

# Practice in Development and Management of The Yangtze Three Gorges Project

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# PRACTICE IN DEVELOPMENT AND MANAGEMENT OF THE YANGTZE THREE GORGES PROJECT

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**ABSTRACT:** The Yangtze Three Gorges Project (TGP) is the largest multi-purpose water conservancy complex in the world nowadays. After seventy years of planning, design, verification and final decision-making, the implementation of TGP was initiated in 1993. The practice of the project development and management over the past eleven years is featured with further understanding about the nature and objective world, the application of advanced engineering technologies in a scientific and rigorous manner and the execution of construction and management through both considering practical situations and trying to open up a creative path. In 2003, the project achieved the scheduled milestone objectives of initial reservoir impoundment, ship-lock navigation and power generation of the first units. At present, with the phase III construction under way, the project has entered a stage featured simultaneous project construction and operation. And the whole project will be completed in 2009.

## 1. INTRODUCTION TO PROJECT MANAGEMENT

Project management refers to the efforts of organization and control in the course of project implementation for the purpose of achieving established project goals. Organization means a management mechanism, i.e., establishment of responsibilities, power and authority for all involved construction parties. Control efforts run through the whole process of a project.

A comprehensive concept of an engineering project management should cover a number of

activities such as the assessment of natural resources, ecology and environment, social demands, community culture and economic benefit, project planning, investigation and design, project verification, decision-making, engineering design, implementation planning, managerial mechanism and organizational structure, project construction, construction supervision, fund raising, acceptance and final accounting, production and operation and operation management. A complete management process for a project can be divided into three stages:

| Stage 1                                    | Stage 2                               | Stage 3                          |
|--|---------------------------------------|----------------------------------|
| Management for pre-project decision-making | Management for project implementation | Management for project operation |

Respective objectives, organizational systems and operation modes are to be established in the three stages.

The first stage (Stage 1), i.e. the management for pre-project decision-making involves the proposal of project, exploration, analysis and evaluation of objective matters, assessment of social and natural environment and economic and technologic conditions, as well as definition of final goals. In another word, an answer has to be given to the question of why the project should be proposed, what the costs and benefits are and whether there are sufficient conditions for project implementation. That is to say, it is required to

complete a feasibility study and to go through the decision-making procedures with common recognition by the government and the public.

The second stage (Stage 2), i.e. the management for project implementation, involves an effective organization of various participating groups, under conditions of limited funds, materials and human resources, so as to realize “three controls” of project cost, schedule and quality, to complete the overall “hardware” construction of the project and to achieve anticipated functional objectives.

The third stage (Stage 3), i.e., the operation management of the project, involves the fulfillment of safe and stable operation through rigorous management in production and operation with the

established “hardware” to meet market needs and to achieve the anticipated and optimum objectives.

For any projects, inconformities with and deviations from original plans will occur inevitably during the implementation stage, no matter how accurate the initial planning is. In this case it is necessary to correct the deviation and modify the plan based on the feedbacks and then take actions accordingly until the final goals of the project are achieved. Due to insufficient knowledge about the natural conditions, it is possible to make mistakes in defining project goals and so it is necessary to make modification in project goals. The

occurrence of deviations is caused by the subjective and objective factors. The deviation caused by subjective factors generally results from the subjective actions of decision-makers, managers and executors and can be corrected in a direct control way. The deviation caused by objective factors always results from unpredictable changes in natural or social conditions, so the implementation plan must be rectified against the objective conditions.

Fig. 1 shows the procedures for project management:

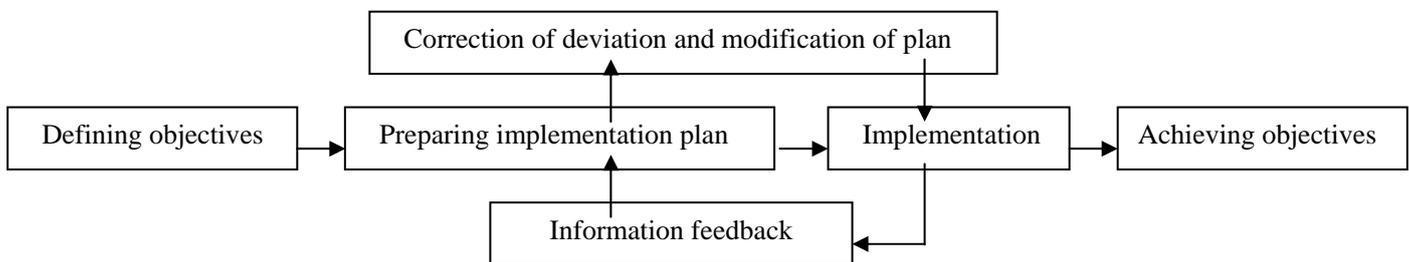


Figure 1 Diagram of the Project Management Procedures

## 2. BACKGROUND AND PROCEDURES OF TGP DECISION-MAKING --- MANAGEMENT AT STAGE 1

The envisagement of the Yangtze Three Gorges Project was proposed at first by Dr. Sun Yat-sen in 1919 in his “The Industrial Development of China”. It underwent a long period till 1993 when it was put into implementation after continuous explorations and deepened understanding of the nature, the Yangtze River and the river basin by several generations of the Chinese people. The Yangtze River is the longest and also the most important river in China with a catchment area of 1.8 million km<sup>2</sup>, covering 18.7% of the whole territory of China, and a water resources volume of 961.3 billion m<sup>3</sup>/year, making up 34% of the total of the country. It is called the Mother River that has nurtured the Chinese nation, but also brought a lot of catastrophes to the Chinese nation. Due to natural changes and population growth in the river basin, the Yangtze has become an unsteady river with flood disasters frequently occurring. Serious flood disasters that can hardly be defended against

occur once almost every ten years in history, resulting in huge losses to the people’s lives and property and restricting the steady development in China’s economy. In order to safeguard the cities and towns, the widespread farmland and people’s lives and property along the river, it is necessary to harness the Yangtze River and at the same time to make full use of its water resource. Through over 70 years’ continuous efforts, a great deal of social investigations, geologic surveys, long-term hydrologic observations, large-scale scientific experiments, multi-alternatives planning and design and phased evaluations in different historical periods were conducted. With the authorization of the State Council, 412 senior scientists, engineers, local representatives and experts in relevant fields were organized in 1986 to carry out scientific verifications for TGP Project in 14 thematic topics, which lasted as long as 4 years. In 1990, a Feasibility Study Report for TGP project was submitted to the State Council, which organized the high-profile senior experts to make a

final review. In 1991, the State Council submitted to the National People's Congress the Feasibility Study Report on TGP and the Final Review. On April 3, 1992, the Resolution on Construction of the Yangtze Three Gorges Project was adopted by vote at the Fifth Session of the Seventh National

People's Congress. Up to that time the procedures for pre-project decision-making were completed and from then on the project entered the implementation phase.

The framework of the feasibility study and verification for the TGP project is shown in Fig. 2:

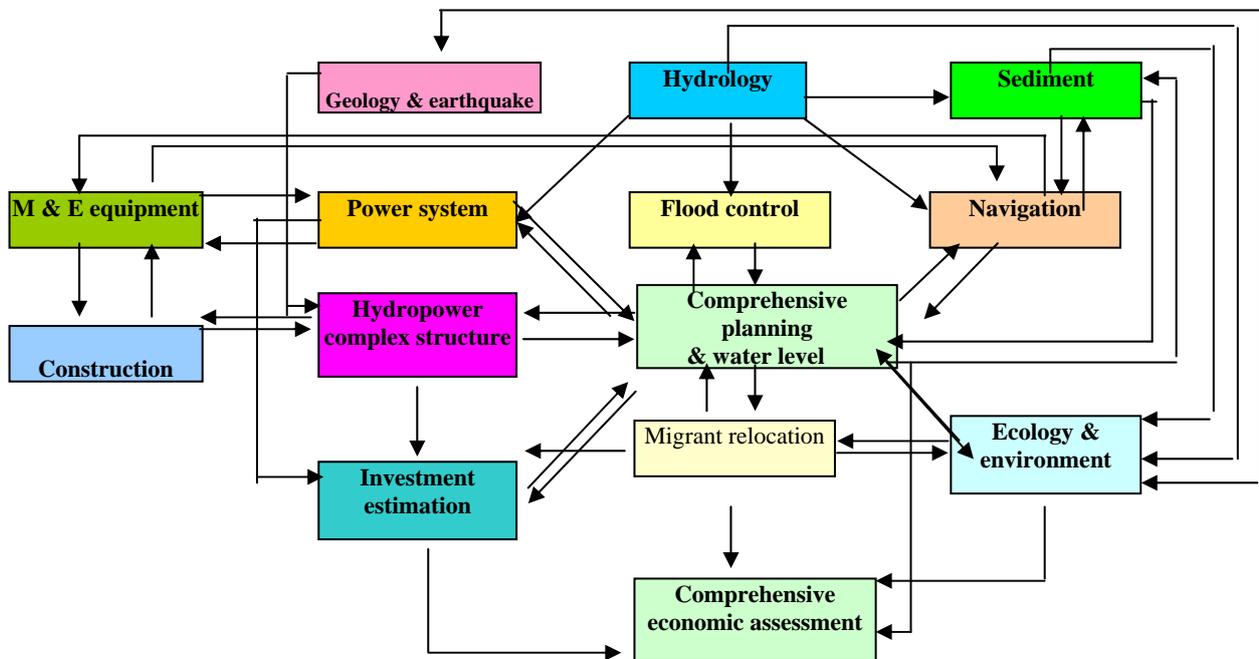


Figure 2 Framework of the Feasibility Study and Verification for TGP

### 3. IMPLEMENTATION MANAGEMENT OF TGP --- MANAGEMENT AT STAGE 2

#### 3.1 General of TGP

The Yangtze TGP is a key backbone project for harnessing and controlling the Yangtze River with huge scale and outstanding benefits. It is also one of the largest water conservancy projects in the world and a world-class multi-purpose project.

TGP dam is located at Sandoupin, Yichang City of Hubei Province, 40 km upstream of Gezhouba Hydropower Complex. It has huge economic and social benefits such as flood control, power generation, navigation and irrigation. TGP mainly consists of the dam, powerhouse, navigation facility and Maoping protection works. The spillway is located in the middle part of the riverbed, with powerhouse intake sections and non-overflow section arranged at two sides. The powerhouses are located behind the intake sections, while the permanent navigation facility is arranged

on the left bank. The dam is of a concrete gravity type with the dam axis of 2309.5m, crest elevation of 185m and maximum height of 181m. The TGP reservoir with the normal pool level at EL 175m and the flood control level at EL 145 m has a total capacity of 39.3 billion m<sup>3</sup>, of which 22.15 billion m<sup>3</sup> is for flood control. The maximum flood discharging capacity of the complex is 102500m<sup>3</sup>/s. The two powerhouses on the left and right banks accommodate fourteen and twelve 700MW hydro turbine-generating units respectively, with the total installed capacity reaching 18200 MW. The construction of TGP adopts a scheme of one-step development, staged impoundment and continuous resettlement.

The first important objective for TGP is flood prevention and alleviation of flood disasters at the middle and lower reaches of the Yangtze River. It will make use of the huge capacity of TGP reservoir for flood regulation and retention and to reduce peak flow discharged downstream, so that the flood control

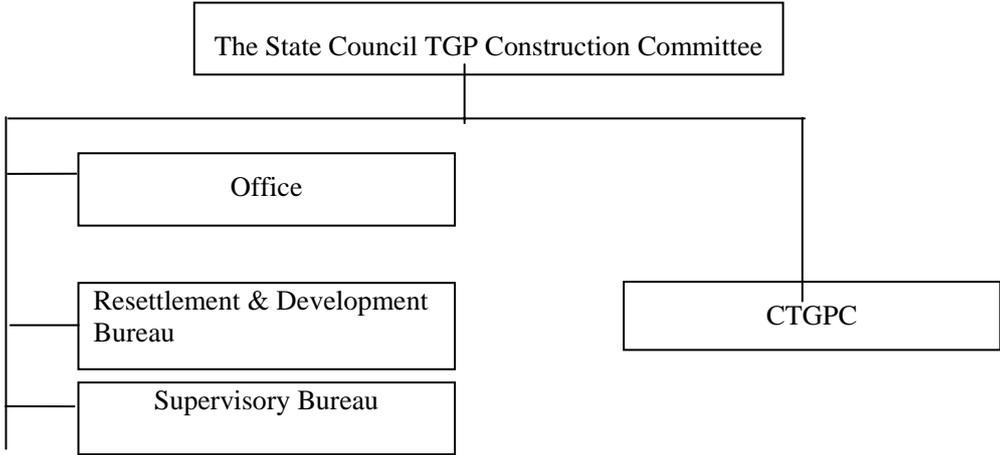
capacity at Jingjiang section downstream can be enhanced from the original of ten-year frequency to that of 100-year frequency. Upgrading the flood prevention capacity at Jingjiang section and its downstream areas and reducing the flood pressure on Jingjiang embankment is the most significant social benefit the project produces. The second objective is power generation. With the construction of TGP, the abundant water resources of the Yangtze can be utilized to produce huge quantities of clean energy. The multi-year average power generation of the station is 84.7 billion KWH. Sales of the electricity will be the most direct economic benefit of the project, with which the huge amount of investment can be recovered. The third objective is to improve the navigation conditions. The impoundment of TGP reservoir can remarkably improve the river course. The one-way annual freight transportation capacity of the navigation facilities can reach 50 million tons, allowing 10000-tonnage fleets to sail from Shanghai upstream to Chongqing, and this will play a promoting role in the development of the western regions in China. The construction of TGP will bring huge political, economic, social and environmental benefits to the Yangtze Basin and even to the whole country, and will produce a far-reaching significance, conforming with the fundamental interests of the community, so it is the actual practice of the “Three Represents”.

**3.2 Management Framework for Construction of TGP**

In 1993, the State Council Three Gorges Project Construction Committee was established with the Premier as the Chairman of the Committee and ministers of relevant ministries and governors and mayors from provincial or city governments as the committee members, constituting the top decision-making authority for all major issues involved in the development of TGP.

In order to enforce the instructions and resolutions from the State Council Three Gorges Project Construction Committee and to deal with and coordinate the routines, an office was established under the Committee. As TGP necessitates a relocation of 1.13 million of population, which is a complicated and difficult social task, the Resettlement and Development Bureau was set up under the Committee to formulate the resettlement policies, coordinate the resettlement plans and supervise the implementation of the resettlement plans. In order to ensure the successful construction of TGP and curb any violation of rules or regulations, a supervisory bureau was set up under the Commission.

The whole organizational structure of TGP management system is shown in Diag. 3:



Diag. 3 Organizational Structure of TGP Management System

With the approval of the State Council in September 1993, China Three Gorges Project Corporation (hereinafter referred to as CTGPC) was established as the legal representative of the

project, the owner for the project development and the economic entity taking full responsibilities for construction management of Three Gorges Project, fund raising for the project construction

and resettlement program and repayment of all debts, as well as for the operation management of the Three Gorges Hydropower Plant and Gezhouba Hydropower Plant, and the continuous development of water resources in the upper reaches of the Yangtze River with revenues from the hydropower plants.

### 3.3 Implementation Management of TGP

CTGPC undertakes the whole-process management for the development of TGP. To comply with the market economic mechanism, the management systems of legal body responsibility, contracting through bidding, project supervision and contract management have been adopted in the construction of TGP.

#### 3.3.1 Management for TGP design

The quality and standard of a design is crucial to the success of a project. The Changjiang Water Resources Committee under the Ministry of Water Resources is entrusted with the design of the TGP. The design is divided into following stages:

Feasibility study report --- reviewed and approved by the State Council;

Preliminary design --- reviewed and approved by the State Council Three Gorges Project Construction Committee;

Technical design --- reviewed and approved by the Technical Commission organized by CTGPC;

Tendering design --- approved by CTGPC;

Detailed drawings for construction --- approved by the Construction Department of CTGPC and the construction supervisors.

#### 3.3.2 Decision-making of important issues in TGP implementation process

A number of major issues in both design and construction phases of TGP call for an accurate and resolute decision-making, which plays a key role in avoiding detours and ensuring the success of TGP. The past eleven years is a process of fully absorbing state-of-the-art science and technology from home and abroad on the basis of widely

seeking and absorbing opinions from experts and experienced personnel, and taking into full account of the actual conditions of TGP, striving for breakthroughs from former experiences and conventions; giving full play to collective wisdom and encouraging creative thought so that a series of important decisions made for management and technical issues prove to be successful and effectively ensure the smooth implementation of the project. Here are some examples.

- (1) The access transportation scheme --- TGP is huge in its construction scale with the annual peak concrete placement of over 5.4 million m<sup>3</sup> and annual transportation volume of cement, steel and various materials of more than 2 million tons. Various kinds of super-large and heavy components, steel structures and M&E equipment, as well as passenger flow of over 10000 persons daily are transported via the Three Gorges access highways. Through repeated discussions and verification, decision was finally reached to give up the original scheme of a special railway line, but to adopt a transportation scheme of combining an over 30 km high-grade and fully-closure quasi-class I mountainous highway with the Yangtze River navigation course, thus achieving a high-speed transportation and avoiding ineffective investment. Since it came into use nine years ago, the access highway has been in normal operating with the scheduled transportation tasks being fulfilled.
- (2) Sand manufacturing system scheme --- The Three Gorges dam area is short of natural sand. And exploring sand from the riverbed will destroy the river regime and also involve a long transportation distance of over 100km, so it was decided to adopt the artificial sand scheme. Xia'anxi, 10km away from the dam site with mica contents 5% lower than the national standard was chosen instead of the limestone site 30km away from the dam site originally selected. Repeated tests demonstrated that the manufactured sand has a good quality and can guarantee the quality of concrete for the dam.

- (3) Concrete construction scheme --- The total concrete volume for TGP dam reaches 28 million m<sup>3</sup>. It is planned that the maximum yearly placement shall amount to about 5 million m<sup>3</sup>, monthly maximum of 500000 m<sup>3</sup> and daily maximum to 20000 m<sup>3</sup>, which are required by the overall schedule of TGP with the peak intensity breaking the world record. Through repeated analysis, it was decided to abandon the conventional method of horizontal transportation with truck and concrete placement with tower crane, but to adopt a continuous transportation and placement scheme that had not yet been widely applied at home or abroad. With this scheme, concrete produced from batching plants is directly conveyed into pours via belt conveyor, overhead self-climbing belt gantry and tower-belt conveyor, so that the world record of annual concrete placement volume of 5.48 million m<sup>3</sup> was made in 2000 and both the progress and quality of the dam construction was guaranteed.
- (4) Decision-making in splitting the project into packages for tendering and Management -- TGP is huge in scale so that no single contractor in China could have sufficient capability to undertake a whole contract for the complete construction of the project. Based on the actual conditions of domestic contractors and the features of TGP, it was decided to split the project into packages for bidding and management supported by overall coordination in view of the characteristics of relatively independent functions and structures of the different components of TGP. It is proved in practice that this decision suits the actual conditions and can guarantee the progress and quality of the project.
- (5) Dam area construction scheme ----It takes of 17 years to complete TGP. Therefore a good environment in the dam area will have a positive impact on construction in a civilized manner, improvement of living standard and health of the constructors and protection of ecologic environment. An enclosed management for the dam area has been

adopted where the permanent apartments and office buildings of 400000 m<sup>2</sup> have been built instead of the temporary houses with a floor space of 800000m<sup>2</sup> that were originally planned. The area is also equipped with public facilities for culture and sports activities, catering and shopping and covered with large stretches of gardening land, achieving the goal of “construct a top-quality project and create a first-class environment”, and reducing the construction cost and ensuring simultaneous and harmonized construction of the project and the environment.

### 3.3.3 Bidding Management for TGP

The system of contracting through bidding has been employed in TGP, thus introducing the market competition mechanism to select the contractors and invite bids for packages to optimize combinations of the construction teams.

The principles for tendering are strictly observed, i.e., open bidding, fair competition impartial evaluation and collective decision-making. The stringent bidding procedures are formulated based on these principles, including preparation of bidding documents, public issue of the approved bidding documents, bidders' preparing of their own bidding documents and finally opening the bids in public under the supervision of the representative of notary institutions. CTGPC invites qualified external experts to make bid evaluation, who give the weighted scores to the bidders by taking into account quotation, performance, technology and reputation according to the features of different works and produce a summary priority sequence and finally submit it to CTGPC for its management to make collective decision and grant bid award. In order to go through these integral procedures, various internal and external interferences must be got rid of and any non-regularized actions must be restricted so as to ensure the tendering process to proceed in a normal way. Bidding is a kind of means and measures aimed at choosing right contractors that are most beneficial to TGP.

Since the Law for Tendering was promulgated and came into force, the bidding procedures have been standardized and perfected and lawful bidding work has been exercised. CTGPC has established a bidding committee responsible for the bidding operations and suspended bid evaluation by negotiation for some small projects. The Three Gorges International Tendering Co., Ltd, with CTGPC as its shareholding company, takes the acting responsibility for the whole bid invitation and evaluation process and a bid evaluation expert team engaged according to the relevant laws and regulations for bidding makes the independent review and assessment.

Since TGP started its construction 11 years ago, all the contracts completed or under implementation are carried out by the contractors chosen via public bid competition. It is proved by the practice that this bid competition management system is successful without any major deviations.

### **3.3.4 Contract Management of TGP**

After bid is officially awarded and contract negotiation starts, the contract will be entered into by two parties through negotiation according to the terms and conditions agreed in the bidding documents and bid proposals. The contract value for various TGP works, for example, the contracts for spillway dam, powerhouse intake section, powerhouse structures and ship-lock is huge. The maximum value reaches RMB 6.685 billion Yuan with a period of several years. We make use of the internationally- recognized FIDIC terms as reference for our contract text. Two forms of contract i.e. unit price and total price are adopted according to different work activities and actual conditions of our country. Fixed price and floating price can be used in the light of different durations of contract. The Owner makes an advance payment around 15% to 20% at the beginning of a year on the basis of the scheduled work quantity of the year and makes installment every month with deduction from the advance payment against the ratio of work finished to the yearly quantity month by month. In each installment, the owner will detain 3%~5% as the quality assurance bond which

will be made to the contractor in final settlement. In case of any deviation in the contract implementation, the contractor can feedback the message via supervision personnel to the project department of the Owner and timely handle it jointly with the site design representative for the problems in design drawings and technology or feedback it to the project construction department of CTGPC for major problems. Proper actions will be taken after decision is made, so that various problems occurring in the contract implementation can be better dealt with.

Contract management is the core of the management in project construction, so special attention must be given to it.

### **3.3.5 Progress Control for TGP**

The construction progress in a hydropower project generally depends upon the phase division of the diversion works. TGP is divided into three phases in its diversion works and the construction is also divided into three stages with a total period of 17 years. The construction schedule and objectives of different stages/phases are as follows:

- (1) Phase I diversion period (1993~1997) is the first construction stage of the project. In this period, several tasks were completed such as, construction of access roads inside and outside the site, requisition of land for dam area (15.28 km<sup>2</sup>), site leveling, excavation of diversion channel, concrete placement for longitudinal guide wall, excavation of main works on land for left bank ship-lock and temporary ship-locks open to navigation. By November 8, 1997, a number of works had been completed such as closure of the main course of the Yangtze River, embankment of upstream and downstream cofferdams, etc., which symbolized the fulfillment of the objectives for the first period of TGP.
- (2) Phase II diversion period (1998~2003) is the second stage of construction. The tasks completed in that period were upstream and downstream cofferdams, spillway, left bank dam, powerhouse structure, non-overflow dam,

ship-lift dam section and double-way & five-step ship-lock and other left bank works. The closure of diversion channel was achieved in November 2002 and construction of Phase III RCC cofferdam was completed by May 2003. In June 2003, the initial reservoir impoundment was made to an elevation of 135m and the double-way five-step ship-lock was open to navigation; and in August of the same year, the first batch of hydro-turbine generating units were put into operation, symbolizing the achievement of the objectives for the second period of construction. In this period, the works for building the right bank Maopingxi protection dam and intake for right bank underground powerhouse were also completed.

- (3) Phase III diversion period (2004~2009) is the third stage of construction. The tasks for this period are completion of the dam and the powerhouse on the right bank, putting the left bank ship-lift into operation, bringing all 26 generator units into power generation. The completion of the whole TGP project in 2009 will symbolize the accomplishment of both the objectives of the third-stage construction and the ultimate goal for the in construction of TGP.

The master schedule was developed in light of the objectives of the three phases, under which the sub-project/component schedules are prepared and bidding progress is controlled. Contracts are signed based on the schedules. The construction progress for different sub-projects will be adjusted by means of contract management for sub-project/component, thus ensuring the achievement of the objectives for various milestone works on critical path. For 11 years, all construction progresses of TGP components have basically satisfied the objectives in scheduled plan, ensuring the completion of various milestones in the master schedule. Neither progress too far ahead of schedule nor delay behind of the schedule is allowed.

### 3.3.6 Quality Control in TGP

The key to success of TGP relies on the quality of the project. For this purpose, CTGPC established a perfect quality assurance (QA) system to strengthen the consciousness of the staff for quality and to strictly control the project quality.

- (1) Set up quality standard. CTGPC has organized relevant specialists to develop the China Yangtze Three Gorges Project Standards (TGPS) in accordance with the existing national codes, industrial standards issued by the ministry and specific requirements for TGP design, as well as the features in construction of TGP. TGPS consists of over 50 standards for quality control, which are collected into a volume for enforcement.
- (2) Establish quality management organization and responsibility system. Relevant responsibility systems are established for different chains of process with designated persons in charge of each chain, from raw material production, processing and manufacture, warehousing and transportation, construction supervision, project management to management personnel at different levels of CTGPC. The TGP Quality Management Commission is also established with construction participating parties as the members under authorization of CTGPC, responsible for the management in quality check, superintendence, coordination and giving direction and assessment.
- (3) Establish quality accident response procedures. Any quality defects or accidents found at site must be reported to the higher level within specified timeframe. The project department will organize the parties participating in the construction to check the site and the construction record. If a case of ordinary defect or accident is identified through preliminary definition, a scheme for restoration or reinforcement should be worked out; for a case of major quality accident, however, thorough rework should be done from the very beginning; the quality problems difficult to be dealt with should be reported to

CTGPC and the design institute for further analysis and a solution, which will be executed upon approval to ensure no hidden trouble left. Any person responsible for the accident should be punished.

- (4) Establish reward and penalty system. In addition to the relevant regulations of the contract, the Reward and Penalty Method for TGP Quality was drawn out. Any economic loss resulting from quality accident shall be borne by the party responsible for the accident and quality assurance bond be detained. The responsible party will make its own decision whether to give penalty to its staff responsible for the accident. CTGPC has established an incentive mechanism for quality assurance to encourage the constructors to ensure the project quality. In the second period of construction, a special quality award is set up with RMB 250 million, to reward those who have no quality defect or accident records.
- (5) Establish unit work appraisal system. Quality appraisal is made for every location and every unit work upon its completion. Since the project started in 1993, more than 140000 items of unit work have been assessed with acceptance quality level (AQL) of 100%, among which the excellent units account for over 80%.
- (6) Establish a stratified quality inspection system. The ex-works inspection for raw materials is done by a qualified institution under authorization of CTGPC, who is responsible for issuing the ex-works quality certificate in accordance with the relevant standards. For steel structure, generators and other equipment,

check is done by the personnel resident to manufacturers from qualified domestic or overseas supervision companies under the authorization of CTGPC, who should adhere to carrying out the delivery check and be responsible for regular reports of quality situation and should carry out the customs check and site check for the equipment imported from abroad. In the construction process, the contractor will do the self-inspection and the supervision engineer carry out the check, while several departments of CTGPC such as the test center, surveying center, safety monitoring center and metal structure test center do the spot checks at different locations according to relevant rules. CTGPC also commissions some experienced experts from home or abroad as chief supervision engineers with professions of concrete, M&E equipment, welding and installation, etc to strengthen quality control. An expert team has been established under the State Council Three Gorges Project Construction Committee, which consists of several academicians of the China Academy of Engineering. The expert team makes follow-up checks twice a year on the project quality and submits the Project Quality Report to Three Gorges Project Construction Committee. This complete quality control system can prevent the quality problems from being covered-up or out of control and ensure that the quality of TGP meets the national codes and design requirements in an all-round manner.

Fig. 4 shows the project quality inspection system:

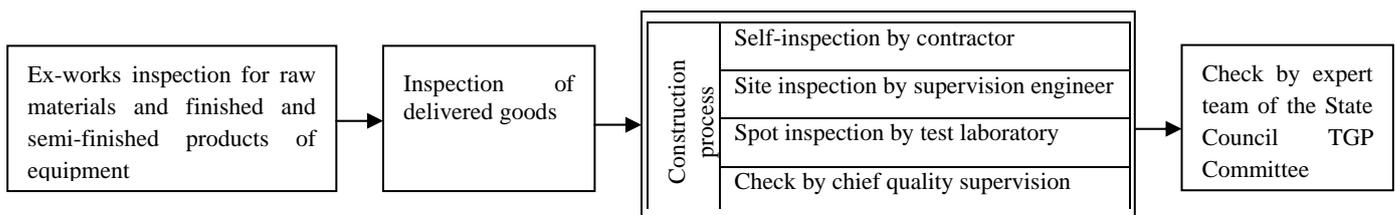


Figure 4 Chart for Project Quality Inspection System

### 3.3.7 Construction supervision

Project construction supervision system plays an important role in assuring the project to reach the objectives in quality, schedule and investment. The supervision in TGP has been made on three different levels.

Project management for TGP --- As the legal body of TGP, CTGPC takes the overall responsibilities to the nation for the development of TGP.

Construction supervision for TGP --- The project construction departments under CTGPC is directly responsible for the management in the construction of TGP and comprehensive coordination for the construction supervision in various sub-project/component works.

Unit construction supervision for TGP --- The companies, design institutes or relevant centers with supervision qualifications have been engaged by CTGPC to perform contract supervision and construction superintendence over the contractors of different component works. They are authorized to issue the work kick-off or suspension order, have the right to make coordination among the owner, the contractor and designer in respect of compensation or claims out of the scope of contract, have the obligation to make site process check and safety monitoring and have the responsibility to review design drawing and construction detail drawings.

Six construction supervision units have been engaged by CTGPC. The number of supervision personnel varied with the progress of the project and reached 900 in the peak construction period.

### 3.3.8 Investment Control in TGP

The budget for TGP approved by the state is RMB 90.09 billion based on the price level at the end of May, 1993, out of which RMB 50.09 billion is for the Three Gorges Complex and RMB 40 billion for resettlement from Three Gorges reservoir area. The whole duration of construction is 17 years. In this period, both internal and external conditions will

change to some extent. For this reason we have taken following measures for investment control.

- (1) Implement the strategy of “static control and dynamic management”. The static investment budget refers to the state-approved RMB 90.09 billion Yuan. In the construction period of 17 years, the price index will change year by year, so it is necessary to make price level adjustment based on the comparison of the price index of the current year with that in 1993. Nearly 40% of the construction capital comes from bank loans, bonds and other financing proceeds with a floating interest rate in the construction period, for which the project should bear debt service every year. These are the dynamic investment. Financial demand for the forthcoming year must be predicted every year for making dynamic management. The “static control and dynamic management” mode is realized in the way with static budget being used for controlling the project investment through optimizing the construction management and cutting down the cost and various expenses for resettlement, and with dynamic price difference payment and multiple financing measures to reduce the financing cost. The total investment predicted in 1994 is RMB 203.9 billion for the period up to 2009 when the project is completed. After 11 years’ project practice, it is predicted now that the total investment can be controlled to RMB 180 billion for the same period and will be controlled within the state-approved budget.
- (2) Carry out the price difference management. As the main works of TGP has a long contract term, price difference adjustment has been made for most of contracts with compensation given to the contractors for protecting them from the unnecessary losses. CTGPC has entrusted intermediary agencies to do price index analysis in building materials, equipment, various commodities and labor cost and to produce the price difference ratio basic index that will have impact on TGP, and submit written reports for review to the Three Gorges Project Construction Committee and the State Development and Reform Committee.

Every year the price difference ratio of the pervious year should be verified, based on which CTGPC will make compensation to the contractors according to their bidding offer and contract quotation of the current year.

- (3) Set up the “Cage” control budget for the sub-project/component. On the basis of the total quantity controlled within the preliminary design budget approved by the state, the Owner’s executive budget will be prepared via adjustment of the technical design. The implementation control price will be set up for the sub-project/component contract according to the contract price in the bidding for the sub-project. The basic reservations in the state budget can be used only when major changes have been made in the design. The budget execution and control analysis will be done every year, allowing the budget for both sub-project and the whole project to be kept under control. From 1993 till the end of 2003, the accumulated investment in TGP fixed assets of 100.5 billion Yuan had been fulfilled, among which 36.3 billion Yuan is for static investment in the hydropower complex, covering 73% of the (static) budget of the complex works; 30.4 billion Yuan for static investment in resettlement, covering 76% of the (static) budget of the resettlement; 19.2 billion Yuan for price difference provisions, 13.5 billion Yuan for interest payment and extra 1.1 billion Yuan of investment for the resettlement from the reservoir area. Compared with the investment scheme estimated in 1994, the total investment would be reduced by 6.4 billion Yuan. In view of the fulfilled work quantity for the hydropower complex and the reported investment match, the proportion of work quantity fulfilled in a great majority of contracts is higher than that of the investment match if compared with the budget, for instance, over 99% of the earth-and-rock works and 75% of concreting works have been finished. This indicates that the hydropower complex has a standardized investment summary and its investment is well controlled.

### 3.3.9 Capital Raising and Management in TGP

Capital for TGP consists of the following:

The Three Gorges Construction Fund --- It is the capital input from the state to the construction of TGP and raised by the state through levying 0.004~0.007Yuan for each KWH of electricity power sales in the whole country, which accounts for 40% of the total investment for the project.

Revenues from power generation --- Revenues from power generation of CTGPC, including those from Gezhouba Hydropower Plant with an annual output of 15~16 billion KWH and from the Three Gorges Hydropower Plant during construction period from 2003 to 2009, will also be used for the construction of TGP, which accounts for 20% of the total investment.

Bank loans --- Bank loans consist of the long-term loans from the State Development Bank and short-term loans from the state-owned commercial banks with interests being paid every year, which accounts for about 20% of the total investment.

Export credit --- It accounts for about 6~8% of the total investment.

Enterprise bond --- CTGPC has succeeded in 6 issuances of enterprise bonds with total amount of RMB 19 billion. The enterprise bond will continue to be issued in future based on financial demand every year with the final amount possibly covering 10~12% of the total investment demand.

In order to manage well the construction capital for TGP, alleviate the burden of interest payment and reduce the financing cost, CTGPC has set up a financial company upon the approval of the central government, responsible for capital raising and financing. To control the fund employment, CTGPC has enforced the total budget management to control various overhead expenses.

To keep pace with the progress of the state-owned enterprise reform, CTGPC incorporated the Yangtze Power Co., Ltd as its major shareholder in 2002. The Yangtze Power has been successfully listed on the stock exchange since 2003, which indicates that China Yangtze Power Company will

become a vehicle of CTGPC for continuous financing on the capital market. CTGPC will undertake rolling development of hydropower resources in the upper reaches of the Yangtze through multi-channel financing and control of enterprise debt ratio.

**3.3.10 Financial Assessment at Intermediate Stage for TGP Construction**

It was estimated in 2001 that the final dynamic investment for TGP would be RMB 180 billion, the on-grid tariff from generation 0.25 Yuan/KWH, and the capital balance (that is to say, without any new debt) could be achieved in 2009. It was predicted that the highest debt ratio of 60% would occur in 2003 and the debt ratio would be 37% in 2009 when the project is completed. The loan repayment term is 22 years, calculated from the date of usage for loan.

**3.3.11 Information Management System for TGP (TGPMS)**

Huge in scale, TGP has complicated boundary conditions subject to a great number of natural and human factors, the construction management itself constitutes a huge and complex systematic undertaking. How to carry out scientific management in an orderly manner is an important subject in the construction of TGP. Therefore, it is necessary to build an integral system relying on state-of-the-art IT and computer network technology, which links together data from various works, management and contractors including a great deal of natural, economic and technical parameters. For this purpose, TGPMS has been successfully developed with great efforts organized by CTGPC, and widely popularized in application.

TGPMS is an integrated project management database system in terms of its structure. Fig. 5 shows the chart for TGPMS:

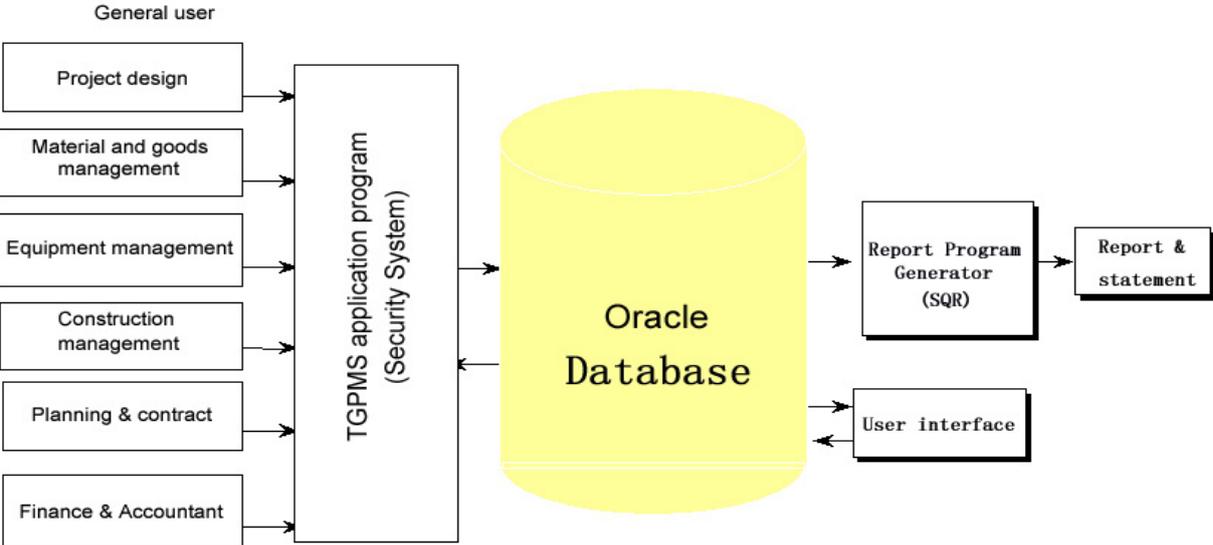


Figure 5 Schematic Diagrams of TGPMS

TGPMS is integrated with a number of sub-systems for data exchanges.

TGPMS can accelerate the information feedback process and effectively support the project management and control. Based on the preset objectives and control reference, the feedback

information can be obtained timely in the implementation period for deviation rectification and adjustment, thus strengthening the control effort for information management.

TGPMS can provide prompt and accurate data and information to support the management for various

works and to offer decision-making service for different phases of the project.

Refer to Fig.6 for information feedback process:

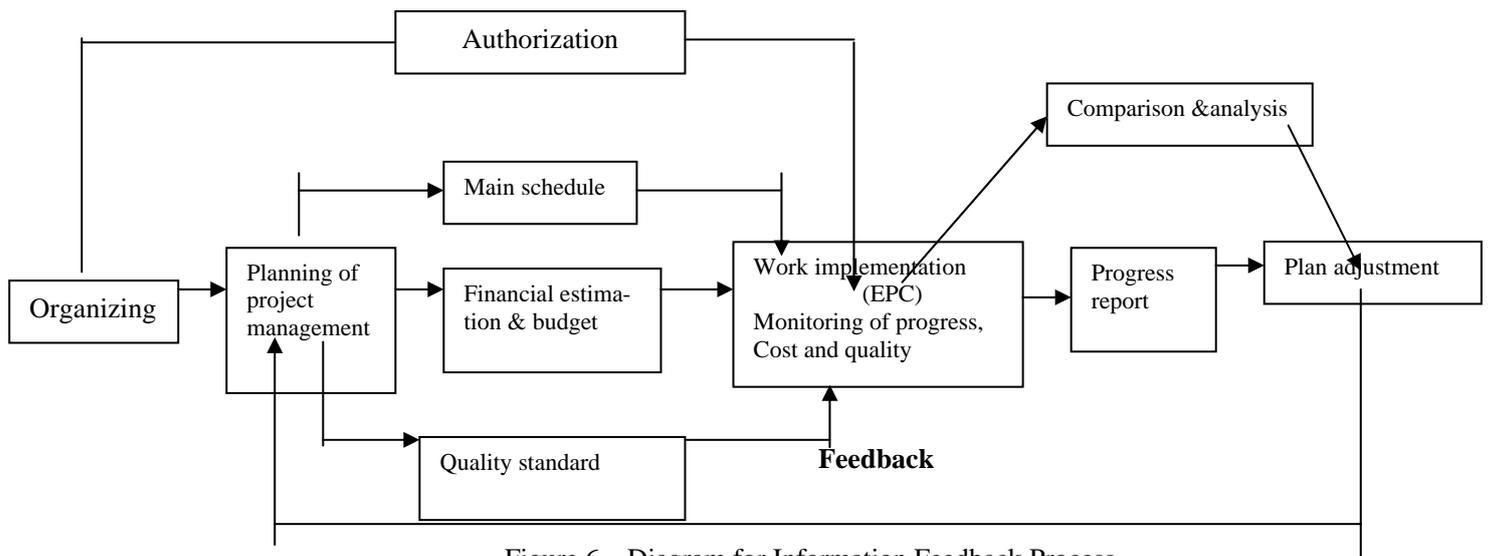


Figure 6 Diagram for Information Feedback Process

#### 4. OPERATION MANAGEMENT FOR TGP --- MANAGEMENT AT STAGE 3

After eleven years' construction, TGP realized its milestone achievements of initial reservoir impoundment, ship-lock open to navigation and power generation in June, 2003. The project management is now in a period when Stage 2 implementation management proceeds simultaneously with Stage 2 operation management. To ensure the safe and stable operation for the part of the Hydropower Complex that has been put into operation, CTGPC has established the Cascade Communication and Dispatching Center, the Complex Management Department and Three Gorges Hydropower Plant, which constitute the operation management mechanism. The Cascade Communication Dispatching Center makes a centralized and unified dispatching of the Three Gorges Hydropower Complex and Gezhouba Hydropower Plant according to river regime and meteorological forecasts combined with the requirements for flood prevention, power generation and navigation and optimizes the work conditions of the cascade power plants, achieving safe, steady and high efficient operation. The Complex Management Department is responsible for a unified management for the structures of the Three Gorges Hydropower Complex and make coordinations

about social security and environmental construction in the dam area. The Three Gorges

Power Plant is in charge of the safe and able operation of the generator units and hydraulic structures already put into service. Strict regulations and rules have been formulated in respect of dispatching and operation management of the Complex. As a result, a high efficient and standardized operation management mechanism has been established. In 2002, CTGPC lost no chance to incorporate the Yangtze Power Co., Ltd to assume the responsibility of power operation and management for Gezhouba Hydropower Plant and Three Gorges Hydropower Plant, creating two levels in the form of cost center and profit center for CTGPC. The "Yangtze Power" stock has been listed on domestic market since November 2003 and the generator units that have been put into service will be purchased by the Yangtze Power Co., Ltd. upon their acceptance in successions. CTGPC has now fulfilled its preliminary restructuring and gained steady access into the capital market, becoming the state-authorized investment entity. At present, CTGPC has started pre-project works for the development of other two hydropower plants, on the Jinsha River, Xiluodu and Xiangjiaba and stepped onto a sound course of rolling development.

## 5. CONCLUSION

The construction of TGP was initiated at a time when China has been establishing and gradually improving its socialist market-oriented economic system. Therefore, the construction of TGP is the practice of a dynamic process. In 2003, we successfully fulfilled the milestone objectives of the initial reservoir impoundment, power generation by the first units, as well as the double-lane & five-step ship-lock opening to navigation. Since the initial reservoir impoundment a year ago, ten 700MW generator units have been put into operation, thus effectively alleviating the current power shortage in East China, South China and Central China. By 2009 when the whole TGP project is completed, the economic system reform of our country will be further deepened and perfected and, at the same time, the restructuring in power industry will proceed steadily as the market-oriented economy becomes more mature. The reform in management system of capital construction and in the state-owned enterprises will exert a direct impact on the restructuring of the project construction management. The project management of TGP is an important component in the enterprise management of CTGPC. Along with the system restructuring of CTGPC, the management in TGP construction will certainly tend to become sounder, more scientific and reasonable and gradually evolve into a socialist project management mechanism with Chinese characteristics.

The eleven years' successful experiences in the construction of TGP gives us full confidence that through our continuous and persistent practice more scientific and more standardized TGP management shall be achieved, and the expected ultimate goals of TGP from the management of project construction to the management in operation shall be realized.

### **Author:**

Lu Youmei is an expert in water resources and hydropower industry. He was born in Shanghai in 1934 and graduated from East China Water Conservancy College in 1956. In 2003, he was

honored as an academician of China Academy of Engineering and has held the title from then on. He has been in several important posts, such as Vice Minister of China Water Resource and Hydropower Ministry, Vice Minister of Energy Ministry, Vice Chairman of the State Council Three Gorges Project Construction Committee and President of CTGPC, and is now is Chairman of China Committee of Large Dams, and also honored professor of Tsinghua University and Hehai University. He has successively participated in and organized the development of a number of hydropower projects such as Liujiaxia and Longyandxia on the Yellow River, Shiquan and An'kang on the Hanjiang River. During the period from 1993 to 2003, he presided over the development of the Yangtze Three Gorges Project, heading important studies on major technical and management issues and relevant decision-making. In 2003, the milestone objectives of TGP were successfully achieved i.e. initial reservoir impoundment, power generation by the first units and ship-lock navigation.