must be acknowledged in the assessment. This has become an invaluable procedural

device by which the various units can air disagreements without making a formal complaint. It seems to provide the kind of safety valve essential to an organization as full of potential conflicts as is the TVA.

It is also important to note that the whole style of the assessment is qualitative. There is seldom any quantitative backing of points made in the written discussions, and most of the figures presented appear to have been prepared on an ad hoc basis--there was no evidence of an agreed set of advance projections. This ties in with the fact that in only one division did we find anybody who considered himself to be in charge of a corporate planning activity. However, it would be misleading to assume that divisions and Offices always act without data or lack the means to analyze it. In OACD and in some other divisions, for example, there are statistical/modeling skills available. There appears to be no formal methods of analysis, such as common statistics, models, formal comparison between plans and objectives, for integrating the various assessments. But again it should not be assumed that cooperation or integration does not take place: informally a great deal is achieved. Much of the content of individual programs is, of course, unrelated and what remains has already been subject (at division level) to informal discussion, e.g., in order to coordinate services. But the compromises that may have been reached during this process may not be those which the General Manager's Office really requires, and since neither is permitted to be clearly stated, a discrepancy may not be apparent. Some corporate planning activity that could both identify and reconcile such discrepancies seems desirable; among other activities it could build alternative scenarios of the region's needs, suitable as a basis for all divisions, construct simple integrating models and ensure common forecasting and data practices in all regions. One curiosity may be noted here. The intentions of the TVA Act are that it should identify and attempt to satisfy the needs of the Tennessee Valley population in the following fields:

- Agriculture;
- Human Resources;
- Forest, Wildlife, Recreation;
- Business, Industry;
- Minerals;
- Governmental Services;
- Water Supply and Use.

In reality these fields interact at the level of the Tributary Development Area. Because of this one might have expected the Office of Tributary Development to have a major integrating role

in the organization and planning, and operation of the TVA. This does not appear to be the case.

Situation assessment is a sophisticated device that solves many planning problems encountered in other organizations, but its formal integrating and analytical mechanisms do not appear to be fully developed to exploit the opportunities that the system provides, or to meet the requirements of the TVA in a changing environment.

2.3.4 Program Planning and Budget Submission

2.3.4.1 The Process

Three months after the submission of the situation assessment each division or Office submits a summary planning document, projecting program plans at least five years into the future, beginning with the forthcoming fiscal year. It is seen by division or Office heads as a policy statement reflecting:

(1) The situation assessments recently completed;

(2) Their own program plans and expectations;

(3) Realistic funding expectations.

Again the demand is for a brief yet complete statement--supplementary information can be given as appendices. This document serves as a guide for branch heads, etc., in the preparation of specific budget proposals. It is also useful to the General Manager's Office because it provides information on program goals, strategy, specific objectives, and accomplishments, as well as on the anticipated manpower and dollar input over the following financial years. Any new activities or projects prepared should have a separate entry indicating expected duration, cost, evaluation, and justification.

In the Fertilizer and Munitions Development program prepared in 1975, the goal is simply "to develop and promote...fertilizers ...throughout the Nation through integrated research, introduction and educational programs". This represents no change on past policy, although the unique national nature of this process should be noted. The strategy statement emphasizes the need for innovative research, as well as the requirements necessary to develop and conduct activities that would speed up the acceptance of new ideas and promote more efficient use of fertilizers. The voluntary cooperation of other bodies is also stressed. Ways of achieving this are discussed, although they are not linked directly to the program elements. There is an examination of trends directed towards establishing the need for more fundamental research. This is followed by a statement on the parts of the proposed programs to be altered if funds are provided at the desired level, and finally tabular information is given for each program element. Typical extracts are given in Table 2.2.

Table 2.2. The development of new improved and more economical fertilizer processes.

Specific Accomplishments	1974	1976	1978	1980
Major processes under development or improvement	6	11	10	10
Inputs				
Dollars (thousands)	2962	4088	4710	4952
Man-years	91.4	99.4	106.4	111.4

Overall, a considerable escalation in manpower and dollars is called for. This is explained only in the appendices to the report (though it had been hinted at in the situation assessment, and informal discussions had taken place with the General Manager).

The escalation is justified in terms of using the increased revenue from further sales to overcome two short-term problems. The first is the need to change the basis of the program without disturbing present work--substantial capital renewal was also required. The second is the need to recruit and train new research staff, to replace the large number who would be retiring in the next ten years. These proposals had already been discussed in outline with the Planning and Budget Staff at Head Office, and calculations have been carried out to explore the availability of funds if fertilizer prices were to fall far below the expected level. This is a rare example of the inclusion of formal analysis in the planning procedure, the work undoubtedly being undertaken by a team responsible for market analysis and intelligence, who also produce the regular status reports of the fertilizer industry.

A contrasting program requiring relatively little effort is being undertaken by the Division of Forestry, Fisheries, and Wildlife Development. This program has five separate goals, a range of strategies (including the use of computer data base systems), and two pages of objectives and project aims. An excerpt from the program is given in Table 2.3. This example shows that accomplishments can be recorded in numerical, if not financial terms, and that short period changes in the level of funding are taken into account.

These program summaries are followed a month later by the multiyear program and financial plan. This is used by the General Manager and the Board of Directors to review program directions and to decide on the total content and balance of the future TVA program. The plan also forms the basis of the comprehensive multiyear program and financial plan that the TVA submits annually to the Office of Management and Budget in Washington. Certain features of this detailed document are worth noting.

Table 2.3. Forestry and wildlife development.

Accomplishment	1974	1976	1978	1980
Annual timber growth	44.2	45.9	48.2	50.4
Acres under management	6935	8000	9000	10,000
Inputs	1974	1976	1978	1980
Man-years	13.0	11.5	22.5	11.5
Dollars (thousands)	394	358	360	360

One important step is to identify the Office or division responsible for capital projects and programs, and to give some authority to approve the degree of participation of other divisions. This may occasionally put too much power into the hands of the coordinating division, but it does at least ensure cooperation.

Another interesting feature is that alternative levels of finance for each program are ensured consideration for the year for which appropriations are being sought (the second year of the five-year program). Two levels (at 80% and 110% of the previous year's figures) are considered in addition to the program recommendations, and for each level the following information is required: the activities that can be carried out and the priority of the activities and their estimated cost. Comments have to be made on the effect of each alternate level of the program.

These documents are then used to prepare the final submission to the President for appropriation in the next fiscal year. The Chairman of the Board and the General Manager have to defend their proposals before a congressional committee, and the final appropriation is known only shortly before the beginning of the fiscal year, some two years after the preparation of the situation assessment by the operating staff concerned.

2.3.4.2 Commentary

The procedure is thorough, with formidable documentation--time consuming so far as each division is concerned and very dependent on the skill and experience of a small number of Head Office personnel for its effective operation. In this it does not differ from procedures in many other large organizations. What is unusual is the lack of mechanical or computerized aids in the overall process.

The whole procedure is also inordinately lengthy. When there is a two-year delay between drawing up a program and receiving

approval, cynicism is inevitably introduced. Such procedures are perhaps inevitable for a federal agency, and the drawbacks are mitigated by two features that allow for maximum operational flexibility.

In the first place the approved allocation is not given in parts--it is a total sum. Thus, provided it can show that change was justified, the TVA has the freedom to change the program as required. If one project falls through, the money is not necessarily lost. Secondly, it is "No Year" money, so that money is not lost if work is delayed, and there need be no rush to spend available capital in the last quarter of the year.

2.3.5 Feedback Control

2.3.5.1 The Process

The prime feedback mechanism for the Authority works through the process of program evaluation. Here a number of programs are chosen for detailed assessment each year, so that all programs are covered on a three- to five-year cycle. The purpose of this is to provide detailed assessment from time to time, whenever it might be thought necessary to prepare a major review of the program. Examples of this follow.

The review for the Agricultural Resource Development program, which was undertaken just before this paper was prepared, consists of four main parts. The first gives the background and describes how the balance of the program changed between 1967 and 1973. At the beginning of this period the program had been assessed by the committee including the land grant universities, and a new program was introduced in 1969. Ways in which it has had to be altered are discussed. Important forces affecting the program in the period were (1) restricted budgets (contractual employees were reduced from 43 to 25 during the period); (2) the significant shift in direction caused by environmental movements; and (3) major concern with the problem of the low income farmer, for whom progress had been all too slow and disproportionately time consuming.

The review then goes on to record how six primary objectives have been fulfilled. One needs to have a thorough understanding of economic and agricultural conditions in the region to appreciate this section, and little attempt is made to provide an overall balance. Third, a section is devoted to the assessment of the present agricultural position in the Valley. Finally, six general objectives for the future are defined as follows:

(1) To promote a more efficient use of resources to increase agricultural productivity and income;

(2) To evaluate new TVA fertilizers and improve soil productivity, management, and land use;

(3) To improve the economic and social well-being of low income rural residents;

(4) To promote more efficient agribusinesses and marketing systems;

(5) To identify environmental problems and determine the productive uses of waste products as related to agriculture;

(6) To provide technical assistance to public and private rural development institutions.

Eight main program elements are then identified and a priority matrix established showing the importance of each element in relation to each objective.

2.3.5.2 Commentary

If a program departs from plan, one of two alternative courses of action must be adopted. Operational action must be taken to correct the program, or the plan must be examined and revised. In many cases both actions are necessary. Operational control is not the subject of this paper, although in financial terms normal control procedures seem to operate. Similarly, at divisional level--and particularly in the operating divisions--normal business practices seem to be maintained. Our concern here is with the use of feedback mechanisms to advise management at Head Office of the realism of their planning procedures. This realism must be apparent to all, for if the necessary action is not taken, the staff will assume that planning is not a serious matter, resulting in a rapid deterioration in the quality of planning.

The time scale on which such a feedback mechanism should operate is debatable, particularly in relation to those functions of an R&D nature. After all, it should be the function of divisional and Office management to deal with this. Since the next situation assessment is submitted to the General Manager's Office about six months after the corporate planning meeting, this would be an ideal time for checking progress. However, it is not at all clear that the form of the situation assessment requires this to be done.

The main concern about the program reviews must be their relative infrequency (three to five years for each program) and with the general lack of firm guidance as to how the review should be carried out. There is within the program little guidance as to the relative value of other programs, nor is there any discussion of relationships with other bodies (TAD inside, TVA land grant universities and other federal agencies outside), who themselves will have programs affecting the work of the Agricultural Resource Development program.

2.3.6 Evaluations

2.3.6.1 Introduction

Planning systems cannot be considered in isolation. As part of the overall decision-making procedure, planning must be matched to the organization, its goals, and the people working in it. This is particularly true if a planning system is introduced into an existing organization without altering the basic command structure. The evaluation of a planning system must therefore be made primarily in terms of its effectiveness, the first step being an identification of its goals. We shall consider this first of all in relation to external agencies and then to its own internal structure.

2.3.6.2 External Relations

The TVA has a special relationship with the federal government and the states. It is not part of a simple hierarchical system, which is the model for most theoretical planning systems. The political hierarchy (national government, states, counties--a geographical hierarchy) completely bypasses the TVA. Its organizational units only coincide with the hierarchical organization at the lowest level and the TVA system is not hierarchical in a geographical sense. It is important also to realize that the political hierarchy was in existence long before the TVA was established, and has not been modified to any degree subsequently. So the TVA must of necessity fit in with these established authorities and their methods of operation. Another important point is that, because of the democratic process operating in the United States, neither the federal nor the state governments have a long-term strategic plan--which is usual for an industrial organization, or for a development authority in a socialist country. Planning therefore tends to be directed towards isolated goals identified as necessary to achieve the more general goal of the improved welfare of the Tennessee Valley population.

These preliminary remarks are important when trying to understand the role of strategic planning in the TVA. Normally, a large organization of this kind would have a strategic plan consisting of one or many alternative scenarios for the future and involving formal methods of analysis for the evaluation of alternatives and for decision making in times of crisis. No such strategic plan exists in the TVA, nor is it possible. What does exist is a series of objectives stated in varying degrees of precision, but not formally integrated.

2.3.6.3 Internal Considerations

The political origins of the TVA not only affect its strategic planning in relation to the external environment, but also its

internal modes of operation. The Authority has a style of management that resembles a highly dedicated public servide R&D corporation. At Head Office there has been a strong Board of Management and General Manager anxious to maintain direct control with divisions and Offices, but unwilling to delegate real responsibility to other staff at Head Office and, because of the small number involved, not perceiving the need for a great deal of formal analysis. Overall the TVA has encouraged an informal style of cooperation between the various elements of the organization, discouraging the formation of coordinating committees. It must be remembered that the present planning system (i.e., that of 1975/1976) has been in operation for only two years and although so far it has had only a limited impact on that style, the prime question is whether it has improved the process of management decision making by adopting that style.

What has been said so far has implied criticism of the TVA's planning system with regard to some theoretical ideal. However, one major advantage possessed by the TVA and its planning system should be mentioned, namely their enormous flexibility. Because they are not part of a monolithic organization structure, they are able to respond to a wide range of very different inputs.

2.3.6.4 Decision Making

The remainder of this discussion will be largely concerned with the interaction of the planning system and the processes of management and decision making within the Authority. Perhaps the first task is to gain security for the immediate future. It has already been noted that the allocation of funds to the TVA is an annual process, and that there is no direct ongoing commitment for money, even though national government approval of certain major works must imply such continuing appropriation. Arguably then the prime external purpose of the planning and budgeting systems is to provide the TVA Board with the means of persuading Congress to fund the necessary monies each year for the continued operation of the Authority.

The annual plans of the different federal agencies do not appear to be formally integrated, but the very cumbersome procedure for clearing the proposals of each agency guarantees that there is no significant area of overlap between their operations. In practice therefore the TVA has to work closely with a number of other government agencies to ensure that their programs interlock but do not overlap. It should also be mentioned that the TVA's proposals will only be put to Congress after they have been seen to satisfy many other requirements concerning the way in which government agencies conduct their business.

2.3.6.5 Overall Effectiveness

We shall now consider the effectiveness of the planning procedures in relation to management and decision making within the

Authority. Good planning is so woven into the decision-making processes of an organization that it has to fulfill different requirements, many of which are normally not considered as planning goals. We shall therefore consider a number of these requirements.

(a) Good planning should ensure the availability of a plan or set of plans for the organization as a whole (where the plan is defined as requiring statements of desired goals, the ways in which they are to be achieved and the resources required). In addition, a good plan should also contain information on the assumptions made in the scenarios and the means of determining the actions to be taken if external circumstances are such that the plan cannot be adhered to. So far as medium- and short-term planning are concerned, the TVA system can be said to meet most of these requirements, every division and section within a division has its medium-term plan and although no formal system of management-by-objectives is used, the staff know their objectives. No strategic plans for the whole TVA are available. However, in view of what has already been said about strategic planning on national and state levels, it is difficult to see what form such plans could take.

(b) Good planning procedures should ensure that the plans in (a) are effective. This requires an identification of alternative future actions and consideration of the consequences in order to determine the best policy options. The procedures adopted by the TVA do encourage the search for alternative actions, and demand that an assessment be made of the consequences of the various alternatives. Basically, they are "good" planning procedures. However, they can be criticized on the grounds that the procedures for evaluation are qualitative. Thus, although some aspects of possible future courses of action are studied in detail, e.g., those relating to possible energy consumption and the use of fertilizers, there is no systematic exploration, nor are the studies undertaken made generally available to the various operating divisions. The whole planning process would be strengthened if there was an overall assessment of trends for the main variables in the TVA region that was regularly updated and used as a planning basis for all divisions and Offices.

(c) A good planning system should be an essential element in the rationalization and unification of the various operations within an organization. This is particularly important in the case of the TVA because of the unevenly balanced dependence of many of its activities on the power operation. It would be very easy in practice for the Authority to operate as a subsidiary of the Office of Power, whereas in practice the Authority operates with Power as an important but essentially secondary part of the organization. A useful analogy would be the role of the cashier/treasurer in a commercial enterprise. On the whole the planning procedures seem to have gone some way towards developing improved coordination and have revealed a number of weaknesses in the present organization structure, one of which is the shortage of planning staff, operational research workers or systems analysts

at Head Office. To get the maximum value out of the present procedure it would be desirable to have a small team of analytically trained problem solvers in the Office of Planning and the Budget at headquarters linked with similarly skilled personnel in the operating divisions.

(d) Good planning should lead to good decision making. The relationship between decision making and the planning process is not easy to identify. This is partly due to the many ways in which decisions are made. Decisions concerning the allocation of resources are linked very closely to the planning and budgeting processes. Moreover, the processes by which the budgets are agreed lead to a consideration of general policy, which forms the inevitable background for further discussions. However, certain major decisions, such as the building of a new nuclear plant, do not seem to be much influenced by the planning system. On the other hand the system does not hinder the decision-making process, which is perhaps more than can be said for very many logically designed systems.

In conclusion, the planning procedures recently introduced have undoubtedly been beneficial. They are flexible and conducive to good planning, but weak in their lack of use of modern forecasting and analytical techniques, and of a team at Head Office capable of undertaking studies, developing general methods of analysis, and coordinating the overall decision-making process. It is an inverted medium-term planning system and would by many standards be considered inadequate for strategic planning. That is a feature of the situation in which the TVA finds itself, rather than an indication of inadequate organization.

2.4 OPERATIONAL MANAGEMENT ACTIVITY OF THE TVA

2.4.1 Introduction

The TVA management structure is similar to those found in large multidivision enterprises. It has two main levels of managerial activity:

- Strategic management, including planning and programing of the organizational activities;
- Operational management, including administrative and operating functions concerned with current operations.

This section deals with an analysis of the operational level of TVA management. We will consider management mechanisms which cover (1) the elaboration of outputs of the planning process and development of current tasks, and (2) the development of work activities for the implementation of these tasks.

The operational management activities vary according to different TVA programs. They are in some respect similar to the

mechanisms of a private corporation and are concerned with activities such as production, marketing, and investment in new projects. However, the operational management for other programs contains some special features relating to the TVA's multipurpose goals and its various restrictions.

The principal TVA objectives are navigation, flood control, power production, reforestation, development of marginal lands, agricultural and industrial development, and the development of other regional resources such as manpower and recreation facilities. In order to realize these objectives, the TVA has developed a series of programs and activities which can generally be divided into the following groups:

(1) Power generation and distribution;

(2) Control and use of the water system;

(3) Fertilizer research, development, and distribution;

(4) Valley resource development.

Some characteristics of the main groups of TVA programs are shown in Table 2.4. They differ in budgeting and planning activities, and in areas of responsibility. These differences result in a variety of decision-making mechanisms that are used for the operational management of these programs.

The nature of the mechanisms employed by the programs to fulfill principal goals can be divided into two categories: direct and indirect. The Power, Water and Fertilizer programs have a direct influence on the environment. The operational management mechanisms in these cases are similar to those of private enterprises and include production, marketing, and new project investment.*

Indirect relationships to the main goals are found in regional resource development programs. The indirect mechanisms listed below vary according to individual program activities:

- Demonstration programs;
- Information supply;
- Educational activities;
- Collaboration with local people and organizations in subregions;
- Creation of laws.

---

*For our purposes "investment activities" have been defined as "construction".

Table 2.4. The framework for TVA activities.

	Related To	Main Programs	Budget	Main Grouping of Operational Management Mechanisms
Power Generation and Distribution	TVA Power area served (two times greater than Valley region)	- Power generation; - Meet new needs of of load; - Power distribution	Revenues, bonds notes	Production, marketing, construction of new projects
Water Systems	The Valley region	- Navigation; - Flood control; - Power generation; - Water resources development; - Water supply	Federal government appropriations, Power funds	Systems operation, project construction
Fertilizer Development and Manufacturing	US & some foreign operations, some special activities connected tc the Tenn. Valley region	- Fertilizer development; - Fertilizer manufacture; - New methods of fertilizer use	Federal government appropriations; fertilizer sales; funds from other agencies (e.g., environment)	Production, marketing, project construction, resource development, (demonstration programs, providing fertilizers)
Valley Resource Development	Valley region, some activities with national aspects	- Agricultural development; - Industrial development; - Forestry & wildlife development; - Manpower development; - Other similar activities	Federal government appropriations	Resource Development: - Demonstration programs; - Information; - Educational programs; - Cooperation with local groups; - Creation of laws

These activities are used in the development of agriculture, forestry, industry, manpower, recreation, and other resources of the region.

The distinction between mechanisms with direct and indirect influence on TVA programs is based on an analysis of the Authority's actual power as a regional development organization and its responsibility for carrying out activities in different areas. Operational management mechanisms with direct influence are used in those areas where the TVA has primary responsibility and the appropriate resources and authority to carry out programs. Mechanisms with indirect influence are used in those programs where the TVA does not have direct authority for regional development. In the latter programs it only participates in activities employing demonstration and persuasion as a means of influence.

The relationships between groupings of operational management mechanisms and the spectrum of TVA programs are illustrated in Table 2.5. The crosses show the groups of mechanisms that play the major role in each program. Other mechanisms can be found within different programs, e.g., in the fertilizer program production marketing and construction activities are evident although this program mainly uses demonstration as a means of influence.

Table 2.5. The relation between operation management and programs of the TVA.

Operational Management		Power	Water	Fertilizers	Agriculture	Forestry	Industry	Recreation	Manpower	Environment	Subregions	Others
		Programs of Regional Resource Development										
Direct	Production	+		O								
	Utilization		+									
	Marketing	+		O								
	New Capacities	+	+	O								
Indirect	Demonstration			+	+			+				
	Information					+	+	+			+	
	Assistance										+	
	Education								+			
	Law Creation									O		O
	Recreation Works									+		O

This matrix illustrates the current situation at the operational level of the TVA's managerial structure. It reflects only those possibilities and opportunities of operational actions available to the TVA as determined by environmental and internal conditions. This matrix does not reflect the situation in terms of budget or employment.

2.4.2 Direct Mechanisms

As indicated in the previous section, direct mechanisms are used to implement activities for which the TVA has direct responsibility. An analysis has been made of major mechanisms used in the most relevant TVA divisions and Offices. The major conclusion is that they generally represent what we would expect to find in any other organization undertaking similar activities. For this reason we do not give a complete description of the direct mechanisms here. Instead we outline areas they cover, and their broad nature, in order to give the reader a feeling of their scope. When comparing direct mechanisms of TVA operational management with those that may be found elsewhere, one important point must be remembered. While the structure of direct mechanisms may be familiar, when using certain mechanisms account must be taken of the constraints arising from the balancing of different TVA objectives.

2.4.2.1 Power Production

The operational management tasks in this area are concerned with meeting the demand for power in the most economic way, while at the same time taking account of the constraints arising from water management considerations. This can be dealt with by considering the availability of stations and the demand for different time scales (e.g., hourly, daily) ahead. Special mechanisms exist for maintenance, fuel supply, and transmission. The elements of these mechanisms are shown in Figure 2.5.

2.4.2.2 Operational Management in Power Marketing

Marketing management plays a very important role in the fulfillment of the Authority's main objectives. First of all, this activity is connected with the operation and expansion of the power system.

The objectives of the power marketing activity can be outlined as an attempt to achieve the lowest possible selling price and the most effective use of power for regional development purposes. The operational management mechanisms in these fields deal mainly with: investigations into power demand, rate studies and pricing policy, influences on power and supply and its quantity, efficient use of power, and the maintenance of good relationships between the TVA and the local population (Figure 2.6). In this figure

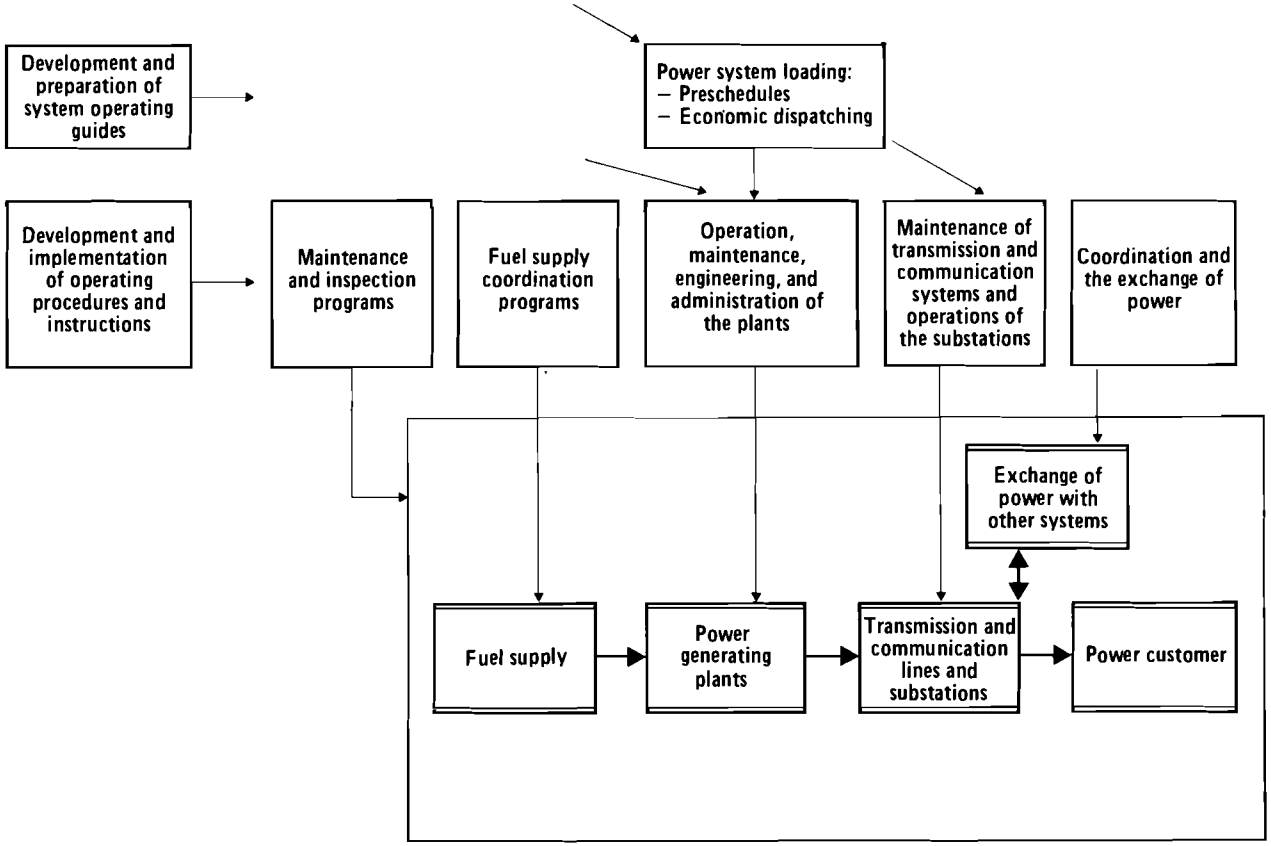


Figure 2.5. Operational management in power production.

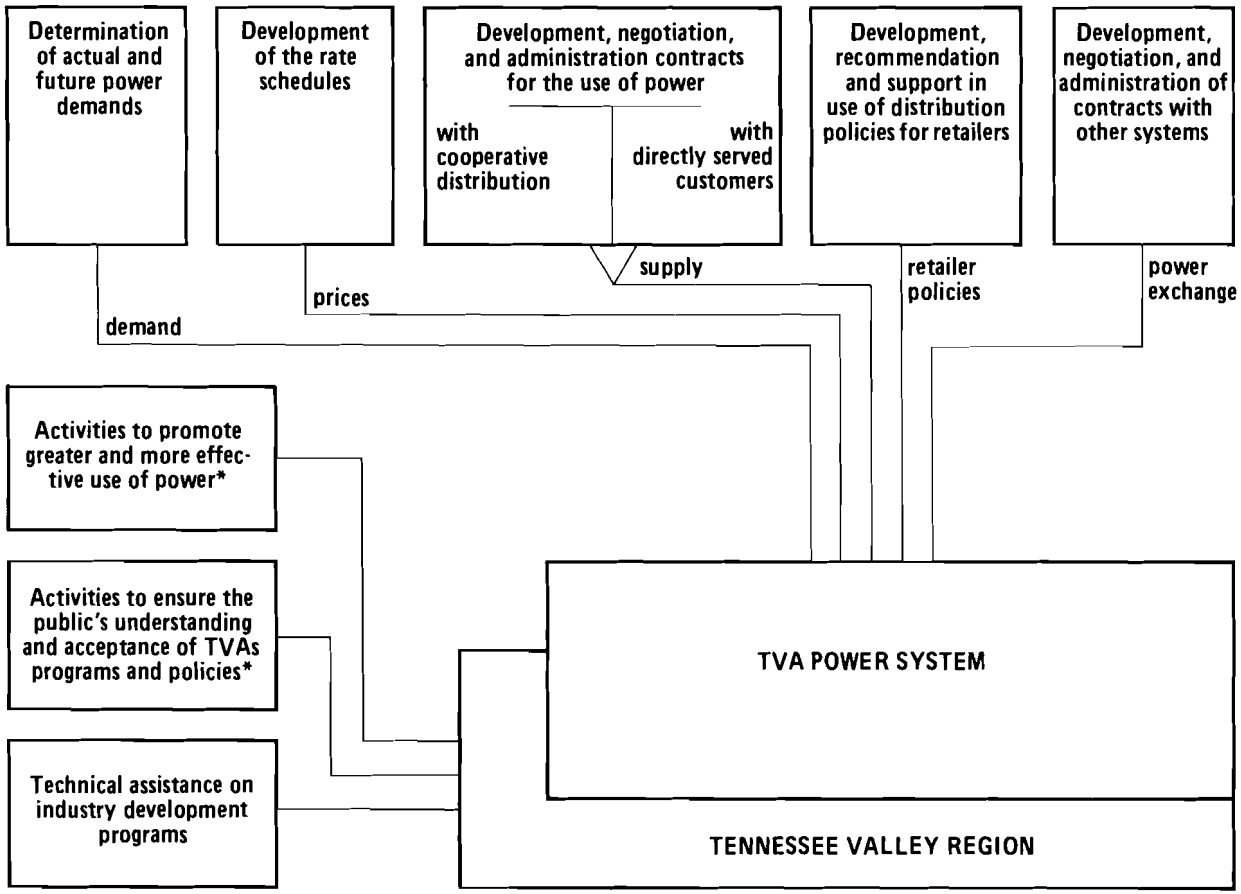


Figure 2.6. Operational activity in power marketing.

the two boxes marked by asterisks (those concerned with promoting an effective use of power and ensuring public understanding of TVA policies) represent activities that have characteristics both of direct and indirect mechanisms. They are, therefore, untypical of activities that one would expect to find in a typical industrial enterprise. For this reason we will discuss them more fully.

One of the marketing activity objectives is to achieve effective power use in order to encourage rural development, agricultural production improvement, increased living standards, and improvement of the production of regional enterprises. It should also minimize losses in all the aforementioned areas of power use.

The activities employed to fulfill these objectives are:

- Cooperation with producers and distributors of electric equipment to increase efficiency;
- Cooperation with agricultural services and local agencies;
- Provision of information and demonstration programs for an economical use of power.

By distributing information comparing heating costs with insulation techniques, the TVA has an influence on house construction. The marketing activities also affect the public's understanding and acceptance of the organization's main purposes. The maintenance of good public relations with agencies and local organizations helps to ensure that the power programs promote the improvement of the region and the quality of life of its inhabitants.

2.4.2.3 Water System

The operational management for the water system was developed to achieve the following objectives established by the TVA Act:

- To promote navigation;
- To reduce flood crests on the Tennessee River, its tributaries, the lower Ohio and Mississippi Rivers;
- To produce electric energy, consistent with these primary purposes.

More recently other objectives have become prominant, for example, the stabilization of pool levels in order to further recreation and fishery objectives.

The primary management mechanism is the dispatch of water from reservoirs. This is done with reference to an annual plan.

2.4.3 Indirect Mechanisms--Operational Activities in Resource Development of the Region

The unified resource development of the Tennessee Valley region is the main goal of all TVA activities. In the previous sections we have discussed the operational management activities of several programs in which the TVA directly influences the development and use of regional resources. In these programs, subject to the restrictions of the TVA Act, the Authority holds the responsibility for planning and executing new construction for production activities, and for other activities similar to those found in private operations.

We will now consider the sector of TVA activities involved in developing regional resources for which the TVA does not have direct authority. These include agriculture, forestry, wildlife, fisheries, recreation, human resources, business, and industry. For the management of these activities the TVA uses a variety of instruments which differ from those previously discussed. Basically there is no long-range planning for these activities. Many different forms of operational influence exist in this field with demonstration, consultation, and persuasion characteristics. These mechanisms include a variety of programs involving cooperative action with government and local institutions, private organizations and local people. One of the more important implementations of these mechanisms is the research work undertaken in TVA organizational units very often in cooperation with universities and research institutes.

2.4.3.1 The Demonstration Programs/Marketing

This is one of the main instruments in developmental activities for the conservation and management of agricultural resources in the Tennessee Valley (Office of Agriculture and Chemical Development, 1974; National Fertilizer Development Center, 1974). There are three types of demonstration for agricultural development:

- Demonstration of new fertilizers and their applications;
- Test-demonstration farms;
- Rapid adjustment farms.

Fertilizer demonstration programs for regional development purposes are designed to introduce, evaluate, and demonstrate new and improved fertilizer practices, and to determine and demonstrate the results of effective fertilization of plots, fields, and whole farms.

The TVA has national responsibility in fertilizer research, development, and usage. Its fertilizer program includes:

- Chemical development of new products and techniques;

- Demonstration production of developed fertilizers in the TVA National Fertilizer Center at Muscle Shoals, Alabama;

- Influencing the private fertilizer industry to use products, methods, and manufacturing processes developed by the TVA;

- Influencing the usage and applications of fertilizers by farmers.

The main activities of these programs are oriented towards the improvement of existing technologies to increase efficiency in the use of fertilizers, to minimize pollution, to conserve natural resources, and to reduce energy consumption.

The operational management of the chemical development process relates to research activities, construction works, and demonstration production. The construction additions consist of demonstration-scale pilot plants and also of large-scale production units. The extension of new developments beyond pilot plants into semi-commercial size production units is usually necessary in order to continue the development process and to resolve new problems that come with expansion.

The production of fertilizers is restricted to demonstration purposes. Operations of the pilot plants, and of the large-scale production units are the main forms of operational management in this field. The purpose is to obtain:

- New products in sufficient quantity for agronomic field tests;

- Data for further development of new processes in industry or in demonstration-scale plants;

- Data for design of large-scale plants. This mechanism covers the maintenance of pilot plants as well as the preparation of reports, economic evaluations, and recommendations for construction of facilities to carry out processes it has developed. Also, it includes the control of industrial emissions related to these processes;

- Information for continuing process development and for resolving new problems in manufacturing operations that come with practical application;

- Fertilizers for TVA regional and national-scale demonstration programs and for market development, which includes cooperative work with commercial firms in testing and introducing their products to customers.

The operational management also includes the management of raw materials processing. In this field, the TVA carries out geological and mining surveys of TVA-owned deposits, evaluates them,

and recommends mining places for selected tracts. It mines and ships phosphate ore to the chemical plants at Muscle Shoals. It carries out reforestation, manages the reforested areas, and provides services for the mining and recovery of other minerals necessary for fertilizer production. The fertilizer demonstration activities of the TVA could be considered to be marketing activities under some circumstances. They include:

- Identification of opportunities for reducing costs and providing appropriate services to farmers;
- Studies of certain aspects of fertilizer distribution, including fertilizer prices, demand and supply trends, etc.;
- Development of pricing policies and rate schedules for the distribution of TVA fertilizers;
- Analysis of economic data related to fertilizer allocation.

When dealing with the private fertilizer industry, the TVA uses a group of operational management mechanisms that are designed to create appropriate markets. It makes its development accessible to all potential users. For this purpose it patents innovations, and grants non-exclusive licenses for their use. According to the 1974 *Annual Report*, the total number of issued licenses is 571 granted to 395 companies for use in 506 plants in 39 states. To encourage commercial producers to produce TVA fertilizers all experimental data from the pilot plants and experimental applications of TVA-produced materials is made available to these firms. The Authority also provides technological and engineering assistance for cooperating firms. The commercial fertilizer producers may send representatives to Muscle Shoals to gain information on current developments and to obtain advice on how to solve their problems.

The TVA also has extensive programs to provide information and instruction on their activities. It collects complete information about national fertilizer production and its use. The data are then published in bulletins such as *Directory of Fertilizer Plants in the United States*. This information can also be provided upon request to individual users. The Authority is also involved in flexible training programs for various courses, varying from 3 days to 8 weeks, that combine techniques of fertilizer production, marketing management, fertilizer use, and other related topics.

Another mechanism of marketing development is direct collaboration with farmers, such as in the farm demonstration programs in the Tennessee Valley region and in other parts of the United States. These programs are prepared and undertaken in cooperation with the state land grant universities. The TVA organizes the demonstration farms, resource development farms, and demonstration projects and provides its own fertilizers, with all recommendations

of usage, to interested farmers. The results of these experiments are communicated and explained to farmers by means of magazine articles, radio and television programs, and university publications.

The TVA's fertilizer program has nationwide application. This clashes with its principal objectives, which are concerned with regional development. But due to its unique position, the TVA was considered able to accomplish a comprehensive national fertilizer development program. Under different circumstances (e.g., private research) it would not have been possible to develop production and marketing influences to reduce fertilizer cost and to introduce efficient manufacturing processes.

Test-demonstration farm programs concentrate on providing information and propagating new methods of farm management, technical facilities, and crops.

The program of rapid adjustment farms is more complex. Intensive planning and management are carried out on a limited number of selected farms. Each of these farms is analyzed in depth and programed for fast change by university specialists. The program consists of fertilizer application, cultural practices for specific crops, and the employment of the latest production and management practices to help increase net farm income.

Demonstration programs are accomplished with the cooperation of land grant universities of seven valley states, and with other institutions, agencies, and organizations interested in agricultural and agriculturally-related resource development. The results are used by professional workers in these programs to help other farmers, and may be employed on other farms in the Tennessee Valley.

Demonstration programs also play an important role in other resource development programs. For example, the TVA has developed "Land Between the Lakes" as a national demonstration in recreation and environment education. The different activities in this open area are mostly oriented towards the management of natural resources. These resource management practices also help visitors to develop an understanding of the importance of maintaining and conserving a quality environment.

2.4.3.2 Providing Information

This instrument is used in the development of industry, agriculture, forestry, recreation, and other resources of the Valley. The TVA carries out complex investigations into the development needs of the region and subregions. In the Division of Navigation and Regional Studies regional modeling activities constitute an important part of these investigations. The results of these studies form the basis of the general guidelines for regional development and are used as a data source for various activities.

Information for industrial development is usually requested by communities or subregions of the Valley region in response to a perceived need or opportunity. In such cases the TVA first provides information on the most beneficial kinds of industry for the particular subregion. This selection is based on results of subregional development models, analysis of employment levels, local natural and manpower resources, market needs, and other factors. The TVA also provides advice on infrastructural problems and preparation for industrial expansion. Then data concerning those companies that may be interested in investment in that subregion are provided for the local groups. The TVA makes the initial contact with those companies informing them of the opportunities for investment and profit potential. When a company shows interest in the subregion, the Authority provides more detailed information, such as construction requirements, land usage, site evaluation, environmental characteristics, etc.

For agricultural development the TVA provides advice for farmers and farmers' organizations on the most profitable crops to grow, fertilizer practices, etc.

One interesting program is concerned with the provision of information for the development of forestry and wildland resources. The forests, which cover 87,000 km^2, are an important regional resource. Most of the forest land (85%) is privately owned. To stimulate the improved management and use of this land, the TVA has developed an information system called WRAP (Wildland Resource Allocation Procedure), which will eventually provide a means for gathering information on wildland resources and for blending this information with stated plans to guide residents in the management of their property.

We should stress that this system provides only suggestions for solving multiobjective problems subject to appropriate restrictions. The final management decisions will be taken by landowners and could be different from those suggested by the WRAP analysis.

Another field in which an information service is provided is the recreational program. Many private and public groups are interested in investing in recreational resources. The TVA provides detailed information for potential investors about those facilities most profitable and beneficial for the region. It also gives technical assistance in the planning of these recreational developments.

2.4.3.3 Technical Assistance and Collaboration with Local Groups

These are the main instruments used in the TVA's Tributary Area Development Program, which is designed for unified resource development in various multicounty areas throughout the Tennessee Valley [8]. The Authority stimulates subregional development, provides information and technical assistance, and collaborates with local organizations in planning and carrying out programs for

economic progress in the area. The implementation of these programs is made possible by local citizens, organizations such as citizens associations, special state agencies, development districts, and educational cooperatives.

2.4.3.4 Educational Programs

Educational programs are used in manpower resource development. The wide range of TVA programs provides a demand for a variety of highly skilled workers and administrators. By means of a variety of activities--education, training, and experience--the Authority can meet most of its own needs for trained personnel and is also able to contribute to the creation of a skilled labor force for the region.

The responsibility for the training of trades is delegated to all divisions of the TVA, and three main kinds of training activity have been designed: introductory, work-improvement, and qualifying. Different types of training are used for salaried employees. Formal training programs for supervisors and managers are also provided.

2.4.3.5 Law Creation

The TVA has the authority to create regulatory laws for activities that have been proved suitable for development by the demonstration programs. Examples include the law for new cities in the state of Tennessee, and the act for strip mine reclamation, which was adopted in several states. In both cases the preparation for the draft of the acts was made by the TVA, using its own experience as a guide.

The mechanisms presented in this section are employed by such units as the Division of Navigation Development and Regional Studies, the Office of Tributary Area Development, the Division of Water Control Planning, and others. The need for an Office of Valley Resource Development has frequently been mentioned. Such an Office could provide more efficient activity and coordination for unified development of the Valley resources.

2.4.4 Summary and Conclusions

The TVA has developed a wide range of operational management mechanisms. These can be divided into two main categories: direct and indirect mechanisms. Direct operational management is used in production, marketing, and investment activities. There are only a few programs in which these mechanisms are used, but these programs play a very important role in the TVA's activities. They are concerned with the power and water systems, the fertilizer program and partly with the recreational program.

Indirect operational management is employed in other programs designed for the development of regional resources, such as

agriculture, industry, etc., and manpower. These programs have an important relationship to the principal goals, but they have many restrictions. Only some of them, e.g., agriculture, appear to have an extensive influence on regional resource development.

As a result of the analysis of the TVA operational management mechanisms, additional problems requiring further investigation were exposed. Firstly, the term "operational management" in relation to regional development organization requires a more precise definition. For the purpose of this report we have considered the operational management activities as a part of the decision-making structure devoted to maintaining day-to-day operations. Mechanisms of operational management act within the framework of established plans, and also relate to statements on strategy. They include the current decisions of the operating units as well as some administrative decisions of other units in the organization structure. This definition was taken according to the division of tasks analyzed in the TVA case study.

Further investigations are needed to develop the process of operational management mechanisms. These mechanisms depend on TVA goals and objectives; on various political, economic, legal, and social restrictions; and also on programs established for fulfillment of the goals of the organization. The investigation of different regional organizations will provide an opportunity to compare and evaluate the influence of these different factors on the development of the operational management and will serve as a basis for establishing methods to solve these problems.

2.5 CENTRALIZATION AND ITS CONSEQUENCES: A STUDY OF TWO TVA DIVISIONS

2.5.1 Scope and Purpose

This section concentrates on two of the divisions of the TVA--the Division of Forestry, Fisheries, and Wildlife Development and the Office of Power. The previous sections have examined some aspects below the corporate level of the TVA, particularly with respect to the planning and operational mechanisms used. We will now undertake an overall investigation into organization at this lower level. This will add to the total picture of TVA organization presented in this chapter. However, our primary purpose here is analytic. It is directed towards elucidating the conditions under which we would expect particular features of the Authority's structure and management mechanisms to be successful.

The variety of forms of organization and methods of management to be found operating apparently successfully both within national frontiers and in different parts of the world contradict the view that there are certain management methods that are optimal, and even appropriate to all conditions. While this may not be a controversial view it is pertinent to note that the TVA itself has been presented as a model that has been adopted in conditions rather different to those generally prevailing in the United States.

To fully explore this idea would take us far beyond our present study. However, concepts will be introduced to allow this aspect to be explored in more detail.

Within a single corporate structure the TVA carries out tasks of great diversity. One could hypothesize that if the nature of the task is a relevant factor in determining appropriate means of management, differences would be found across different TVA divisions. If these differences are not evident, then we would expect evidence of maladaption in some divisions. This section is broadly concerned with this hypothesis. First of all concepts that help to identify relevant differences in organizational activity and their consequences for organization are presented. These are then tested against the two divisional cases.

While doing this, we will comment in more detail on some of the observations brought out in the earlier cases. In particular, we will try to present a framework in which the issues of centralization, planning systems, and means of achieving coordination can be viewed in a new way.

2.5.2 Theoretical Frame

In the course of 1976 a small team of scientists from IIASA worked on the development of a framework for providing policy support to the organizational dimension of large, multisectorial programs. Because the approach was to be used for diverse programs in various settings it had to be sufficiently general to take account of those differences. Such programs also usually involve the interaction of many different bodies--they are multi-organizational problems and the approach had to take account of this. It is not now possible to fully apply that framework to the TVA. We have already indicated that the TVA is only one agent in the total picture of Tennessee Valley development, so our data are not adequate. Nevertheless some of the ideas embodied in the framework are useful for the analysis of single institutions such as the TVA. Particular aspects of the framework have been explored by many researchers in the field of organization, but the development of the work at IIASA has found its most consistent course in the area of management cybernetics, and particularly in the writings of Ashby [9] and Beer [10].

2.5.2.1 System and Environment

The most general statement that can be made about an organization or institution is that (a) it is a system directed towards the achievement of either internally generated or externally set goals; (b) its environment includes external factors affecting the system's possibilities for goal achievement, and the environment is changeable; (c) the system is in constant exchange with its environment. Changes in environmental state evoke a response conducive to goal achievement.

Viewed in this way the central issue in analyzing a management system is its capacity to respond adequately to changes in its environment, so that its objectives can be achieved. Stated in this abstract way, these characteristics may seem unfamiliar. However, on reflection, it is not difficult to view the problems of an enterprise in this way. It has goals to achieve, and the actions it takes to achieve them are based upon feedback from its environment in terms of such factors are material costs, labor availability, markets, etc.

This statement is too general to directly allow comment on the particular ways in which a system may respond. However, its value as a starting point is that it contains nothing that is likely to be specific either to the nature of the objectives, or to the environment in which they are to be achieved.

An implicit equation has been made between an organization (in the conventional sense of corporate entity) and a system. In fact the concept of system is much more universal and may comprise a collection of "organizations". Looking within "an organization" we will often find subunits which have their own identity and degree of autonomy. So we can think of "the organization" as a system including these subunits, or subsystems. This is the case with the TVA and some of its divisions. In our framework we view a number of units as a system, rather than as some random collection, when they subscribe to, or their objectives are influenced by, a common overall goal. This will be true of units which are within a single corporation. On the larger multiorganizational scale, the TVA itself is part of the US government system, together with many other bodies. We are concerned here with an exploration of the rules relating to the structure of multiorganizational systems and single corporations.

The nature of the environment of a management system is a primary consideration in organizational analysis, so it is worth explaining this idea a little more fully. In one sense system environment could be taken to include all factors external to the system. However, this wide definition includes influences that make no impact on the system, which does not need to regard them as relevant to objective achievement. It is a system's objectives that define the relevant environment. The relevant system environment consists of those factors which, when they change, require a response from the system. As a very simple example we may consider the weather--part of the total environment of all systems. If one is manufacturing ice cream, it is likely to form part of the relevant system environment, for a steel manufacturer it probably is not.

System environment will generally include other organization units, i.e., a system will often have to take account of the activities of other separate systems. The rate of change of factors may determine their relevance. Thus, population is probably relevant to many systems, although where it changes slowly it can often be ignored, but where it is increasing rapidly, as is often the case in development areas, then it becomes relevant to the

system environment. Each factor of the environment may adopt many different states each of which requires a particular response. And in some cases the appropriate response may not be well known. A further important consideration is the degree of interrelation between states of the environment. Can they be considered separately, or do several factors have to be considered together? In this latter case we find a multiplicative increase in the number of different states a system may have to recognize and respond to. All of these considerations--the number of factors in the environment, their interconnectedness, the number of states they may adopt, the rates of change and the uncertainty of the relationship between environment change and system response--are important when considering an environment. For situations where the number of factors is high, each with many states, high rates of change, and high uncertainty we use the term complex environment. Within organizational research many ways have been suggested to recognize and classify complex environments [11]. As the complexity of a system environment becomes greater, the management demands on the system increase.

2.5.2.2 Structure

The TVA has accepted from the Federal Government rather general objectives broadly connected with the welfare of a region. Ultimately many different environmental factors relate to these objectives--the price of coal, rainfall, growth of population, actions of private industry, etc. From the general statement of objectives it would be almost impossible to make a response to changes in any of these factors. Instead it is common observation that these objectives are elaborated step-by-step. At the initial stages only general environmental factors are taken into account. As they become more elaborate, more of the detail of environmental change can be responded to. This process of elaborating objectives through a system is the process by which system structure is defined. We can illustrate this process with respect to the TVA. The first elaboration of the general TVA objectives into particular projects is made at what we will call the TVA system level. Here choices and trade-offs have to be made between major alternatives. A typical example might be the priority and resources to be given to power interests rather than non-power projects. At this level rather general environmental factors will be considered--an aggregate view of demand for power, needs of the communities of the Valley, attitudes and likely responses of other bodies. Once these choices have been made they provide the framework within which the next level of elaboration can be made. At this lower level the choices are, in a sense, received objectives. Only these environmental factors relating to those objectives need to be considered. For example, the power-related activities can further define the construction of power stations, say, without needing to consider issues of fertilizer manufacture. All of this is perfectly familiar organization behavior, and in some cases evidently maps an organization's structure. However, we must emphasize that it is the logic of objectives' elaboration

that we are using to define system structure and this might not always neatly correspond to an organization chart.

When the level of objectives supported by a particular unit is examined, this may lead it to be placed at a level that is different from its position in conventional descriptions of organization hierarchy. Within the TVA we can recognize the divisions considered in this chapter as subsystems, which themselves contain recognizable subsystems.

2.5.2.3 Centralization

Centralization is usually described as the concentration of decision-making capacity within a hierarchy. Using the ideas just introduced we are able to define it more accurately. The extent to which a system is centralized follows from the rate at which objectives are elaborated through system levels. At the various system levels equal opportunities exist to recognize and respond to changes in overall system environment. Where a high degree of elaboration occurs at an upper system level (a centralized tendency), this implies that all relevant aspects of the environment need to be considered in sufficient detail to support the detailed objectives being issued. This throws large demands on the upper level, but relatively small demands on the lower levels. The detail in their received objectives leaves only a narrow area of environmental change of which they have to take account.

We can illustrate this with a hypothetical example from the TVA. If the Board or General Manager were to give the power subsystem the very general objective of meeting demand at the lowest possible cost, all responsibility for examining environmental factors relating to current and future demand, alternative fuels, etc., would fall on the power division. If the objectives were set in terms of building specific capacity using defined fuels, there are fewer external factors to which the power division would have to respond. The factors that lead to those objectives being considered as a sensible choice with regard to current and future conditions will have been considered at the higher level. It is important to emphasize that this is not just a shift of work from one level to another. Where such detailed choices are made at the higher level they are considered with, and traded-off against, possibilities connected with quite different aspects of the total TVA program. Therefore, the degree of choice and the balancing of possibilities increases rapidly as greater detail is considered at higher levels.

Some general comments should be made to correct for oversimplification arising due to this brevity of presentation. Firstly, it is recognized that the picture of objectives being "handed-down" is not a realistic model of most organizations. In practice information and influence flow both up and down and the process is highly dynamic. Nevertheless, there are points at which those choices or policy trade-offs are made, whatever might be the complex process upon which those choices depend. Secondly, the

ratification of a decision made at one level by the level above should not be regarded necessarily as the decision point. The essence of decision in this approach is the idea of choice or trade-off. If the Board ratifies a power decision without specifically considering consequences for non-power aspects, it is at that time not behaving as the upper system level.

2.5.2.4 Consequences of Differences in Levels of Centralization

A tendency towards centralization has the effect, as has been discussed, of placing very great demands on the higher system levels. The more complex the system environment, the greater those demands. Therefore, these levels need great capacity to examine the environment. We can regard this need as being effected by what we call the intelligence or planning function of the system level. Each level of the system will contain this function. Sometimes it is provided by a formal planning system, sometimes it is not so distinguished. In a previous section in this chapter, for example, it has been observed that planning is not separated from the everyday functions of management. When this capacity is not sufficient to fully support the elaboration of objectives because there are just too many relevant factors to take into account, then the system will lack a responsiveness to those aspects of its environment. This leads ultimately to a lack of effectiveness. Centralized systems are, therefore, characterized by large capacities to plan or monitor the environment and frequently by a lack of responsiveness, despite this capacity, if they operate in a complex environment.

A highly decentralized system contains quite different dangers. Here, because the need to respond to environmental complexity is more uniformly spread between levels, no great demands are placed on an intelligence or planning capacity. However, because the higher system levels, when setting objectives, are examining the environmental factors at a general level, they may not see interactions between the objectives set to different subsystems, which are apparent only at a higher level of definition. For example, two general policies--cheap power and environmental protection--are both reasonable derivations from the TVA's overall goal. However, if put to two subsystems in these terms, contradictions between them would rapidly arise. The two subsystems would interact with each other to the detriment of the objective achievement of both, and the level of generality at which the upper level operates would not provide a logic for resolving this. To do so it would have to look into the environmental aspect in greater depth--thus increasing the extent of centralization. In more abstract terms, we can see that it is the degree of connectivity or interdependence of environmental factors that limits the possibility for decentralization.

Coordination can lessen this dilemma. Through coordination, subsystems can directly communicate so that they minimize their negative interactions with one another. This takes place at a

greater level of definition than that defined in the objectives of either subsystem. Therefore the higher level cannot define the issues or the results of coordination; this is done by the subsystems in order to achieve their own objectives. To understand the limits of coordination we have to introduce another idea, that of balance between subsystems. A balanced environment is one in which there is a degree of symmetry between subsystem interactions. That is, the perceived benefits of coordination appear similar to both subsystems, or the costs of non-coordination are equally high to both. In balanced environments a high degree of coordination is likely to occur. Unbalanced environments are asymmetric between subsystems. That is, benefits of coordination are not seen equally, and therefore coordination is unlikely to occur to a degree that satisfies both. The elements of balance are diverse and include objective environmental factors as well as factors such as relative sizes and influence of subsystems. When balance occurs it allows for an increased level of decentralization. It is a result of the initial way in which objectives are set by the higher system level.

One further idea will be introduced before moving on to our cases. Technology is a term which has occurred frequently in organization literature and we use it here in a modified form, e.g., [12,13]. Technology relates to the degree to which a system's activities are understood, or routine, so that decisions can be made according to preprogramed rules, i.e., can the process be modeled? It extends to considering the interactions between tasks, i.e., can they be understood and modeled? In the terminology we are going to use, a process has a simple technology if it is well understood and in some sense routine, and a complex technology if it is not. The significance of this in relation to earlier ideas is that it is linked to the internal environment of a system. Simple technology allows the higher levels to better define and control the activities and relationships of subsystems. It is supportive of centralization.

2.5.2.5 Summary Hypotheses

We have identified several factors relating to the level of centralization that we would expect to find in any system.

Centralized systems will be most appropriate in relatively simple environments with a simple technology. They place high demands on planning but less on coordination. They, therefore, do not require balanced subsystem environments.

Decentralized systems will be most appropriate in relatively complex environments with complex technology. They place lower demands on planning, but more on coordination. They, therefore, require balanced subsystem environments.

Where a system is overcentralized according to these criteria it will be subject to a loss of responsiveness. Where it is undercentralized, benefits made possible by increased integration of

activities will not be realized, and negative interactions may occur between subsystems.

In the cases that follow we will test these hypotheses within the limits of our data. We will comment from the perspectives of both TVA as the system under examination, and the case divisions as the system. At the end of each case is a brief concluding subsection, which specifically relates the description to the concepts presented.

2.5.3 The Division of Forestry, Fisheries, and Wildlife Development

2.5.3.1 Objectives and Technology

The broad objectives of this division are to develop wildlife, fisheries, forests, and recreation areas for the benefit of the region. To this end it conducts both investigative and development studies. It has close relationships with state, federal, and other agencies concerned with similar issues. Implementation is effected primarily by educational and demonstrational means.

While some of the work (concerned with monitoring) may be said to be routine, other important parts are more complex. Division staff constantly deal with situations which are single events, requiring decisions that cannot be based on the application of preprogramed rules. Moreover, different aspects of the same tasks may require inputs from several areas of scientific expertise. The contribution required of the different experts will vary from problem to problem. There are no models of natural resource systems that can simply define these contributions and structure the interactions of all those concerned with the problem. The technology of the workload of the division is, therefore, highly complex.

2.5.3.2 The Environment Outside the TVA

The complex technology of the workload is to some extent a reflection of the complex environment in which the division operates. The concerns of the division can affect the quality of life of the Tennessee Valley population. Hence, the environment may be said to be complex in two distinct ways. Firstly, the natural resource systems studied are complex in the usual sense. Moreover expectations must be studied and acted upon if the division is to be effective. The way in which the division seeks to implement its programs in the community is wholly by the traditional TVA demonstrational/educational methods. These methods are likely to be successful only to the extent that the division has correctly perceived the region's needs.

2.5.3.3 The Environment Within the TVA

In addition to the usual relationships with the General Manager's Office and routine relationships with the purely service divisions (e.g., Law), the Division of Forestry, Fisheries, and Wildlife Development (FF&WD) is involved in projects with other program divisions, for example, the Division of Environmental Protection. The problems involved here are usually complex, as described above, and the contributions of the individual divisions have to be negotiated. However, the respective contributions will generally be complementary and the potential for conflict in these relationships will be low.

Another important relationship arises with the Office of Power. A large part of the workload of the division is carried out as a contribution to the power program and charged as such. In this sense the division is acting as a research contractor to the Office of Power.

The relationship of the division to its environment, both inside and outside of the TVA, is shown diagrammatically in Figure 2.7.

2.5.3.4 Organizational Behavior

The division employs almost 400 people. Its formal organization chart, as shown in Figure 2.8, shows no linkages between branches that do not go through the Division Director. In practice the organization is characterized by constant cross-communication. This is required by the nature of the work and appears to be encouraged by the general ethos of the organization. In decision making there are few levels of hierarchy. It appears to operate through the project leader, branch head, and division director. The levels of hierarchy are fewer than experience would lead one to expect for a unit of this size.

In internal control, the division seems to be fairly decentralized and indeed this is a necessary consequence of the few levels of hierarchy. The heads of branches have substantial control over developing and operating their own programs. The Division Director has two principal means of controlling the work of the division. The first is through the formal budget control system. This compares expenditure and man-days used for each project against a target figure. It is not seen as an effective tool since some projects cut across the branch accounting codes. Also this type of financial information may not be the most appropriate for controlling some projects. In character with the general style of the organization, the Division Director maintains some control over the work of the division through informal and ad hoc meetings with division employees. With the information we have it is not possible to quantify the extent to which this is used deliberately as a means of strengthening central control, although it would seem that at the branch level there is no feeling of "over control".

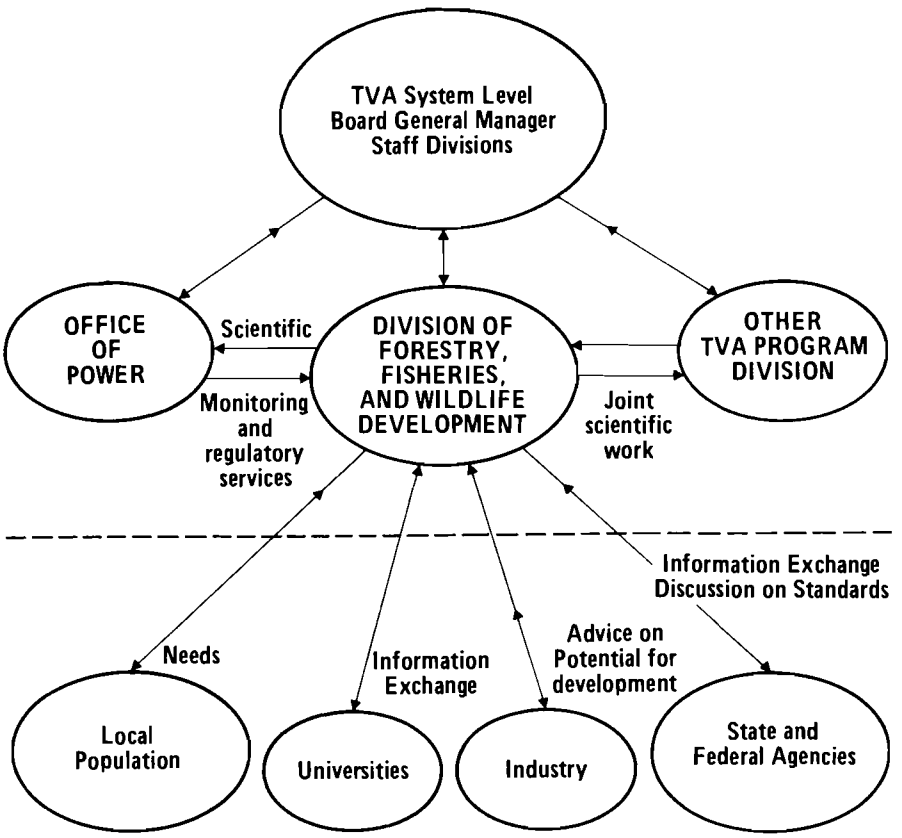


Figure 2.7. The Division of Forestry, Fisheries, and Wildlife Development and its environment.

The basis for generating the program of the division is the situation assessment. Prior to this becoming a TVA-wide system, the division had experimented with similar means of relating its future activities on a wide assessment of the requirements of its environment. The mode of operation of this procedure is inverted in the extreme. In its guidance of planning procedures the division emphasizes the need for all employees to submit their ideas on the future direction of the division. Suggestions are also sought from other TVA employers, cooperators and interested citizens, and advisory groups. The compilation and coordination of these ideas is carried out by a program coordinator in close but informal contact with branch heads. Senior management in the division believes this type of approach is both necessary for and successful in tackling complex natural resource problems, which can have a wide effect on the community.

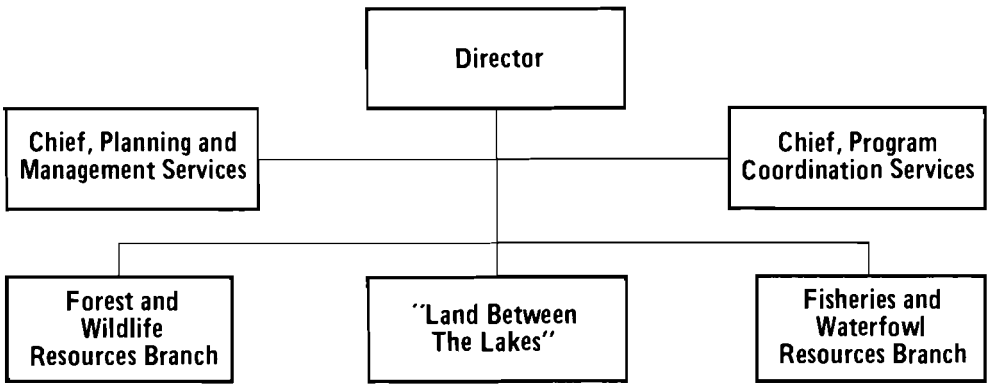


Figure 2.8. Division of Forestry, Fisheries, and Wildlife Development, organization chart.

By means of this process the division easily adapts itself to the needs of its environment. Because of changed perceptions of these needs, over the past few years there has been some restructuring of the internal organization.

The planning system described and the system of informal communication in an organization of this small size act effectively to coordinate those parts of the program that only overlap or interact to a limited extent. However, for some tasks, in which up to 20% of staff are involved, the interactions are too strong to be handled in this way and superimposed on the function-based structure is a matrix type of operation not recognized in formal procedures.

For example, many projects employ people from more than one branch or division and, in some cases, from more than one division. Formal procedures do not distinguish this type of project from those occurring purely within a single branch and the establishment of these project teams is handled informally. Also within the Planning and Management Services branch is a systems development group that operates almost entirely as a systems design and computing resource to the program branches. Again the mode of operation is largely informal and there is no procedure laid down for setting work priorities for this group.

Despite the rather ad hoc manner in which coordination is achieved both within this division and FF&WD's other division,

there is little feeling here that informal procedures are failing and need to be strengthened.

The principal features of the organization referred to are summarized in Table 2.6.

2.5.3.5 Summary

The small size of the division, the effectiveness of informal communications, and the general style of management all contribute to a high level of employee satisfaction and commitment to the division's objectives.

The inverted mode of planning, which draws upon many separate sources, enables the division to be responsive to the needs of the community it serves. In so complex an environment and with such a dependence upon educational and demonstrational means for implementation, this responsiveness is essential for continuous effectiveness. A consequence of the efforts made to mirror the perceived regional requirements is that less energy is devoted to changing local perceptions, and thereby to achieving a genuine innovatory role in the region.

Because of the nature of natural resource systems, tasks that cut across both branch boundaries within the division arise, and, on occasion, they require an input from several divisions. Despite a lack of formal procedures for dealing with this, project teams have arisen informally and the level of coordination achieved appears satisfactory. This lack of a need for formal procedures probably arises from the nature of the interactions; all the parties involved have distinctive contributions to make and there is generally no potential conflict of objectives.

2.5.3.6 Analysis

The evidence suggests that both internally to the division and with respect to its received objectives, we are looking at a rather decentralized system.

It has a complex environment and a complex technology. The division as a subsystem of the TVA has a generally balanced environment with several similarly oriented subsystems. Its own subsystem operates in a balanced environment. Coordination, therefore, occurs spontaneously.

All of these factors are consistent with an effective decentralized system and within the limits of our observations the division was well adapted.

Table 2.6. Comparison of original features across the cases studied.

Organization Features	Unit		
	Office of Power	Division of Forestry, Fisheries, and Wildlife Development	Office of Agriculture and Chemical Development
Number of employees	9392	380	961
Number of branches	49	6	22
Type of formal structure	Divisionalized mainly functional lines	Functional lines	Divisionalized mainly functional lines
Control			
Centralization	Aspects of centralization and decentralization	Centralized	
Formality	Informal	Informal	Informal
Hierarchical levels	6	3	5
Coordination			
Formal coordination mechanisms	Regular meetings	Low	Meetings
Informal coordination mechanisms	Many	Many	Many
Matrix type operation	Limited use	Yes	Very limited use
Planning			
Inverted/top-down	In practice top-down	Inverted	Elements of both
Reacting/initiating	Initiating	Largely reacting	Elements of both
Rigid/adaptive	Adaptive	Adaptive	
External environment	Simple	Complex	Complex
Interactions within the TVA			
Many/few	Many	Many	Few
Conflict potential	Often high	Generally low	Generally low
Task technology	Simple	Complex	Complex

2.5.4 The Office of Power

2.5.4.1 Objectives and Technology

The Office of Power is responsible for the generation and transmission of electricity in the region. It has to maintain the generating system and develop plans for new stations to meet future demand. A primary objective is to ensure that power is sold at the lowest possible rate.

Although power generation may be highly complicated from an engineering viewpoint, in our sense of the word the technology involved in operating the system is quite simple. Most of the operating decisions that must be made and some aspects of planning extensions are routine in nature. Rules will have been established to deal with the range of contingencies that are likely to arise. Indeed, like other large utilities, the Office of Power is characterized by the extensive use of computer-based models used directly in the decision-making process. Such models can also be used to integrate the work of different divisions and steps are planned in this direction. On the whole, compared with the previous case, decisions may involve less discretion by the individual; and for tasks involving interactions between several groups, the contribution of each group can be specified in advance much more easily. As we have defined the term, these are characteristic of a lower level of technology complexity.

2.5.4.2 External to the TVA Environment

The Office's main external interaction comes from providing electricity to meet demand. Although the level of demand at any particular time depends upon many factors, standard control procedures will balance supply with demand, and models are used to forecast future demand. This type of environment is essentially simple and does not require the Office to include many organizational devices that make it sensitive to change. Power generation does make a substantial impact on the environment, but the complex set of responses that this involves, for example, in changing fish stocks around power stations or reducing air quality, are handled by other TVA divisions. Therefore some of its external environmental effects are handled through relationships with other TVA offices.

2.5.4.3 The Environment Within the TVA

The Office of Power is at the center of many relationships with other TVA organizational units. These relationships may be grouped into several categories.

First there are the more or less routine interactions that occur with staff divisions, such as Personnel, Law, and Purchasing. Within the TVA this type of function is strongly centralized. It

would not be unusual within a divisionalized structure for a division as large as the Office of Power, for example, to manage its own purchasing function. Yet within the TVA structure all contracts for coal for power stations are signed by the purchasing division. In its most recent situation assessment, the Office referred to an unsatisfactory situation regarding the service it was receiving from Purchasing, from Law, and from Personnel.

The second group of relationships arise from other divisions acting as research contractors to the Office of Power. With increased concern for the environment and the enacting of legislation, this area of work has increased greatly in recent years. The Forestry Division is involved in monitoring fish stocks around power stations, and the Division of Environmental Protection is monitoring air quality. There is clear potential for conflict of objectives between these divisions and the Office, and the Office of Power refers critically to some of the relevant programs in its situation assessment. Informal coordination has not satisfied the needs of the Office, and self-coordination has recently been strengthened so that projects of other divisions requiring power funds can now be formally submitted to the Office.

A special relationship occurs between Water Control and the Office of Power. The generation of electric power is only one of three primary objectives of the TVA; the others are flood control and navigation. The Water Control Division has the responsibility for water release from reservoirs. Although hydroelectric power is now only a small part of total power generated, through its use as a supplement to the rest of the system at times of peak demand it can have a disproportionate effect on generating economics. This, however, requires release of water at times of peak demand, therefore real conflicts can arise between several interests. This conflict has been present since the early days of the TVA, and formal daily meetings to discuss the next days water release are held between the divisions concerned. This formal and long-standing coordination mechanism appears to be quite distinct from those established to handle other interunit relations in the TVA.

Close links are also maintained between the Office of Power and the Office of Engineering Design and Construction, which is responsible for building power plants and derives 98% of its budget for power funds.

Finally, because power generation forms such a large part of TVA activity, close links exist between the Office of Power and the Office of the General Manager. In conclusion, it can be said that the Office has a complex environment in the TVA, part of which provides a high potential for conflict. The total environment is presented schematically in Figure 2.9.

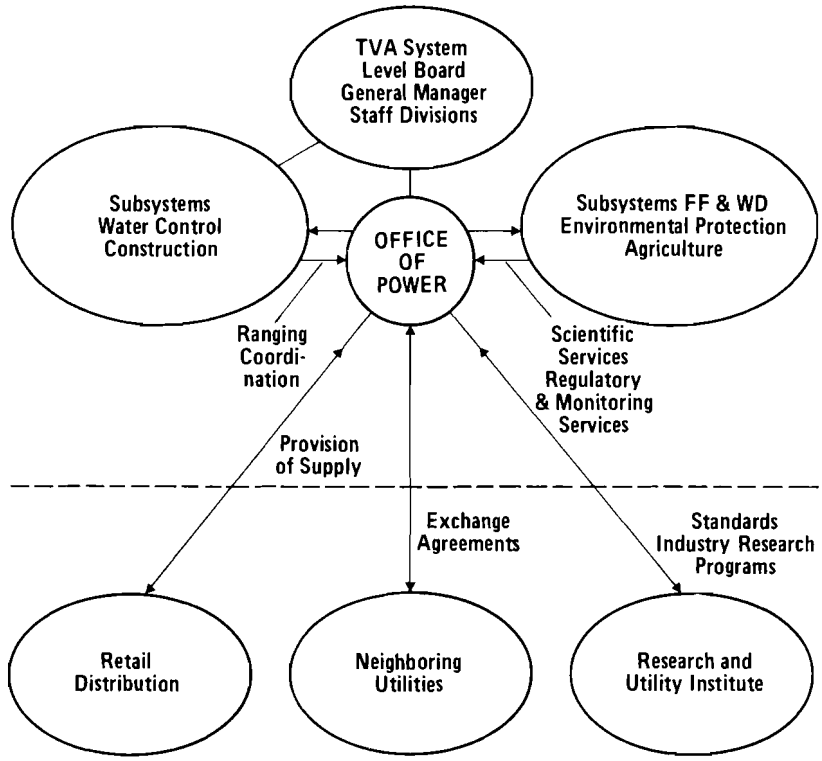


Figure 2.9. The Office of Power and its environment.

2.5.4.4 Organizational Behavior

The Office of Power is a large unit employing over 9800 staff. The split into divisions is largely a function of the technology of generation (Figure 2.10) and closely follows the Central Electricity Generating Board of England and Wales. It is a structure which contains no lateral links at the lower levels, but again the impression is that a high level of lateral communication occurs informally. For its size, it has few discrete decision-making levels, the maximum being six from project supervisor to Office Manager. Although the Office Manager has assistants who are concerned with the activities of particular divisions, the assistants do not see their role as one of control and the impression is that substantial power is decentralized from the level of Office to the divisions.

Like other units in the TVA, the Office of Power has produced situation assessments; in doing this it has requested suggestions

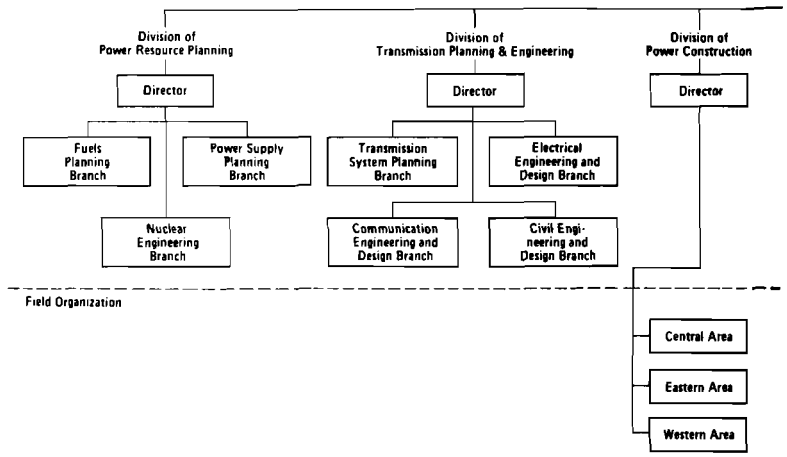
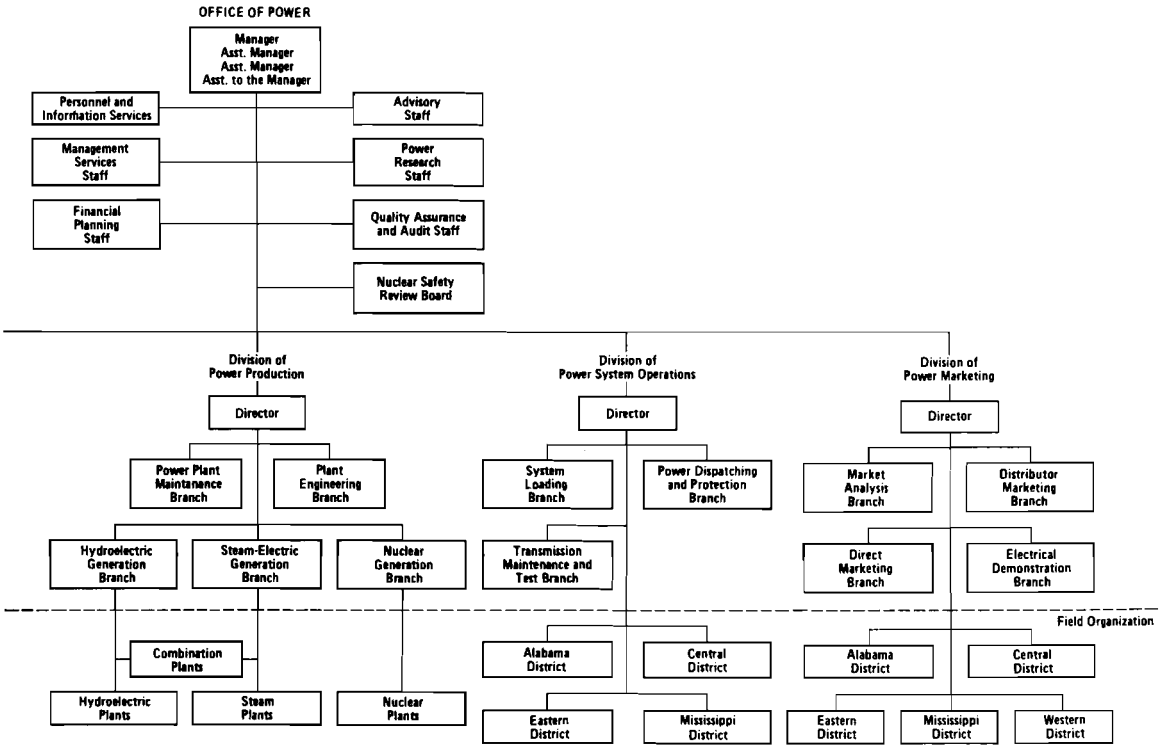


Figure 2.10. Organization chart of the Office



of Power (1974).

from the lower echelons of the organization. These suggestions have been reviewed to see whether they form the basis for new inclusions in the future program of the Office. However, while the view was expressed that the situation assessment is a useful device for exposing differences between the Office and other TVA units, it has not been successful as a means of involving all staff in the future program. In this respect distinct criticisms of the procedure were made.

Firstly, because of the nature of the work, staff have a narrow outlook and suggestions have tended to be concerned with specific engineering considerations that would have arisen naturally.

The second criticism is related to the size of the Office and the one-way nature of the channels used by the situation assessment procedure. If a suggestion from the bottom of the organization were to result in some shift in the program, the shift may be so slight and compounded with other influences that it may not be identifiable to the employee concerned. The result has been that the procedure is not viewed seriously as a means of increasing employee involvement and of broadening the planning base by any of the participants in the system.

The most significant criticism of the inverted approach to planning is that the perspectives held at senior levels in the division are the most relevant ones on which to base plans. The nature of the operating environment is such that no high value is placed on the multiplicity of inputs as is the case for FF&WD. Furthermore, models exist that can be used to generate the basis for future developments. These models are not yet fully integrated. However, this step is planned together with a shift in the level for major planning input from the division to the Office.

Since the Office of Power has few interactions with its environment, it receives few stimuli that would lead to change. Nevertheless projects have been initiated to increase efficiency both in the control and extension of the system. Pressures to achieve this have come mainly from within the organization, for example, for the construction of nuclear power plants the TVA has gone further than many other power utilities. In comparison with FF&WD we may typify it as an initiating organization.

The growth of the power system over the years and the addition of nuclear capacity have been reflected in organization structure. New divisions have been added and the structure of existing divisions has been changed. The organization has shown itself to be adaptive.

In contrast with FF&WD formal mechanisms do exist for coordination within the Office of Power. At monthly intervals a meeting is held between senior Office personnel and all division directors. At fortnightly intervals the division directors meet to coordinate their work without the presence of the Office Manager. Further

coordination is achieved via the assistant managers. Coordination of all power-related research is the responsibility of a Power Research Staff. These formal mechanisms operate at a high level and conflicting ideas may not be discussed until they reach a developed stage. To achieve initial coordination the Office depends entirely on informal mechanisms. On occasion staff of different divisions or branches may work together, but in FF&WD no formal mechanisms exist to control this.

2.5.4.5 Summary

The rather large size of the Office of Power and degree of differentiation around specified engineering tasks leading to a narrower outlook have made it more difficult to involve employees and commit them to the total objectives of the Office.

In its planning systems, the Office is placing increasing importance on a centralized approach. The exercises in inverted planning via the situation assessment do not appear to have contributed to this approach.

At a high level in the Office, internal coordination mechanisms exist, but for lower level coordination reliance is placed on informal communication, as elsewhere in the TVA.

Because of its many links with other TVA units, coordination has been a matter of concern to the Office. In contrast to early coordination centered on water control, few mechanisms now exist to coordinate potentially conflicting objectives, i.e., power generation with environmental considerations. Self-coordination has not successfully handled these, and recently a new system has been set up to deal with the problem.

2.5.4.6 Analysis

An analysis of the Office of Power shows a more complex picture concerning centralization, with tension between centralizing and decentralizing forces. Thus, although the situation assessment procedure is followed and involves low levels (a decentralized form), it does not produce worthwhile results. Conversely, although the benefits of centralized planning using computer models are appreciated and the models are being constructed (a centralized form), no intention exists to introduce such planning procedures.

We can say that the Office has a relatively simple environment and technology and could, therefore, support a high level of centralization. However, through the use of decentralized systems of a TVA-wide nature, it has not been able to fully introduce this and, therefore, shows evidence of inefficiency in its planning.

When looking at the Office within the structure of the TVA, it appears as a subsystem of a decentralized system. For some

important interactions (e.g., with water control) it has a balanced environment and effective coordination occurs. However, for others the environment is unbalanced and coordination has not reached a satisfactory level. Resolution of these conflicts that can arise between power generation and factors contributing to the general quality of life is one that can only be made at the higher system level. This implies a need for greater involvement from the Board and General Managers in these issues, thus effecting an increase in centralization.

2.5.5 Concluding Comments

A more detailed exploration of two cases has revealed a degree of consistency throughout the TVA in terms of style and specific mechanisms in management. It generally relies heavily on informal lateral contacts and adopts forms of planning procedures that allow for substantial inputs from the lower levels.

Although these common features exist, they are applied to areas where the activities and the demands made by the complexity of the environment are radically different. It has also been our observation, with an admittedly limited data base, that these same organizational features have not been of equal benefit in the two cases examined. The concepts introduced earlier would seek to link these separate points directly. The outcome of this study is consistent with our theory and, if accepted, could point to the types of change that might be beneficial.

We have reached the conclusion that the organizational features discussed are better adapted to the divisions broadly connected with quality of life issues than to the power program, which by many indicators is the most important to the TVA. This suggests that the TVA pays more attention to quality of life issues than is immediately evident and also that the adoption of more centralized forms, which would be beneficial to power, might be unacceptable in a multipurpose agency in the US setting.

REFERENCES

[1] Lilienthal, D.E., the TVA Years 1939-1945, in *The Journal of David E. Lilienthal*, Vol. 1, Harper and Row, New York, 1964.

[2] Derthick, M., *Between State and Nation: Regional Organization of the United States*, The Brookings Institution, Washington, D.C., 1974.

[3] Lilienthal, D.E., *Democracy on the March*, Chicago Quadrangle Books Inc., Chicago, 1966.

[4] Banner, G., Toward More Realistic Assumptions in Regional Economic Development, in J.R. Moore, ed., *The Economic Impact of TVA*, University of Tennessee Press, Knoxville, 1967.

[5] Steiner, G.A., *Top Management Planning*, Macmillan, New York, 1969.

[6] Ginsberg, N.S., *The Regional Concept and Planning Regions*, presented at the Seminar on Regional Planning, Tokyo, 28 July-8 August, United Nations, New York, 1959.

[7] TVA, *Analysis of the TVA Fertilizer Program*, Office of Agricultural and Chemical Development, Knoxville, 1972.

[8] TVA, *Tennessee Valley Authority Handbook*, July 1974.

[9] Ashby, W.R., *Introduction to Cybernetics*, Wiley, New York, 1956.

[10] Beer, S., *Brain of the Firm*, Allen Lane, London, 1976.

[11] Jurkovich, R., A Core Typology of Organisational Environments, *Admin. Science Quarterly* (1974).

[12] Perrow, C., A Framework for the Comparative Analysis of Organization, *American Soc. Review* (1967).

[13] Woodward, J., *Industrial Organisation, Theory and Practice*, Oxford, 1965.

Chapter 3: The Instrumental and Informational Basis of The TVA Planning and Decision-Making Process

3.1 CONCEPT OF THE ANALYSIS

In this short introduction we describe the consecutive stages of the analysis, development, and use of mathematical models and computer applications (MM&CA) as the instrumental and informational bases for the management of the TVA.

3.1.1 Goals of Study

The goals of this study can be formulated as the following set of questions:

- How are MM&CA embedded in the decision-making process?
- What are the general features of this embedding?
- What is the distribution of MM&CA development and use among different organizational units along vertical and horizontal axes?
- What is the scope of their use, i.e., what real influence do they have on decision making and to what extent are they used as information tools?
- Did there ever and does there now exist any conscious managerial strategy oriented towards the development and use of MM&CA tools?

In order to provide satisfactory answers, clarification of two additional points was sought:

- How has MM&CA design and use developed and what are the future plans?
- How did "computer power" and its use evolve?

Answers to these questions enable us to understand the ways in which MM&CA tend to be used as tools and informational bases in planning and decision-making processes within the TVA.

The information presented in this chapter is taken from the TVA presentations at the Conference in Baden, Austria, from TVA organization bulletins, reports of Cresap, McCormick, Paget consultancy firm, and from personal contacts with TVA employees

during our field visit. It reflects the state of the system and potential for future development as of Fall 1975.

3.1.2 Inventorization

The first step consisted of compiling a list of computer models for operational or planning activities developed or considered by the organization's staff or obtained from outside. The purpose of this exercise was to identify the tools already possessed by the organization, their position with respect to management, the potential use and the nature of scientific background. This last feature was investigated to determine the development of MM&CA and was regarded as a scientific undertaking or as an activity to locate existing tools for management support.

MM&CA thus analyzed (see section 3.3) were placed within the managerial structure to obtain an understanding of their practical use. On the basis of the list, a statistical survey summarizing the data was prepared.

3.1.3 The Systems of Decisions and Calculations

As an approach to the identification of the actual role that MM&CA play in a specific organization, the framework of the System of Decisions and Calculations (SDC) was employed for the description of decision-making mechanisms. This approach enabled us to construct a structure into which MM&CA could be embedded. Identification of the roles of MM&CA required a detailed analysis of the managerial input (assumptions, strategies) for their development and use as well as management interest in the results.

The intent was to present a scheme of existing and planned MM&CA, which permitted a comprehensive understanding of the relationship between MM&CA and the decision-making processes.

3.1.4 General Statements

The general analysis of TVA organizational structure and behavior together with the statistical survey of the set of models listed give a deductive basis for some general statements about the use and role of MM&CA. This complements and crosschecks the the inductive approach of SDC. The verification of these statements is done in two different ways: by verifying the elementary data that formed existing statistics (referring to specified MM&CA), and by examining whether the qualifiable phenomena that are the straightforward consequences of the general statements really did take place.

3.1.5 Verification of the Hypothesis: A Field Study

The three stages of work described in the previous subsections complete the conceptual background of the analysis. To

achieve the final formulations, it was necessary to carry out a field study in the organization analyzed. Before the field study began, two sets of prerequisites were formulated:

- The SDC structure based on the already known MM&CA and decision-making processes;
- The set of general statements based on the statistical survey of MM&CA and organizational characteristics.

3.2 THE DEVELOPMENT OF THE COMPUTER BASIS AND THE USE OF OUTSIDE FACILITIES

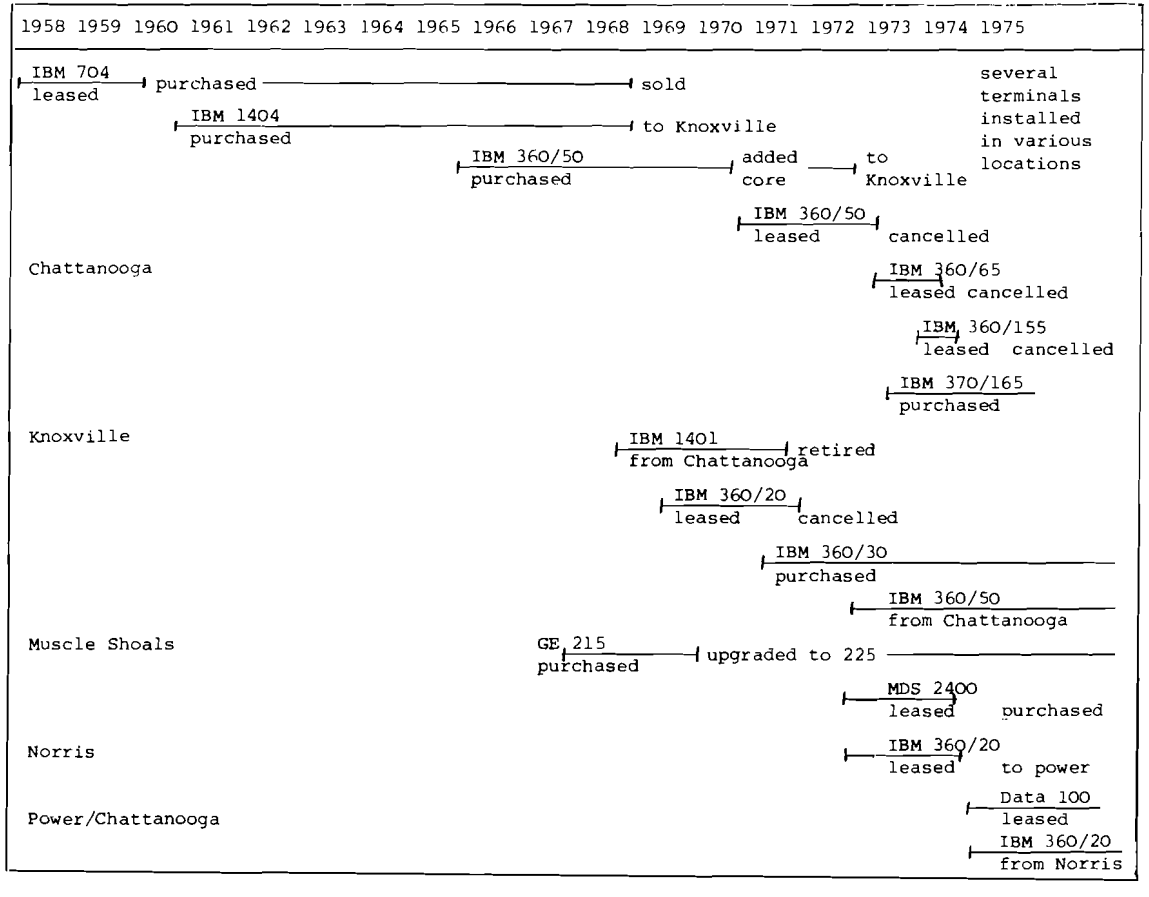
The need for computational equipment in the TVA was identified in about 1952. The organization was to some extent prepared for the use of computational devices, since tabulating machines had been in use for sales statistics since 1939. In the late 1950s the wide commercial availability of computers made it possible for the Office of Power to purchase a computer for their use. At that time it was decided that the computer operations would be carried out by the Division of Property and Supply for the benefit of all Offices and divisions. An IBM 704 was leased and later purchased. Not only the beginning of MM&CA activities in the TVA, but the subsequent evolution of computer equipment and staff, as presented in Table 3.1, was greatly influenced by the requirements of the Office of Power. It is worth mentioning that much of the computer equipment was purchased directly from Power funds, which gives an idea of the potential possessed by the Office of Power and, as we shall see later, its ability to recognize needs.

The Computer Services Branch (CSB) of the Division of Property and Supply (P&S) in Chattanooga now has about 120 people. The staff are responsible not only for current operations and maintenance, but also for providing programing and some operations research services (about 25 people). Nevertheless most of the customers of the CSB--the program users--design, develop, and program their MM&CA themselves.

The CSB does not function as a coordination center for systems planning and development activities; it is simply a service oriented utility. This fact is underlined by the extensive use of outside facilities and software. Frequently the equipment operated by the CSB is not sufficient for the computational needs of a specific user. This fact, and the availability of the required software from outside systems, has resulted in many users becoming accustomed to other time-sharing facilities, opting for the outside facilities rather than those of the CSB. This is particularly true for broadly available scientific information and bibliographical services. Many software packages have also been purchased by various divisions (e.g., in the Office of Engineering Design and Construction (OEDC)).

The next step in the development of CSB would have been the purchase of a large IBM 370/168 computer, capable of monitoring

Table 3.1. Development of the computing equipment of the TVA.



the multiaccess time-sharing system envisaged for the TVA. This computer was to have been bought with Power funds, but because of federal policies and procedural considerations, an IBM 370/165 was purchased. The CSB, along with other organizational units, proceeded, however, in the construction of a multiaccess time-sharing system, installing terminals of various types (MDS Mohawk, Harris) in Chattanooga, Knoxville, Muscle Shoals, and other locations. The growth of the set of terminals (projected at 70 by 1978), the realization of connections between main central processing units (particularly for the Chattanooga-Knoxville line), so that some jobs could be taken over in case of switch-off of one of the units, and the addition of the Chickamauga center have resulted in a computer system network. As far back as early 1973, four on-line connections were already in service. Now the extension of the main central processing unit in Chattanooga with an additional 3 Mbyte core modified units of memory has made it possible to control all the systems and to handle other functions. Nevertheless, despite the development of its own network and the access to great time-sharing systems, the work in this domain seems to be executed without any general, unifying plan for the overall TVA-wide network and its connections to surrounding systems.

3.3 STATISTICAL SURVEY

3.3.1 Classification

A full list of major MM&CA developed/used in the TVA is presented in tabular form in Appendix 3. This list contains only those MM&CA that were considered significant by the TVA representatives or those that were of interest to us from the standpoint of decision-making use. Together with Table 3.2, which does not contain more detailed MM&CA descriptions, we present statistical surveys on indices that provide a summarized view of the way MM&CA interact with the decision-making activities, how they are being used now, how they were developed, etc. (see Tables 3.3-3.9 and Figures 3.1-3.2).

3.4 MATHEMATICAL MODELING AND COMPUTER APPLICATION (MM&CA)

3.4.1 MM&CA Efforts in the Office of Power

The Office of Power was the first to introduce MM&CA to its operational activities and was one of the first to design a comprehensive integrated planning system based on MM&CA.. It is, therefore, worth analyzing MM&CA status in this Office, the nature of its Integrated Planning Model and the preparations for its installation.

The first important computer application envisaged by the TVA in 1957, and the one for which the first computer was purchased was the Economic Loading Dispatch System. This was devised for

Table 3.2. Purpose of current MM&CA use.

	Number	%
(A) Analytical and scientific*	37	57
(O) Operational**	44	68
(F) Forecasting	32	50
(P) Planning	26	40

*As opposed to practical use expressed by all three following points. MM&CA belonging to this group could, however, be sporadically used for demonstration purposes.

**In a broader sense: production, design, service, instrumental use in the daily out-and-inside operations.

Sums of figures in both columns are greater than 65 and 100% respectively because some MM&CA were reported to be used for more than one purpose.

Table 3.3. State of development of MM&CA for various purposes.

State / Purpose	Planned	Underdeveloped	Tested	Used	Developed Not Used	Total
(A)	7 19%	3 8%	11 30%	15 40%	1 3%	37 100%
(O)	9 20%	1 2%	11 25%	21 48%	2 5%	44 100%
(F)	10 31%	1 3%	7 22%	13 41%	1 3%	32 100%
(P)	11 42%	3 11%	5 20%	7 27%	0 0%	26 100%
Total Number	37	8	34	56	4	

Table 3.4. The organizational level on which MM&CA were used and/or developed*.

Level	Number**	%
Section	12	20
Branch	28	47
Division	17	30
Office	2	3

*Refers to the active participation or involvement in the development, testing, and use (the vast majority of the maintenance jobs are of course given to the section-level staff); only the basic classification of the organizational units was considered here--for the complete sequence see Figure 3.1.

**Total number of MM&CA considered here is smaller than the overall total of 65 because many MM&CA are not sufficiently developed to justify any evaluation.

the optimal scheduling of power generation from the plants according to current forecasted loads, transmission losses, and generation costs and capacities. The Division of Power Systems Operations claimed an urgent need for this program in order to produce and distribute electrical energy at reasonable cost. Today, much attention is paid to the elaboration of the Power Program Integrated Planning Model (see Figure 3.3), which will unify 16 complex modules into a consistent system About 20-25% of MM&CA for this integrated system have already been developed and about 10% are currently in use. Others will have to be developed or obtained from outside sources (e.g., the Wharton model to be used for the econometric forecasts). Some of the modules, however, will not necessarily be computerized in the future (e.g., Fossil or Nuclear Fuel Management Modules). In order to complete the Integrated Planning Model design, it will only be necessary to determine their operating principles so that they can be coordinated with appropriate cost modules. The system of models presented here encompasses almost all of the areas covered by the planning activities of the Office of Power. It involves MM&CA used and/or developed by the Divisions of Power Resource Planning, Transmission Planning and Engineering, Power Marketing, Power Production to some extent, and the Financial Planning Staff from Manager's Office. It also covers some that up to now were not covered at all by the Office of Power (e.g., the Regional Analysis and Forecasting) or were only partially covered (e.g., the Environmental Accounting).

The activities in the field of MM&CA development and use are mainly carried out by the following divisions:

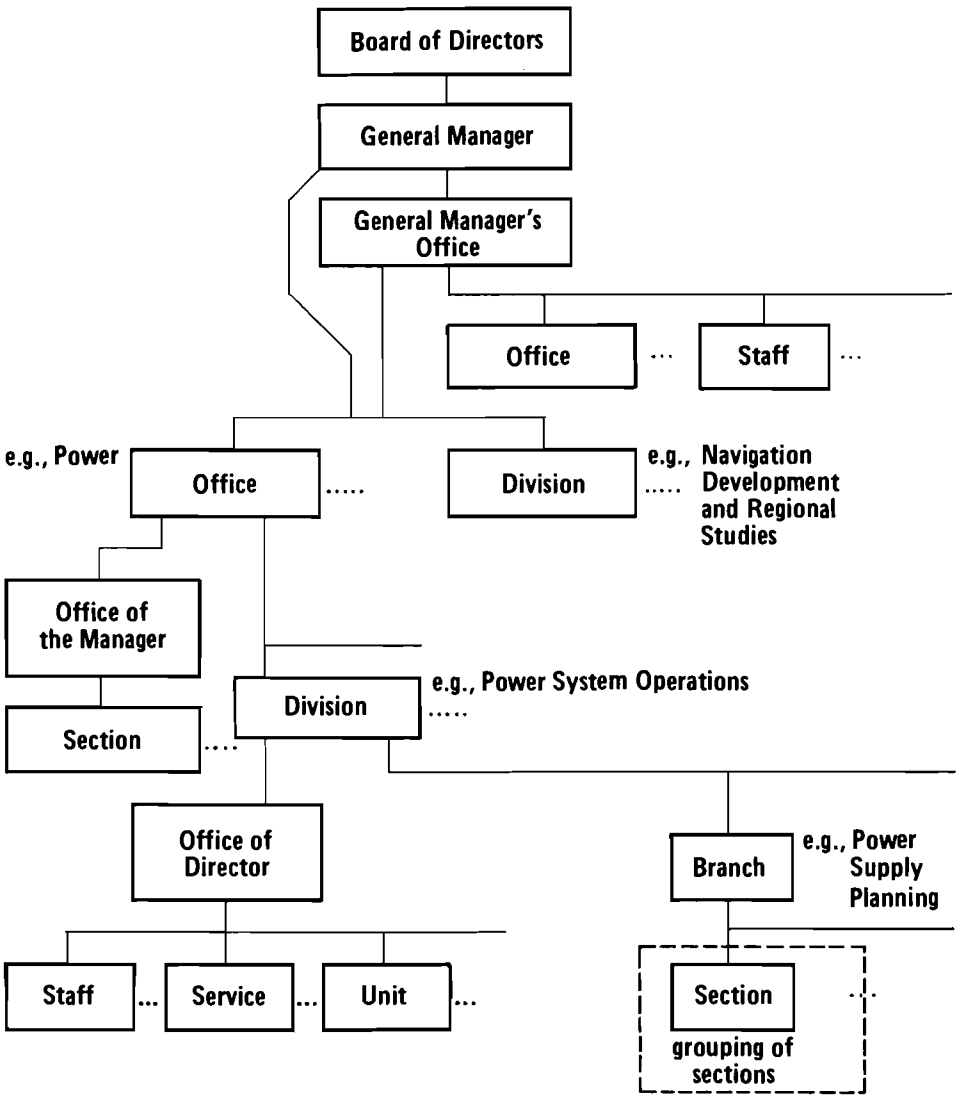


Figure 3.1. Vertical sequence of organizational units.

Table 3.5. Effective use of MM&CA in decision making and operations.

	Inside the TVA		Outside the TVA (demonstration, service)	
	Number*	%	Number	%
None	2	5	0	0
Rare	5	12	4	18
On a longer period basis	12	30	13	59
Constant	22	53	5	23

*Total number of MM&CA considered here is smaller than the overall total of 65 because many MM&CA are not sufficiently developed to justify any evaluation.

Table 3.6. Development initiative.

	Number	%
Line staff/current maintenance responsibility	37	57
Management (at least one step higher)	28	43

Table 3.7. Level of MM&CA usage and development (number of major MM&CA compared to number of branches) at most common level of development.

Office of Power:

$$\frac{13 \text{ MM\&CA}}{19 \text{ branches}} = 0.68$$

Office of Agricultural and Chemical Development:

$$\frac{12 \text{ MM\&CA}}{11 \text{ branches}} = 1.09$$

Water Control Planning:

$$\frac{10 \text{ MM\&CA}}{7 \text{ branches}} = 1.43$$

Table 3.8. Connectivity ratio of all existing connections among MM&CA to all hypothetical connections (number of MM&CA squared--number of MM&CA).

	Number of Connections	Connectivity %
MM&CA used	44	~ 1.5
Used, tested, planned, and developed	130	~ 4.5

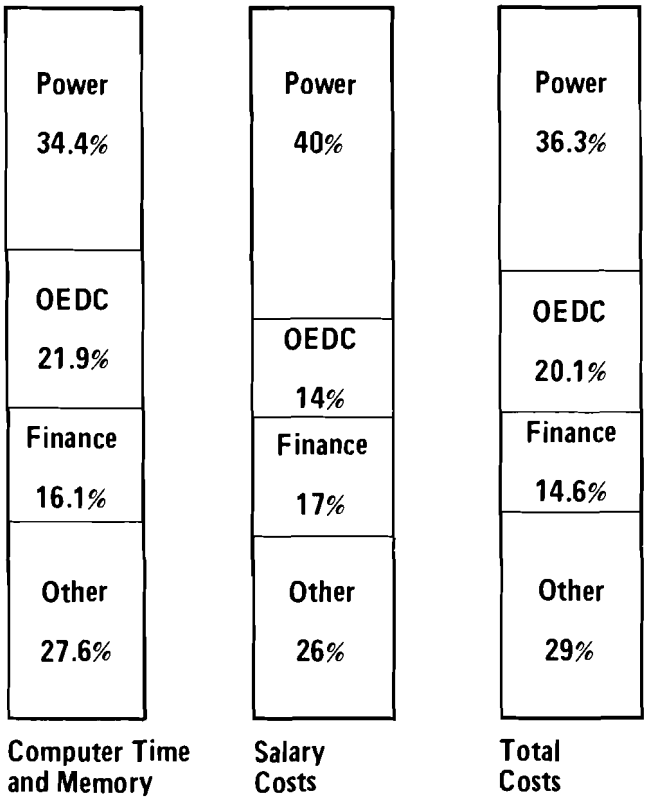


Figure 3.2. MM&CA activities distribution by computer time and salary costs (excluding CSB).

Table 3.9. Ratios between staff with Automatic Data Processing (ADP) skills and other TVA employee groups.

Unit		RATIO: ADP/FTE* White Collar	RATIO: Salaried White Collar	RATIO: ADP/FTE White Collar	RATIO: Total Employees
Office of General Manager	1974	0/102	0.0	0/102	0.0
	1975	2/104	1.9	2/104	1.9
Finance & Law Personnel Medical Services Purchasing		67/959	7.0	67/959	7.0
"Land Betw. Lakes" Reservoir Properties Tributary Area Dev.		0/563	0.0	0/767	0.0
Computer Services Branch		96/112	85.7	96/119	80.7
Other Property and Supply		2/562	0.4	2/733	0.3
Office of Engineering Design and Construction		40.3/2740	1.5	40.3/9946	0.4
Environm. Planning		23.5/268	8.8	23.5/268	8.8
Division of Forestry, Fisheries, and Wildlife Development		11.5/128	9.0	11.5/132	8.5
Office of Power		99.8/2963	3.7	99.8/9526	1.0
Water Control Planning		19.6/517	3.8	19.6/554	3.5

*FTE = Fulltime equivalent

(a) Power Resource Planning

- In about 1960 an early reliability analysis model based on the Calabrese method was developed for the purpose of planning additional generation. Data obtained with the aid of this model were often provided for the managerial staff of the division and Office level, but no evaluation on the influence of the decisions could be made.

- In about 1965 a chronological production costing deterministic model was developed (similar to the current General Electric (GE) system), but it was rarely put to use because of inadequate assumptions.

- In 1968 construction of a probabilistic model was begun. Although in current use, this model is constantly undergoing modifications.

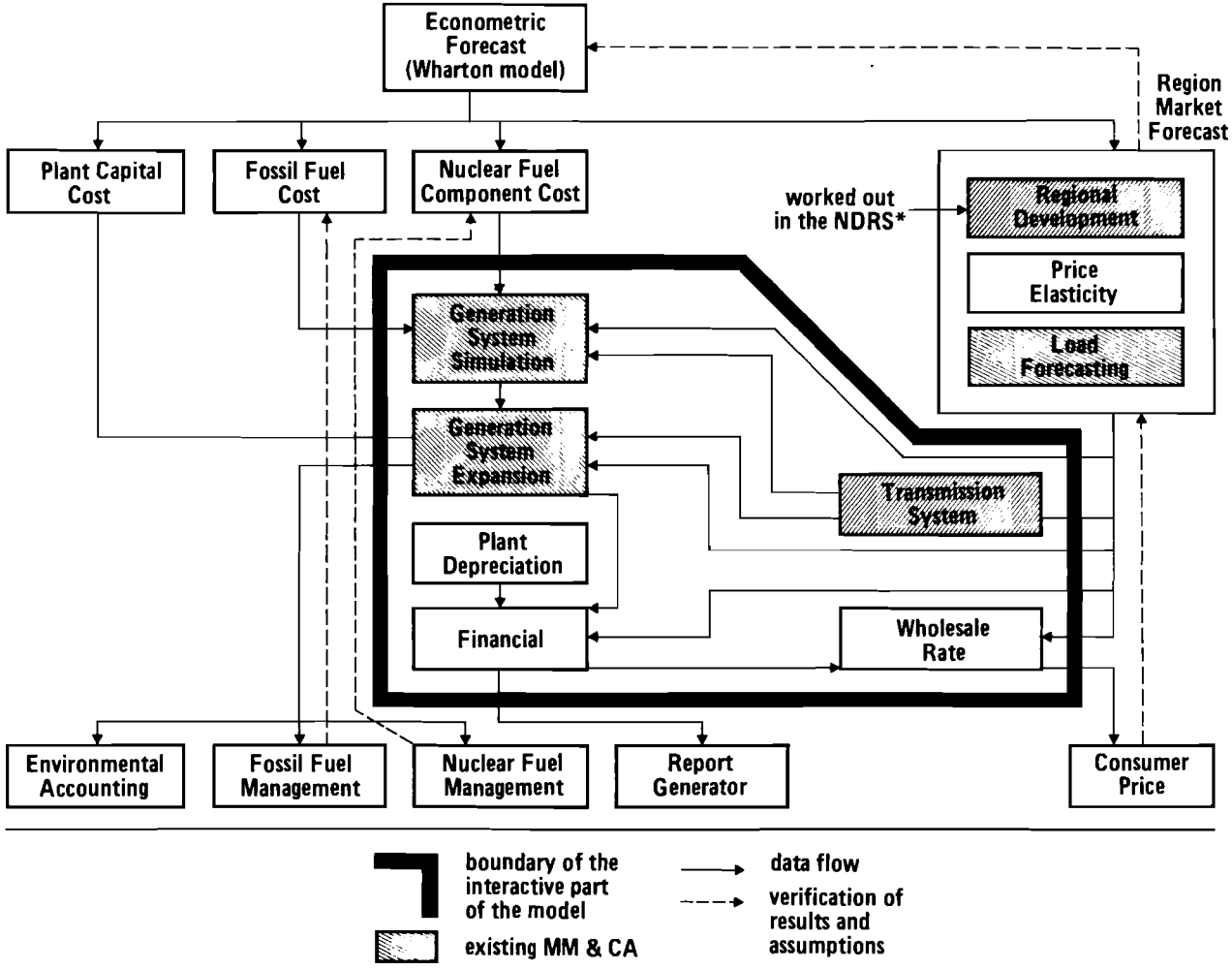


Figure 3.3. Power Program Integrated Planning Model. Navigation Development and Regional Studies.

- In 1970 a system representing power generation expansion was built around the probabilistic model. As the main planning system, it is constantly reviewed and amended. In the near future it will also include the Calabrese Model.

- With the aim of providing adequate load and generation forecasts a Generations System Simulation Model was also built.

(b) Power System Operations

In order to perform continuous generation allocations and scheduling, a system of MM&CA was developed. Now a closed-loop system of dispatching and controlling is being installed in the Chickamauga Dispatching Center (CDC). The present system consists of:

- A monthly load forecasting model independent of the one used in Power Resource Planning;

- Determination systems of basic and economy-rule curves executed every three to four months for each reservoir with generating units;

- A next-day hourly load forecasting program (can also be executed manually);

- Preschedule economic dispatching systems for determining the hourly preschedules for the following day.

The same system is used every half hour during the day in question for determining actual economic generations. The results are used directly to control a few generating units. Other plant operators now receive the appropriate instructions by phone. In the new closed-loop system, most data handling functions are executed by computer: load forecasts are repeated every few hours, economic dispatch is run every five minutes, and most generating units can be directly controlled by computer. (The Generation System Simulation Model was not made on the basis of the economic dispatch programs.)

(c) Transmission Planning and Engineering

There is a simulation model of the transmission network for planning purposes. Planning is performed by parameter adjustment to obtain optimal configuration with regard to cost. The model includes transmission line networks, switchyards, substations, sources, load forecasts, and socioeconomic growth forecasts.

(d) Power Marketing

This division is involved with short- and long-term forecasting models.

The above list of MM&CA certainly does not include all of those developed or used in the Office of Power divisions; only the most important ones still being developed have been mentioned. It is worth noticing that many MM&CA with the same objectives were developed and used independently in different divisions. The objectives tracing of economic trends and indices or of load forecasting are of obvious interest to all divisions as well as the managerial staff of the division and Office headquarters. Lack of visible coordination of these MM&CA indicates that they were probably not used any higher than at the branch level. Their development and use is due to the initiative and work of the line economists and engineers and not to the suggestions of the upper level managers.

The example of the Office of Power activities in the fields of MM&CA use may, however, be regarded as nonrepresentative for the general TVA situation since this Office is larger than any other in the organization. Further it is the only one that must behave as if it were profit-oriented, because of its business obligations to bond-owners.

3.4.2 MM&CA Efforts in the Office of Agricultural and Chemical Development

In turn, the MM&CA developed/used in the Office of Agricultural and Chemical Development (OACD) will be classified according to their use rather than organizational breakdown.

(a) Farm Development

- Since about 1960, in the first stage of development of the rapid adjustment farms, a linear programing approach was applied in order to determine the optimal direction of development.

- Recently, an electronic farm records system was initiated in order to control investment and production and to encourage more conscientious farming policies. (This step was influenced by the fact that some farmers in the Tennessee Valley region made use of the bookkeeping facilities offered by existing computer systems.

(b) Operational Management, Cost Analysis and Engineering

- About 1970, the package of programs for determining the least-cost mixes in the bulk blending operations of fertilizer production was developed. This was then offered, free of charge, to the CDC and GE time-sharing systems, with the aim of achieving nationwide use.

- A production planning system based on cost flows was recently developed and is being implemented in one production unit. This system contains an optimization model using the pseudodynamical linear programing formulation with ca. 800 rows.

- An order-management system is now operating in Muscle Shoals for order allocation and billing. This system, run on a GE computer, will be completed in the near future in order to form a closed loop.

The systems mentioned above and below use the data base on the transportation network. This contains the freight rates inventory stored on 35 tapes, as well as the short line mileage on 20 tapes.

(c) Marketing

- Analysis of the market sensitivity to the availability of the removal byproducts--first of all sulfur and sulfuric acid. This study was requested by the Environment Protection Agency (EPA) and includes an analysis of the impact of removal byproducts on scrubbing steam plants and the existing producers of sulfur and sulfuric acid, and the determination of shut-down conditions for the specified producers. In the near future this study will be completed, with the possibility of analyzing a broader spectrum of strategic alternatives for fossil-fueled plants. Until now about 800 steam plants and 200 sulfur plants were incorporated in the model.

- Most of the users of the "least-cost-bulk-blending" linear programing package later turned their attention towards other information that could be provided by computer systems (i.e., market data summaries). This resulted in the development of a nationwide and international data base on producers and products in the fertilizer industry. In order to facilitate the acquisition of data, cooperative contracts between the TVA and producers involve the provision of data for this data base, which is now maintained on a time-sharing system.

- A system of potential production and use based on natural resources and land use analysis was developed for application in the international TVA services.

- A linear programing model for US agriculture as a whole with a regional breakdown, Tennessee Valley being one of the producing regions. This huge model (8056 variables, 2100 constraints, 44,760 nonzero elements in the matrix) was supposed to provide data on the optimal directions of TVA agricultural development. No specified use of this model was ever evaluated. Possible use could be made if it were treated as a simulation tool, but until now, running it in the simulation mode was far too expensive.

- The soyabean processing model of similar construction to the previous one, served to recognize potential processing locations and production areas. On the basis of data provided by this model, Gold Kista's plant was located. No other uses were indicated.

This list of MM&CA requires some comment. Almost all MM&CA are of the operational kind, in the sense that the existence of the specific MM&CA does not result in any managerial implications inside the Office,* although a few models can be used for planning and forecasting purposes by outside customers. This list gives an impression of well-organized MM&CA activities inside the Office. All MM&CA were carried out from beginning to end by staff economists or engineers. In November 1974 there was no programer on the staff of the Musle Shoals Computing Center.

3.5 IMBEDDING OF MM&CA IN DECISION-MAKING PROCESSES

3.5.1 Principles of the Analysis

Considerations presented in this section are based on the SDC approach, which applies the following principles:

(a) All activities that can be regarded as parts of the decision-making process of an organization may be categorized as: (1) formal, algorithmic procedures, which ultimately may be or are automatized or computerized (referred to later on as "calculations" - Σ - although this notion does not fully express the possible complexity of operations); and (2) non-formal human actions such as formulation of qualitative choice among given quantitative policy assumptions, evaluation of alternative strategies, situation assessments, and decision making itself (referred to as "decisions" - Δ -). The classification is made on the basis of internal mechanisms of specific actions (i.e., the ways the result is obtained) rather than their formal, organizational characteristics (i.e., their definition given by a bulletin or code, or structural chart).

(b) The whole planning and decision-making system may then be represented by enumerating all elements belonging to the "calculations" class, all elements belonging to the "decisions" class, and all connections between those two. It is this representation that is called SDC. The SDC thus defined forms a matrix of Calculations versus Decisions with adequate connections as its elements.

These connections are oriented, as they reflect the temporal sequence of events, so that they can be represented by some positive or negative functions of their modes (i.e., Σ or Δ) to indicate direction, strength, and possibly other features. This fact enables us to analyze the SDC in graphic form.

---

*This notion of the operational use will be used in the following sections of this chapter.

(c) We assume that the two following operations may be carried out:

- If there is an isolated series of elements Δ's or Σ's exclusively then these may be aggregated to form one element;

- Subgraphs (subsystems) of the whole graph (system) may be aggregated to form one element, such that all their connections with the other elements of the system are homogeneous ($\Sigma \rightarrow \Delta$ or $\Delta \rightarrow \Sigma$). The whole subsystem will then belong to the same class as its bordering elements.

(d) We shall not be interested in the part of the system where the MM&CA (calculations) are so dispersed and isolated that the operations performed above lead to a situation in which the inputs and outputs of the Δ blocks are very feebly, or not at all, related, and the Δ blocks are incomparatively more important than Σ blocks. This assumption allows the determination of specific subsystems, which, being simple enough, will be analyzed in their graphic form.

In the structure thus created, each Σ block is on the one hand preceded by appropriate Δ blocks, which provide assumptions and determine the input data collection process, and on the other hand it is followed by the Δ blocks, where alternative strategies, obtained or verified by means of calculations, are evaluated. Consequently decisions are made. Hence the analysis leading to the determination of the SDC will specify:

- Goals of each of the decision-making and calculating blocks;

- Assumptions needed for initializing the calculating procedure;

- Data fed into the calculatory blocks;

- Type and contents of the evaluation of results;

- Type of decision made with the help of a given calculatory block;

- Decision maker.

It is obvious that where the ratio of formalized (less computerized) calculation blocks is small compared to all distinguishable activities, the character of the analysis presented above is changed. It becomes more recommendatory and arbitrary, and is thereby outside the scope of this report. The main intentions of the TVA study were:

- To embed the MM&CA listed in the previous section in the appropriate decision-making processes;

- To identify the subsystems with well-structured, analyzable Decisions and Calculations, and to analyze them;

- To estimate the possibility of building the overall SDC for the TVA as a whole;

- To set a basis for comparing different organizations from the standpoint of the approach presented here.

The main focus of this chapter is on the use of MM&CA as decision-making instruments, i.e., the use by managers of various organizational units, at various hierarchical levels. If we consider all managers, from the section level upwards, there are several hundreds of potential MM&CA users (Σ blocks), each of whom deals with at least one Δ block. The then versatile and multifunctional character of MM&CA should result in the following:

Let us denote j-th decision action (Δ block) of an i-th manager by δij, and the MM&CA helping to carry out this action by σij, we have then

$$\{\Delta\} \text{ (set of repetitive decision actions)} = \Sigma\ \Sigma \delta ij$$

$$\{\Sigma\} \text{ (set of MM\&CA)} = \cup^{j}\cup^{i}\sigma ij$$

$$\text{and the numbers of elements of } \{\Delta\} \quad :N(\Delta) = \sum_{j} Ji$$

$$\{\Sigma\} \quad :N(\Sigma) << \sum_{i} Ji$$

where Ji is appropriate number for i-th decision maker. Straight summing Σ in $\{\Delta\}$ is to emphasize non-overlapping of δ_{ij}. The above considerations may be commented on in the following way:

Let us analyze the SDC in a matrix form, as in Figure 3.4. By filling in the boxes of the table when appropriate Σ-Δ connection exists and leaving them blank when it does not, we may obtain structures as presented in Figure 3.4 b,c,d. In the first hypothetical extreme case we have N (Δ) = N (Σ), i.e., m = n (considering, of course, all these Δ's that do interact with some Σ). In the last case shown we have m >> n, and if we treat as Σ's the shaded "systems" blocks, the ratio is even greater. In the TVA we are dealing with the intermediate situation, where there is m > n, but not very much, and the ratio cannot be increased as in case c. The small shaded boxes of case b are separate SDC analyzed later in graphic form. The "growth" of blocks goes in two directions: along the Δ axis as a result of data base type applications and along Σ by coupling various MM&CA in the systems.

In the following subsections some planned and existing TVA Systems of Decisions and Calculations are described. It must be noted that the complexity of the overall system requires some aggregation at the higher level (long-range and organization-wide planning) before proceeding to the breakdown into subsystems and their analysis. This aggregation means that each block appearing

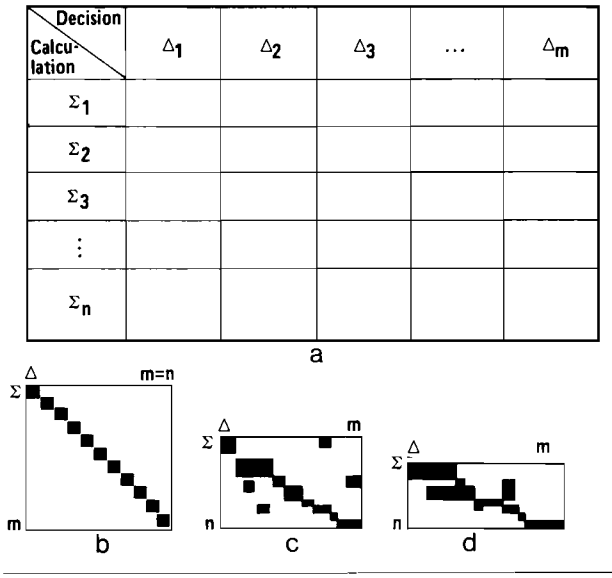


Figure 3.4. Matrix representation of SDC: stages of MM&CA development.

in the overall system structure represents either a system of decisions/computations, or a set of them--if they do not form a system.

3.5.2 The Overall System

When trying to set up a consistent SDC for the TVA based on formal calculatory activities shown in Appendix 3 one can easily conclude that the establishment of an overall consequent structure is not achieved by embedding SDC in day-to-day or strategy decision processes. This is also evident from the example of the connectivity or connectance index (as introduced by Gardner and Ashby [1]) shown in Table 3.8. The magnitude 1.5% is much below the minimal "system" level (over 3% for this case), and 4.5% for the planned systems does not ensure system-like behavior in the future. (This becomes more obvious if we consider the fact that the number of MM&CA is in the branch number range--see Table 3.7--while they are actually being operated and used in sections, and also that not all the future links will come into existence.)

In view of this we have chosen to present and describe the overall TVA System of Decisions and Calculations as it will probably look in the future, and to show the existing possibilities (currently used, already developed or tested) of realizing some

planned modules. The classification of subsystems that could be identified on the basis of existing and planned MM&CA and the TVA's organizational structure will then be provided, together with a short characterization.

In Figure 3.5 the hypothetical overall structure of the future system is presented. It provides on the one hand an insight into the philosophy of planned systems and on the other the pictorial background for Figure 3.6 and Table 3.10 (they will be spatially organized in the same way and will use the same notation). Figure 3.7 shows existing MM&CA that could be used in the field of socio-economic strategic planning.

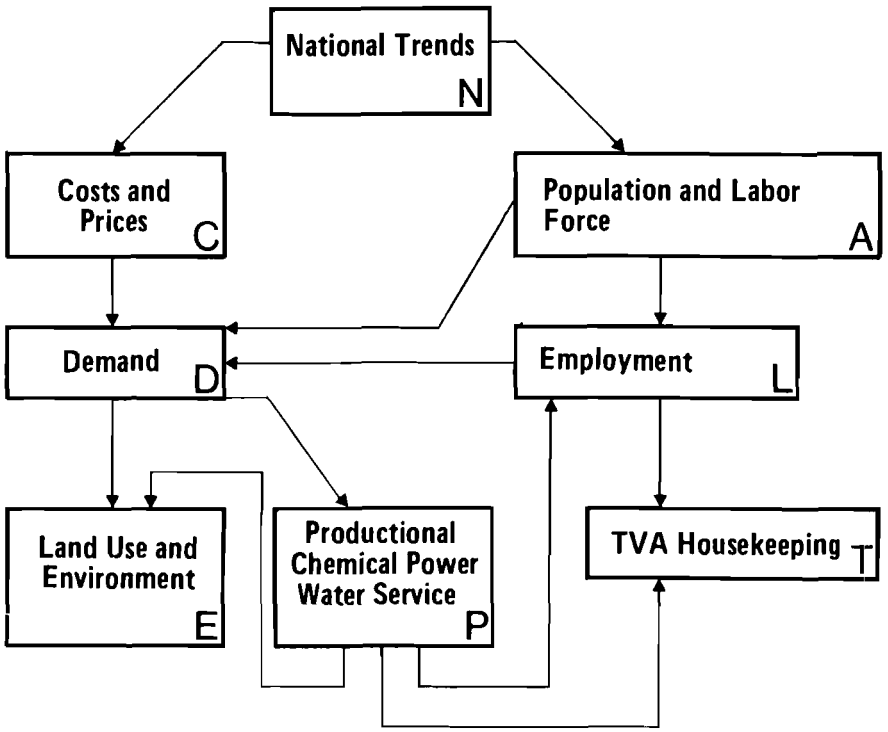


Figure 3.5. The hypothetical overall structure of the system.

Notations: For Figure 3.6 and Table 3.10

□: Calculation; Δ: Decision

N^1 (itl): National modeling: trends in national socioeconomic indices; itl: (commodity/branch/sector), time, location.

Q^2 (atl): Regional population trends; atl: (age/sex), time, location.

L^3 (iqtl): Regional employment development; iqtl: (branch/sector), qualification, time, location.

D^4 (itl): Demand and market situation; itl: (commodity/sector), time, location.

C^5 (itl): Costs, prices; itl: commodity, time, location.

P^6 (itl): Production; itl: (branch/sector), resource.

E^7 (itl): Environmental conditions; itl: resource, time, location.

T^8 (iqtl): TVA housekeeping; iqtl: (branch/sector), resource, time, location.

The numbers in the computation blocks refer to the number of MM&CA in the specified class.

The following breakdown of economy was used (second digit of the upper index, if sector/branch is specified):

1. power
2. water
3. agriculture
4. forestry
5. chemical industry
6. recreation
7. urban
8. service

General land use application was appropriately split between 3, 4, 6, and 7:

i.e., $P^{6\,1\,1}_{tl}$ means P^6: Production, ^{1}: branch/sector: power generation

^{1}: First MM&CA in the class, tl: time and location specified inside the block or not specified at all

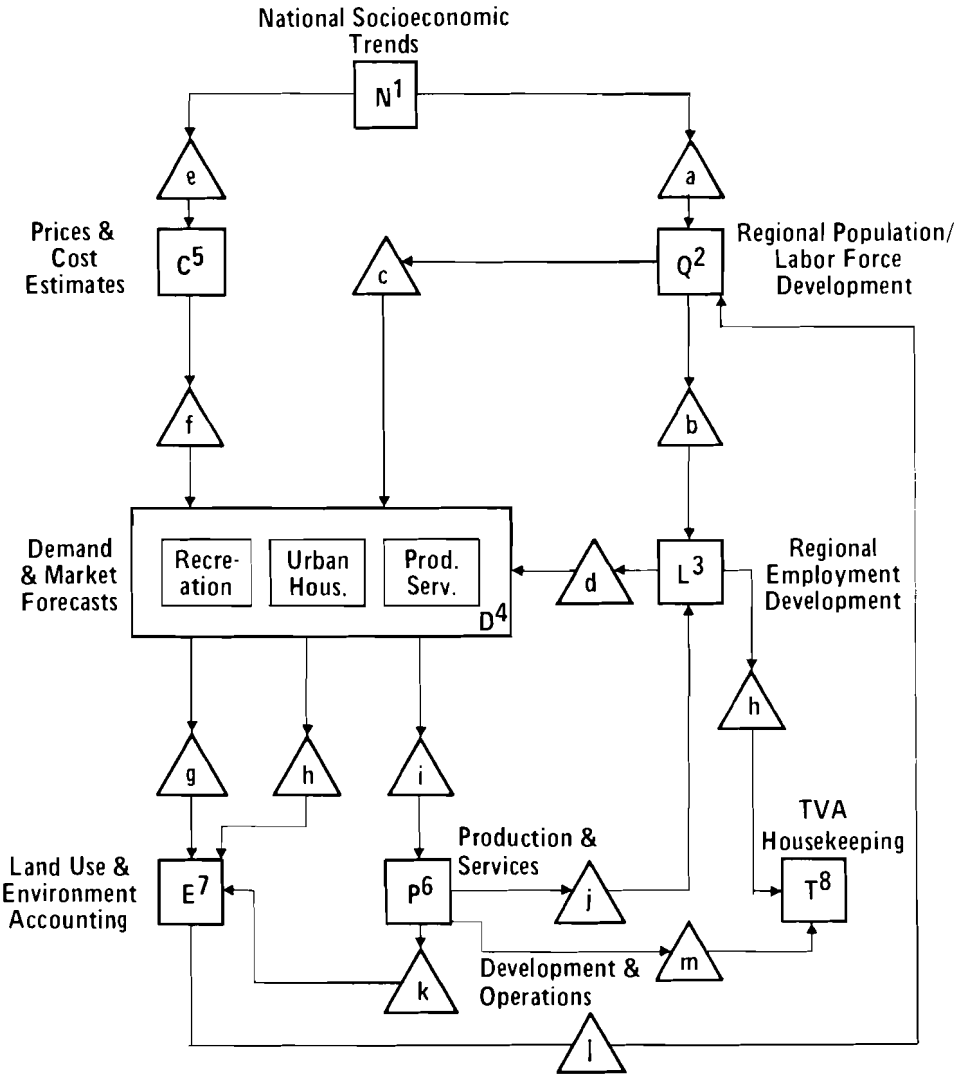


Figure 3.6. The structure of the proposed system: the socioeconomic strategic planning procedure for regional development (for Notation see page 137).

Table 3.10. Description of the decision-making blocks shown in Figure 3.6 (for Notation see page 137).*

Symbol Δ	Decision-Making Body	Objectives	Assumptions		
			Qualitative	Quantitative	Breakdown
a	Board of Directors	Establishing general policies and programs for meeting the needs of the developing region's population in relation to national trends	- The actual forms of TVA activity will be continued; - TVA is not vested with administrative power on business and individual behavior; - The TVA region std. of life should grow to meet national average	National socioeconomic trends, verification of the national socioeconomic growth indices, long-range Office and division recommendations	A rough economic classification, age, sex, and labor force estimations, employment and income projections
b	Board of Directors	Establishing general guidelines and controlling the effectiveness of specific actions undertaken for fighting detrimental socioeconomic phenomena; outmigration, unemployment, etc.	- The general assumptions on responses of individuals and families to economic changes; - Development of industry; - Commercialization of agriculture and forestry; - Recreation	Regional population and labor force projections based on extrapolated growth trends, general economic policies, long-range Office and division recommendations	Age, sex, and labor force, time trends, regional mobility, branch/sector development trends
c	Interested Offices and Divisions	Forecasting future needs of population and business; identification of opportunities arising: long-term recommendations and internal policies	- Fulfillment of population's needs as set by general policy decisions (a); - Favoring industrial development; - Anti-stagnation attitude	- Population development trends, labor force availability, income and std. of living projections; - Price and cost estimations for	Age, sex, and labor force time trends, income and property distribution and time trends, commodity/branch price and costing

Symbol Δ	Decision-Making Body	Objectives	Assumptions		
			Qualitative	Quantitative	Breakdown
				direct consumption commodity market and capital investments	
d	Office of General Manager, Interested Offices and Divisions	Same as above, but on a shorter period basis, with more information on population and business responses; can be seen within the framework and time-scope of the summary planning document or even the situation assessment.			
e	Office of General Manager, Interested Offices and Divisions	Realistic investment and budgetary planning providing the basis for internal cost control and external price and cost projections	- Continuous change of regional prices and costs; - Convergence or other relations to national costs and prices of neighboring regions	- Changes in branch/sectoral production demand and supply; - Investment trends; - Regional development trends	Commodity or service/branch/sector, time and region
f	Office of General Manager, Interested Offices and Divisions	Identification of best possible ways to fulfill the main statutory obligations in view of cost/market situation	General--same as for (c)	- Market situation assessment; - Investment process forecasting; - Financial considerations	Commodity or service/branch/sector/producer/customer, time and location
g	Office of General Manager	Providing recreational areas for the TVA region population as well as tourist industry resources for people from outside the region	- Multipurpose development character of recreational areas; - Fulfilling the recreational needs of people;	- Income and std. of living of TVA inhabitants; - Land use actual data and trends forecasted;	Not determined yet

			- Providing recreation business basis	- Other business projections; - Interested units' recommendations	
h	Office of General Manager, NDRS, FF&WD	Playing an active role in establishing a comprehensive policy in regional land use management	Preservation of the specially valuable natural areas with due recognition of urban and business use of land	- Business and urban growth/ industry, service, housing, etc.; - Characteristics and land use surveys	- Type of use--mapping, time trends; - Land characteristics
i	Office of General Manager	Development of industrial means for enhancing the region's social and economic growth	General--same as for (a), with addition of financial, time and specific legal considerations	- Offices and Divs.' summary planning documents and long-range recommendations in any form; - Business contract and other applications	- Multiyear manpower and financial plan location; - Financial, manpower, location et al.
j	Office of General Manager, Interested Offices and Divisions	- Provision of possibly full and equal opportunity employment; - Provision of manpower for own projects	- Providing good staff for the TVA projects; - Good relations with private business; - Promoting future business development with a view to full employment	- Project plans of TVA organizations; - Business contracts and other applications; - Industry and service growth forecasts	As provided by individual specific documents
k	DEP, FF&WD	Ensuring maximum environmental stability within the framework of actual legislation	Preservation of the quality of air, water and natural areas, with due recognition of industrial growth requirements	Assessment of environmental impact for each new project often with more elaborate analyses	Types of wastes and treatment

Symbol Δ	Decision-Making Body	Objectives	Assumptions		
			Qualitative	Quantitative	Breakdown
l	Office of General Manager	Minimizing the bad mutual impacts of various uses	Same as above	Same as above specific legal and other matters implied by certain undertakings	As provided by individual specific documents
m	Staffs of the Office of General Manager	Ensuring effective operation of the organization	Accomplishment of the other goals with less expense possible	Prices, contractors, plans of the TVA organizations	Sectoral, temporal territorial
n	Personnel and other General Manager lower level offices	Provision of skilled manpower and its proper instruction and care	Same as above and the enhancement of manpower development of the region	Applications, needs, personal data	According to personnel and other staff's requirements

*This table contains a verbal and general description of Decision blocks, which at present or in the future will interact with some specific Calculation blocks. Most of the blocks are presented in Appendix 3 and some MM&CA will be shown in the description of future socioeconomic planning system envisaged by NDRS.

Concerning the relation to the TVA formal planning system, the table contains only a few remarks on the nature of the relationship. This is mostly due to the great dispersion of the formal Calculation blocks, their actual underdevelopment, and (in this particular connection) their long-range character, as opposed to most of the TVA operations.

Some already existing or developed MM&CA that fit into above framework of the systems are shown in Figure 3.5 along with their position in the system and existing or possible connections.

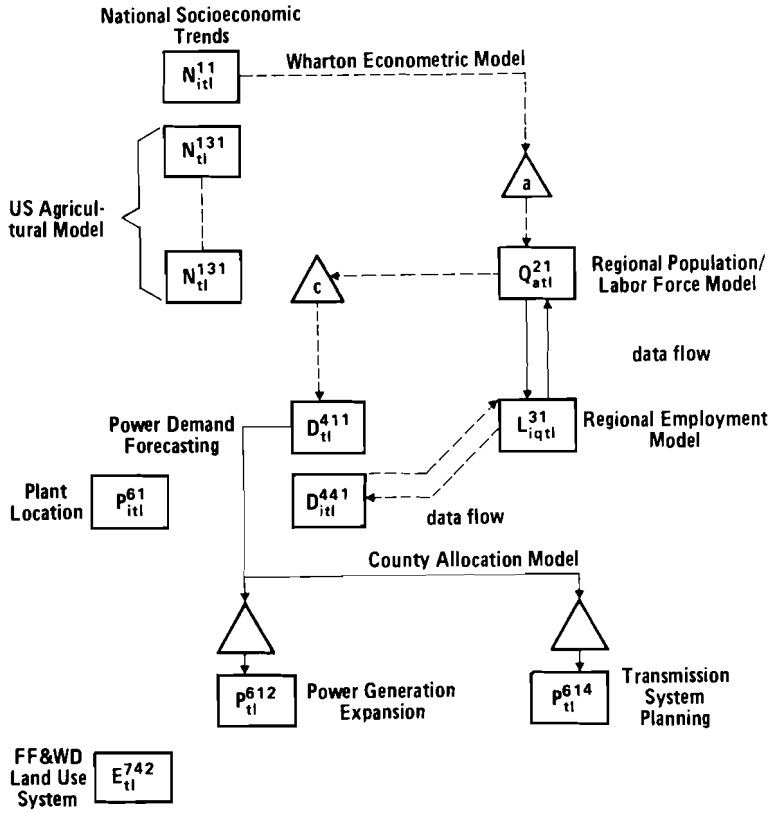


Figure 3.7. Existing MM&CA that could be used in the field of socioeconomic strategic planning.

3.6 CLASSIFICATION OF SUBSYSTEMS

This paragraph is based on the data provided in Appendix 3. It is evident from this table that the number of well defined managerial decision-making subsystems using the Calculation blocks of MM&CA as instruments for verifying alternatives, or as informational back-ups on a regular basis, is very small. It should also be noted at this point that the real strength of connections among MM&CA shown in Appendix 3 varies greatly according to a given case. Only some can be referred to as fully functioning information or decision flow channels.

Table 3.11 summarizes the identifiable subsystems which are of interest for us. Together with each subsystem there is a short evaluation of the use of MM&CA and the possibility of identifying an appropriate SDC.

Table 3.11. Subsystems and characteristics.

Name/Area	Characteristics
Socioeconomic long-range planning	New MM&CA developed, never used for decision-making purposes. A plan for developing a comprehensive planning system was prepared.
Power system planning and operations	A considerable number of MM&CA, many of them used, provide appropriate information for Office or division staff. Feeble traces of systematic, even informal, step-by-step use. Preliminary program for constructing a long-range comprehensive planning system is underway.
Water discharge control	Operation-oriented procedure carried out by the Office of Power and WCP (Water Control Planning), with the aim of a coordinated water flow control for multipurpose use. A number of MM&CA are used and well placed in the overall procedure.
Fertilizer production planning and operations	A set of market-oriented MM&CA was greatly sponsored from outside and is now mostly used for outside purposes (service, demonstration). The same applies partly to operational applications.
Agricultural planning	A wide gap exists between two large-scale agricultural models, rarely used and hard to handle, and two individual-farm-level management-aiding applications. No use for organizational decision making.
Design and construction	A well-developed, highly automated system with major (planning) decisions taken externally. Some operational decisions are made within the framework of CPM package use. Almost all MM&CA purchased or subscribed to.
Environmental monitoring system	Consists of many separate MM&CA, used partly for demonstration or general outside purposes, partly for operational purposes and partly for planning. All three different uses take place in different organizations (FF&WD, DEP, and WCP respectively); there are no evident links between these activities. The main and most prospective effort, however, takes place within the framework of the land analysis system of FF&WD.

There are new major MM&CA in the planning stage, one in the Office of Power Planning System, one in the NDRS Planning System. A number of MM&CA are used or planned by the Division of Finance, but there is no indication of how they could form a consistent SDC.

3.6.1 Socioeconomic Planning Subsystem: A Development Program

As was stated before there is no actual working regional socioeconomic SDC for planning purposes. Hence, the general pattern for a future system as envisaged by the NDRS Division will be shown in this subsection.

Calculation blocks and Decision blocks (two of which, i.e., a and b, have already been described in Table 3.10) that can potentially use or coordinate adequate calculations are shown in Figure 3.8. Three out of eight modules have been developed so far, but their use is restricted to mere analysis and has no evident influence on decision making. The national socioeconomic trends block has been shown only to indicate its place within the system. The system, however, is meant to be connected to the national trends model in as much as it is now being tested for its usefulness in the Integrated Power Planning Model in the Regional Market Forecast module.

3.6.2 Actual Power Planning System

This system is composed of a set of internal decision-making (internal Office or even internal division) procedures and calculation algorithms. The divisions, which mostly participate in the part of the planning system presented here, are: Power Resource Planning, Transmission Planning and Engineering, Power Marketing and Power System Operations (on the operational level). The structure of the system, along with the names of Calculation blocks and their symbols is given in Figure 3.9.

In the following descriptions of Decision blocks, the decision-making body will not be specified. Decisions that are recommendations to higher management for future development are formulated within the branches and divisions. (These are very common, but outside the scope of the formal TVA planning system.) Decisions that are approvals for development programs are generally made in the Office of the General Manager and the Board of Directors. The forecasts constitute the main integrating factor in the system presented. They are carried out in the Power Marketing Division.

Decision-Making Block	Characteristics
w	The changes in load forecasts--provided with customer type (housing, industry, service, etc., magnitude) and location breakdown--are analyzed in order to find possible directions of development. Generation system expansion programs can be run to check specific additions, or the overall system. The possibility of purchasing the power needed is also taken into consideration. This decision concerns the evaluation of temperature sensitivity of power loads (heating, air conditioning, etc.) as provided by the Market Analysis branch. The decision is made in the Power Supply Planning branch.
o	The locations and magnitudes of new plants or units proposed as a result of generation expansion, projecting

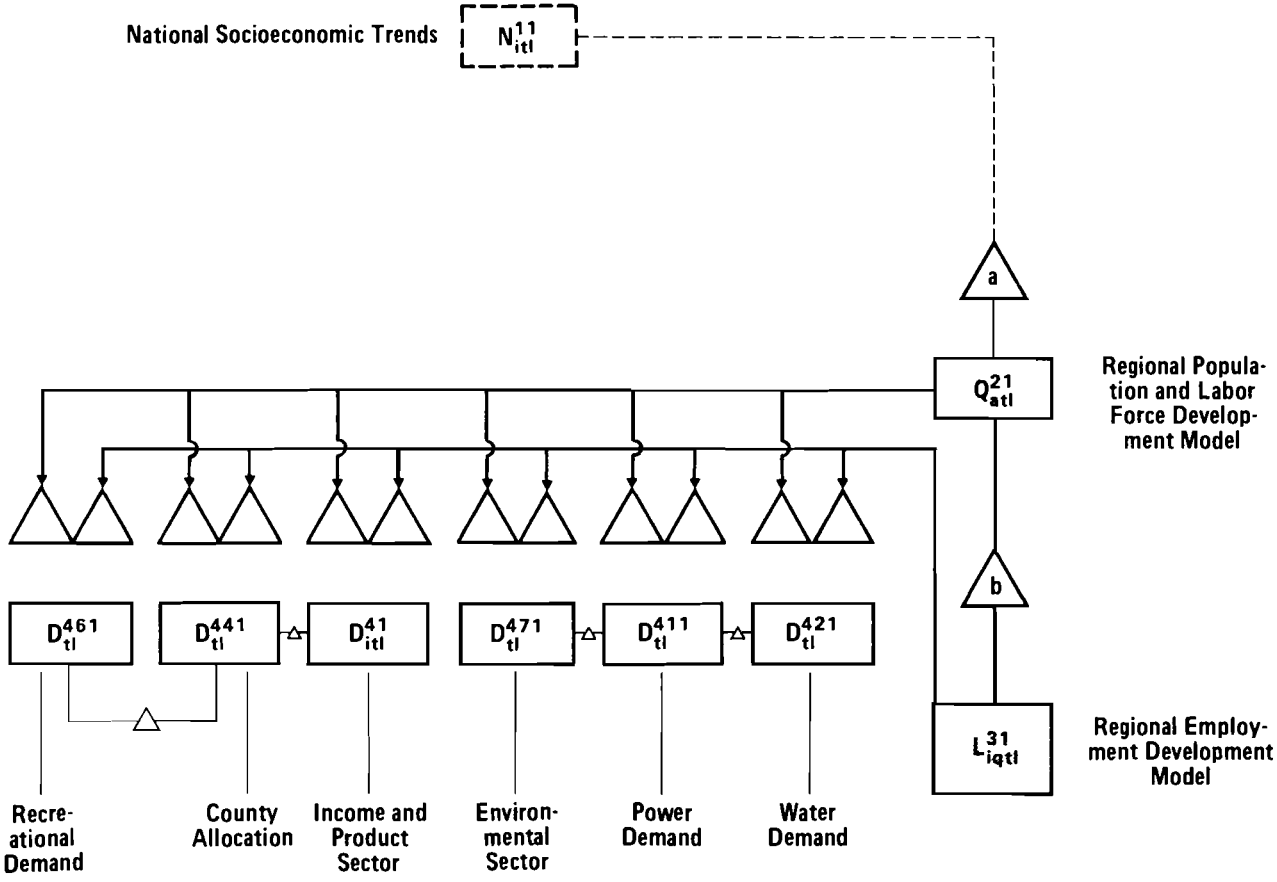


Figure 3.8. Potential development of the regional socioeconomic planning system. Shaded boxes are the modules that were already executed.

Decision-Making Block	Characteristics
	much influence on the transmission network planning procedure. Adequate decisions are made mainly in the Transmission System Planning branch on the basis of alternate sites.
P	This decision, made in the Transmission System Planning branch concerns not only the additions to the existing transmission network to ensure the stability and reliability of operations, but also leads to determination of a least-cost combination of transmission responsibilities between the TVA and distributors.
q	As the reliability analysis module will be incorporated in the generation system expansion module in the near future, this decision will also be incorporated in m. Presently, it provides for establishing the right reliability conditions and verification of appropriate additions proposed.
r	In cooperation with OEDC the Power Supply Planning branch determines cost assumptions for planned facilities and obtains verification from OEDC of cost estimates. This part of the system will be automated, according to Integrated Power Planning Model propositions. At present the extent of this MM&CA use is not known.
s,t	Cost and revenue implications greatly influence the final choice of one or more alternative sites, magnitudes, and types of additions, to the generation system as well as to the transmission network. Appropriate decisions are made within interested branches.
u	On the basis of known generation projections the revenue forecasts made for financial purposes (Financial Planning staff) are evaluated and validated.

3.6.3 Water Discharge and Hydrogeneration Scheduling Subsystem

This system is one of the best organized, structured, and equipped with MM&CA tools in the TVA. It already exists in the form presented in Figure 3.10. At present it is undergoing modifications, as mentioned in the description of MM&CA development in the Office of Power, section 3.4, and in the future it may change its character considerably. This second change will be due to the fact that the actual system is a result of constant cooperation or bargaining between at least two organizations

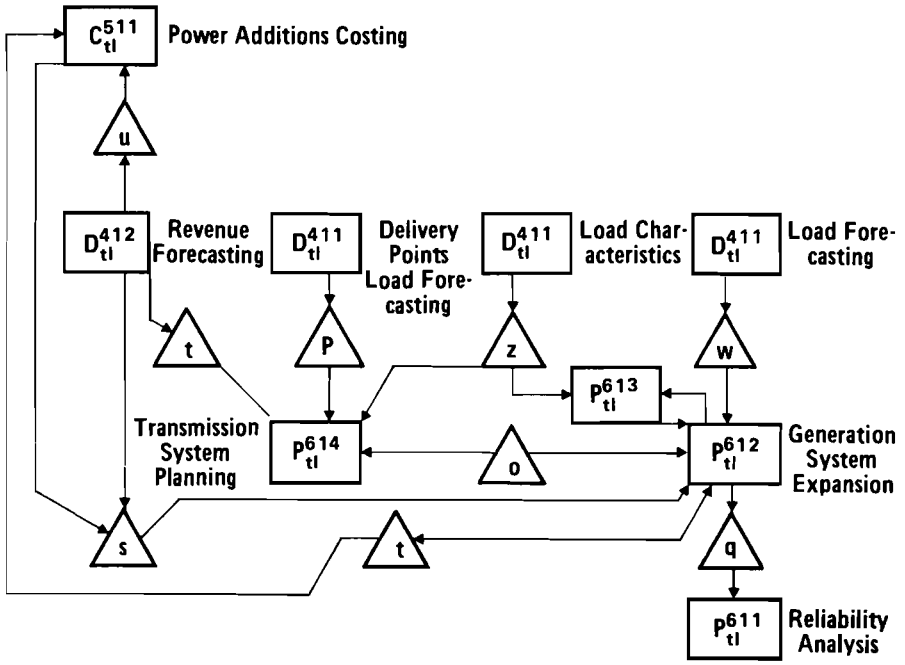


Figure 3.9. Part of the power planning instrumental decision-making system: existing expansion evaluation.

inside the TVA: River Control branch of the WCP (left part of the figure) and Power Systems Operations Division in the Office of Power (right part of the figure). At particular moments even more participants make decisions regarding the shape of discharge operations, as will be seen from the Decision blocks characteristics). In the WCP Division, research and testing work is being carried out that will lead to the establishment of a complex multi-objective optimizing discharge scheduling system (P^{623}_{t1}). At the moment, tests are being performed for the programs that use the dynamic programing methodology and two objective functions: flood cost function and hydrogeneration cost function. This effort, however, is not likely to give satisfactory results in the near future, because of the number, informality and fuzziness of objectives and of means available for their fulfillment.

The description of Decision blocks which follows has been shortened because many decisions are taken on a routine basis and are alike.

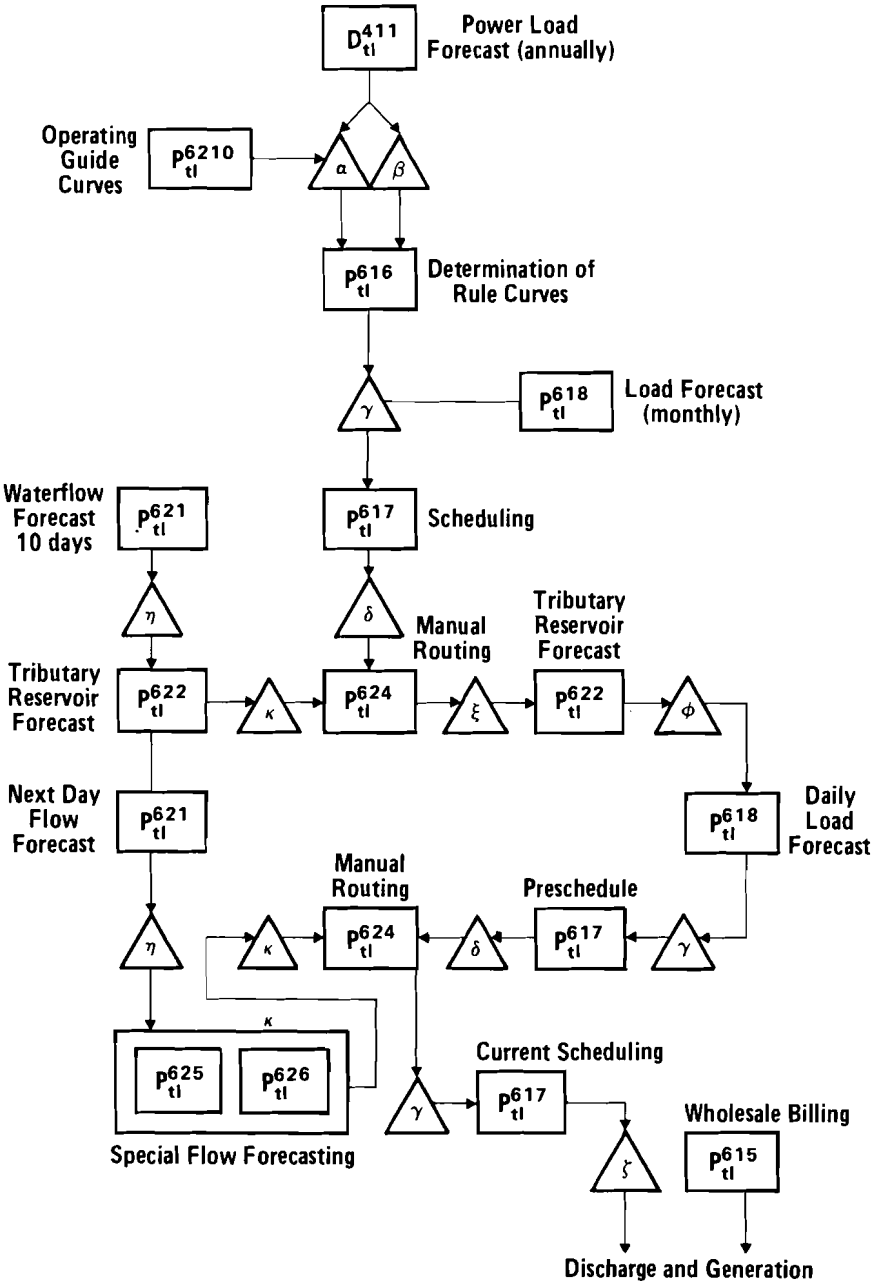
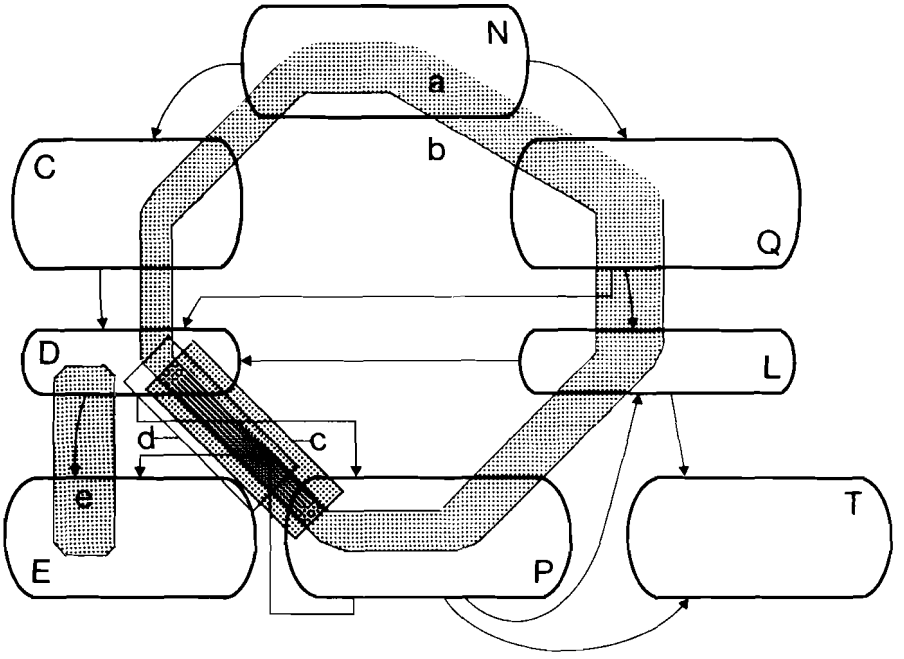


Figure 3.10. Operating system for water discharge and hydrogeneration control and scheduling.

Decision-Making Block	Characteristics
α	Decision made in the Power System Operations Division consists of matching the operating guide curves, known weather conditions, and the operation conditions of power plants, in order to see whether modifications should be made to rule curves, or how they should be used in following months.
β	A set of decisions made at the annual reservoir operations meeting, where all interested participants meet to present their needs. As a result, a schedule of special operations for next year is prepared.
γ	On the basis of the rule curves, load forecasts and reservoir levels, an economic dispatch system is run, requiring additional assumptions as to reservoir operations β purchase or sale of power to neighboring companies, etc.
δ	Results of the scheduling must be evaluated from the point of view of guide curves and other basic requirements, before they are manually routed.
η	Inflow forecasts from uncontrolled drainage basins to system reservoirs may indicate an emergency situation, or the possibility of returning to normal operations. Sometimes it is needed to forecast the inflows between the routine forecastings.
κ, ϕ	Special forecasts may require additional routing for future situations, but usually their results are evident enough to cause adequate action.
ζ	Eventual changes in the schedule proposed by Power Systems Operations (PSO) Division may be caused by too great an error of operation in relation to operating guide curves or any other emergency situation. These changes are immediately communicated by the River Control branch to the PSO Division.
	These decisions are taken by operators in the generating units in view of received general instructions, actual situation and the schedule.

Figure 3.11 presents a sketch of subsystems in the overall system, as presented in Figure 3.5. The contours of subsystems account only for overlappings and not for the soundness of the connections.



a. socioeconomic planning system
b. integrated power planning system
c. water release planning system
d. power generation scheduling
e. land use monitoring system

Figure 3.11. Some of the existing and projected systems in the hypothetical general planning system structure (see Figure 3.5).

3.7 GENERAL PATTERN OF MM&CA USE IN THE TVA PLANNING AND DECISION-MAKING PROCESSES

The general analysis of the present state of development and of the plans for the future in this section is based on the inventory of MM&CA provided in Appendix 3, the statistical survey made on the basis of this inventory (section 3.3), and the analysis of MM&CA embedded in decision-making activities in various fields and on various organizational levels (section 3.6). This analysis was formulated in a general manner to enable a comparison between the TVA and other organizations to be made.

We shall begin with an analysis of the correlations between goals, structure, management structure, horizontal information flow, and MM&CA systems use.

3.7.1 The Impact of Organizational Characteristics of the TVA on MM&CA Use and Development

3.7.1.1 Decentralization

This very important feature of the TVA organizational structure is the result of the early stages of the TVA's evolution. From the very beginning the main objectives were subdivided into sets of goals. This breakdown stemmed from a recognition of the need to vary mechanisms in order to realize the primary objectives under given regional conditions. Not only specific areas of economic and social life were considered in the effort to enhance the overall socioeconomic growth of the TVA region, but also the mechanisms of TVA action in these areas had to vary greatly, according to existing administrative, legal, and other regulations. The TVA organizational structure and behavior was a straightforward consequence of this situation. According to the classification of the secondary goals, organizational units were designed and created, and were assigned operational possibilities and authority fitting into the general administrative framework.

The relative isolation of organizational units and the wide variety of their operational mechanisms led to greater effort being made to coordinate separate activities. However, these did not prove very satisfactory. This evaluation especially applies to the top managerial measures taken during the course of the TVA's history. In day-to-day operations there are many objects of activity that are common to some units, and in these cases coordinated action must take place, the coordination being maintained on a relatively low managerial level. Such a situation occurs when the necessity for common or coordinated action is obvious (e.g., water discharge scheduling for hydrogeneration and other purposes, or the construction of new facilities, such as power plant). But when the object of potential common interest becomes greater, or more ill-defined, and exceeds the scope of responsibility or capability of a specific branch or division--e.g., the present state of environment--then coordination would not occur (monitoring). We are referring here, to coordination with respect to MM&CA use and development. There are some coordination instruments, such as the Situation Assessment mechanism or periodic TVA-wide meetings with the General Manager, but these do not really clarify MM&CA policy. For example, the chief of CSB is not present at the meetings with the General Manager.

In the case of environmental monitoring, except for the formal procedures of the environmental impact assessment and the like, there is not center that could direct comprehensive action, uniting present division efforts and capabilities for the purpose of creating a system of environment monitoring worthy of its name. A core of this system could be provided by the survey and MM&CA

mapping maintained and updated in the FF&WD. The planned regional blocks could be incorporated (and the first step in this direction is already planned in the FF&WD). At the same time, however, many other organizational units plan to develop, or are even now developing, MM&CA that are particularly oriented towards environmental impact evaluation and costing.

The first feature of the TVA that has an important influence on the MM&CA embedding is decision making, followed by decentralization. Each unit tends to be oriented towards its own set of objects, (and objectives) and to develop instruments and measures for achieving a satisfactory degree of efficiency. This statement also applies to the development and use of MM&CA.

3.7.1.2 Mixed Profit and Nonprofit Orientation

As a federal government corporation, the TVA was to be nonprofitable in its own activities, but beneficial to the population and businesses of the region. For 25 years it relied exclusively on federal appropriations. After this period part of the organization took on businesslike principles of operation. Most units of the TVA were, and still are, achievement- rather than profit-oriented. The main criterion of their own efficiency is not the most "economic" behavior, but the attainment of special, outstanding goals.

Many units of the TVA, because of their specific embedding in the regional social and economic structure, or their national position (e.g., OACD, in the fertilizer promotion field), do not create their own goals to the same extent as others, but tend to be responsive to the demand existing in their field. Sometimes they even play the role of a specialized national institution, providing services for other federal institutions, or, free of charge, for private business. This nonprofit orientation provokes less strict self-control in homeostatic actions, but the requirement to attain spectacular effects makes it necessary to employ skillful and well-proven staff, especially in the line economic and engineering units, as well as in the top management.

The description of the financial and criteria sides of TVA operations allows us to apply S. Beer's evaluation of the homeostatic functions' performance inside the TVA. This evaluation, based on the viable system model approach, states that there could be an important deterioration of homeostatic function in the TVA, leading to the behavior known as the "decerebrate cat" state, when an organism, if it is fed, is capable of surviving but nothing more. It was not stated in the Beer evaluation [2] whether such an organism may still be an effective one, in the sense that it produces an important output. The decerebrate organism may be a part of a larger cerebrate organism, and not itself constitute a second level of recursion. This seems to be the case of the TVA. It is partially externally fed by appropriations and is very effective, not in the sense of "viable-system" behavior, but in the sense of special, outstanding

results--a social and economic benefit of the region--reported to higher authorities representing a greater "viable" organism. At this point, the evidence cited above can be completed with the remark that only one of the essential organizational units of the TVA is really planning its operations and forecasting future conditions and opportunities--the only one that is oriented towards the measurable benefit--the Office of Power. A number of MM&CA instruments are being used for planning and forecasting its operations.

The second feature of the TVA that has its influence on MM&CA use and development is the emphasis placed on "productive" output activities connected with the work of economic and engineering line-staff and more practical and short-term planning approach, as opposed to self-control, self-preservation and development activities, connected with the managerial control, long-range planning and strategic approach.

3.7.1.3 Management's Attitude

The inception conditions of an organization, which to a great extent determine its structure and future behavior, also determine the choice of top management. The way in which the managerial functions are performed, and the skills and background of the managerial staff, tend to have a very stable character. Throughout the history of the TVA, two previously mentioned features of the organization have remained unchanged. Promotion is not granted for aggressiveness, dynamism, risk-taking or innovations but rather for stability, experience, sound knowledge of the region, the field and the organization (recalling the civil service profile but with more freedom of operations). These facts, as well as the educational background of the present TVA middle management, formed before computers were recognized as important to management and engineering, imply that the development of more modern decision-making aids and information bases will probably not be promoted from the managerial level, and that prospective changes will rather have an inverted character (see section 3.3).

3.7.2 Engineering Approach

The currently prevailing practice in the TVA today is an "engineering" approach (Figure 3.12). The general rule governing the recognition of MM&CA as tools, and of their implementation in the framework of an engineering approach can be seen in the Office of Power example. At the time of the first computer lease, the nature of decision making in generation scheduling passed from the non-qualifiable, decision maker dependent stage to a fully algorithmic procedure. The cost of the decision (which was computed afterwards) increased greatly. As the complexity of operations and their cost increase with time, a certain moment arrives when it becomes impossible to control or monitor the process without computer facilities.

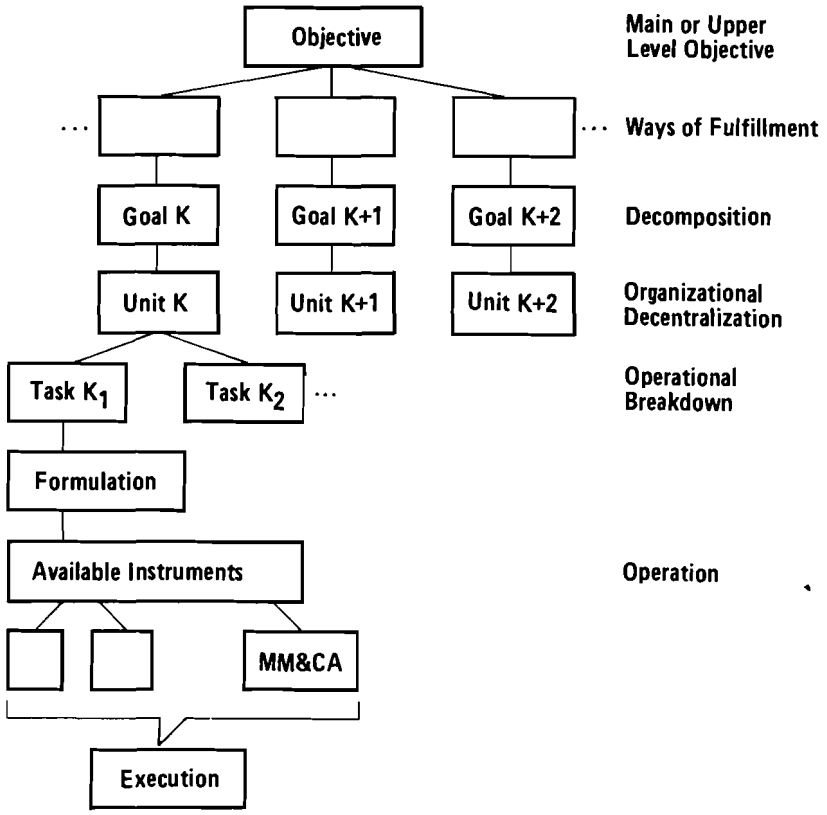


Figure 3.12. A simplified illustration of logical sequence leading to the "engineering approach" to MM&CA development and use.

One of the most characteristic features here is the use of MM&CA methods--even for purely analytical purposes--which are proven, widely used and reliable. Many of the MM&CA that could easily be developed in the TVA by its experienced staff are subscribed to or purchased from outside sources. This can partly be attributed to inadequate coordination, and partly to an unwillingness to use non-verified, noncommercial tools. In addition, the TVA is accustomed to obtaining this necessary service from renowned and long-established firms. This approach, together with particular usage and development of the MM&CA, can be an obstacle to the modernization of the instrument and information base in decision making, especially under conditions of inverted evolution.

Another good example of the engineering approach to MM&CA can be provided by OEDC, where many programs and systems, often

of external origin, are used for design, data handling and other engineering operational purposes. On the other hand, the same Office is introducing new, higher level techniques for controlling and coordinating such elementary operations: Design Control and Monitoring System (P^{969}_{tl}) or DED Document Control System (T^{84}_{iqtl}). Another step forward was made with the implementation of the Project Control System (PCS) package.

A further example, can be given--the Intermittent Stack Gas Control System of DEP. This system, which was elaborated in a division having no field of direct operation, is an example of a very skillful application developed in isolation, with no prospective managerial implications*. We must also mention here that the engineering approach, and hence the operational use with which it is most often connected, changes character dramatically according to variability of principles of the operations of different units. Therefore, besides the productive and service-oriented uses of MM&CA, there is a wide range of demonstration-oriented computer applications in those areas where the influence of the TVA is constrained (such, first of all, are the MM&CA uses in agricultural and chemical domains).

It should be noted that almost all operational MM&CA listed in Appendix 3 are clearly if not always exclusively assigned to operations. There are other uses for the models, such as analysis, forecasting and planning. These often refer to more sophisticated managerial applications, which almost always confound each other, thus giving an average of 2.1 "uses" per MM&CA. This is a consequence not only of the fuzzy use of nonoperational MM&CA, but also of the lack of a proper organizational place for them, at a time when they are increasingly required in many fields.

3.7.2.1 Plans and Policies for the Future

The spontaneous process of creation and purchase of instrumental MM&CA has now reached the point of design and execution of integrated systems, which influences managerial decisions. We shall take a closer look at this upward process from the examples provided in section 3.6.

Of the two subsystems of Decisions and Calculations, one is fully operations-oriented and the second is a planning system unique to the TVA. The water release scheduling SDC was the first in the TVA to contain a fully operational MM&CA--an economic power dispatching system (P^{617}_{tl})--which is now being reviewed for integration purposes (new closed-loop P^{617}_{tl}), and an integrated multipurpose system (P^{623}_{tl}). This system contains a full flow of

---

*This procedure was finally adopted as a TVA-wide approach, but recently had to be dropped because of changes in federal environmental legislation.

decisions and information concerning water release scheduling. When considering the power planning system it becomes evident that the connections are far more loose. The calculated results are much less used and the integrating effort is now in the preliminary drafting stage (see Figure 3.8). This shows us the timetable of modernization for decision-making instruments. Another example (see section 3.6) can be provided by OEDC uses. A number of design and other engineering MM&CA instruments replacing slide-rules, numerical tables, etc., are now followed by T^{84}_{iqtl} monitoring systems, and on the next level by T^{85}_{iqtl} scheduling and analysis systems that are already having certain impacts on decision making, but still at an operational level.

The turning point in the policy towards MM&CA development and use has now been reached. This is recognized by the fact that most offices and independent divisions, as well as some inter-Office divisions, have special units for the development and coordination of MM&CA design and implementation. The Computer Application section and the Systems Planning and Development Staff section (Figure 3.13) did not exist before the summer of 1974. Many of the special units consist of one person who previously worked in another unit. The Systems Planning and Development Staff has responsibility for the development of the systems for aid to coordination with other projects in the same field, and for comprehensive, long-range systems that may prove to be of great utility for the management.

We shall begin our short overview of the integrating efforts of the various departments of the TVA with the Office of Power. In section 3.4 we reproduced the block-diagram of the preliminary draft of the future Integrated Power Planning Model. This system is worth mentioning, not only because it is the first all-Office program in the TVA (perhaps together with the Regional Planning System of NDRS) but also because it integrates other organization efforts and is extended to include general national socioeconomic trends. It also tends to unify the assumptions that are made separately for different models.

The Water Management integrating effort (P^{623}_{tl}) is the classic inverted case. It does not aim at long-range policy determination, but at the operational integration of water control. This must involve other groups such as the Office of Power, NDRS of DEP, because the system is likely to contain objective functions for all water system control objectives. No visible support from other sides had been given to this program, which is now in development/test stage. For example, no information on Water-Power weather forecast data collection cooperation has been provided.

The third system to be mentioned is the Regional Socioeconomic Planning System of NDRS (O^{21}_{atl}, L^{31}_{iqtl}, D^{441}_{tl}, D^{471}_{tl}, D^{41}_{itl}, and D^{461}_{tl}). Even if this does not prove fully satisfactory in providing general guidelines for overall TVA policies (because of the number

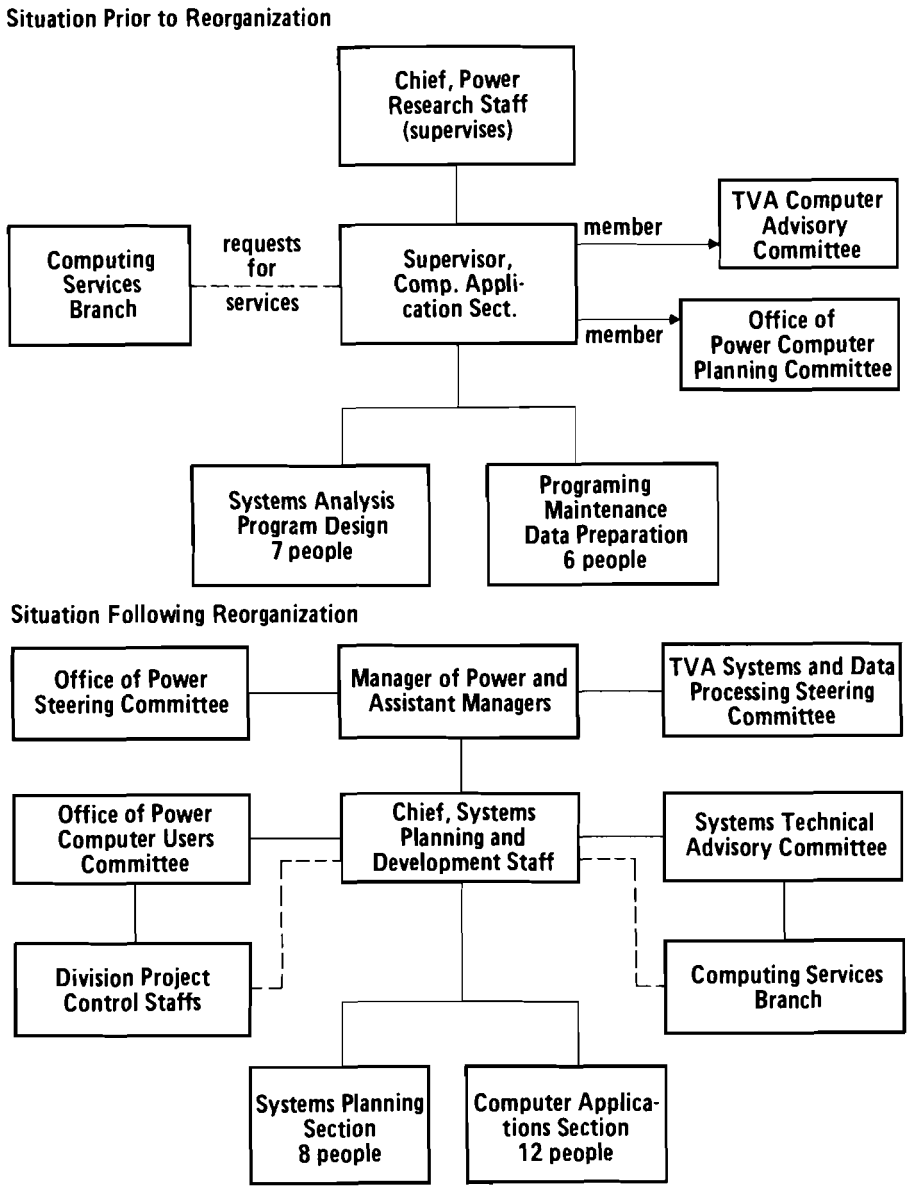


Figure 3.13. Old and new organization of computer resources in the Office of Power.

of unquantifiable assumptions), it may be most effective in generating regional projections for more specific applications, such as transportation and water supply, or--as is presently planned--a number of power forecasts, each requiring projections of regional or even national trends of specific indices.

In FF&WD Division there exist a certain number of mapping applications for land use and forest monitoring, which may constitute a basis for more future-oriented and comprehensive systems. This potential has already been exploited to a certain degree--some advisory and other procedures have been built around the central applications (E_{t1}^{754} on the basis of E_{t1}^{742}), and some further development is envisaged. However, neither in the FF&WD, plans, nor in those of NDRS is there an explicit statement on the mechanism of cooperation in the field of land use and allocation. The same applies to the potential for cooperation between FF&WD and DEP on environmental impact assessment analysis.

So we can see that a number of efforts are being carried out in the direction of integrated and management-oriented systems, and that these are firmly based on operational experiences. However, at the same time the MM&CA developed from operational experience still suffer from some cooperation gaps, which could be filled with complementary managerial coordination efforts.

3.7.3 Management/MM&CA Interface

As can be concluded from the considerations presented previously, until recently the TVA was not suffering from an overabundance of managerial input to the modernization and updating of the instrumental and informational bases of decision making and planning. The particularization of goals, units, operations and measures has led on the one hand to difficulties in introducing a coordinated effort, and on the other to the creation of specific instruments and tools for planning and decision making in specific organizational units. These tools were developed with little knowledge on the part of management and in isolation from other units. Even now, when discussing the program for the Integrated Power Planning Model, the necessity of coordinating all the planning and forecasting efforts, or at least ensuring the provision of information on these efforts, throughout the Office of Power is stressed. The inverted process is once again in operation.

As previously stated (section 3.4) it was in the Office of Power that the first instrumental, operational use of automated decision-making tools was recognized. The point has now been reached where more comprehensive, system-like uses are proposed, requiring the coordination of many MM&CA efforts. To overcome the barriers created by the spontaneous proliferation of narrow MM&CA uses, special administrative bodies and new mechanisms are needed. The problem is to ensure that the phenomenon mentioned in section 3.5 does take place. Otherwise, the lack of proper coordination and unification of assumptions and principles will lower the efficiency of the operations. There have been some minor consequences of MM&CA uses as in the Process Control System

package case of power generation scheduling. We shall return to these later.

We have reached the conclusion that in the closed-loop system of interactions between management and MM&CA uses and staff, connections were so weak that they lacked any significant influence on either side.

In relation to this case of partitioned organizations and isolated MM&CA uses in decision making, it is interesting to make a verification of the systems-connectivity features, where the connectivity is understood in the Ashby-Gardner sense. The connectivity indices for both existing and planned MM&CA are very low. According to Ashby and Gardner's hypothesis, partially proven by the experiences of R. Curnow [3], this level of connectivity ensures that the system remains stable by itself; it therefore does not need any external managerial action. On the other hand, the organization in which this "system" is embedded forms a real system in itself, which needs certain organizational measures in order to remain stable. There is, then, at least a two-order difference between the complexity of two systems.

There are two types of MM&CA that can have a more important influence on management, and also may require more direct managerial input. The first is the strategy and coordination type. This class of activities, although similar to the operational one, has a deeper influence on decision making at both line and managerial levels, and can lead to a reshaping of the organizational structure and behavior, particularly when long-range considerations are taken into account. Such long-range planning has until now been used only in the Office of Power (transmission network, generation additions, power demand), but its connections with actual TVA planning systems are so loose that it has very few managerial implications.

The second type is related to more functional, housekeeping activities, such as financing or personnel. The specific MM&CA uses in this area rarely have an important direct influence on managerial decision-making processes. More frequently they serve as an informational base rather than as tools for clarifying actions. Their very existence and range may cause serious managerial changes in longer processes, e.g., more centralization (in which systems form the requirement or informational contact with central management, thereby permitting central management to be quickly informed on matters concerning the whole organization; or more formalization stemming from computer-oriented or even computer-coded information flow). There are in existence a number of MM&CA of this type in the TVA, but major development has yet to be achieved.

Combining the data from the statistical survey (section 3.3) with the above two types of MM&CA uses, we reach the following conclusions:

- The number of strategic-coordinational MM&CA is lower than the number of operational and housekeeping MM&CA (an adequate ratio drawn from Table 3.3 is about 0.6, and from Table 3.4, as reflected by section and branch division and Office use number relation, it is about 0.5);

- The MM&CA intended for service and demonstration (outside use) are more likely to belong to the strategic-coordinational type than those used inside the TVA (Table 3.5);

- The development of strategic-coordinational MM&CA is more dynamic than for the other two types (Table 3.3), although the statistics may to some extent be misleading because of a number of important housekeeping MM&CA that have been developed or purchased recently.

The housekeeping MM&CA (in the statistical analysis these are treated together with operational MM&CA because of their similar time-span--daily activity) are much less likely to develop as a natural consequence of the operational MM&CA development than the strategic-coordinational type. This development must stem from a specific recognition of the needs and executive possibilities of the functional staff. But, on the other hand, these MM&CA with few exceptions tend to have heavy time and manpower requirements and are difficult to manage with limited resources, particularly in an environment that is not well prepared. This was the case of the TVA, and therefore the firm of Cresap, McCormick and Paget, which specializes in the analysis and design of management computer applications and systems, was asked to provide a report on the present MM&CA situation in the TVA, and to prepare recommendations on the subject. (It should be noted here that expertise was not sought in any scientific institution, but in a well-known commercial firm. No in-house staff were employed for these purposes.)

Subsequently, this firm was also asked to design the Materials Management System concept of development for the TVA, which is now being reviewed. The Cresap, McCormick and Paget proposals included the payroll and related applications system, automated vouchering system, automated budgeting and control system, and also a management decision system. (Undoubtedly to be identified with a Management Information System (MIS) for top management.) Evidently, given the inverted development process, such a system would not have been envisaged until that time.

3.7.3.1 New Policy

The recognition of coordination needs as well as growing awareness of the usefulness of MM&CA for managerial purposes resulted in the creation of two bodies within the Office of the General Manager, both devoted to the control and supervision of systems development inside the TVA. These two bodies are (Figure 3.14): Systems and Data Processing Steering Committee, composed

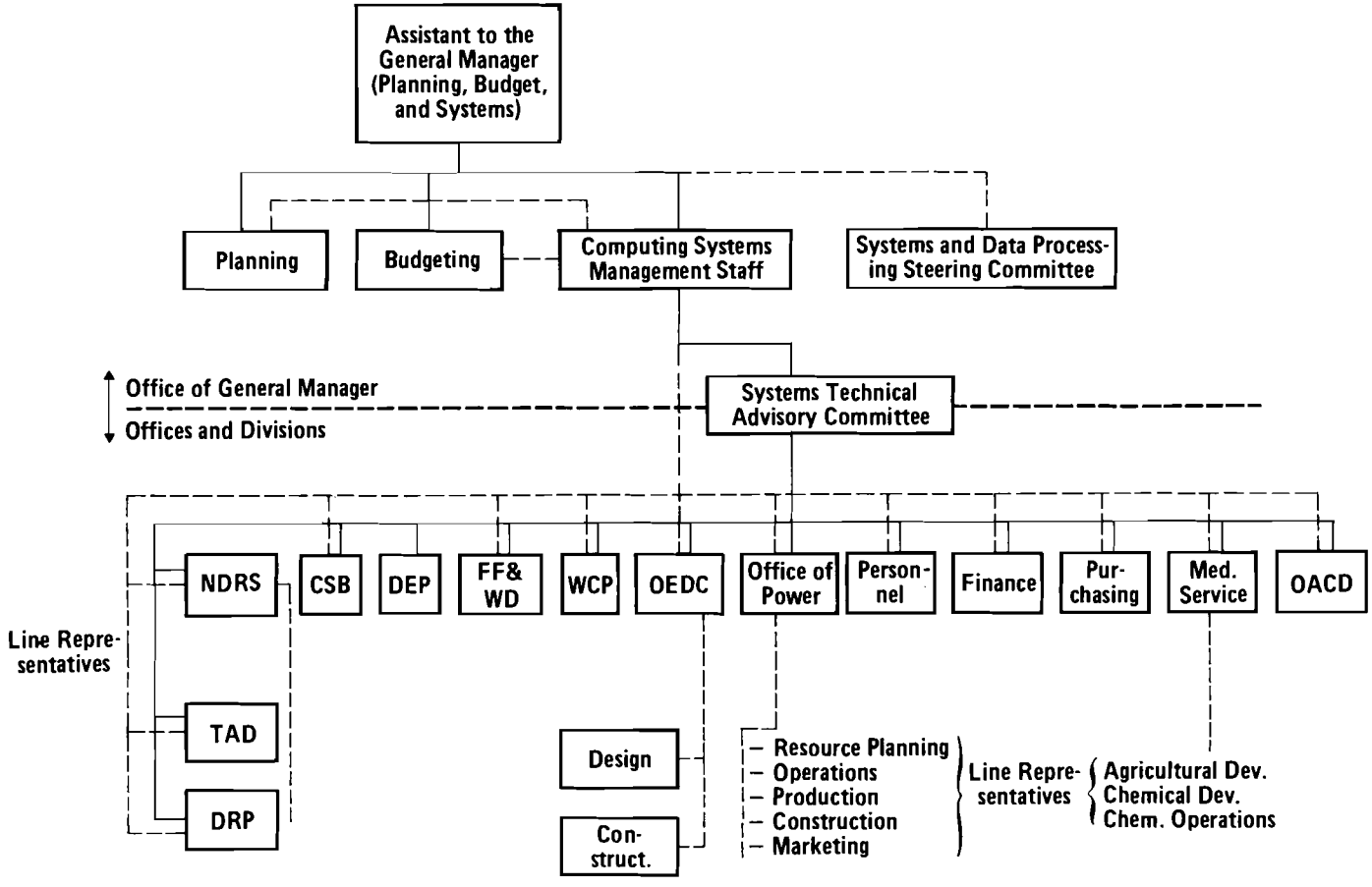


Figure 3.14. Proposed functional organization chart of systems and data processing coordination and control in the TVA.

of management representatives from divisions and Offices, and the Systems Technical Advisory Committee, composed of live representatives of Offices and divisions.

Both bodies communicate directly with the Computing Systems Management (CSM) Staff, now consisting of two people. The overall structure (Figure 3.14) had not been given any administrative power as of June 1975, and served exclusively in an informational capacity.

The task of the CSM is to provide coordination, and, if needed, guidance from outside (in-house forces are inadequate) for systems development programs, particularly in cases of management-oriented systems.

It should be noted that standardization forms one of the bases for ensuring good cooperation and coordination. Before any exchange of information can occur, mutual understanding must be assured. The standardization of program documentation has already been done by the Computing Services branch, but this includes a negligible portion of the MM&CA information.

Recognizing that MM&CA developments could be classified as (1) presently operating, (2) in initial development stages, (3) under discussion, and (4) opportunities envisaged, it was decided that the coordination work must begin to provide mutual information for all units interested in the development of a specific MM&CA belonging to group 2. In this way a set of 10 systems of primary interest, early development stages, was identified. It included:

- Material Management System: T^{811}_{qtl};
- Budgeting Information System: T^{81}_{iqtl};
- Regional Economic Model: Q^{21}_{ate}, L^{31}_{iqtl}, D^{441}_{tl}, D^{471}_{tl}, D^{41}_{itl}, D^{461}_{tl};
- Power Program Integrated Planning Model: $P^{611,2,3,4,5}_{tl}$, $D^{411,2}_{tl}$, N^{11}_{itl}, E^{761}_{tl}, P^{619}_{tl};
- Land Analysis: E^{742}_{tl}, E^{745}_{tl};
- Water Resources Management System: P^{623}_{tl};
- Automated Small Order System: T^{82}_{iqtl};
- Materials and Equipment Monitoring System: T^{83}_{iqtl};
- Integrated DB for Personnel, Medical and Financial Purposes: T^{811}_{itl};
- TVA Employment System: T^{811}_{itl}.

This list of systems can easily be divided into two groups:

- Integrated decision-making operational and strategic planning systems;

- Functional managerial housekeeping applications.

If the functional, managerial housekeeping needs are to be satisfactorily achieved with the help of outside specialists or with the purchase of the appropriate packages, much in-house work and coordination is required for the realization of decision-making systems.

After the creation of an organizational framework and routines for coordinating development of important MM&CA, two further steps are necessary:

- The listing and internal publication of all MM&CA belonging to group 1 (thousands of items);

- Analysis and coordination of group 3 activities.

These two steps will be carried out in the future. In Figure 3.15 the hypothetical procedure is shown in diagrammatic form. From this scheme it is obvious that in order to maintain adequate dynamics of the 4 → 3 → 2 flow and its controllability by the main loop, the Computing Systems Management Staff must be strong enough to avoid the formation of bottlenecks and to maintain the main loop flow, leaving the rest to organizations' discretion.

It may be concluded, then, that the turning point will be reached when the need for integrated decision-making-oriented MM&CA systems emerges in the TVA and its subunits. This need will be satisfied by future systems, which grow up from skillful line engineering and economic applications. Recognizing the necessity for intervention in this process to prevent duplication of efforts or divergent results, and to direct attention towards more managerial decision-making applications, top management has for the moment taken preliminary steps. First of all Cresap, McCormick and Paget took an objective look at the computer use, and then Computing Systems Management Staff was created. Further development must bring more decisive and positive managerial inputs into the formation of homogeneous, well-based and well-instrumented systems of decision making.

3.8 CONCLUSIONS

The classic organizational and managerial features that characterize the TVA, when realized, used, and operated by its skillful and experienced managerial and line staff, do not seem to require major changes. However, this chapter demonstrates that at least some minor changes are necessary in order to ensure further normal development of the organization.

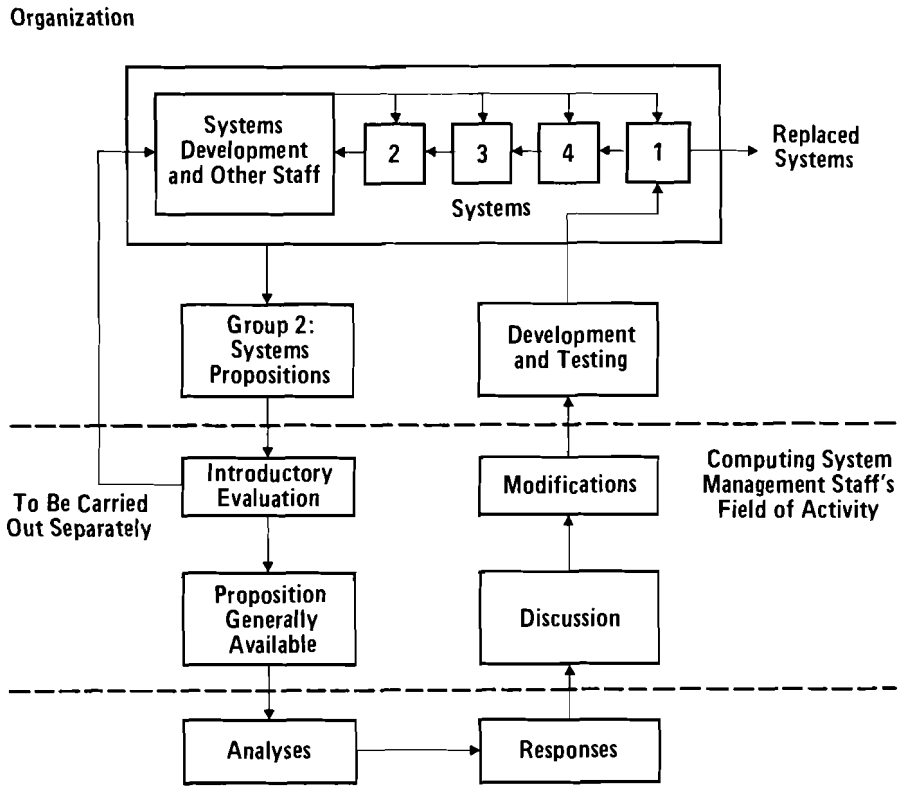


Figure 3.15. Coordination procedure for MM&CA in the initial development stage.

The yardstick for the critical analysis was the recognized potential of the TVA, rather than its actual achievements. Objectively speaking, the TVA achievements in the field are outstanding for a regional program.

3.8.1 Alternatives for Future MM&CA System Development

The Systems of Decisions and Calculations analyzed in section 3.6 are characterized by two factors that hinder MM&CA effectiveness:

- Relative isolation;
- Lack of connection with the general TVA planning system.

Two clear areas for future TVA activity can be identified:

- Creation of integrated comprehensive systems, if possible based on those already existing;

- An effort to bring these systems into close relation with decision making on planning and operational levels.

If these two objectives are to be effectively achieved, the past "upward" process can no longer be exclusively relied upon to create and organize MM&CA into structured systems covering increasingly broad fields. On the other hand, the managerial coordination efforts are not very likely to be successful in conditions of considerable decentralization. Yet, in a longer process, which has already begun, the introduction of centralized, functional MM&CA instruments, together with the prospective development of the MIS will provide the General Manager's staff with sufficient centralized power to control these activities. The process of centralization or coordination, however, if not consciously hastened, may take so long that it will not ensure the spreading of control over systems development and implementation early enough. It may, on the other hand, be detrimental (psychologically and otherwise) to operational mechanisms and human interactions already developed. Another way may be chosen. This requires the creation of a center (or promotion of an existing one) focusing in a natural, non-supervisory way. All the development efforts conducted in this case are strictly within the project-team framework. The focusing center may not be vested with any administrative power, but it must give out sufficient information on present and future developments, and must be strong enough in manpower and technical support to provide real assistance for project teams. At present no alternative has been chosen.

Another point to be stressed is the necessity for the establishment of a well-defined, unified policy for the development of a computer network and connections with outside systems.

3.8.2 Comparability of Experience

The TVA experiences in this field, as in others, prove to be unique. However, there is a possibility of comparing the general characteristics and guidelines of MM&CA uses as instruments and information bases for decision making in the TVA and other organizations. The approach has been outlined in this chapter:

- Recognition of main organizational features (structural and behavioral);

- Identification of major MM&CA with particular emphasis on their use in decision making, MM&CA being classified according to organizational breakdown and their specific objects and functions;

- Reconstruction of SDC into those parts, where it can objectively be defined.

At this point a general evaluation can be made from two standpoints:

- Deductive: by making hypotheses on the overall MM&CA/decision-making system ("black-box" approach), and then verifying these in particular cases;

- Inductive: by analyzing the possibilities for construction and the characteristics of constructed SDC, and then reaching general conclusions.

Comparison with any other organization may include:

- The overall indices used by MM&CA in various decision-making activities;

- The existence of specific, consistent SDC and their characteristics;

- The directions of the best and the least developed MM&CA usages in decision making;

- The way the applications have evolved;

- The management/MM&CA interface.

These features seem to be sufficient for comparing two different organizations even if by themselves they do not provide a final qualitative evaluation. Such an analysis would have to take into account the effectiveness of MM&CA in decision making, which is so hard to measure and rarely stated.

REFERENCES

[1] Gardner, M.R., and W.R. Ashby, Connectance of Large Dynamic Cybernetic Systems: Critical Values for Stability, *Nature*, 228 (1970).

[2] Beer, S., *A Diagnostic Look at TVA Organization*, internal preparatory paper, Large Organizations Project Study on the Tennessee Valley Authority, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1975.

[3] McLean, J.M., P. Shepherd, and R.C. Curnow, An Empirical Investigation into Systematics. The Study of Behavior of Large Complex Systems, in A. Straszak and J. Owsinski, eds., *New Trends in Mathematical Modelling*, Ossolineum, Wroclaw, 1977.

Chapter 4: Integration of Environmental Factors into TVA Planning and Management

4.1 ANALYSIS OF TVA ENVIRONMENTAL MANAGEMENT

4.1.1 Introduction

The TVA has often been criticized for not paying sufficient attention to the environmental implications of its activities. Recently this criticism has been directed at controversial programs such as nuclear power development.

The large and controversial projects are only one aspect of the TVA, although perhaps the most obvious due to the publicity they receive. The attempt by the TVA to institute an environmental management system has aroused similar concern. This system is designed to control not only the impact of large TVA projects on the environment, but also to develop a system that ensures the quality of life for Tennessee Valley residents. Quality of life has repeatedly been used to explain the ultimate motives of the TVA throughout its operational history, and to justify major directions or changes in TVA policy. With the passage of environmental protection laws in the United States, "quality of life" has been interpreted as containing environmental as well as economic components. TVA projects, which make a significant impact on the environment, must be examined on the basis of these impacts.

In addition, the TVA operates within a multijurisdictional region; primarily subject to the legal constraints of the Federal Government, but also partly subject to the laws of the seven states in which it operates. The TVA operated with relative freedom from legal environmental requirements until 1970, when the National Environmental Policy Act (NEPA) was passed. NEPA [1] requires all federal agencies to establish procedures for the planning and maintenance of environmental quality in all phases of their governmental operations [2, pp. 69-74].

Such requirements include:

- Listing the environmental impacts of a proposed action;
- Identifying adverse environmental effects which cannot be avoided in the event of proposed implementation;
- Determining alternatives to a proposed action;
- Specifying the relationship between local short-term use of the environment and the maintenance and enhancement of long-term productivity;

- Listing any irreversible and irretrievable commitments of resources involved in a proposed action.

NEPA also created a Council on Environmental Quality (CEQ), which was directed to report annually on the state of the environment, and to review and comment on those federal agency activities having an environmental impact.

Shortly after the passage of NEPA, further legislation was enacted, dealing with air and water quality and the occupational environment. These acts set minimum standards of environmental quality, and required the implementation of new industrial technology in order to safeguard both the environment and the health of the population. The acts also permitted individual states to set more stringent standards, which could take precedence over federal standards.

The net result of these environmental laws was that the TVA had to consider some type of an environmental management system to satisfy these new criteria. Two ways were possible. The first would have been to employ outside consultants on a contractual basis; the second possibility would have been to integrate an environmental management system into TVA operations. The TVA chose the latter approach--to consolidate and coordinate environmental expertise within the TVA and to develop a system of integrated environmental management. This was an important decision, because it showed that the TVA recognized that environmental protection was not just a matter of pollution control.

4.1.1.1 Approach to the Study

The Management and Technology Area of IIASA had previously established aspects of environmental management and organization in its research plan. The TVA Conference presentations [3] provided valuable material in this area. They were supplemented by an additional meeting of experts on environmental management, which was held in conjunction with the United Nations Environment Programme [4].

A procedure had to be developed, using the principles developed through these meetings and conferences, which could be applied in a short time-span to a field study of the TVA environmental management system.

The study of a developing environmental management system contained several unique problems. Should it be examined only in respect to large-scale development programs, such as reactor siting for nuclear power plants, construction of water power systems, or the use of fossil fuel for power production? Or should a more comprehensive view towards environmental management be taken, and the TVA examined on the basis of both large-scale program development--and its environmental components--and on the environmental programs per se in which the TVA has traditionally been involved? The latter approach was taken in

order to emphasize that environmental management included not only the control of those projects producing an environmental impact, but also the provision of recreation and education facilities, and the preservation of the environment. Large projects have more appeal to a researcher because they are obvious points of interaction between environment and development, and they are usually well documented both in the planning and in the decision-making process. However, the smaller aspects of an environmental management program may affect a given population just as significantly as the larger program. These smaller programs operate over a much longer time-span and are difficult to assess on a short-term basis.

How was the TVA attempting to handle these two aspects of environmental management, and were they becoming integrated? Environmental considerations need to be built into a development process, and into the planning and management process. In this way environmental impacts will be recognized before they occur and potential effects can be alleviated through proper design, engineering control, or site selection. Also the long-term development effects will have due consideration, and steps can be taken to maintain and enhance environmental quality.

This is certainly a large order for any organization, and coupled with the size and responsibilities of the TVA, a difficult one. It was not expected, given the TVA's recent emphasis on environmental considerations, that a comprehensive and integrated system would exist. Our criteria for examining the TVA environmental management program consisted of the following questions:

- Is it comprehensive?
- Is it integrated?
- Is it effective?

Comprehensiveness implies that a total set of environmental processes exist within the organization in order to achieve a system of environmental management. These processes include:

- Determination of environmental goals;
- Determination of the objects of environmental management;
- Environmental research efforts;
- Environmental planning procedures;
- Environmental monitoring systems;
- Environmental communication systems--both within the organization and with the population affected by the organization;

- Environmental impact assessment capabilities;

- Openness to environmental advocates.

Integration implies that the above criteria function in conjunction with the normal management system of the organization. The environmental management system is not an auxiliary approach to development and operations, but participates in the decision-making hierarchy both at the policy and operational level. It is an independent unit with status equal to the engineering and development parts of the organization.

Effectiveness is a criteria that is extremely difficult to handle on an objective basis--especially in the studies of large organizations. We have attempted to map out the organizational characteristics of the environmental management system, and look for uniform flows of information and environmental decision input. Examination of an organization on this basis implies reliance on published material. The information available in published form was supplemented with an extensive interview process, in order to gain an impression of how the TVA thought their environmental management system was functioning, and to find out whether any changes in operational characteristics or in organizational input were being considered. This approach implies the use of two methods of estimating effectiveness.

The first is a more external measure--that is, to ascertain whether the TVA, through its environmental management system, is meeting the judicial and legal requirements imposed on it from exterior federal and state sources. The second is an internal organizational measure--that is, to discover whether the environmental management system is accepted as a valid part of the TVA management system. In the cybernetic sense, is environmental management a viable part of the TVA? Are environmental goals supported by the TVA divisional hierarchy, and are the environmental methods accepted as valid components of the TVA development system?

These initial ideas are developed throughout this chapter. The first section deals with the history of environmental activities in the TVA in relation to the changing perceptions of environmental needs and goals. Three main periods are considered: 1933 to 1950, 1950 to 1967, and 1967 to the present. Major programs of an environmental nature are indicated, and the influence of changes in power operations are considered as the driving force for changing environmental perceptions.

The second section discusses the current environmental activities of the TVA distributed throughout the TVA organizational structure. Three main environmental areas are considered:

- Solid waste management;

- Air quality management;

- Water quality management.

The third section deals with an analysis of the TVA environmental management system. The development of the system is traced up to the present time, and special emphasis is given to the very different nature of management for environmental concerns in comparison with the decentralized approach normally followed by the TVA. This centralized approach is traced according to the flow of decisions and calculations within TVA organization. This method serves to show the integration of environmental management within the TVA operational system, and how environmental considerations fit into the modeling apparatus.

The final section deals with a general discussion and evaluation of the TVA environmental management system, and its implications for other regional development programs of similar scope.

4.1.1.2 Limitations of the Study

Due to the limited time available for the field study, concentration had to be placed on the internal functioning of the TVA. For this reason, external organizations that play a role in safeguarding and enhancing the environment of the Tennessee Valley region could be considered only cursorily.

The lack of an objective measure of effectiveness for environmental management systems is a problem affecting many of the current studies in the environmental management field. The study team attempted to overcome this difficulty by examining the TVA system in a systematic manner--from goal and objective formation to implementation and operational management. It is hoped that the team has been as objective as possible in its examination of the environmental management processes and their implications.

The study also exposed some of the TVA's limitations regarding environmental management. There appear to be two basic types of activity in this field. The first is the solving of problems of a regional nature--such as river basin and tributary control of water systems. The second type deals with activities that may be applied to a region, for example, the TVA covers a large forest area, but because only five percent of this is directly under TVA control it cannot "solve" forest problems on a regional scale. Therefore it has attempted to suggest a pattern of solutions, using those areas under its control as an example of effective forest management. The results are then made available to all interested parties, such as governmental agencies, private companies, local communities, farmers, and landowners.

4.1.1.3 Summary of Major Findings

The TVA has played a major role in developing the Tennessee Valley. It has always been a source of debate in US literature whether or not this development would have occurred naturally without the formation of such an organization. From an environmental standpoint, the formation of such an organization was necessary in order to coordinate development with environmental considerations. This was certainly done in the past, although the allocation of finances was much smaller than that allocated to development of the natural resources of the region.

The increasing reliance on power operations has resulted in the TVA being interpreted as a power company. As such it has come to be considered not as an advocate of environmental protection, but as an organization spurred on to development by the profit motive.

This study points out that the TVA has had considerable environmental success in the past, and is actively seeking organizational and operational solutions to improve the environmental quality of the Tennessee Valley. Limited success has been achieved on an external basis, but internally the environmental management system remains in the development phase.

Problems of internal acceptance by the TVA division, and the centralized "policing" nature of environmental management have resulted in internal coordination and integration difficulties. Several emergency solutions to these difficulties have been initiated--such as the introduction of an environmental coordinator into the Office of the General Manager--but it is emphasized in the study that this approach may have a detrimental effect if the TVA sincerely wants to become an advocate of environmental protection.

4.1.2 Chronology of Environmental Activity in the TVA

As the identification of problems depends on the ability of management to perceive areas that need attention, we have divided TVA activities into three main periods of perception. These periods reflect the changes undergone by the TVA in the area of environmental management.

4.1.2.1 Initial Period: 1933 to 1950

This period reflects the perception of the environment as being included among the general goals of the TVA. The key words during this phase were Regional Resource Development--the environment was considered part of the total resource of the Tennessee watershed to be developed and enhanced to make the region attractive for industry and labor, and thereby

strengthening its economic base. This idea is mirrored in programs started by the TVA in its developing years, a few of which are noted below [5,6,7].

Water control on the land was considered to be of extreme importance. Demonstration projects were initiated on the efficient use and replacement of forest land; land terracing was encouraged to prohibit soil and water runoff; and water holding cover crops were introduced as a means of controlling erosion and replacing nutrients in depleted soils.

The TVA also converted a munitions plant into a National Fertilizer Development Center. A demonstration program for the reclamation of land destroyed by phosphate strip mining was conducted from 1935 to 1936. During this same period, studies of stream pollution and transference of water-borne diseases were begun, as were tuberculosis studies and assistance programs to local health services in the TVA area for sewage treatment and water quality. In 1937, the TVA began programs in mosquito control and eradication designed to prevent the spread of malaria. One aspect of this program was the varying of water level in the TVA reservoirs during breeding periods--this procedure was found to be an effective method, and is still a standard procedure.

The TVA also began conducting a biological readjustment program. It was recognized that a change from a predominantly stream and river environment to one of lakes and reservoirs created by TVA dams would destroy many areas of lowlands and alter the existing patterns of wildlife along the Tennessee River. The program was designed to compensate for losses in wildlife and to determine the best uses for the newly created lake habitats. It also included studies on commercial fisheries and sport catches, the establishment of recreational facilities along the shoreline, and on the creation of new lakeside industries.

Employee health and accident programs were also initiated together with occupational health and safety plans. While these may appear somewhat remote from environmental management, they are directly related to the immediate environment of the employees and families of the TVA and were determined to be an important part of the early TVA environmental programs.

All of the environmental activities mentioned were started prior to World War II. New programs of an environmental nature were not introduced until the war activities had ended.

4.1.2.2 Second Period: 1950 to 1967

It became increasingly evident in the years following the end of World War II that the production of electricity by hydropower alone would not be sufficient to achieve the TVA goal of providing cheap electrical energy. Power use had increased

dramatically during the war years in the TVA area, due more to the use of TVA power generation for the munition and fertilizer plants and the nuclear facilities at Oak Ridge than to the increased private and industrial usage. Thus, the TVA found it necessary to turn to the construction of coal-fired steam generating plants [8,9].

In the early 1950's, important developments also occurred outside the structure and dominion of the TVA. A new type of conservationist began to develop, concerned with the aesthetic aspect of environmental quality and the necessity of preserving the environment in a natural state for the benefit of the present and the future population. Although relatively small in number, these environmental groups began to exert an influence on governmental policies.

When the TVA took the decision to rely on coal, there were no established standards concerning that atmospheric emission of exhaust gases. However, it decided to incorporate machinery into the coal plants in order to reduce emissions of fly ash. It was necessary for the TVA to design much of the equipment because of the limited available technology. The equipment initially installed consisted of mechanical ash collectors with an efficiency rate of 60 to 80 percent. Later technological improvements allowed plants to be equipped with electrostatic precipitators with 95 to 99 percent efficiency.

In 1951 the TVA began an air pollution monitoring program. This was intended to clarify the interactions between pollutant materials released into the atmosphere and their effect on the environment. Data was needed to determine harmful levels of pollutants and the effect of atmospheric conditions on the dissipation and distribution of these pollutant materials--especially in relation to sulfur dioxide. Air distribution models that incorporated stack height, combustion rate, coal quality, and atmospheric conditions were then developed. The models were used to indicate the adverse atmospheric conditions that would necessitate a limitation on coal burning in order to reduce sulfur dioxide concentrations at ground level. Much of the activity in this area of research influenced the setting of air quality standards in the United States.

In the late 1950s and the early 1960s it became evident that the TVA would rely on coal-fired steam plants for most of its electrical production. One aspect of this increase in coal usage was that the Authority began to develop into one of the major coal buyers in the United States. The main source of the coal purchased was from companies involved in strip mining. The TVA inserted reclamation clauses in its coal contracts in 1965 in an effort to reduce the environmental damage caused by this process.

A wilderness area located in the TVA region was purchased in 1964 with appropriations from the Federal Government. This

land was designated as an environmental education center, and as a model for testing theories and approaches for public education in environmental awareness.

The latter years of this second period give an indication of the changes regarding environmental management and TVA policy in environmental affairs versus economic and industrial expansion. The programs mentioned during the first period were continued in the second.

4.1.2.3 Third Period: 1967 to the Present

The end of the 1960s showed signs of a change in environmental concerns for the Authority--from one of unified resource development, where the environment was an asset to be used for economic and industrial expansion, to one of priority consideration for the environment itself. Advances in scientific knowledge and increasing pressure from well-organized environmental groups influenced the passage of NEPA. For the first time, binding national legislation existed for strong control and regulation of environmental pollution. This control superseded national requirements for industrial expansion, and required the installation or upgrading of pollution control equipment to meet the standards set by new government bodies--the Environmental Protection Agency (EPA), and the President's Council on Environmental Quality (CEQ) [10].

Clearly, the TVA had been aware of the importance of environmental considerations before the passage of this landmark legislation. The emphasis on unified resource development began to change. Environmental concerns were incorporated into the TVA management structure, and systems for assessing environmental impacts were codified. A department for environmental planning was organized to direct and review the TVA operations in order to ensure compliance with the new laws pertaining to environmental quality.

Another significant occurrence during this period was the decision to rely on nuclear power for electrical production during the coming decades. This decision was due in part to the limited availability of coal reserves, but also to the environmental constraints imposed on power production from combustion processes. These constraints and the increasing price of fuel materials have made nuclear power production economically attractive, but the particular environmental problems of nuclear plant operations and waste disposal have yet to be resolved.

Table 4.1 presents the development of environmental activities in the TVA.

Table 4.1.

	1933-1950	1950-1967	1967 to the Present
Air Quality		XX	XXX
Energy Conservation			XX
Environmental Education		XX	XX
Health Programs	X	X	X
Natural and Scenic Resources	X	XX	XX
New Town Planning		X	X
Radiological Research			X
Resource Recovery	XXX	XX	XX
Solid Waste Management			XX
Water Quality	X	XX	XX
Strip Mine Reclamation	X	XX	XX
Vector and Weed Control	XX	X	X
Wildlife and Waterfowl Resources	XX	XX	XX

XXX - Intensive Program
XX - Active Program
X - Program

4.1.3 Environmental Activities in the TVA

This subsection of the environmental report attempts to classify and explain the activities of the TVA environmental concerns. Table 4.2 presents the roles of Offices and divisions in three areas of environmental management: solid waste, air quality, and water quality [11]. In each area, the Department of Environmental Planning (DEP) has the major coordinating role for environmental activities.

The extensiveness of the environmental activities, and their distribution throughout the TVA organizational system, are indicated in Table 4.2. It should be remembered that environmental considerations at the present time represent only a small percentage of total TVA activities. Indications are that

Table 4.2. Roles of TVA Offices and divisions in three areas of environmental management activities.

Activity / Office	Solid Waste Management	Air Quality Management	Water Quality Management
Environmental Planning	- Planning/coordination, internal TVA; - Interagency technical advice/assistance; - Interface with regulatory and other agencies; - Field advisory and inspection; - Research/demonstration projects; - Liaison with educational groups in Solid Waste Management; - General source for planning, etc.	- Internal TVA planning/coord.; - General planning and review assistance for Offices; - Monitoring and data analysis; - Complaint investigations; - Assessments of emissions on agriculture and forests; - Research for emission control; - Recommendation for air quality control requirements; - Plan evaluation and review for compliance.	- Planning and coordination, internal; - Standard recommendations and criteria; - Water quality surveillance; - Pollution complaint investigations; - Field investigations; - Downstream water use impact assessment; - Collaboration with internal TVA Offices on water impoundments and pollution impacts; - Technical assistance to local groups; - Technical assistance in planning and operation of waste disposal facilities; - Research on municipal and industrial waste; - Interface with state and federal agencies.
Office of Engineering Design and Construction	- Technical studies on solid waste separation and use in construction; - Design and construction of solid waste disposal facilities.	- Design, cost estimates, and specifications; - Construction services.	- Research on engineering improvements for water quality control.
Agriculture and Chemical Development	- Research on disposal and applications of composting; - Assistance/advice on strip mined land to FF&WD; - Research on animal and agricultural waste, fertilizer, and crop residues; - Research on solid waste from fertilizer plants.	- Chemical engineering research on atmospheric waste emission; - Control for National Fertilizer Development Center.	- Research on agricultural and chemical waste impact on water resources; - Methods for control and use of waste; - Provides facilities for waste disposal.

Table 4.2. (continued)

Office \ Activity	Solid Waste Management	Air Quality Management	Water Quality Management
Power	- Research and liaison with organizations working on use of solid waste from power generation	- Research on waste control; - Liaison with other electric utility organizations.	- Research on waste impacts; - Oxygen depletion research in reservoirs.
Water Control Planning	- Hydraulic, hydrological, and geological data; - Sample collection assistance for DEP; - Research on surface and ground water pollution; - Site selection for solid waste disposal facilities.	- By request: total responsibility for atmospheric and meteorological monitoring systems; - Liaison with National Weather Service for data and forecasts--service to other Offices.	- Engineering research for improvement of water control; - Water quality monitoring and investigations; - Research in water quality, geology, and hydrology; - Collection of samples for surveys with DEP.
Navigational Development and Regional Studies	- Assists in planning, including economic aspects.	- Studies of economics, waterfront industries and water commerce; - Advice for industrial and urban development; - General economic advice; - Public relations on TVA air quality policy; - Information on zoning and planning approaches.	- Water quality measurement procedures for abatement requirements of pollution agencies, joint with DEP; - Demographic and economic projections for long-range regional pollution control.
Reservoir Properties	- Programs with regard to reservoirs and reservations; - Promotional campaigns, demonstrations with DEP.	- Public relations of TVA air quality objectives in dealing with land right purchases; - Deed compliance with air quality provisions.	- Pollution control provisions for deeds and permits involving reservoir lands; - Studies of recreational use of water resources with DEP; - Secures compliance with control provisions in deeds for land rights.

Forestry, Fisheries, and Wildlife Development (FF&WD)	- Research on impacts in operation of forests and harvesting of forest products; - Demonstrations of disposal on stripmined lands; - Advice/assistance to OACD and DEP in forest studies.	- Studies of airborne emissions on forests; - Biological and forest air quality investigations, including economic impacts.	- Impact on wildlife, aquatic life and fisheries--research; - Stream water quality investigations with DEP.
Law		- Prepares provisions incorporating air quality control requirements for land conveyances.	
Property and Supply		- Incorporates air quality control provisions in land conveyance.	- Incorporates antipollution provisions in land conveyances.
Tributary Area Development			- Reviews plans/approves water quality studies in tributary area development; - Coordination of water quality technical advisors with tributary area development.

both the personnel time and monetary expenditures attributed to environmental concerns will increase dramatically in future years. Expenditure in 1972 attributed to environmental protection measures amounted to approximately $75 million, and in 1973 were estimated at over $156 million. The 1974 budget for environmental concerns was $167 million with the following breakdown:

- pollution control facilities at plants under construction: $102,138,000,
- pollution control improvements at existing plants: $37,992,000,
- power system operating and maintenance costs for existing pollution control facilities: $3,704,000,
- research, development, and demonstration projects: $23,421,000.

Only 14% of the total funds were allocated for non-power related projects of environmental activities.

4.1.3.1 Environmental Education

In addition to the activities listed in Table 4.2, the TVA has developed a unique education program called "Land Between the Lakes". The original concept was formed in 1959, and in 1961 a preliminary plan was sent to the Federal Government. Federal appropriation for development was approved in 1963, and the TVA was given the responsibility of executing the plan, which was to serve as a national demonstration in outdoor recreation and environmental education [7].

A major purpose of the demonstration was to show how an area depleted of most natural resources could be restored to serve a wide range of national recreation needs. However, it also demonstrated to other state and federal organizations that an environmental education program can be most effective when coupled with the experience of direct communication with the natural environment.

The TVA also has programs related to environmental education, in which special talks and presentations are delivered to interested schools and civic groups. In this way the local population is made aware of the environmental programs and policies of the TVA.

4.1.4 The Management of Environmental Activities in the TVA

The TVA has traditionally allowed considerable autonomy to individual units in their operations. We now observe the addition of environmental considerations to the traditional

operations of these units. This was a response to federal and state requirements concerning pollution control and environmental preservation, and to the increasing awareness shown by the population in environmental concerns. In other words, external pressures on the TVA have led to internal changes. It is not clear whether or not the TVA would have developed such a system without such pressures.

4.1.4.1 Development of the Environmental Management System

Because the present system of environmental management is a relatively recent development in TVA history, we can consider the structure, function, and position of environmental management to be in a state of flux; subject to changes in all three categories depending on evaluation of effectiveness, resolution of conflicts, and the increasing or decreasing importance assigned to the TVA environmental activities.

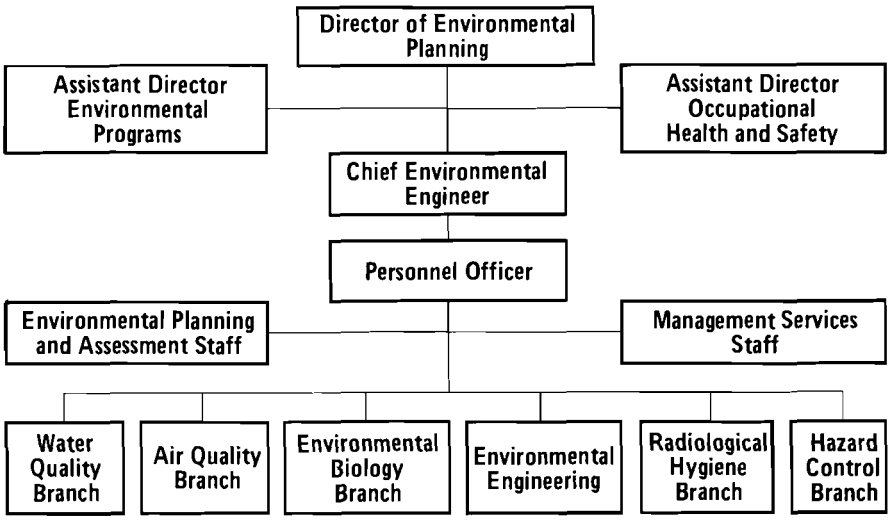
The management system currently used to deal with environmental problems represents a significant change from the management system of other TVA operations. The requirements of NEPA and the directives of the federal CEQ, necessitated the creation of a more formal organizational structure to deal with the environmental aspects of TVA activities. This policy act caught the TVA unawares. The upper management decided to delegate environmental responsibilities to the Division of Health and Environmental Affairs--a change in name and responsibility for the old environmental division concerned with health and safety. This immediately resulted in a series of conflicting ideas as to what should be done to fulfill the meaning of the act, mainly because there were no precedents or court decisions to refer to.

Internal difficulties also arose, such as the failure of the Department of Health and Environmental Affairs to direct the environmental impact analysis of the other departments' activities. It was soon obvious that the structure and the leadership of this department--although successful in its previous mission--did not have the ability or the cooperation to organize and direct an overall environmental program.

At the beginning of 1972, the Department of Health and Environmental Affairs was reorganized into the Department of Environmental Planning (DEP), see Figure 4.1a, and a new position was created in the Office of the Director--Assistant to the General Manager for Environmental Affairs. These two events were designed to: (1) eliminate the backlog of environmental impact statements; (2) achieve coordination across divisional barriers; and (3) strengthen DEP as the coordinating body for the TVA environmental program.

The Assistant to the General Manager for Environmental Affairs was charged with the coordination of the TVA-wide

a. 1972 to March 1975



b. March 1975

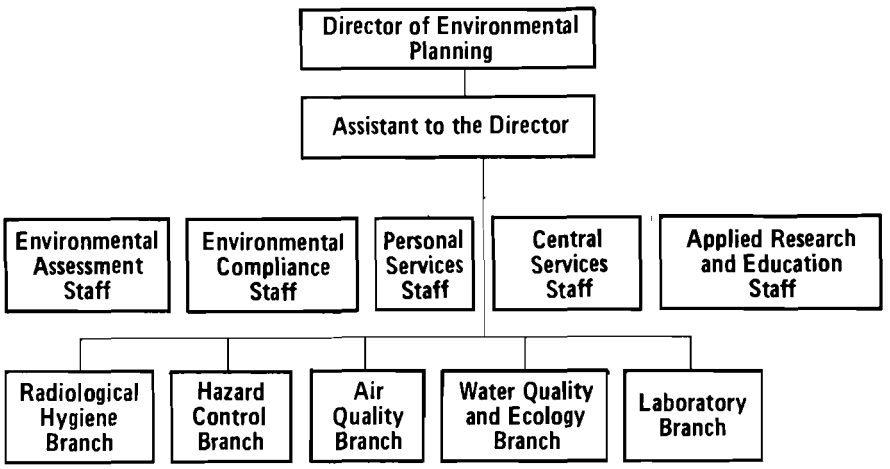


Figure 4.1. DEP organization charts.

environmental program, and functioned with the authority of the General Manager. He is now assisted in these responsibilities by a group of five lawyers assigned to the Division of Law who aid in interpreting the legal environmental requirements of state and federal agencies. The Director of DEP acts as the main assistant in these coordinating activities [12].

Two new staff groups were created from the previous Environmental Planning and Assessment Staff-the Environmental Assessment Staff, and the Environmental Compliance Staff. The former has become the principal source of staff assistance to the Director of DEP, and has the primary function of coordinating the preparation and examination of the environmental impact of new TVA facilities. The latter group deals with regulations that affect existing facilities. The present DEP organizational chart is depicted in Figure 4.1b.

4.1.4.2 Determination of TVA Environmental Policy

The management system, which has developed as a result of the TVA environmental policy, contains two basic components: a policy-defining procedure and an operational management system. The process of determination of TVA environmental policy is illustrated in Figure 4.2, and generally involves the following steps.

Regulations and laws concerning environmental protection are received by DEP. These are then discussed with the Legal Services Staff and the Environmental Assistant to the General Manager. The applicability of the regulations to TVA activities is provisionally determined, and a brief is prepared for review by the General Manager.

The finalized brief is presented to the Board of Directors. The Board then sets a general policy for the TVA and returns this policy to the Office of the General Manager for implementation. Upon receipt of this policy, the General Manager, his Environmental Assistant, and representatives from DEP determine which units are affected by the policy. Tasks are then outlined and responsibilities assigned.

It should be noted that provision for noncompliance also exists in the formulation of the general policy. If the Board of Directors concurs with the legal department on the inapplicability of an environmental regulation to the TVA, they can designate a "wait until suit" policy whereby an environmental regulation and its application to the TVA is determined by a court of law. In this case, information concerning the TVA position is accumulated before legal proceedings begin.

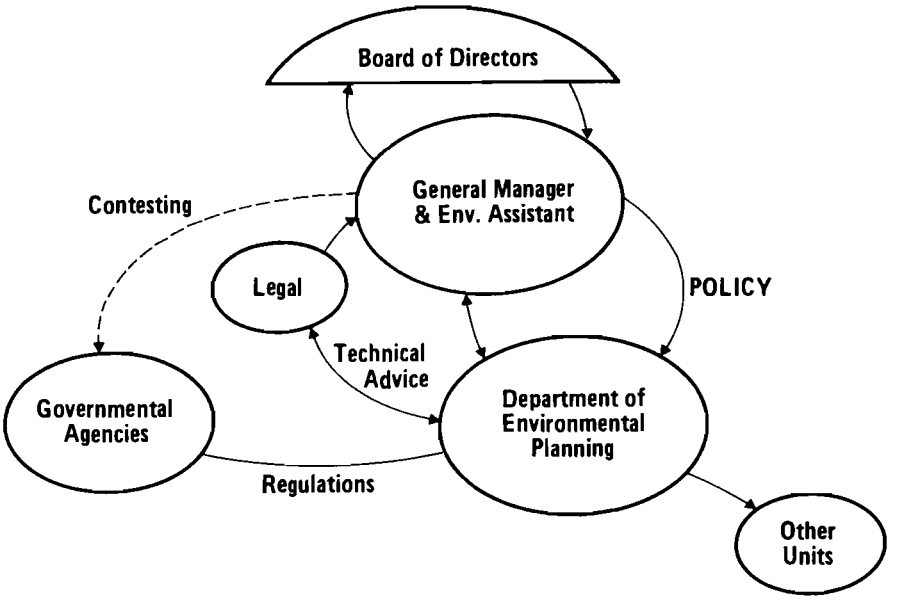


Figure 4.2. TVA environmental policy setting system.

4.1.5 System of Decisions and Calculations*

The second approach of the TVA study dealt with the operational aspects of the TVA management system, and employed a System of Decisions and Calculations (SDC) that was applied to all phases of the TVA management structure. For further background information on the applications of such a system, see [13,14].

The basic assumptions employed in the development of SDC are the following:

- In large organizations, especially those involved in integrated regional development, model calculations are being made that deliver inputs into the decision process.

- In conjunction with the preparation of models and calculations, assumptions that determine the form of the model, or the calculations to be considered, are employed.

---

* This basic approach of analyzing operational characteristics of large organizations is attributed to Prof. H. Knop. The initial ideas were developed during his tenure as Director of the Institute for National Economic Planning in Berlin, and were further expanded at the University of Economic Sciences, Berlin and at IIASA, prior to the TVA study. For a more detailed explanation of the approach and its application, see [13].

- Through the interaction of the three processes--assumptions, calculations and model formulation, and decision making--a sequence can be determined and mapped out allowing for a systematic description of the operational activities of an organization.

We found the SDC to be useful in designing a realistic description of the interaction between modeling and decision making, and in determining the extent of integration. In addition, linkages could be traced between different model and decision-making points in order to determine input and output relations of the system of models.

Difficulties were encountered in the mapping out of such a process. We were not able to effectively determine the influence of bodies outside the formal organizational structure of the TVA. (This aspect was found to be very important in dealing with the TVA system of environmental management, and has been studied more closely in the Bratsk-Ilimsk case.) The informal interaction process could also not be mapped as well as desired. We found that informal linkages play a very important role in ameliorating conflicts arising in their operational management system, and in its relationships with external organizations. We have attempted to define these informal characteristics of interaction, but their position and role in the SDC could not be effectively determined.

When trying to set up a consistent TVA-wide model based on decisions and calculations, we found that the TVA was in the beginning phase of developing what could be called a systems approach to its operations. For this reason, certain operations were lacking in systematic procedures.* In the light of some TVA problems regarding regional development, we have formulated a possible systems approach to regional development using decisions and calculations as the basic modeling device (see Figure 4.3).

In this representation a □ represents a calculation step, and a △ represents decisions, assumptions, evaluations, and information inputs and outputs involved in the calculations.

Notations:

Calculation	Decision
N^1 (itl)	- National modeling, trends in national socio-economic indices; itl: commodity/branch/sector, time, location.
Q^2 (atl)	- Regional population trends; atl: age, sex, time, location.
L^3 (iqtl)	- Regional employment development; iqtl: branch and sector, qualification, time, location.

*A comprehensive analysis of the TVA based on SDC can be found in Chapter 3.

Calculation	Decision
D^4 (itl)	- Demand and market situation; itl: commodity and sector, time, location;
F^5 (itl)	- Costs, prices; itl: commodity, time, location;
P^6 (itl)	- Production; itl: branch/sector, time, location;
E^7 (itl)	- Environmental conditions; itl: resource, time, location;
T^8	- Internal organizational control system.

A further expansion of the environmental section of the total plan is represented by Figure 4.4 and by the notation which follows. The TVA environmental experience is used as a basic guide.

As an example of how to interpret the environmental subsystem, the notation presents a further breakdown of the categories to be examined.

Environmental Subsystems E^7

71 - Land use	- 711(601)	- land requirements for the growth of the counties
	- 712	- land needs for urban uses
	- 713(754)	- forest, water area, and land use
72 - Flood/water control	- 721	- inflows
	- 722	- wave dynamics
	- 723	- stream flow
	- 724(617)	- optimal release
73 - Water quality	- 731	- water quality factors
	- 732	- liquid waste treatment alternatives
	- 733	- O_2 in deep reservoirs
	- 734	- heat transport in water
74 - Air quality	- 741	- air dispersion
75 - Forests, wildlife	- 751(651)	- optimal forestry
	- 752	- forest area, maps influence of industrial trends
	- 753	- plant resources
	- 754(713)	- forest, water area, land use.

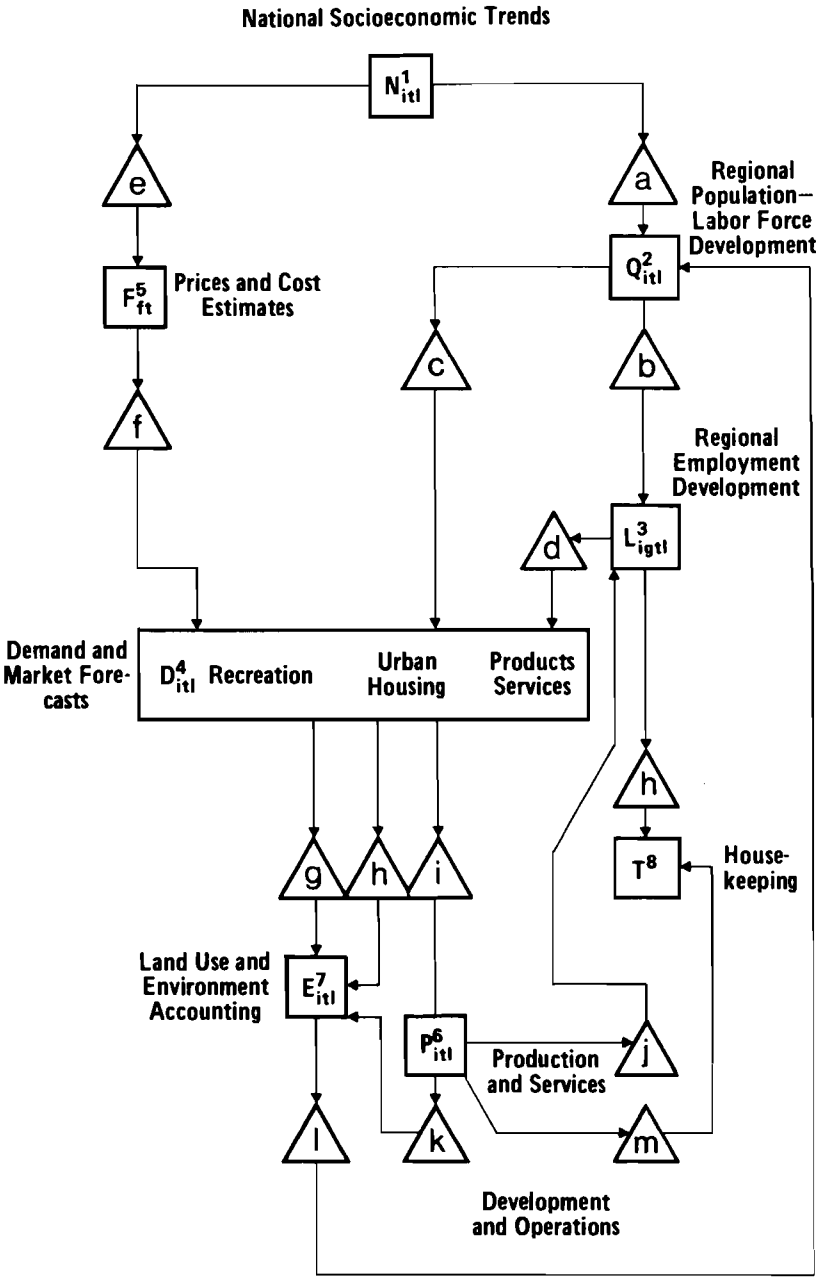


Figure 4.3. General system of regional development.

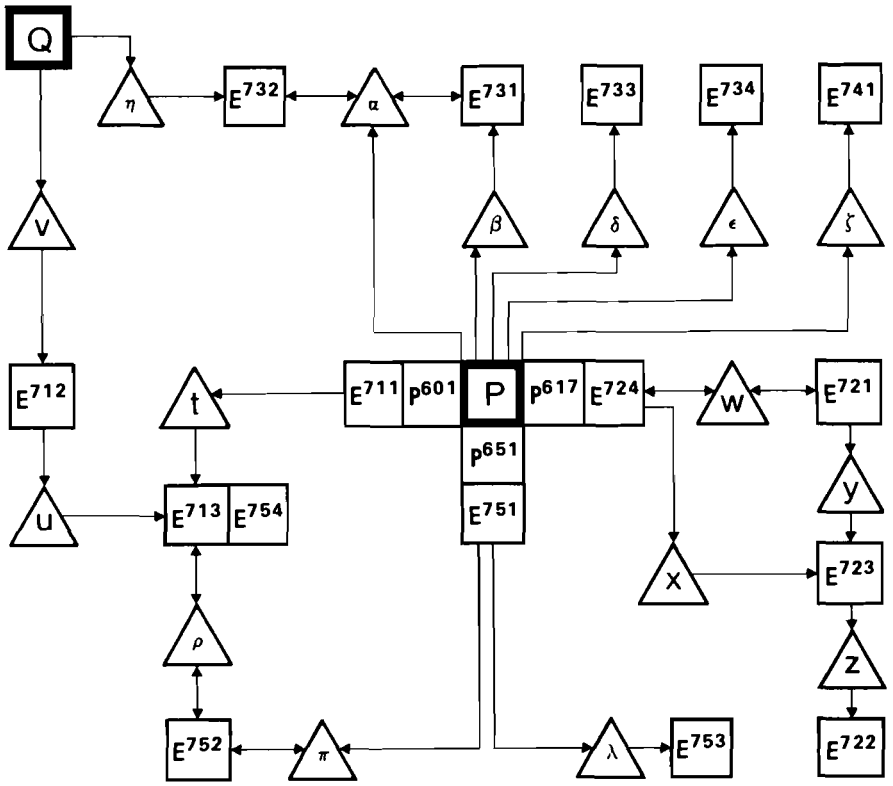


Figure 4.4. Environmental subsystem.

Environmental Subsystems: Decisions, Assumptions, etc.

t Accumulation of data from three separate divisions of the TVA structure. Attempts to resolve conflicting objectives occurring in land usage and land requirements involve the assumption that conflicts of interest can be resolved in relation to expansion and preservation of land resources in county regions.

u Attempts to resolve conflicts occurring from the demand for the expansion and preservation of urban land for recreation and aesthetic value.

v Uses extrapolations of growth patterns to determine future needs of the population concerning power, land, and recreation facilities.

w, x, y, z — Part of a complex decision process involved in determining the regulation of water in the TVA system of dams and reservoirs. Involves a hierarchy of objectives: to maintain a navigation channel with sufficient water depth to provide navigation possibilities adequate for vessels of 2.74m draft; to control floods through release and storage of water; and consistent with the previous two objectives, to provide power through release of water into the turbine system; and fulfill secondary objectives of recreation, vector control, aquatic plants, water quality, fish spawning, etc.

α Involves the determination of the pollution-carrying capacity of waterways, identification of pollutant characteristics of wastes released into waterways, and the determination of the "best method" of pollution treatment.

β Involves two basic decisions in the determination of water quality factors: emissions which affect water quality by a process of production or manufacturing, and a determination of the essential water quality required for a production system to process.

δ Attempts to determine the relationship between pollution discharge into the TVA water system, and depletion of dissolved oxygen in deep reservoirs, and effects on aquatic life with the release of oxygen depleted water from deep reservoirs.

ε Involves determining the amount of cooling of heated waters before discharge, and possible uses of heated water for irrigation, fish farming, and the recycling of nutrients and animal wastes.

ρ Involves the maintenance of air quality standards set by the Federal Government. Relates to power production from coal-fired plants, with methodological conditions to determine ground level concentrations of SO_2.

ζ Involves the determination of environmental impacts of proposed projects on forest, water, and recreation lands.

π Used as an aide in decision making involving the TVA and the private owners of land in the TVA region. The process is designed to provide information that may be used to determine the best method of forest land use.

λ Involved in defining and clarifying the relationships between forest resources and potential uses.

Series 74 deals with air quality problems of the TVA. The Air Quality branch of DEP within the TVA organizational structure is responsible for the Air Quality program. We used the

decision and calculation approach to identify the process whereby environmental considerations override the power production considerations of the Office of Power. Figure 4.5 relates in slightly more detail, the information and decision flow occurring in a normal operation procedure between the Air Quality branch of DEP and the manager of a power plant within the system of the TVA Office of Power.

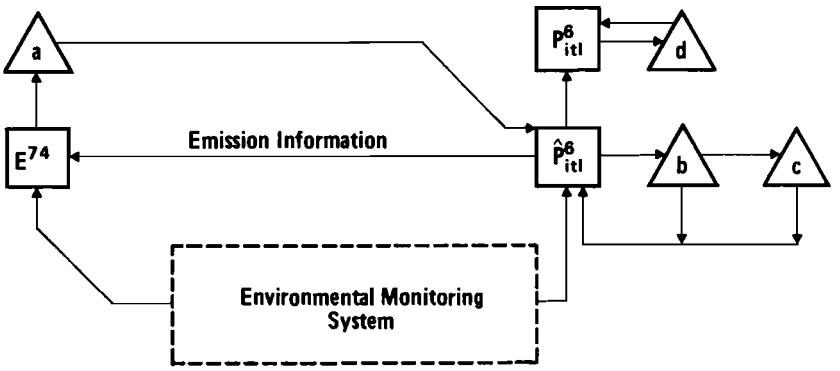


Figure 4.5. TVA Air Quality Control System

Explanation of System.

E^{741} Represents the calculation steps involved in the determination of ground level SO_2 concentration.

$\hat{P}^6_{itl}$ Represents the calculation procedure giving production and emission information from a single plant.

P^6_{itl} Represents the TVA power production system.

a Decision made to instruct a power plant to restrict emissions, based on the calculations from E^{741}: input meteorology and emission data, calculation of plume rise, and calculation of ground level SO_2 concentration.

b Decision by power plant to reduce production.

c Decision by power plant to cease production.

d Decision by the Office of Power to reschedule the power production of other plants, or to purchase power from outside sources.

The TVA has developed an extensive monitoring system dealing with air quality in the regions affected by the TVA power plant operations. It operates on a continuous sampling and reporting basis and transmits information to individual plants and the Air Quality branch of DEP. The individual plants use this information in the preparation of their 24-hour schedules. In addition, the Air Quality branch receives short- and long-range forecasts of meteorological conditions in the TVA area and in regions most likely to be affected by individual plant operations.

When an indication is received by the Air Quality branch of the possibility of an inversion layer or other adverse weather conditions reducing air quality in the region to an unacceptable level, this information is relayed to the plant operators, who discuss the situation with the Office of Power. A joint decision is then reached on whether to proceed with the normal power generation schedules or to cut production.

If weather conditions, such as an inversion layer, already exist in the region of an operating plant, the Air Quality branch has the authority to instruct the power plant operator to reduce emissions of pollutant materials immediately. The power plant operator has only two choices, to cut production, or to cease production entirely. A decision is usually reached in conjunction with the Office of Power, which must then reschedule system production, or purchase power from outside sources.

In like manner, the other categories can be traced out in order to determine the interaction of units within an organization and the types of information that are needed to make a decision.

We hope to continue to develop the SDC with the help of the other IIASA projects in order to formulate a methodology that could be applied to all phases of a regional development project, and could have particular importance as an assessment procedure when dealing with environmental considerations.

An important result of the TVA study was the identification of basic problems in regional development that require further scientific study and attention. This was especially true in relation to aspects of environmental assessment and management needed for an effective and comprehensive regional development program.

Even though the TVA had previously established an environmental department, the environmental considerations of its operations did not become a significant factor until the passage of NEPA. Major decisions now affecting the TVA have failed to take sufficient account of the environmental factors necessary to satisfy present legal requirements. As a result of these earlier policy decisions, we found that the TVA is now overconcerned with power operations, but directed by the TVA charter to include

programs that allow for integrated development of the region. It appeared to us, and our view is supported in the literature [15,16], that the major changes from reliance on hydroelectric generation, to coal-fired steam plants, and finally the decision to rely on nuclear power in the future, stemmed primarily from economic considerations and the uncertain future of natural fuels.

With the passage of NEPA, it was originally hoped that the TVA would become an example of proper and effective environmental management--with programs covering a broad spectrum of environmental considerations. We now find that the TVA has developed a multitude of programs, but the majority of personnel and funds are delegated to power considerations. The Authority has developed an environmental policymaking activity, to meet the environmental protection laws of the federal and state governments. The present system of environmental management reflects this situation.

The assignment of the coordinating role to one division of the TVA disrupted the compartmentalized system. The lack of a specified goal of environmental protection, and the taking of major policy decisions without a full examination of the environmental impacts (especially the nuclear power decision), forced a policymaking role upon a department having no relationship with the activities of the other divisions, and with no suitably developed internal organization to handle the additional tasks and responsibilities. This resulted in the development of two basic conflict situations. The first involved the relations of DEP with the other units of the TVA, and the second concerned internal DEP conflicts.

In the first situation, the problem of authority lines and status perception arose almost immediately. The Director of DEP was forced to direct the activities of the Office of Power towards the fulfillment of legal environmental requirements. The leadership of the Office of Power felt that if Office of Power money was required, they should have control over how it was spent. In addition, environmental requirements assigned to the activities of other departments were treated as additional to the normal operating costs. Environmental considerations were not viewed as necessary to the operations of the departments. The environment was not included in the determination of departmental goals, but as an expensive and time-consuming addition. From experience with other management systems [17], complicated changes to a pre-existing technological or management system inevitably result in conflict.

The internal conflict was more difficult to clarify. In our discussions with staff of DEP, we received the general impression that conflicts arose among the staff members themselves. They did not see themselves as a police or staff unit to enforce environmental laws within the TVA, but rather as an independent unit concerned with missions of importance in their fields of

expertise, and involved in programs and research deemed important by the staff members themselves. The new emphasis on the policy-making activities of DEP has resulted in losses of competent personnel, and a decrease in the morale of the unit.

As a means of eliminating the divisional conflict situation, a special Assistant for the environment was hired and placed in the Office of the General Manager. This allowed environmental considerations and compliance activities to be directed with the authority of the General Manager. This procedure appears to have solved many of the problems, but it also may have hindered the formation of effective environmental management integrated into the TVA management system. An assistant placed in the Office of the General Manager becomes a focal point for the environmental considerations. The divisions have a tendency to pass over DEP and refer questions and conflicts to the highest possible level--in effect a communication "short circuit".

Codes and procedures in environmental planning and assessment are now in operation [18]. They appear to be meeting the imposed legal requirements effectively, but this fact tends to conceal the existence of divisional and goal conflicts. This adaptation to handle changes in management by adding a new level of authority may be effective in meeting an emergency situation, but could exacerbate a conflict situation and result in more harm and permanent long-term damage.

4.1.6 Concluding Remarks

Throughout this report it has been emphasized that the present system of environmental management in the TVA is a response to the federal and state legislation affecting TVA operations. The TVA was required in effect to incorporate a major change into its management procedures, i.e., to develop a management system involving almost every branch and including monitoring, policymaking, and integration tasks.

The establishment of the present system was not accomplished smoothly. Conflicts arose concerning goals and perceptions, as well as the actual integration of environmental management itself. In order to ameliorate some of these difficulties, the TVA established a new position endowed with the authority of the General Manager. In certain respects this was an effective procedure to deal with certain immediate and visible problems of the environmental management system. The preparatory steps and the procedures to be used for environmental impact assessment were codified and formalized and a reporting procedure concerning the status of environmental projects was also established. All of these integrating devices were formalized in the relatively short time-span of two years, by no means an easy task for such a large and complex organization.

The TVA approach towards environmental management has been successful in achieving a specific goal: meeting legal requirements that relate to environmental protection. At the same time, however, this approach may have hindered the process of establishing a truly integrated approach to environmental management, because of its effect on DEP.

We were told that the future goals of the TVA environmental management system have been determined by the policymaking level and are summarized as follows:

- To place greater emphasis on meeting national environmental criteria and standards;
- To participate more actively in setting national standards;
- To initiate more environmental demonstration projects;
- To obtain greater internal coordination among TVA units;
- To develop a system of long-range environmental planning;
- To develop integrating mechanisms between the TVA and state agencies in order to solve environmental problems.

To fulfill these goals and objectives, it may be necessary to strengthen the position of DEP in the hierarchical structure. Environmental management and environmental preservation need to be incorporated as goals rather than as constraints on TVA operations. In the TVA we found that the handling of environmental considerations as constraints proved to be one method of establishing an initial environmental management system. The next phase would involve a further integration in the TVA management system--the establishment of specific environmental goals, which are not treated as constraints in their management system.

The TVA study has also led us to identify certain items that need consideration for the development of an environmental management system. They are:

- The theoretical basis for the selection of goals and objectives in the environmental field;
- The basis for environmental goal integration; both internal to the system, and between environmental management and general management activities;
- The mechanisms and criteria of goal measurement;
- An assessment and evaluation system of project environmental analysis not specifically based on economic criteria;

- Long-range planning and budgeting systems applied to environmental activities;

- The mechanism of possible interactions between external organizations, such as industry, agriculture, and agencies of the governmental system, with the TVA.

Our experience in studying the TVA system of environmental management proved valuable in establishing a basis for further research, and in the formulation of an approach which could be applied to future case studies in different socioeconomic systems. We found the SDC to be a useful tool for examining internal mechanisms and the workings of a management system, applicable in many diverse situations. More work on the influence of conditions external to the organization needs to be done, especially in relation to environmental policy and environmental regulations dictated by an external body. These characteristics are studied more extensively in the case study--the Bratsk-Ilimsk Territorial Production Complex in the Soviet Union.

4.2 A CASE STUDY OF THE TVA'S ENVIRONMENTAL DECISION MAKING: THE HARTSVILLE NUCLEAR POWER PLANT PROJECT

4.2.1 Purpose of the Case Study and Outline

The purpose of this section is to supplement and illustrate the preceding general analyses of the TVA's environmental planning and decision-making processes with a case study of a recent large TVA project. The case selected is the latest nuclear power project in Hartsville, Tennessee, with emphasis on the subproblem of site selection. This project was traced throughout the divisions and Offices of the TVA from interviews with the responsible managers and other staff involved. This information together with various published reports, unpublished documents, and in-house memoranda about the Hartsville project is put together here to create a picture of the real information-processing, decision-making, and implementation strategies in the TVA.

More specifically, this case study addressed the following questions:

- How did the TVA initiate, plan, and manage the Hartsville project?

- How did the TVA solve the subproblem of selecting an appropriate site when planning the Hartsville plant?

- What were the sources of conflicts and how were they resolved?

- What are the formal characteristics of the TVA's information-processing and decision-making strategies in

nuclear power projects in general, and in site selection in particular, and how are these characteristics to be evaluated?

The outline of this section follows these four questions. First, the planning and budgeting system for the Hartsville project is described. The processes of forecasting, planning, and implementation in the development of that project are analyzed. Among the planning process subtopics are goal identification, generation of alternative courses of action, information collection, evaluation, and decision making.

In the second part the subproblem of siting the Hartsville plant is examined in more detail. The goals and objectives of the TVA as a whole are discussed as well as how these goals are reflected in the various Offices and divisions. Beginning with the search for suitable sites, the second part analyzes how information about these sites is aggregated, and evaluated, emphasizing the interdivisional coordination in the process of screening alternatives and selecting the final site.

The third part examines the conflicting goals and interests that can be identified in the development of the project. It describes the conflicts between the TVA and other groups and organizations, and it discusses TVA strategies to resolve such conflicts.

The last part attempts to formalize and criticize the TVA's information-processing and decision-making strategies in the Hartsville project. These strategies are characterized as unstructured and informal, highly sequential, and noncompensatory. The conceptual problems involved in such strategies are emphasized, and it is shown that these strategies are in contradiction to expressed TVA policy.

4.2.2 The TVA's Hartsville Project

4.2.2.1 Hartsville in the Context of the TVA's Power Projects

When the TVA was created in 1933 it tried to achieve its multiple objectives--to provide power, agricultural development, flood control, and navigation for the Tennessee Valley--by building multipurpose dams. These dams were a natural vehicle for an integrated regional development, and the many conflicting goals in the development of the Tennessee Valley had to be carefully considered in the design and site evaluation of a proposed dam. Between 1933 and 1950 the TVA's power supply was mainly hydrobased; 29 dams created a capacity of over 3000 MW. Energy considerations and other goals of regional development appeared to form a reasonable balance in the TVA's power projects.

This picture changed when, in the early 1950s, the rising demand for electricity in the Valley bypassed the hydrocapacity

of the region and the TVA began to supplement its hydrocapacity with fossil fuel plants. The objectives for the design and site of these plants shifted towards considerations of power, cost, and engineering feasibility. Today the Authority operates 14 fossil fuel plants, which are predominantly coal-fired, and which have a total capacity of nearly 19,000 MW. Other goals of regional development in the TVA's power projects began to be dominated by the need to satisfy rising energy demands.

In comparison with other utilities in the United States, the TVA began its nuclear projects relatively late. In the early 1960s a study comparing the costs and benefits of nuclear power with its closest competitor, coal. The results were published in 1966 [19] and they concluded that, from the overall consideration of feasibility and cost, nuclear were preferable to coal-fired plants. As a consequence of this study the TVA's first nuclear plant, the Browns Ferry plant, was designed. Today this plant is essentially complete, although commercial operation has not yet begun. Three additional nuclear plants, the Sequoyah, Watts Bar, and Bellefonte, are presently under construction. These will add a capacity of approximately 11,000 MW to the TVA's present power system. When compared to these figures all other capacity increases are marginal.

Originally the planning and evaluation of these nuclear plants were oriented exclusively towards energy, engineering, and cost considerations. In 1969 this situation was changed with the passing of the Environmental Act, which required the assessment of environmental and socioeconomic impacts, leading back to a somewhat more integrated view of the costs and benefits of a TVA power project for the Tennessee Valley region. In this context the Hartsville project was planned in 1970 as the TVA's most recent addition to its power system. The main objectives were to meet the energy demands of the early 1980s with cheap energy for the Valley, while keeping costs and social and environmental impacts minimal.

4.2.2.2 The Structure of the Hartsville Project

The TVA's nuclear power projects impose complex information-processing requirements and decision-making problems on the organization. The tasks performed in the Hartsville project are not unlike those that any decision maker or decision-making institution faces when solving complex decision-making problems:

(1) Problem identification (Is there any problem? What is the nature of that problem?);

(2) Identification of goals and objectives (With what criteria should possible solutions be evaluated?);

(3) Identification of alternative courses of action (What are the available options?);

(4) Collecting information (On what aspects do these options vary?);

(5) Evaluation and decision (Which is the best alternative?);

(6) Implementation (How can the selected alternative be best realized?).

Forecasting is the main tool used for problem identification in the TVA's power projects through continuing assessment of future power needs. In the planning phase Tasks 2-5 are taken on, Task 6--to implement the project--is split into a construction and an operation stage. Table 4.3 summarizes the process by which the TVA attacked these tasks in its Hartsville project. The following three stages of the project--forecasting, planning, and implementation--will be analyzed in their relation to the six basic information-processing and decision-making tasks.

4.2.2.3 Forecasting

Short- and long-term forecasting (1 and 10 years respectively) of system loads and capacities is a joint effort of the Division of Power Marketing (load forecast) and the Division of Power Resource Planning (capacity forecasts). The forecast of future system capacity is relatively simple, but becomes--already in the Hartsville case--complicated through the unexpected construction delays in the previously planned nuclear plants. The presently used forecasting model is, however, quite adaptable to delayed information (from the Divisions of Engineering Design and Construction), and is able to revise its forecasts in a matter of minutes. The demand or load forecast is much more complex, integrating a wealth of information ranging from historical TVA loads, estimates of conservation effects, to national economic data. The load forecasts are updated annually, and they include--besides the short- and long-term forecast--a very long-term forecast for the year 2000.

These forecasts are compiled by the staff of the Division of Power Resource Planning to estimate future supply and demand. These are then presented to the General Manager and the Board of Directors. On the basis of these data the Board decides when to add capacity to the system. In 1970, forecasts of the expected net and peak system loads in the early 1980s indicated that the TVA would be unable to fulfill the future demands with its existing and planned power plants. Table 4.4 summarizes power supply and demand projections if capacity is increased by 1205 MW in 4 steps between December 1980 and June 1982. If the assumptions of this forecast were correct, (such as an annual increase of peak power load of 6.5%), the TVA would clearly be unable to

Table 4.3. The TVA's structure of the Hartsville project.

Time	Phase		TVA Divisions Involved	Task	Coordination	Output
1970	Forecasting		Power Resource Planning	Capacity forecasts	Power Resource Planning	Capacity need assessment (10 yr)
			Power Marketing	Demand forecasts		
1970-1972	Planning	Preliminary	Power Resource Planning	Screening alternative fuels, baseload alternatives, prescreening of sites	Power Resource Planning	Preliminary project authorization request (for Board approval)
			Engineering Design	Conceptual design, bids, estimates, preliminary site studies		
1972-1974		Final	Power Resource Planning	Site selection, impact studies, safety studies	Power Resource Planning	Final project authorization request (for Board approval)
			Engineering Design	Engineering design criteria, basic engineering		Environmental impact statement; Safety report
			Environmental Planning	Environmental impact assessment		
			Fish, Forestry, and Wildlife	Site studies, environmental impact studies		
			Other	Legal aspects, procurement, etc.		
1974-1980	Implementation	Construction	Engineering Design	Final design	Engineering Design (first two years) and Engineering Construction	Constructed plant
			Engineering Construction	Construction (plant)		
			Power Construction	Construction (transmission lines)		
1980		Operation	Power Operation	Test and commercial operation	Power Operation	Electricity
			Others	Monitoring impacts		

Table 4.4. The TVA's load and capacity forecasts for 1980-1981 (in 1975).

Period	Estimated Peak Demand TVA System MW	Interchange Delivered MW	Load Served by TVA-MW	Dependable Capacity MW
Winter 1980-1981	31,300	-2060	29,240	34,813
Summer 1981	28,050	+2060	30,110	37,142
Winter 1981-1982	33,100	-2060	31,040	38,436
Summer 1982	29,450	+2060	31,510	40,752

	Margins				
	Desired		Available		Surplus
	MW	%	MW	%	MW
Winter 1980-1981	6725	23.0	5573	19.1	-1152
Summer 1981	6715	22.3	7032	23.4	317
Winter 1981-1982	7201	23.2	7396	23.8	195
Summer 1982	7058	22.4	9242	29.3	2184

meet its reliability criterion (system load can be expected to exceed the available generating capability during 1 day in 10 years) in the early 1980s. The Board decided that a capacity increase was necessary. The problem was identified and passed on to the Division of Power Resource Planning to investigate possible alternative plans and solutions.

4.2.2.4 Planning

The task of the Division of Power Resource Planning was to develop a concrete power project that could fulfill the system requirements. This included an investigation of alternative fuels, alternative design concepts, possible servicing areas, plant sites, etc. In a preliminary planning phase which lasted from 1970 to 1972 some of these alternatives were eliminated. During the following two years more detailed information was collected about the remaining alternatives and a final project, the Hartsville nuclear plant, was designed.

4.2.2.4.1 Goals and Objectives: When the Hartsville project was initiated in 1970 the main goal of the Division of Power Resource Planning was to meet the capacity needs in 1980 within the TVA's reliability criterion. In addition, any such project had to be suitable to obtain authorization and feasible from an engineering viewpoint, while the costs and impact on the environment were to be minimized. These goals were never explicitly formulated, nor were particular subobjectives worked out. The goals were also apparently not seen in the context of the TVA's global task to develop the resources of the Tennessee Valley area. Besides the benefit of cheap electricity only the indirect benefits of some power projects were mentioned (such as providing employment during the construction phase, etc.).

4.2.2.4.2 Identification of Alternatives: The Hartsville project staff considered a long list of alternatives to solve the problem posed by the capacity need forecasts. Besides conservation programs, increasing peak capacity, and other improvements within the existing system, they considered the following alternative means of increasing baseload capacity:

(1) Hydroelectric power;

(2) Geothermal power;

(3) Fossil fuel power

- natural gas,
- oil,
- coal;

(4) Nuclear power.

It did not take much information collection to narrow this list down substantially. The first two alternatives were not feasible, since there are no more sites for additional hydroelectric plants in the Valley and the area's geothermal resources are poor. Among the fossil fuel alternatives natural gas and oil were eliminated because of short- and long-term supply problems.

Coal was considered the only serious competitor of nuclear fuel. The project staff considered 20 possible plant sites, and plant design concepts that varied on 12 dimensions ranging from different heat dissipation systems to different water intake systems.

4.2.2.4.3 Information Collection: The part of the planning phase involving information collection was executed in two steps. First preliminary studies were performed to eliminate unsuitable alternatives. Second the remaining alternatives were studied in more detail to finalize the project. This information collection task was coordinated by a project staff in the Division of Power Resource Planning. They determined the type of data needed, asked other divisions to perform studies to provide such data, and complied reports from this information. These were submitted to the General Manager and the Board.

In general this process appears somewhat informal and unstructured. There appeared to be no plan that determined what information was needed and why. Also it is difficult to separate what constituted information in that process, and what was evaluation, prescreening, or recommendation.

The first part of the information collection process involved a study comparing nuclear fuel with coal, several preliminary engineering studies on plant design concepts, and some investigation of candidate sites. Only the Office of Power and the Office of Engineering Design and Construction (OEDC) were formally involved in these studies. Other divisions were informed, but did not themselves provide any data or evaluations.

The comparison between nuclear and coal-fired plants came to the same conclusion as the 1966 study: total generating costs for nuclear plants were estimated to be substantially lower than those for coal-fired plants (6.8 mills/kWh against 10.3 mills/kWh respectively). Map searches, analyses of possible servicing areas, and preliminary engineering studies were the main sources of information used to narrow down the number of possible plant sites to four. On the engineering side studies on site related design concepts were initiated. These studies were summarized in a preliminary project authorization request submitted by the project staff to the General Manager and the Board in 1972. It recommended that two nuclear plants should be built with two identical boiling water reactors, both to be made by General Electric. Four alternative sites were recommended for detailed investigation, and different site related design concepts were suggested for further study by OEDC. The Board approved the preliminary project and the detailed studies began in 1972.

In the second part of the information collection process almost all TVA divisions became involved in the project development. The staff in the Division of Power Resource Planning

determined the information and studies that were needed. It funded other divisions and sometimes outside consultants to perform these studies. DEP and FF&WD concentrated on the environmental impact of the planned nuclear project, and on gathering information about the four remaining sites. OEDC and the Office of Power performed detailed design and site studies as well as safety and cost-benefit analyses. Other divisions were also involved with, for example, procurement questions, and the legal aspects of the project.

The results of this part of the information collection process were summarized in several reports such as the draft environmental statement, safety and siting reports, and the final project authorization request. These reports recommended the site at Hartsville, specified the details of the Hartsville plant design, all the information about the other alternatives studied, the relative environmental and socioeconomic impact as well as direct and indirect costs and benefits of these alternatives.

4.2.2.4.4 Evaluation and Decision: The budgetary and other aspects of the project were reviewed in the General Manager's Office in 1974. The project was approved by the Board in the same year. The draft Environmental Impact Statement was submitted to the Environmental Protection Agency (EPA) for approval and to other governmental and nongovernmental agencies for review. The public was informed about the project in November 1974. The final environmental impact statement was submitted to the EPA in May 1975, and it is still (June 1975) being reviewed. There is considerable public discussion about the Hartsville project, and the TVA's general strategy appears to be to "sell" or at least defend the project.

4.2.2.5 Implementation

As of June 1975, construction has not yet begun in Hartsville but some general principles of the implementation process in the TVA's nuclear power projects can be sketched here. From the date of Board approval of the Hartsville project, the project leadership passes from the Office of Power to OEDC (see Table 4.3). The staff in the Division of Engineering Design control and coordinate the project during the period between Board approval and construction. From then on the Division of Engineering Construction will take over. This preconstruction and construction phase will be highly organized and controlled. OEDC has developed a project control system that imposes a firm structure and control on their tasks of scheduling construction and monitoring progress. Construction will begin in November 1975, and it is expected to be completed by 1980.

Test operations will start in the beginning of 1980. This phase as well as the phase of commercial operation (June 1980)

will be controlled and coordinated by the Division of Power Operations. During operation of the plant, other divisions are involved mainly in monitoring the environmental impact.

4.2.3 The Siting Problem in the Hartsville Project

An interesting subproblem in the planning of the Hartsville project is the question of where to locate the plant. The site selection is handled independently of a specific nuclear project. The search for and evaluation of feasible sites is a continuing process, which ensures that 10-20 sites are available whenever a nuclear project begins. Staff members in the Division of Power Resource Planning have the specific task of coordinating the site search and evaluation process.

4.2.3.1 Goals and Objectives

At the time when the multipurpose dams were the main source of power from the TVA, the site of the plant was a question involving all the major divisions. The site would be evaluated with respect to many goals and objectives, such as engineering feasibility, flood control benefits, power benefits, etc. During the 1950s and the 1960s sites for coal-fired and nuclear plants were selected mainly to meet the objectives of power, cost and engineering feasibility. The National Environmental Policy Act of 1969 has changed this situation, and the environmental impact of a site is now carefully considered in the evaluation. There existed no clear picture in any division of the value dimensions or overall objectives for sites and of their relative importance in site evaluation. From discussions in the divisions and from the evaluations implicit in the selection process, it appears that the sites are evaluated from the following main criteria:

- Power system improvement;
- Engineering feasibility;
- Environmental impact minimization;
- Cost minimization.

The first criterion is in some senses very strong, but it is also very general and leaves out many site alternatives within the areas needing improved energy supply. In spite of its importance, therefore, it does not seem to have much impact on the selection process. Areas are selected on the basis of power system needs, but the sites within these areas will not differ much with respect to that criterion.

The second criterion is an essential condition. If a site is not feasible from an engineering viewpoint, it will be dropped

very early in the selection process. But there are many different engineering criteria, and there certainly will be some trade-offs--explicitly or implicitly--between these. Some of the more important subcriteria used in the Hartsville site selection were:

- Seismic feasibility;
- Geological feasibility;
- Flooding condition;
- Site accessibility;
- Cooling water availability, etc.

On the environmental impact side, the number of conceivable subcriteria is substantial. Among others, the Hartsville site study included the following environmental impacts:

- Radiological impact;
- Impact on fish and wildlife;
- Water and air quality impacts;
- Socioeconomic impacts;
- Aesthetic impacts, etc.

Cost considerations carry quite a bit of weight in site selection partly because of the relative ease with which they can be assessed and communicated. In the Hartsville case the following cost considerations were considered:

- Land acquisition costs;
- Site preparation costs;
- Transmission costs.

4.2.3.2 Identifying Alternatives

The search for candidate sites for the Hartsville nuclear power plant was in the hands of a site study group in the Division of Power Resource Planning. Between 1970 and 1972 this group looked at approximately 50 sites in the areas in which system improvement was needed. These sites were screened purely on the basis of global judgements of land use, ownership assessments, and engineering feasibility. OEDC aided in this search. Twenty sites survived this screening process.

4.2.3.3 Information Gathering

Most of these candidate sites were further eliminated by a preliminary evaluation of engineering and economic feasibility. The Division of Power Resource Planning, and the Division of Engineering Design provided the necessary data for this initial process. Only four alternatives were considered for detailed study: Antioch, Hartsville, Council Bend, and Rivers Bend.

In 1972, the site study group in the Division of Power Resource Planning funded other divisions to conduct more detailed on site studies of the four proposed sites. Those especially involved were DEP, FF&WD and OEDC. Each of these divisions delivered their reports to the site study group, which coordinated the work, collected the information, challenged it if necessary, and compiled a special siting report. This process was not formalized. Its main objective was to comply with NEPA.

In the Hartsville case, there was apparently fairly unanimous agreement between divisions about the rank order. All four sites were suitable for improving the power system. The Division of Engineering Design rank ordered the four sites identically for seismic feasibility (all equal), geological feasibility (Rivers Bend first, Hartsville second), and flooding conditions. Few other reports on the sites include such subcriteria rank ordering; usually they are given in the form of raw or simply aggregated data and they are combined with some qualitative evaluation or recommendation. The TVA hired some outside consultants to assist in gathering information about the historical significance of the site and the area around it, its archeological value, etc., but the bulk of the work was done in-house. From cost considerations Hartsville won by a margin of between $6 million and $28 million with a cost of $109 million, offsetting a cost disadvantage in transmission line construction. The site studies group compiled this information in a report and passed it to the General Manager and Board together with the recommendation to build in Hartsville for its economic and engineering advantages.

4.2.3.4 Evaluation and Decision

The General Manager and the Board reviewed the report from the site studies group, went through their own evaluation, and decided to follow the recommendation and build in Hartsville. After this decision, extensive on site investigations began.

4.2.4 Conflicts and Their Resolution

4.2.4.1 Conflicts Within the TVA

For nuclear projects in general, and for the Hartsville siting problem in particular, many potential sources of conflict

exist within the TVA, but they are difficult for an outsider to discover. Therefore this section stresses the word potential.

Obviously different divisions would subscribe to different objectives when choosing the site for a nuclear plant. The four major goals sketched previously will have a different relative importance in each division, and it is not difficult to see which division would rank their goals in which order.

The problem is resolved partially by means of the process itself. First, the coordination and control of the site studies are in the hands of the Office of Power. Secondly, the sequential considerations of these goals reduces the possibilities for actual clashes. By the time OEDC examines the sites, the Office of Power is already reasonably satisfied with the alternatives; by the time the environmental studies begin, the remaining alternatives are usually quite acceptable from an engineering viewpoint. Still, conflicts can and do exist, particularly if the divisions have more lead time to follow the prescreening processes. The more recent attempts to improve the site identification and selection process seem to point in that direction. Table 4.5 gives a description of the siting procedure as it is envisaged in the future. Phase 1 is of particular importance here, since certain problems arise from disagreement among divisions about compatibility. The implicit solution of this conflict comes from the informal veto right of each division. A site will not be pursued against the expressed objection of one division.

What about minor conflicts? What happens if the Division of Engineering Design ranks the sites differently from the Division of Fisheries, Forestry, and Wildlife Development? The site study group may solve this conflict in its final recommendation by checking and balancing, and informational weighing of the value aspects that have created this difference. If the study group cannot find a solution, the problem is passed to the General Manager's Office. This appears to be a rare occurrence. In the Hartsville case, the disadvantages, such as destruction of a possibly historical site, the archeological potential of the site, and other environmental impacts were registered by the site study group, but they considered them to be greatly outweighed by the economic and engineering advantages.

4.2.4.2 Conflicts Between the TVA and Other Groups

If internal TVA conflicts are quietly solved, conflicts between the TVA and other organizations are loud and obvious.

There are several examples of such conflicts in the Hartsville case. The owners of the sites for the plants and the transmission lines strongly objected. The TVA solved this problem by having the land condemned and by beginning litigation. The Upper Cumberland Development District (an organization of local government and industry representatives) strongly

Table 4.5. Summary of typical site selection process.

Time Required	Phase	Action
Continuing	Preliminary	System Studies Study Area Identification
	(Completed by August 1 each year)	
2 Months	I	Potential Site Identification And Office study of compatibility--obvious incompatible sites eliminated
	(Completed by December 15 each year)	
12 Months	II	Alternative Site Evaluation Based on intensive recon. studies--preferred site selected
24 Months	III	Preferred Site Detailed Studies Acquisition process initiated, Environmental Assessment Report filed
12 Months	IV	Draft Final Environmental Report filed--preoperational monitoring initiated

disapproved of the project, the Office of Urban and Federal Affairs of the State of Tennessee had strong objections to the draft environmental statement, the EPA offered a number of technical criticisms. In addition the conservationists are against the project, although--at least at present--no particular pressure group has been formed to fight it.

The type of arguments used by the TVA to deal with such conflicts vary from technical to personal and political. The mechanisms to resolve such conflicts are:

- To defend the project by providing more technical information or by performing additional supporting studies;
- To change details in the project to accommodate the criticism;
- To make political moves to reach an agreement with the critics;
- If the above mechanisms fail, to go to court and try to overcome the resistance against the project by legal means.

Since the TVA informs the public relatively late in the planning of the project (about four years after the plan has been formulated and after the plant design and site are selected) its position in such conflicts is very defensive. The goal appears to be to get the project implemented as it stands and as soon as possible.

4.2.5 Analysis and Evaluation

4.2.5.1 Characteristics of the TVA's Strategies

Strategies to cope with complex information-processing and decision-making problems of the type faced by the TVA in the planning and management of the Hartsville project seek to make the problem manageable by reducing its complexity. Most TVA managers describe their strategy as "checking and balancing", by which they mean a sequence of collecting information about alternative courses of action, establishing the positive and negative aspects, weighing them against each other in relation to some common goal, and deciding on the basis of such evaluation. This is a verbalization of a compensatory strategy, which looks at all the value relevant aspects of the available alternatives, and it is always willing to give up good points in one aspect for an improvement in some other aspect. Most normative models for information processing and evaluation are compensatory, since the logical traps of noncompensatory strategies are well known. The question is whether or not the TVA has really lived up to its norm of a checking and balancing strategy.

Looking at the Hartsville case it is very difficult to detect the form of the planning and management strategies. Unlike the well-controlled implementation process in which OEDC applies its project control system to assist in managerial decision making, the planning phase looks rather loose and informal. The actual planning strategies can only be extracted from a curious mixture of informal sequences of information collection and evaluation, defined more by the process through which they evolved than by any inspired policy. The foremost problem in realizing a compensatory strategy was the lack of well-defined goals and operationalized objectives. This leaves the question open: information for what and evaluation from which criteria? Possibly because goals and objectives were vague, no precise format was given either for the collection of information or for the evaluation. No formal rules for collecting and aggregating information and no analytical tools for the evaluation of the alternatives were applied. The results of the information collection process were thick, unreadable reports, usually accompanied by strong recommendations on the basis of one value aspect. These reports together with their short and abstracted summaries constituted the basis for the General Manager's and Board's evaluation and decision. Checking and balancing in the form postulated by the TVA management may have taken place during that process--in some part evaluations of the coordinating agencies, or in the evaluation of the Board--but certainly not in any well-defined and integrated fashion.

If there was not much analytical structure in the project planning for Hartsville, there was substantial organizational structure that determined the procedure and sequence by which alternatives were generated, screened, and evaluated. The interesting point is that this sequential procedure itself seems to contradict the TVA's claim of a compensatory checking and balancing strategy. In the Hartsville project and particularly in the siting problem, the TVA's planning strategy has a multistage sequence, in which alternatives are eliminated at each stage because they fail to meet the set criteria. Each stage taken by itself probably leads to a reasonable subselection. The problem is that these set criteria change because the various divisions have different goals and objectives, and not all divisions participate at each stage as equal partners.

Another aspect of the TVA's planning strategy that deserves attention is its deterministic nature. The reports often reduce doubt and complexity by stating certainties where in reality none exist. For example, demand and capacity estimates, as well as cost and time estimates, are usually given as a best point estimate or some average value. Or, in the evaluation of reactor safety, the reports simply discount the enormous consequences of disasters (which are described in much detail) on account of the small probability of their occurrence.

In short, the TVA's planning is characterized by a loosely structured highly sequential, and deterministic strategy. It is unclear how the staff check and balance information about alternative courses of action, and it is also unclear how the decision-making organs can assume a checking and balancing function on the basis of highly selected, preevaluated, deterministic information that comes to them in the form of a mass of data with a few simple recommendations.

4.2.5.2 Evaluation

The TVA's planning practice clearly falls short of its goal of checking and balancing. It is impossible to check and balance to establish trade-offs between various value dimensions, when goals are not formulated explicitly, objectives are not operationalized, and no format for information collection and evaluation is given. The only possible benefit of such an informal approach to planning is the prevention of conflicts, since possible sources of conflict are buried in the procedural planning detail, rather than brought out for discussion. The main negative aspect of such an informal approach is its susceptibility to biases, and prejudices in information collection and evaluation.

One such bias is a result of the sequential nature of the planning procedure together with the lack of a firm and formal goal structure. Since at each stage different goals are considered, and alternatives are almost exclusively selected on the basis of these special goals, the goals and criteria set at early stages receive undue weight in the evaluation and selection of alternatives. Consider, for example, the siting problem. A site that may be excellent from an environmental viewpoint may never be discovered or considered as a candidate, unless it managed to survive the screening of the Office of Power and OEDC. Now compare that with the information-processing and decision-making strategies in the problem of siting a multipurpose dam. In no way could the flood control staff be convinced that they should only look at alternatives that have been preselected by the Office of Power or by the Office of Agricultural Development.

Finally, the deterministic nature of the information on which planning decisions have to be based takes away an important aspect of risk-benefit trade-offs in managerial decision making. Conceptual risk reduction through ill-understood models (expected value models, net present value models, etc.) or vague notions of extremely small probabilities is another example of the shortcomings of the checking and balancing process in TVA strategy. When secondary objectives tended to be ignored in sequential information processing and evaluation, the trade-off between uncertainties and consequences of alternative courses of action also tended to be neglected. This may lead to the misevaluation of alternatives in which such probabilistic aspects play an important role. Nuclear reactor safety is only one example. Uncertain construction costs or construction completion dates are others.

There is some indication in the TVA that in the future the planning phase will be more structured and that it will have less of that element of biased sequential elimination. The site selection process, for example, changes rapidly. Non-power and non-engineering divisions have been asking for and are being given more lead time. They will participate to a greater extent in the early planning phases. In the Division of Power Resource Planning a study group researches possibilities for more structured power planning systems. If this means a step in the direction of more formal compensatory information processing and decision making, it will be a definite improvement over the present planning situation.

REFERENCES

[1] 91st Congress, *Public Law 91-190, National Environmental Policy Act of 1969*, S.1075, January 1975.

[2] Matuszeki, W., in *Regional Environmental Management*, Wiley, New York, 1975.

[3] Knop, H., ed., *The Tennessee Valley Authority Experience*, CP-76-2, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1976.

[4] Knop, H., ed., *Proceedings of the Joint UNEP/IIASA Meeting of Experts on Environmental Management*, CP-75-6, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1975.

[5] Greene, S., et al., *Rescued Earth*, University of Tennessee Press, Knoxville, 1948.

[6] TVA, *Annual Report for the Year 1938*, Knoxville, 1939.

[7] TVA, *Annual Report for the Year 1947*, Knoxville, 1948.

[8] TVA, *Annual Report for the Year 1953*, Knoxville, 1954.

[9] TVA, *Annual Report for the Year 1960*, Knoxville, 1961.

[10] TVA, *Annual Report for the Year 1973*, Knoxville, 1974.

[11] TVA, *1974 Directory of TVA Environmental Programs*, Knoxville, April 1974.

[12] TVA, *Organizational Bulletin, Division of Environmental Planning*, Knoxville, February 1975.

[13] Kinze, H.- H., H. Knop, and E. Seifert, *Volkswirtschaftplanung*, Berlin, 1974.

[14] Knop, H., and R. Tuch, *Environmental Assessment in Regional Planning*, presented at the HESC Conference, Kyoto, Japan, 1975.

[15] Derthick, M., *Between State and Nation: Regional Organizations of the United States*, The Brookings Institution, Washington, D.C., 1974.

[16] Moore, J., *The Economic Impact of TVA*, University of Tennessee Press, Knoxville, 1967.

[17] Porter, L., et al., *Behavior in Organizations*, McGraw-Hill, New York, 1975.

[18] TVA Code, Office of the General Manager, *Procedures for Environmental Planning and Assessment*, Knoxville, 1974.

[19] TVA, *Comparison of Coal Fired and Nuclear Plants for the TVA System*, Knoxville, 1966.

APPENDICES

Appendix 1: List of Participants in the IIASA Field Study of the TVA

A. Aganbegyan
Institute for Management and Organization of Industry
Siberian Branch of the Academy of Sciences of the USSR
Novosibirsk, 90
USSR

B. Milner
Institute of US and Canada Studies
Academy of Sciences of the USSR
2/3 Khlebny per.
Moscow, G-69
USSR

G. Popov
Moscow State University
Moscow
USSR

A. Straszak
Institute for Organization, Management and Control Sciences
KRN 55
Warsaw
Poland

R.C. Tomlinson
Operational Research Executive
National Coal Board
Coal House, Lyon Road
Harrow, Middlesex
UK

IIASA's Planning and Management of Large Organizations Project

C. Davies
H. Knop
R. Ostrowski
J. Owsinski
U. Tokhadze
J.O. Tomb
R. Tuch
D. von Winterfeldt

Appendix 2: Funding and Budget Allocation in the TVA

Table 1. Sources of funding for TVA Offices and divisions, 1973.

Offices and Divisions	Outside Sources in $ million	% from Office of Power	% from Non-power Sources
Division of Environmental Planning	9.4	68	32
Division of Water Control Planning	18.0	55	45
Division of Navigation Development and Regional Studies	2,5	8	92
Office of Engineering Design and Construction	826.0	96	4
Office of Agricultural and Chemical Development	18.0	2	98
Office of Tributary Area Development	1.5	-	99+
Division of Forestry, Fisheries, and Wildlife Development	10.4	23	77

Table 2. Allocation of TVA expenses for different years.

Area or Activity	Operating Expenses in $ Million						% of Total Expenses					
	1947	1953	1960	1964	1967	1973	1947	1953	1960	1964	1967	1973
Power	22.3	85.6	192.8	224.2	255.4	578.8	29.3	22.8	59.0	38.6	49.2	28.8
Flood Control	2.4	2.2	2.9	3.6	5.4	5.1	3.2	0.6	0.88	0.62	1.04	0.25
Navigation	2.9	2.6	3.3	4.3	4.9	5.9	3.8	0.7	1.0	0.74	0.94	0.29
Agriculture	4.1	0.2	1.4	3.0	8.8	1.5	5.4	0.07	0.42	0.51	1.51	0.07
Chemical	1.4	0.08	3.4	5.9	1.7	15.7	1.8	0.02	1.0	1.01	0.29	0.78
Ind. Devmt.	0.3	0.04	1.0	1.0	1.4	4.4	0.4	0.01	0.3	0.17	0.27	0.21
Forestry	0.8	0.64	0.5	0.9	1.0	1.3	1.0	0.17	0.15	0.15	0.19	0.06
Environment	0.09	0.15	-	0.1	1.1	5.0	0.12	0.04	-	0.01	0.21	0.24
Recreation	0.3	0.16	-	4.0	0.8	4.7	0.49	0.04	-	0.69	0.15	0.23
	Construction Expenses in $ Million						% of Total Expenses					
Power Generating Facilities	16.3	152.0	94.8	206.5	82.3	1224.0	21.4	40.4	29.0	35.6	15.8	60.8
Additions to Power Facilities	-	46.2	20.3	31.7	45.0	89.4	-	12.3	6.20	5.4	8.7	4.4
Multipurpose Facilities	5.4	5.7	0.1	19.4	21.6	0.3	7.0	1.0	0.03	3.3	4.16	0.03
Investigation for Fut. Projects	-	-	-	1.1	1.0	4.0	-	-	-	0.18	0.19	0.19
Total Power	21.7	203.9	115.3	258.9	150.0	1318.6	28.5	54.2	35.3	44.6	28.9	65.6
Manpower Navigation Facilities	-	-	2.8	10.1	0.08	5.3	-	-	0.85	1.7	0.01	0.26
Flood Control Facilities	-	-	-	-	0.4	0.5	-	-	-	-	0.07	0.02

Multipurpose Facilities	8.1	8.7	0.7	47.0	72.0	53.3	10.6	2.3	0.21	8.10	13.8	2.65
Chemical Plant	1.0	2.1	0.8	8.6	3.6	2.8	1.3	0.5	0.24	1.48	0.69	0.13
Recreation, Conservat. Education	-	-	-	3.3	19.0	3.7	-	-	-	0.56	3.6	0.18
General Plant	-	-	1.3	2.3	4.5	1.4	-	-	0.39	0.39	0.86	0.06
Total Non-power	9.1	10.8	5.7	73.5	87.4	68.6	11.9	2.8	1.7	12.6	16.8	3.4
Total Constr.	31.3	212.9	121.0	332.4	237.4	1387.2	41.1	56.6	37.0	57.3	45.7	69.0
Total Expenses	76.2	375.8	326.7	579.8	518.4	2010.1						

Table 3. Structure of TVA expenses (operation plus construction) for different years.

Area of Activity	Budget in $ Million (operation plus construction)						% of Total Expenses					
	1947	1953	1960	1964	1967	1973	1947	1953	1960	1964	1967	1973
Power	44.0	289.5	308.1	483.1	405.4	1897.4	57.8	77.0	94.3	83.3	78.2	94.4
Flood Control	2.4	2.2	2.9	3.6	5.8	5.6	3.2	0.6	0.88	0.62	1.11	0.27
Navigation	2.9	2.6	6.1	16.4	4.98	11.2	3.8	0.7	1.85	2.44	0.95	0.55
Agriculture	4.1	0.2	1.4	3.0	8.8	1.5	5.4	0.07	0.42	0.51	1.51	0.07
Chemical	2.4	2.18	4.2	14.5	5.3	18.5	3.1	0.52	1.24	2.49	0.98	0.91
Ind. Developmt.	0.3	0.04	2.3	3.3	5.9	5.8	0.4	0.01	0.69	0.56	1.13	0.27
Forestry	0.8	0.64	0.5	0.9	1.0	1.3	1.0	0.17	0.15	0.15	0.19	0.06
Environment	0.09	0.15		0.1	1.1	5.0	0.12	0.04		0.01	0.21	0.24
Recreation	0.3	0.16		4.0	0.8	4.7	0.49	0.04		0.69	0.15	0.23

Appendix 3. MM&CA Usage

Division Number	Symbol D&C System	Area/ Object	Character/ Purpose	Use: Demonstration Advisory	Use: Analysis	Use: Forecast	Use: Planning	Use: Operations Control	Connections	Remarks
OP-1	$P^{611}_{t\ell}$	Reliability analysis for power generation units	Calabrese-type probabilistic model for generation additions planning		XXX	XXX	X		$P^{612}_{t\ell}$	Results used as recommendations for higher level management--to be incorporated in OP-2
OP-2	$P^{612}_{t\ell}$	Generation system expansion	SAGE--a probabilistic model for optimal planning of power generation additions		XXX ...	XXX ...			$P^{611}_{t\ell}$ $P^{613}_{t\ell}$ $D^{411}_{t\ell}$ same as above + $P^{614}_{t\ell}$, $D^{412}_{t\ell}$, $P^{619}_{t\ell}$, $E^{711}_{t\ell}$, $Q^{21}_{qt\ell}$, $L^{31}_{iqt\ell}$, $D^{441}_{t\ell}$	See above; planned is the system incorporating OP-1 for integrated model
OP-3	$P^{613}_{t\ell}$	Generation system simulation	Longer period systems behavior simulation for expansion costing--Booth-type probabilistic model		XXX	XXX			$P^{612}_{t\ell}$ in future: similarly as $P^{612}_{t\ell}$	

Division Number	Symbol D&C System	Area/ Object	Character/ Purpose	Use: Demonstration Advisory	Use: Analysis	Use: Forecast	Use: Planning	Use: Operations Control	Connections	Remarks
OP-4	$P^{614}_{t\ell}$	Transmission system planning	20- & 10-year development programs determined on the basis of the future situation modeling and load forecasts of substations		XXX	XXX	XX		$P^{612}_{t\ell}, P^{613}_{t\ell}, D^{411}_{t\ell}$ $Q^{21}_{at\ell}, L^{31}_{iqt\ell}, D^{441}_{t\ell}$	Planned one is the simplified system for the integrated model purposes
OP-5	$D^{411}_{t\ell}$	Load forecasting	Long (20 & 10 years ahead and up until year 2000) medium (1 year or more) load forecasts and load characteristics (elasticities)		XXX	XXX	XX		$P^{612}_{t\ell}, P^{614}_{t\ell}$	
OP-6	$D^{412}_{t\ell}$	Revenue forecasting	Revenue forecasts made for financial purposes on the basis of load and price forecasts		XX	XXX			$D^{411}_{t\ell}$ in future: $Q^{21}_{at\ell}, L^{31}_{iqt\ell}, D^{441}_{t\ell}$ $D^{41}_{it\ell}$	

OP-7	P^{615}_{tl}	Wholesale billing	Wholesale customers power billing on the basis of magnetic tape cartridges in the substations	XX			XXX	($D^{411,2}_{tl}$ eventually)	
OP-8	P^{616}_{tl}	Rule curves determination	Basic and economy rule curves are determined for guiding power discharges at hydrostations with regard to inflow forecast and generation needs, each 4 months		XX	XXX	XXX	P^{617}_{tl}	The rerunning of these procedures is caused mostly by changes in hydropower operations
OP-9	P^{617}_{tl}	Economic power dispatching	Optimization system for minimizing losses of production and distribution of power, based on incremental losses balance principle				XXX	$P^{616,8}_{tl}$ $P^{622,4}_{tl}$	Run on the previous day, and each half hour on the current day
OP-10	P^{618}_{tl}	Short-term load forecasting	Monthly and shorter load forecasts with hourly breakdown, next-day load forecast				XXX	P^{617}_{tl}	Also manually performed

Division Number	Symbol D&C System	Area/ Object	Character/ Purpose	Use: Demonstration Advisory	Use: Analysis	Use: Forecast	Use: Planning	Use: Operations Control	Connections	Remarks
OP-11	N^{11}_{itl}	National economic trends	Wharton econometric forecasting model will provide other modules of the Integrated Power Planning system with basic socioeconomic data: population, income, living standard, income distribution, productivity and costs, sectoral and industrial growth rates, etc.		XXX	XXX	X		P^{619}_{tl}, D^{411}_{tl} Q^{21}_{atl} L^{31}_{iqtl} D^{441}_{tl} D^{41}_{itl}	Subscribed to by Power Resource Planning Branch
OP-12	P^{619}_{tl} C^{511}_{tl}	Power costing	Three planned modules for future system: -Plant capital cost; -Fossil fuel unit cost; -Nuclear fuel component cost		...	...	..		$P^{612,3}_{tl}$ N^{11}_{itl}	

OP-13	$E^{711}_{t\ell}$	Environmental accounting	Planned module for computing discharge characteristics as a function of electric generation of a plant; can be used for manual controlling of the plant operations	..	...	...	.	$P^{612}_{t\ell}$		
WCP-1	$P^{621}_{t\ell}$	Inflow forecasting	Forecasts of inflows into reservoirs from uncontrolled drainage basins, based on observed and predicted rainfall for the next day or few days				XXX	$P^{624}_{t\ell}$		
WCP-2	$P^{622}_{t\ell}$	Tributary reservoirs level forecasting	Based on all-year average rainfall and inflow the short-term (e.g.,10 days) level forecasts are given			X	XXX	$P^{617}_{t\ell}$ $P^{621,4}_{t\ell}$		
WCP-3	$P^{623}_{t\ell}$	Water operations planning	-Weekly time-step planning and operation model (for year and more);	XXX	XXX	XXX	XX	($P^{617}_{t\ell}$,$D^{411}_{t\ell}$ for short term: $P^{621,2,4,5,6,8,9}_{t\ell}$)	The result will be the multivariate guide curves, adjustable to given conditions	

Division Number	Symbol D&C System	Area/ Object	Character/ Purpose	Use: Demonstration Advisory	Use: Analysis	Use: Forecast	Use: Planning	Use: Operations Control	Connections	Remarks
WCP-3 (continued)			-Daily time-step planning and operations model with feedback to weekly models; Based on dynamic programing with power and flood control objective function							
WCP-4	$P^{624}_{t\ell}$	Water routing	Manual routine procedure based on inflow prediction and generation schedules					XXX	$P^{621,2}_{t\ell}$, $P^{617}_{t\ell}$	
WCP-5	$P^{625}_{t\ell}$ / $E^{712}_{t\ell}$	Steady water flow	Quantity and quality of water model for the overall impact analysis		XXX		XX			
WCP-6	$P^{626}_{t\ell}$ / $E^{712}_{t\ell}$	Heat transport in water	Approximate heat transport models for steam-plant cooling analyses		XXX		XX		($P^{623}_{t\ell}$) $P^{629}_{t\ell}$	

WCP-7	$P^{627}_{t\ell}$ ------ $E^{722}_{t\ell}$	Quality/ biology of water	Multivariate ecosystem modeling by simulating on the basis of each ecosystem's element's equations	...	...	.			
WCP-8	$P^{628}_{t\ell}$	Transient water flow	SOCH package models for routing the emergency inflows			X .	XXX ...	($P^{623}_{t\ell}$) $P^{617}_{t\ell}$ $P^{624}_{t\ell}$	Planned is the SOCH-type model to be incorporated to WCP-3 daily-step mode
WCP-9	$P^{629}_{t\ell}$	Generation and release system simulation	Steam and hydroplants generating schedule and release simulation for planning system's purposes	XXX	XXX	X		($P^{623}_{t\ell}$) $P^{626}_{t\ell}$	
NDRS-2	$Q^{21}_{at\ell}$	Regional population and labor force	Simulation model for projecting population and labor force up till year 2020	XXX	XXX			$P^{612,3,4,5,9}_{t\ell}$ $D^{411,2}_{t\ell}$, $L^{31}_{iqt\ell}$ $D^{441}_{t\ell}$, $N^{11}_{it\ell}$, $D^{471}_{t\ell}$, $D^{41}_{it\ell}$	
NDRS-2	$L^{31}_{iqt\ell}$	Regional employment	Simulation model for projecting the employment up till year 2020	XXX	XXX			$P^{612,3,4,5,9}_{t\ell}$ $N^{11}_{it\ell}$, $D^{411,2}_{t\ell}$ $Q^{21}_{at\ell}$, $D^{441,71}_{t\ell}$, $D^{41}_{it\ell}$	

Division Number	Symbol D&C System	Area/ Object	Character/ Purpose	Use: Demonstration Advisory	Use: Analysis	Use: Forecast	Use: Planning	Use: Operations Control	Connections	Remarks
NDRS-3	$D^{441}_{t\ell}$ / $E^{741}_{t\ell}$	County allocation and land requirements	Allocation of economic growth to counties; land requirements for this growth; simulated projections till year 2020		XXX	XXX			$Q^{21}_{at\ell}$, $L^{31}_{iqt\ell}$, $D^{41}_{it\ell}$	
NDRS-4	$P^{61}_{it\ell}$	Plant location	Simple transport minimization optimal location system	XX Seemingly never used	XX					
NDRS-5	$D^{471}_{t\ell}$ / $E^{771}_{t\ell}$	Environmental analysis	-Community growth and land requirements projections; -Other considerations		...	...	...		$Q^{21}_{at\ell}$, $L^{31}_{iqt\ell}$, $D^{411}_{t\ell}$	Part of the planned socio-economic regional model based on NDRS-1,2
NDRS-6	$D^{41}_{it\ell}$	Income and product sector	Population income and other related indices projections		...	...	...		$Q^{21}_{at\ell}$, $L^{31}_{iqt\ell}$, $D^{441}_{t\ell}$	Same as above

NDRS-7	$D^{461}_{t\ell}$	Recreational demand	Projections of recreational demand based on income, population and employment forecasts		...	...	$Q^{21}_{at\ell}, L^{31}_{iqt\ell}, D^{441}_{t\ell}$, $D^{41}_{it\ell}$	
FF&WD-1	$P^{641}_{t\ell}$	Individual forest management	WRAP--an advisory system for individual forest owners determining the optimal management policy according to owners' objectives	XXX	XXX		($E^{742}_{t\ell}$ in future)	
FF&WD-2	$E^{742}_{t\ell}$	Land analysis	Computerized mapping (SYMAP) of the region on cell basis along with synthetizing and retrieval programs	XXX	XXX	XX	$P^{641}_{t\ell}$, $E^{743,4,5,(6)}_{t\ell}$	Based on data base system 2000 (in coop. with Nat. Sc. Found. and Oak Ridge Nat. Lab.)
FF&WD-3	$E^{743}_{t\ell}$	Fish resources	Data base activity similar to FF&WD-2 and to be incorporated into it in the future	XXX	XXX	XX	($E^{742}_{t\ell}$ in future)	Data base same as above

Division Number	Symbol D&C System	Area/ Object	Character/ Purpose	Use: Demonstration Advisory	Use: Analysis	Use: Forecast	Use: Planning	Use: Operations Control	Connections	Remarks
FF&WD-4	$E_{t\ell}^{744}$ / $P_{t\ell}^{642}$	Forest resources	Data base (SYMAP) on forest resources, but not yet compatible with FF&WD-2	XXX	XXX	XX			Same as above	Data base same as above
FF&WD-5	$E_{t\ell}^{745}$ / $P_{t\ell}^{643}$	Regional land use monitoring	A set of approaches based on FF&WD-2:							Not computerized procedures involving various MM&CA mainly FF&WD-2
			-Assessments of land use conflicts before they occur;	XXX	XXX	XXX				
			-Environmental impact assessment can be simplified (e.g., powerline location system);	...	...	...	...		$E_{t\ell}^{742}$	
			-Land management decision system: for any specified area	XXX	XXX	XXX	XXX			
FF&WD-6	$E_{t\ell}^{746}$ / $P_{t\ell}^{644}$	Regional natural resources	A planned system that will combine efforts FF&WD-1 through FF&WD-5	...	...	...	...		$E_{t\ell}^{742,3,4,5}$	

DEP-1	E_{tl}^{721}	Water quality management	Liquid wastes treatment alternatives with some cost considerations	XXX	XXX	XXX		
DEP-2	E_{tl}^{722}	Oxygen in deep reservoirs	Dynamic model of dissolved oxygen depletion		XXX	XXX		
DEP-3	E_{tl}^{747}	Stack gas control	Intermittent control of stack gases based on several developed plume behavior modes				XXX	Used by the TVA plants
OACD-1	P_{tl}^{631}	Farm management	LP* package used for each of the "rapid adjustment" program farms at the beginning of 4-year program	XXX			XXX	Full operation given to land-grant universities extension service
OACD-2	P_{tl}^{632}	Farm recording	Computer farm recording and bookkeeping	XXX			XXX	Same as above

*Linear Programing

Division Number	Symbol D&C System	Area/ Object	Character/ Purpose	Use					Connections	Remarks
				Demonstration Advisory	Analysis	Forecast	Planning	Operations Control		
OACD-3	P^{651}_{tl}	Least cost bulk bleeding	LP package for determining least cost mixes of raw materials with various cost considerations	XXX				XXX		Given to and available on the GE and CDC time-sharing systems
OACD-4	P^{652}_{tl}	SO_2 removal	Two studies were conducted: -Least cost SO_2 lime removal, and -Cost and investment analysis for various SO_2 removal processes	XXX	XXX					On the request of the EPA
OACD-5	P^{653}_{tl}	Production planning	An LP optimization system for production planning with pseudo-dynamic structure, 800 rows				XXX	XXX		
OACD-6	P^{654}_{tl} ------ C^{551}_{tl}	Freight rates	A data base for freight accounting. Consists of 35		XXX	XXX		XXX	P^{655}_{tl} D^{451}_{tl}	Run on GE time-sharing system

			main inventory along with 20 short mileage tapes								
OACD-7	$P^{655}_{t\ell}$	Order management	Automatic allocation and billing of fertilizer orders, based on the OACD-6 data base					XXX	$P^{654}_{t\ell}$		Run on the GE time-sharing system
OACD-8	$D^{451}_{t\ell}$ / $C^{552}_{t\ell}$	Removal by product marketing	Analysis of the marketing possibilities for removal byproducts and market impact caused by these products; based on the OACD-6 data base	XXX	XXX	XXX	XXX		$P^{654}_{t\ell}$		
OACD-9	$D^{452}_{t\ell}$	Fertilizer market	A data base on fertilizer producers and processes with appropriate report generators	XXX							
OACD-10	$P^{656}_{t\ell}$	Potential fertilizer use and production	System of determination of possible fertilizer products and locations and possible use, for underdeveloped countries	XXX							

Division Number	Symbol D&C System	Area/ Object	Character/ Purpose	Use: Demonstration Advisory	Use: Analysis	Use: Forecast	Use: Planning	Use: Operations Control	Connections	Remarks
OACD-11	$N_{t\ell}^{131}$	US agriculture	LP US agricultural model: 2100 constraints (equalities) 8056 variables 44710 nonzero elements (0.25%)		XXX	XXX				Now not run, but possibly in the future on more constant basis
OACD-12	$D_{t\ell}^{431}$	Soyabean processing	LP model, similar to the previous one but smaller, used for determining potential soyabean production and processing locations	XXX	XXX	X				
GM-1	$P_{t\ell}^{691}$	Personnel data base	The data base will consist of personal, financial, medical and hazard control data				...	...		To be implemented with the use of system 2000
GM-2	$P_{t\ell}^{681}$	Medical care	An automatic electrocardiogram analysis and	XXX				XXX		Same as above

			diagnosis data base and utility system		
GM-3	P^{692}_{tl} / P^{6110}_{tl}	Project costs	A reporting system on financial, budgeting, manhours and quantity data of current project statuses. It will enable a comparison with private business costs	...	
GM-4	P^{693}_{tl}	Accounts payable	Automatized accounts payable system to be executed in three stages, after completion of which the system, based on GM-5, will automatically process all material purchase requests	...	P^{694}_{tl}
GM-5	P^{694}_{tl}	Material management	An MMS, designed by Cresap, McCormick and Paget firm,	...	P^{693}_{tl} (P^{695}_{tl})

Division Number	Symbol D&C System	Area/ Object	Character/ Purpose	Use: Demonstration Advisory	Use: Analysis	Use: Forecast	Use: Planning	Use: Operations Control	Connections	Remarks
GM-5 (continued)			first of all will be implemented for Power Stores							
OEDC-1	P_{tl}^{695}	Material and equipment monitoring	MEMS is used for scheduling and retrieving the flow of requisition and procurement for construction needs				.	...	(P_{tl}^{694})	
OEDC-2	P_{tl}^{696}	DED document control	Maintenance system for various kinds of documents and other materials					...		
OEDC-3	P_{tl}^{698}	Critical path method for project control system	CPM analysis and control package was continuously used and updated during the Brown's Ferry construction, use in Sequoyah, Watts Bar and Muscle Shoals				X	XXX		

OEDC-4	P^{697}_{tl} / E^{713}_{tl}	Preliminary Safety Analysis Report	PSAR developed for Sequoyah is now being entered into a computer data base to serve for Watts Bar	X?	XXX
OEDC-5	P^{696}_{tl}	Design control and monitoring	Data handling and analysis system for monitoring the design phase of project: scheduling, progress, man-hour et al. reports	X	XXX
OEDC-6	P^{698}_{tl}	Project control system: a cost processor	One of two main modules of the PCS destined to productivity, man-hour, duration and progress reports generation	X	XXX

Listed in this table are 60 major MM&CA of the TVA. Many of existing and used MM&CA were not listed because of their relative unimportance for the purposes of this paper (e.g., a great number of MM&CA used in design and construction). Symbols in parentheses mean future or planned connections (which for planned or tested MM&CA is obvious, and the adequate symbols were not put into parenthesis). Information as of Fall 1975.