

439

Turnkey Substations

**Working Group
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Members

Tibor Kertesz (CA) – (Convener), Gunnar Adamczewski (AU), Alexandre Barreira (PT),
Andres Cadenas (ES), Andrew Cheang (SG), Enrico Colombo (IT), Ciprian Diaconu (RO),
Hiroshi Imagawa (JP), Koji Kawakita (JP), Mark McVey (US), Toly Messinger (CA),
Akira Okada (JP), Alexandre Parisot (FR), Anne-Marie Sahazizian (CA), Slawomir Samek (PL),
Brendan Stafford (IE), Gilles Tremouille (FR), Antônio Varejao De Godoy (BR),

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1. I INTRODUCTION

The purpose of this brochure is to give the reader an insight into the turnkey process and allow the reader to make an informed decision before opting for a turnkey solution.

Due to deregulation of power industries, a shortage of specialised resources worldwide, fewer utilities with in-house design resources and emerging economies upgrading and investing in new infrastructure, the trend to opt for a “single source” solution is on the increase. While the concept was established in the early 70’s, the turnkey option is becoming a more common practice amongst utilities and government bodies worldwide in their effort to achieve tight deadlines for medium to large scale projects.

Opting for “turnkey” allows the Asset Owner, once the tendering process is complete and the contract is awarded, to turn over the project responsibility and risk to the Service Provider. In some cases, the Service Provider is required to bring innovative ideas and solutions to intricate problems and in all cases there is a high level of knowledge and experience transferred to the project.

The downside to the turnkey solution is that generally the project cost is higher than that of an in-house-build solution and the Asset Owner can pay a premium for variations and changes after the scope of the contract has been agreed. Also, the Service Provider may purchase equipment from a preferred manufacturer, which may limit the options or technologies for the future expansion of the substation. This may also mean that the Asset Owner loses the opportunity to gain an understanding/knowledge of the equipment which makes future maintenance increasingly difficult.

The following chapters will guide the reader through the full turnkey process from conception to completion and enable the reader to adapt the turnkey process to the particular project they are about to embark upon, from single bay extension to a complete new station build. The brochure also covers the issues arising from conversion from the traditional process of completing the project in-house to the turnkey process.

As previously mentioned the turnkey process is not a new concept to the market and there are many globally recognised companies who have gained a wealth of experience in offering turnkey solutions. The areas of pre-qualification, preparation of specifications, the tendering and evaluation process and contract award are covered in detail and will enable the reader to adopt best practices when opting for this solution.

Finally we look at project execution and project closure, the best practice in terms of programming, project management and dealing with project variations, what quality indicators to look for and how to review the project in relation to the original estimates of time and finance.

2. D DEFINITION OF TERMS & ACRONYMS

- **Asset Owner** (A.O.) the entity (public or private utility, industrial or commercial customers, cooperatives, etc.) which has regulatory and financial responsibility for the asset – in this document the expression “Customer” will have the same meaning and will be used,
- **Service Provider** (S.P.) - An entity that provides services to other entities.
- **Request for Proposal** (RFP) -is an invitation for suppliers, often through a bidding process, to submit a proposal on a specific commodity or service. A bidding process is one of the best methods for leveraging a company's negotiating ability and purchasing power with suppliers. The Request process brings structure to the procurement decision and allows the risks and benefits to be identified clearly upfront. The Request purchase process is lengthier than others, so it is used only where its many advantages outweigh any disadvantages and delays caused. The added benefit of input from a broad spectrum of functional experts ensures that the solution chosen will suit the company's requirements.
- **Request for Tender** (RFT) - is a structured invitation to suppliers for the supply of products and/or services. An RFT is usually an open invitation for suppliers to respond to a defined need as opposed to a request being sent to selected potential suppliers. The RFT often requests information gathered previously from a RFP. This will usually not only cover product and service requirements, but will also ask for information about the capability of the supplier to execute the project and its financial soundness.
- **Prequalification process** - Preliminary stage in a bidding process in which screening of potential contractors, suppliers, or vendors (on the basis of factors such as experience, financial ability, managerial ability, reputation, work history, etc.) is performed to develop a list of qualified bidders who will receive the invitation-to-bid documents.

- **Qualification process**- A detailed review of the technical capabilities and quality of potential bidders before choosing which bidders will be considered for the project.
- **Turnkey Substation** - a substation designed, built and commissioned by a Service Provider to Specifications set forth by the Asset Owner (A.O.),
- **Handover Day (Take over Day)** – the date designated in the contract for transfer of ownership and safety and operating responsibilities from the Service Provider to the Asset Owner. Transfer Day does not imply that the Service Provider is relieved of all other responsibilities set forth in the contract, e.g. warranty for workmanship and materials, liabilities, achievement of performance targets agreed in the contract, etc.
- **System Integration** – the total of activities required to integrate the new installations into the Asset Owner’s existing system,
- **Original Equipment Manufacturer (OEM)** - An original equipment manufacturer, or OEM is typically a company that is manufacturing at his own factory or assembly a component made by a second company or sells the product of the second company under its own brand. The specific meaning of the term varies in different contexts.
- **Blanket Order** - Confirmed long-term order by a buyer to a seller for supplying specified good(s) or service(s), for a fixed period or in a fixed quantity, at agreed-on prices or pricing method. After its acceptance by the supplier, supplies may be made against it periodically, on as-and-when-required basis, or as specified in the order, without calling for new purchase orders.

3. B ENEFITS AND DRAWBACKS OF TURNKEY PROJECTS

3.1 BENEFITS

- In a Turnkey project setup the Asset Owner deals with a single administrative entity, the Service Provider, who provides Design, Construction and Commissioning Services for the project under one contract package. This simplifies the projects management task for the Asset owner,
- The Asset Owner obtains a number of bids, each bid with its own solution and approach to the project. This process offers the Asset Owner a variety of options and solutions of which the Asset Owner might not have been otherwise aware of,
- Turnkey projects can facilitate implementation of new technologies in a particular utility. The Service Providers are compelled by strict contractual performance requirements to use reputable equipment manufacturers as suppliers of major equipment for the turnkey project. These equipment manufacturers are in the forefront of new technologies development and have a vested interest to offer the Service Provider such technologies. In contrast, on in-house projects, the Asset Owner would normally encounter difficulties to introduce new technologies, due to inherent conservatism and reluctance to take unnecessary risks by stakeholders in the Owner's organization, lack of knowledge and long process required for technical review and tendering. The Service Provider may assume the risks involved and provide all the services required for acceptance of the new technologies by the Asset Owner.
- Usually turnkey projects are fixed price projects. The Service Provider assumes the bulk of the risks related to detailed design, construction, commissioning and site testing which must be delivered as contractually agreed and within the time frame provided. Provided the contract has been set up correctly, the Asset Owner assumes fewer risks, and claims for cost overruns and adjustments can be reduced or avoided altogether,
- The Service Provider is responsible for the design, general contracting and execution of the project. Therefore, the Service Provider must provide the Asset Owner with a guaranty that the project will be completed on time and that it will achieve the expected performance, The contract can provide for compensations (such as liquidated damages or penalties) in case of schedule delays.
- Where the certainty of the final price is of major importance to the Asset Owner, turnkey projects can deliver on the pre-agreed fixed price. In such cases Asset Owners must be willing to pay the required premium for their project, and agree to include total outsourcing of project engineering, construction, site testing and commissioning, and the contract must contain clear and tight clauses covering various aspects, such as foreign exchange adjustments, escalation costs on major equipment and materials, construction adjustments, etc.
- Another advantage offered by turnkey projects is the shortening of the time period required to obtain total project pricing: the Asset Owner can obtain a definite price for the project in a much shorter time compared to the time required for pricing an in-house project,
- Where the completion date is of major concern, turnkey projects offer the Asset Owners a firm schedule that will guarantee them that the substation can be placed in service by a given date.
- In case of lack of sufficient internal resources – the Asset Owner is compelled to select the turnkey solution provided that the end result meets the performance requirements of the initial specification. The Asset Owner must be prepared to pay the premium associated with turnkey projects.
- Turnkey projects offer simplified contract management. In some cases the Asset Owner prefers to manage a single contract – with the Turnkey Project Service Provider – instead of a multitude of contracts with equipment suppliers, contractors, inspection agencies, etc.
- Turnkey projects provide simplified claims management during or after project completion. If a problem occurs during installation or after the in-service, it is not the responsibility of the Asset Owner to determine which of the participants is at fault. The Service Providers must resolve problems within a specified time frame. The Asset Owner's task is considerably simplified.

3.2 DRAWBACKS

- By handing over almost entirely the control of the project and its evolution, the Asset Owner relinquishes the opportunity to make changes or adjustments to the project that may become obvious during the project implementation. In in-house project, the Asset Owner retains total control of the project and can make significant changes as required without paying the hefty penalties a Service Provider would request in a turnkey project setting,
- In general, the Asset Owner must, right from the very beginning of the project, provide the Service Providers with a detailed documentation of the final product it wants. Hence the Asset Owner must spend significant additional up-front resources for production of the detailed documentation and specifications. For Asset Owners with less experience, production of this documentation might require retention of outside consultants to help determine the needs, assist during the design and bid review process and supervise construction. This results in increased costs for the project and, most frequently, the consultant is kept outside of the design and execution process, which are controlled by the Service Provider,
- In most turnkey projects several bids are received by the Asset Owner, each bid with a potentially different concept. In such situations, it may be difficult for the Asset Owner to correctly evaluate the proposed solutions, compare prices and select the best proposal,
- Usually substation turnkey projects involve significant risks (especially in substation refurbishment and retrofit projects). There is the possibility and probability that only a few Service Providers will be interested in submitting bids. This may result in less competition which translates in higher prices and longer delivery times offered by the participating bidders. Projects with perceived higher risks will generate up-front higher prices from the bidders to cover more than the potential cost of such risks,
- During the project the Service Provider may run into unexpected difficulties. In such situations, unless contractual requirements are very clear, it might be tempted to skip on the quality of construction, overall reliability and/or maintainability and operability of the project. This situation may occur where the Asset Owner doesn't have continuous control over construction supervision to make sure that quality of execution is maintained, that design changes are made to deal with unexpected issues and monitor compliance with expected deliverables and deadlines,
- Under certain unexpected circumstances, such as major financial or economic upheavals the Service Provider may become insolvent and the entire project has to be stopped, completion postponed or cancelled altogether, Such incidents may be avoided or minimized by a thorough pre-qualification process of bidders, that includes evaluation of their financial standing, and existing assets and liabilities and by requesting up-front financial guaranties, e.g. letters of credit from solid financial institutions.
- Given the competitive pressures on the Service Providers at the time of bidding, their selection of major equipment required for the project will tend to be based on lowest pricing offered for such equipment, rather than quality and reliability considerations. Marginally acceptable equipment will impact the performance of the new substation or extension. On Handover Day the finished product may meet the short term performance indicators (up to 5 years) specified in the contract, but it may come short of expectations for the long life expectancy (up to 40 to 45 years) of power projects. Maintenance costs may rise exponentially in later years. Similarly, additional costs related to use of non-standard equipment should be evaluated.
- Turkey projects carry an additional price tag for System Integration costs. These are costs that must be born by the Asset Owner, as they pertain to elements that are out of the control and knowledge of the Service Providers, and are often overlooked at the project evaluation time. They include such costs as revision of existing drawings to include the new installations, integration of the new substation/extension into the protection, control, telecommunications and metering systems and integration into the utility's Operating System.
- Some of the risks above could be mitigated by various measures, but with an inherent increase in the overall construction cost of the turnkey project. Solutions to the specified risks include:
 - The Asset Owner retains an internal or external project management team to define the owner's needs as well as monitor the progress of the work.

- The Asset Owner provides comprehensive documentation which accurately indicates the expected deliverables (scope), the time frame (schedule) and the financial resources (cost) of the project,
- The Asset Owner retains some control over critical phases of the project and provides a very strict quality control during the construction phase of the project,
- The Asset Owner performs a thorough pre-qualification process of bidders that includes evaluation of their financial standing, and existing assets and liabilities and obtains up-front financial guarantees, e.g. letters of credit from solid financial institutions.
- The Asset Owner has to be very specific in the detailed technical specifications in regards to the Major Equipment that is acceptable for the project. It may be advisable to insist on the Service Providers using only pre-qualified manufacturers and types of equipment.
- Loss of expertise - engineering staff of the Asset Owner does not have a “hands-on” approach on the project and is not involved in the detailed design. If most of the projects of the Asset Owner are Turnkey, the Asset Owner’s engineering will be resumed only to production of specifications for the turnkey projects with the expected loss of expertise in the detailed design of substations.

4. TRANSITION FROM IN-HOUSE PROJECTS TO TURNKEY PROJECTS

A turnkey contract is a natural opportunity for both the Asset Owner and the Service Provider to share their experience and learn from each other.

4.1 THE SUMMATION OF TWO EXPERIENCES

The Asset Owner has in-depth knowledge and experience with his own network and substations. He will be able to share with the Service Provider the critically important data required to ensure that the completed substation will meet his requirements and expectations.

The Service Provider, due to his worldwide experience, has acquired knowledge from widely different standards, tools and situations and will be able to advise the Asset Owner on network evolution and new substation arrangements.

4.2 SHARING FOR SUCCESS

While this balance of knowledge and experience is obvious from an outside perspective, in reality the relationship between the two partners can be difficult, at least at the start of the process. It involves sometimes difficult changes in the frame of mind of both venture partners.

Within the Engineering departments of the well established utilities that are only now starting to use Turnkey contracts, there could be a defensive attitude that is not conducive to cooperation to bring the contract to a successful completion.

In order to create the necessary positive spirit relevant communication channels should be created.

For example daily or weekly engineering contact & discussion could be established between utility Engineering department and Service Providers Design Office.

Other larger monthly design meetings with larger representation of technical staff could be scheduled to address the most important design topics,

A design front office is a small design structure that could be established, if required, for the benefit of the project in order to provide daily contact between the Asset Owners design team, maintenance team, and the Service Providers engineering team (which could be located in a different country). This front office comprises one or two Engineering staff in charge to understand the Asset Owners needs, to address the Asset Owners comments and needs and to support the Service Providers design solutions, provide clarifications and respond to questions.

Similarly, even within large Engineering firms that engage with established utilities to build new substations, the Service Provider's staff is often overwhelmed by the vast experience residing with the utilities and will be hesitant to ask critical questions, concerned that it may reflect unfavourably on the Service Provider's experience.

It is these attitudes that require a concerted effort to change, if the project is to be successful.

For staff of an Asset Owner used to do in-house projects, the change to turnkey projects involves a change in the way things are being done. With projects done in-house there is no need for detailed interface Planning Specifications since engineering staff of the Asset Owner is familiar with some of the requirements and informal communication between departments clarifies missing information.

For turnkey projects however, the Asset Owner's Planning Department develops a Planning Specification to the detail required for Service Providers to bid on the project. For Asset Owner's planners this involves more time spent in collecting all the information needed for the specification and for production of the formal document for the tendering process.

Turnkey project Service Providers are also capable of proposing detailed specifications if the Asset Owner doesn't want or have enough time or expertise to develop and/or improve its own specifications,

For the Asset Owner's Engineering department changes from in-house to turnkey projects could be significant. In depth knowledge of the Asset Owner's equipment and design standards and the experience of the design and drafting staff allows production of technical specifications for in-house projects with less details. References to previous similar projects and design details are often used which also reduces the time spent on production of the specification. However, these specifications need continuous revisions to keep the specification updated with the latest developments in the field. Familiarity with Stations Maintenance and Construction procedures and techniques is another factor which allows engineering staff to optimize the in house engineering process.

With substation turnkey projects all the information which engineering staff was communicating informally within the engineering department and with other Asset Owners departments during in-

house projects has to be included in formal interface memo's or letters, or discussed during design meetings with stakeholders.

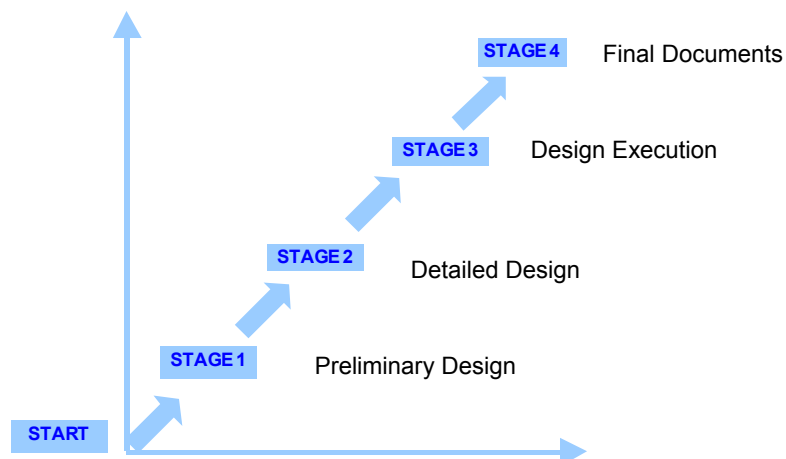
This means that some of the design standards which are outdated (but being used with modifications for in-house projects) have to be formally revised or cancelled. In the absence of such Asset Owner's standards, the Turnkey project Service Provider will propose International standard as alternatives.

Another change in the way business is conducted for substation turnkey projects versus in-house projects is the level of involvement of the Asset Owner's Engineering staff during the life of the project. Asset Owner's Engineering staff has the tendency to take ownership of the projects they are working on. During substation turnkey projects, drawings produced by the Service Provider are usually sent for review or information to the Asset Owner's Engineering staff. This staff, by nature of their approach to the in-house projects has the tendency to not only review the drawings but also to try to impose some of the solutions and practices they are using for in-house projects. This approach could lead to strong discussions between parties, the balance should always be between functional, comments, and comments having no impact on substation operation, reliability, maintenance. Therefore, it is important for the Asset Owner's Engineering staff to change their mind set and to give the Service Provider only the level of comments/suggestions required for them to do a satisfactory job.

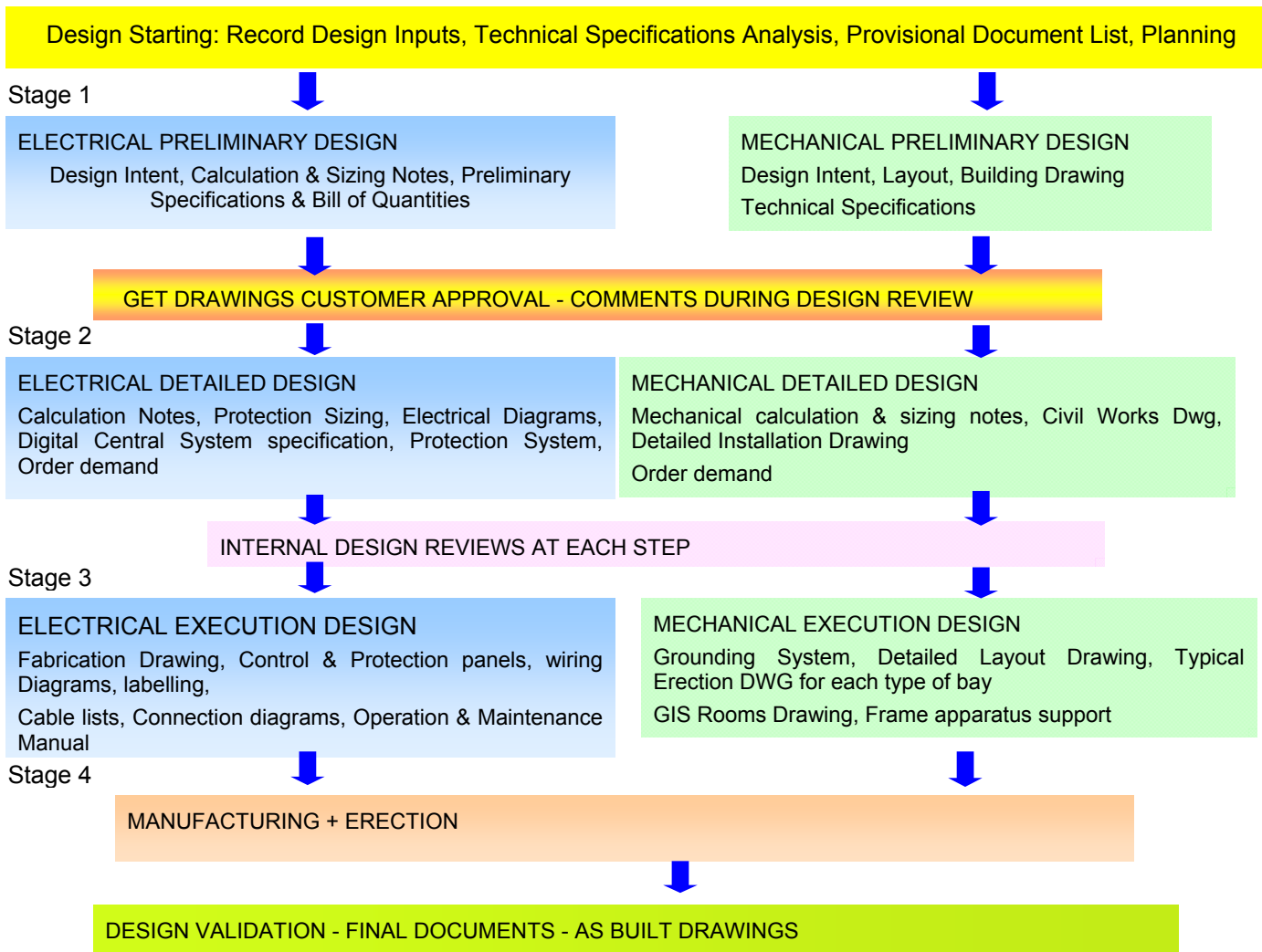
4.3 ESTABLISH A DESIGN FRAME

The design process could be planned in 4 Stages (ISO9001):

- Preliminary Design - Stage 1 (Electrical & Mechanical): performed at the beginning of the Project. The purpose is to show the main technical solutions, the material selection and to validate Design Intent.
Approval & Review Meeting with the Customer/Contractor/Consulting Office should be planned and conducted to conclude this Preliminary phase. The Technical agreement is an essential step to allow start of Stage 2
- Detailed Design - Stage 2 : conceptual data issued from Stage 1 are used to perform the detailed installation drawings & electrical diagrams,
- Design Execution - Stage 3 : Manufacturing & Erection drawing are issued from data design & treatment of files prepared at the Stage 2
- Final Documents - Stage 4 : issued As Built drawing



Stage 0



4.3.1 A NECESSARY DESIGN PRACTICE SHARING

The submission of Service Provider documentation for Customer approval is an important phase to verify that Service Provider's proposal matches with Customer expectations.

Design review meetings including all involved parties (Service Provider and its consultants, Customer design team, Customer maintenance team) are also necessary at all design stages especially at Stage 1 (beginning of the design phase),

In order to understand the customers' technical expectations, various topics have to be addressed before submission of drawings for approval. This could be done through the development of general specifications covering:

- Material/equipment specifications,
- Technical design specifications, dealing with the design methods to be used, explaining which standards and methods the contractor should follow in order to design the substation as expected by the Customer,
- Maintenance standards and practices having an impact on the design,

4.3.1.1 MATERIAL SPECIFICATION

In this chapter, typical descriptions of the required material/equipment should be included,

4.3.1.2 MATERIALS STANDARDS SPECIFICATION

A specification describing general requirements for all equipment, applicable for all individual material standard specifications could be used as a general introduction.

4.3.1.3 MANUFACTURING AND FIELD EXPERIENCE.

Example:

The equipment/material manufacturer shall have at least xx years manufacturing experience, with a minimum of xx years field experience in similar services conditions. For new technology equipment/material, where the specified xx years of field experience requirement cannot be met, a minimum of xx years of field service experience at the time of prequalification might be considered.

4.3.1.4 TECHNICAL DESIGN SPECIFICATIONS

In this chapter, all engineering standards and Customer practices (including safety factors) dedicated to calculation and design method in order to specify the accurate equipment/material in the substation should be included.

For example following design method and configuration principle could be including as substation design specification:

- Insulation coordination study method (standard to follow, modification/complementary method required by the Customer, Country required safety factor)
- Surge protection method regarding direct lightning strikes.
- Clearances and working distances,
- Tubular busbar design method,
- Post insulator checking method,
- Supporting structures design rules,
- Grounding design rules,
- Seismic requirements for the specific location,
- Foundations,
- Buildings,
- Primary and secondary parameters for the substation (HV, LV, Installed MVA, Short Circuit levels on HV, LV bus, etc.),
- LV cable raceways and cable installation practices,
- Fire and loss prevention requirements,
- Lighting for substation and building,
- LV cable selection and sizing,
- Auxiliary power systems,
- Control of substation equipment,
- Supervisory control & data acquisition (SCADA),
- Security requirements for the substation,

4.3.1.5 MAINTENANCE AND OPERATION PRACTICES

These concerns have direct impact on the design.

A good practice could be to introduce a chapter dealing with operation and maintenance requirements in the technical design specification.

The participation of teams in charge of substation maintenance during technical meeting and documentation approval is very desirable and could be also a solution to manage this important aspect of the project,.

Some examples could cover:

- Testing made during substation maintenance and requiring special design,
- Configuration of the systems when one bay is under maintenance, can the adjacent bays remain energized or not,
- Description of the crane to be used at site, in order no manage access road in the switchyard and allow access and work on a bay with adjacent equipment energized,

5. T URNKEY PROJECT PROCESS

As a common usage the word turnkey refers to something that is ready for immediate use, such as requesting a Service Provider to perform or supply all required work to the final stage, before handing it over to the Asset Owner. In Construction, the term “turnkey” means a method of construction whereby the Service Provider assumes total responsibility from design to completion of the project. In the Electrical Utilities business, a “turnkey substation” will involve the process of selecting a qualified and proven Service Provider to design the substation, supply or procure equipment, construct and commission the substation, or a number of substations, to specifications set forth by the Asset Owner.

In a full turnkey contract for a substation, the work to be performed by the Service Provider will include, on a lump-sum, fixed-price, “turnkey basis”, any and all work and services required or appropriate in connection with the design, engineering, procurement, construction, erection, testing and commissioning of the substation project, as well as the provision of all materials, equipment, machinery, tools, labor, supervision, transportation, administration, training and other services or items required to complete and deliver, to the Asset Owner, the substation and allow the Asset Owner to commence operation of the substation, fully tested, integrated and operational, designed and constructed to comply with all relevant and applicable laws, environmental and local regulations and Safety Code requirements, national and international standards, to comply with the ‘ Asset Owner’s Requirements’.

The Service Provider shall also among other things:

- Provide detailed design engineering of the substation,
- Provide all the drawings and schedules and coordination of engineering efforts of subcontractors, if any,
- Procure all materials and equipment to be installed in the substation,
- Provide handling of material, equipment and construction equipment, including, as necessary, inspection, expediting, shipping, customs clearance, unloading, receiving, transportation to and storage at substation site, e.g. transportation and delivery of equipment from manufacturer’s works to substation site,
- Provide construction of civil works and fabrication of metallic structures for supporting of high-voltage apparatus and gantries,
- Provide erection of all substation equipment,
- Provide all labour and personnel required to construct and test the substation,
- Provide all the factory tests and site commissioning of substation,
- Provide site security until final completion,

In a Turnkey project setup the Asset Owner deals with a single administrative entity, the Service Provider, who provides Design, Construction and Commissioning Services for the project under one contract package.

The Turnkey process starts with the decision of the Asset Owner to contract out the design and construction of a new or refurbishment/retrofitting of an existing substation. Such a decision is a major undertaking with significant implications in the way the project will be handled.

A turnkey project relieves the Asset Owner from the burden of having to deal directly with all the aspects of the project during the life of the project. On the other hand, the Asset Owner must spend a significant amount of effort at the beginning of the process with preparation of the documentation required for clear definition of the project and for hiring/retaining a reputable Service Provider/Design-Builder.

Depending on the expertise residing in the Asset Owner’s organization, the Turnkey Management process can be done in-house or it can be contracted out to an Asset Management consultant.

The turnkey project process is complex, especially if the project deals with construction of a major substation. Regardless of the size of the project, the most important steps in the turnkey project process are:

5.1 PREQUALIFICATION OF SERVICE PROVIDERS

The Service Provider Pre-selection Process represents the effort of the Asset Owner to limit the pool of potential Service Providers to a manageable number while retaining the most qualified and competitive candidates.

The process comprises the issuance of a Statements of Intent by the Asset Owner and request of Expression of Interest from the Service Providers followed by Prequalification meetings with potential Service Provider teams.

5.2 PREPARATION OF TENDERING DOCUMENTS FOR TURNKEY PROJECTS.

The tendering documents of a turnkey project covers all technical and commercial aspects of the project. It also addresses all the environmental and safety issues associated with the project.

The tendering documents comprise three major components:

- Part I – Commercial Conditions,
- Part II – Technical Specifications,
- Part III – Form of Tender,

This documentation shall include at a minimum the following components:

- Technical Specifications,
- Building Specification,
- Environmental and Safety Specification,
- Major Equipment Specifications,
- List of Referenced Standards and Drawings,
- Commercial Terms and Conditions document,
- Form of Tender,

5.3 TENDERING PROCESS

This part of the turnkey project process deals with:

- Issue tendering documents to selected Service Providers,
- Tendering closing process,
- In-depth review of the documentation submitted by the Service Providers,
- Technical review meetings with the Service Providers,
- Selection of the successful Service Provider and notification,
- Official acknowledgement/acceptance by the Service Provider,

5.4 PROJECT MANAGEMENT

Project management refers to the process to manage the turnkey project successfully which normally means completing the project within the following benchmarks:

- Within budget,
- Within schedule,
- Minimal variations,
- Safely without accidents,
- Comply with specified quality,

The contract document (including drawings, specifications, standards, schedule and so on) is considered as the ultimate binding document for each project. The key to good project management is to develop a set of guidelines on how to use the contract document for project management. One of the most important tools of project management is to establish proper project management plan starting from clear and precise project organisation structure. The function of each member within the project organisation should also be clearly defined. Proper lines of authority should be established in the project organisation and feedback channel is important.

The scope of work for the project must be clearly defined and the responsibilities of Asset Owner and Service Provider should be clearly demarcated to avoid any ambiguities regarding each party's scope of work.

The proper monitoring of work progress is crucial to completing the project within schedule. Therefore, project planners/schedulers are important in assessing the correct progress of various activities in the project. Any slip-ups or potential slip-ups must be identified quickly and remedial action implemented to minimise any delay to the overall progress of the project.

Of paramount importance in any project is the safety and quality of the equipment and construction work, thus the latest guidelines and specifications regarding these aspects should be included into the contract and technical specification. Inspection or supervisory committees on the safety and quality of work must be established to monitor the performance of the Service Provider.

Regular project progress meetings are an essential component of project management as these sessions will summarise the progress, problems and delays encountered in the day to day operation of the project. More details of project management tools are discussed in [Chapter 9](#) of this brochure.

5.5 PROJECT EXECUTION

Project execution is the most important component of the turnkey process. This phase of the project deals with:

- Detailed design and production of Construction drawings by the turnkey supplier and submission for approvals to the Asset Owner,
- Ordering of Major Equipment (if it is to be free-issued to the turnkey supplier),
- Construction and Commissioning by the turnkey supplier, and acceptance by the Asset Owner

[Chapter 10](#) focuses more on the details of how to achieve contract schedule and time completion of the project including the detail interface between the various parties and components:

- Asset Owner and Service Provider,
- Various Contractors and other contractors,
- Various Systems (e.g. Electrical and Civil system),

5.6 CLOSING OF PROJECT

After completion of the equipment erection and commissioning the Asset Owner will review all commissioning reports and, once satisfied that the original performance parameters are met, issue a Notice of Acceptance to the turnkey supplier.

Most progress payments, with the exception of withholding payments that are tied to the Key Performance Indicators can now be released. A Notice of Warranty Commencement is issued to the turnkey supplier.

The attached flowchart presents an overview of the most significant steps of a typical Turnkey project from its beginning to full completion and hand-over to the Asset Owner.

Turnkey Project Process - Flowchart		
	<u>Process Flow</u>	<u>Process Items / Descriptions / Sub-process</u>
(A)	Preliminary Design/Planning	System Planning Study
(B)		Feasibility Study
(C)	Pre-qualification of Service Provider	Based on:
		1) Previous experience (History)
		2) Client Selection
		3) Factory Review
		4) Financial Position
		5) ISO (Quality)
(D)	Prepare Tender Document	a) Terms & Conditions
		b) Technical Specification/Technical Schedule
		c) Form of Tender
		d) Scope of Work
		e) Price Schedule - definite/optional work
(E)	Issue Request for Tenders	a) Public announcement
		b) By invitation to qualified Service Providers
		c) EU Journal
(F)	Evaluation of Tenders	a) Tender review meetings
(G)	Contract Award	a) Agreed price
		b) Agreed schedule
		c) Agreed T&C incl. penalties
(H)	Management of Turnkey Project	a) Project Management documents
		- Project Organization Structure
		- Project Schedule (incl. Equip. delivery time)
		- Progress Reports
		=- Site Safety Reports
		- Quality Assurance Plan
		- Project Safety Plan
		- Document Register
		- Document Submission / Approval Procedure
		- Progress Payments / Cashflow / Milestones
		b) Regular Project Schedule Review
		c) Follow-up demarcation of responsibilities
		between Asset Owner & Service Provider
	d) Regular Review of Variances/Claims	
(I)	Project Execution	
(J)	Project Closing Out	a) Station Handover Document
		b) i Ensure complete list of As-Built drawings
		ii Safety file
		c) i Payment retention
		ii Period of Maintenance

6. P REPARATION OF TENDERING DOCUMENTS FOR TURNKEY PROJECTS

Production of comprehensive technical and commercial/financial documents for a substation turnkey project by the Asset Owner before the tendering process is essential for the success of the project.

6.1 PART I – COMMERCIAL CONDITIONS

To prepare the Commercial Conditions for a turnkey substation contract the Asset Owner may start with their routine set of commercial conditions but they need to be customized, to cover the specific aspects associated with such agreements. The commercial conditions mentioned below follow a specific structure, but this is only an example.

DEFINITION OF TERMS

Terms that are frequently used in the Tendering Document are defined here (e.g. “Service Provider”, “Subcontractor”, “Take-over Day”, “In-service Date”, etc.) The definitions are required to clarify the terms in case a dispute arises during the execution of the contract.

ORDER OF PRECEDENCE OF CONTRACT DOCUMENTS

This section outlines the order of precedence of the contract documents which is necessary in case of a later dispute. Normally the documents are ranked in the order they are listed in this section. They should start with (1) the Purchase Order, (2) the Tendering Documents, including the General and Special Commercial Conditions, the Technical Specifications, Drawings and Data, the Invitation to Tender and Form of Tender, followed by the Service Provider’s tender, drawings and data.

Other subsequent documents, such as minutes of the Tender Review meetings, amendments, etc. can also be listed.

CLARIFICATIONS AND COMMUNICATIONS

To avoid any misunderstandings and breach of Contract Law, this section must contain the clear path of communications between the Asset Owner and the potential bidders, both prior to submission of tenders and after.

LANGUAGE AND MEASUREMENT

The terms clarify the acceptable language for communications and for the contract (unilingual, bilingual or poly-lingual, depending on the prevailing legislation in the respective jurisdiction), as well as the system of measurement to be used in the contract (e.g. the International System of Units – SI, or the Imperial System) and – in case both systems are acceptable - a clear statement in the tender as to which system is being used.

PROOF OF ABILITY

In this section the bidders are requested to provide current information of their financial situation, managerial and technical abilities and their delivery capabilities as related to the proposed contract.

INFORMATION TO BE INCLUDED WITH TENDER

The bidders are requested to include into the tender all pertinent technical and commercial information, schedules, procedures and drawings, quality program for Major Equipment and construction site and any other pertinent information that will facilitate a thorough evaluation of tenders.

EVALUATION OF TENDERS AND ALTERNATIVES

This section is particularly important for turnkey substations. It should clearly state that, in addition to the base bid, the Asset Owner strongly recommends that tenderers submit alternative offers, which may include other manufacturers equipment. Such alternatives may include innovative solutions that may result in significant savings in the immediate cost or over the life of the equipment. Other alternatives may offer advantageous commercial terms and conditions (e.g. extended warranties, substation operating contracts for several years after in-service by the Service Provider, etc.)

The same section must contain wording to the effect of life-cycle cost evaluation of tenders and penalties that may be applied for non-conforming tenders.

PRICING REQUIREMENTS

The currency applicable to the contract and the evaluation of tenders must be clearly stated.

DELIVERY OF MAJOR EQUIPMENT

Responsibilities regarding the delivery of the Major Equipment to site must be outlined under this clause. Several options exist, depending if the contract will be based on free-issued Major Equipment by the Asset Owner on its existing blanket orders (in which case the delivery of such equipment may or may not be part of the Asset Owner's responsibility) or the Service Provider is required to obtain the Major Equipment. It is important to clarify these responsibilities, as progressively longer lead time deliveries can affect the project schedule negatively.

STRATEGIC SPARE PARTS

The Service Provider should be requested to submit with the tender a list of recommended spare parts and proposed deliveries to the Asset Owner. The price of parts should remain valid for the period required to complete the project and an additional one year thereafter – though the price may be subject to the same terms of escalation and foreign exchange as the rest of the goods and services offered.

APPLICABLE TAXES AND DUTY

To allow for a fair evaluation of tenders, the applicable taxes and duty payable in the respective jurisdiction must be clearly stated. Any tax or duty exceptions or remissions may require collaboration between the Asset Owner and the Service Provider, and the clause must clearly assign responsibilities for obtaining such exceptions/remissions, and who does the money belong to.

IMPORTER OF RECORD

This clause refers to Major Equipment and assigns the responsibility as to who is the Importer of Record for such equipment, the freight costs and the resulting paperwork submissions.

FOREIGN EXCHANGE

Significant fluctuation among various currencies can have a major impact on the price of the contract, in particular on the cost of Major Equipment. It is important to understand that such fluctuations translate into major risks which the bidders are understandable not willing to accept. The foreign exchange risks can be mitigated by various means (e.g. currency hedging), but to do that, the risks must be properly quantified.

The bidders must be requested to state the four components that define the foreign exchange exposure:

- The portion of their price that is subject to foreign exchange adjustments,
- The currency (or currencies) against which the price is subject to adjustments,
- The base rate to be applied at the time of tenders' closing,
- The Published Authority against which the rate must be calculated (e.g. Bank of Canada noon spot rate of the date),

The date at which the amount of adjustment must be calculated (could be a single date or multiple dates, e.g. Date of delivery (actual or scheduled) to site of the respective Major Equipment)

SOURCE OF SUPPLY FOR MAJOR EQUIPMENT

The bidders must provide detailed information on the proposed sources for Major Equipment (Power and Instrument Transformers, Circuit Breakers, Surge Arresters, Capacitor Banks, Reactors, SVC's, Diesel Generators, etc.).

DRAWINGS AND DATA

Requirements regarding the format of drawings, reproducibles, schedules and other data to be submitted with the tenders, as well as after the Contract Award for approval are to be clarified under this clause.

OPERATING INSTRUCTIONS AND SERVICE MANUALS

Similarly, the requirements covering the format and details for Operating Instructions and Service manuals for Major Equipment, and submission for approval to the Asset Owner must be detailed.

SCHEDULES

Requirements and firm dates for Project Schedules submission after the Contract Award are set out in this clause. They should cover both construction schedules as well as the delivery of major equipment to site. They may also cover schedules for subcontractors work.

QUALITY PROGRAM

The major Quality Programs governing the contract (e.g. ISO 9001, ISO 14000, etc.), the means of monitoring and surveillance by the Asset Owner, records required to demonstrate compliance (e.g. Quality Assurance Plan, QA manuals, etc.) and methodology to mitigate “non-conformances” are set out under this clause.

HAZARDOUS MATERIALS

Rules and regulations applicable under the respective jurisdiction to hazardous materials and their disposal must be detailed.

SHIPPING AND HANDLING

If the Service Provider is responsible for delivery of Major Equipment to site, this section should detail the transportation and shipping instructions as necessary.

PERFORMANCE SECURITY

This section contains requirements for Performance Bonds or any other surety and information covering reimbursement.

CORRECTION OF DEFECTS

The warranty terms for both equipment and installation work are set out, detailing the Service Provider responsibilities and obligations, as well as penalties for delays in providing warranty service, back-charging for labour provided by the Asset owner or third parties where the original Service Provider was not available, etc.

TERMS OF PAYMENT

Most turnkey contracts for substations will involve progress payments. While the actual schedule of such payments will be tied to milestones negotiated during Tender review meetings and be finalised in the Purchase Order, it is wise to set out the proposed progress payment schedule under this clause. The information necessary for the Service Provider to submit invoices should also be contained in this paragraph. This section must also contain references to the Performance Targets, withholding payments, bonuses and penalties for availability or un-availability of the substation or components of it.

PATENTS

This section outlines the legal obligations of the Service Provider regarding Patent Law : paying any royalties and patent license fees required by the equipment or work performed, as stipulated by law, defending at their cost any claims or actions that allege patent violations, or paying any penalties for infringement of such patents.

LAWS AND REGULATIONS

The Service provider will have to comply with the laws, bylaws and regulations prevailing in the respective jurisdiction, regardless of their nature or level: federal, provincial, or municipal. A statement specifying that all subcontractors are also subject to those laws is required.

CLAIMS AND ARBITRATION

Disputes or claims arising from the contract must be settled via a commonly agreed venue, rather than through costly legal action. Some jurisdictions provide for binding arbitration, governed by specific legislative acts. In such case, a statement to that effect must be included.

DEFAULT BY THE SERVICE PROVIDER

Sometimes, in spite of best efforts to pre-select Service Providers and evaluate tenders, the company selected is not performing as expected or unable to fulfil the contract. This clause defines what “default” on the part of the Service Provider is, and in such case, under what circumstance is the Asset Owner entitled to declare the company in “default”. It also specifies the remedies and penalties that the Asset Owner is entitled to in such case.

CONTRACT CANCELLATION

Due to unforeseen events the Asset Owner may be forced to cancel a substation turnkey contract that is already under way. This section defines the terms and conditions under which the Asset Owner has the right to cancel the contract, and the costs and expenses to which the Service Provider is entitled as re-imbusement for work already carried out.

SERVICE PROVIDER LIABILITY

The Service Provider will be required to arrange for insurance to cover his liability for personal injuries (including death) and property damage that occurs during or after the construction work. Most jurisdictions require that such liability survives acceptance, approval or use for work by the Asset Owner.

However, this clause must also clarify the Asset Owner's position in regards to claims for consequential damages and claims by third parties (other than personal injury, property damage or patent infringement). It is recommended that the Service Provider not be held accountable for such claims, as the insurance costs to cover these aspects would significantly increase the total cost of the project.

INVITATION TO TENDER - COVER LETTER

In this section the Asset Owner can state the most relevant items concerning the project, such as rough description of the scope of the project, delivery requirements, proposed project schedule, main technical requirements, required deadline for submission of tenders and validity time of tenders as well as contact information if clarifications are required.

The Asset Owner can also provide a short description of the main principles that will be applied for the tenders evaluation.

6.2 PART II – TECHNICAL DOCUMENTATION

There are significant differences in approach to this documentation between the “in-house” design of a substation and a “turnkey” approach.

Usually “in-house” designs are done by Asset Owners which are large utilities with tremendous experience accumulated in the design, construction, and in particular in operation of these substations. These Asset Owners have a long history in the business and have their own detailed standards and specifications that are based on the accumulated experience and knowledge. For an “in-house” project, the Asset Owner’s engineering staff would not require detailed technical documentation for the project, since they are very familiar with the Asset Owner’s requirements. Therefore, the time and effort required to produce such documentation for an “in-house” project is minimal.

In contrast, if the Asset Owner makes the decision to go for a “turnkey” project, the technical documentation has to be much more detailed, to convey to the Service Provider all the Asset Owner’s requirements. It also has to contain a complete set of the Asset Owner’s equipment specifications and design standards which the Service Provider has to follow during the project. These Asset Owners might want to produce a **detailed specification** based on their past experience and on availability of their own detailed standards and specifications. Such a detailed specification will contain very precise requirements for the Service Provider to follow.

With deregulation of power industries the number of substation Asset Owners has increased significantly. However, most of these new Asset Owners don’t have the background experience, technical documentation and Know How to produce detailed a comprehensive technical documentation for a substation project. These Asset Owners have two choices to address the problem:

- Retain a Consultant with solid technical experience as well as expertise in the field of technical documentation writing. This Consultant would produce the detailed technical documentation and would represent the Asset Owner during the entire tendering process of the project.
- Produce just a **functional technical specification**. A functional specification describes the principle and basic design requirements of the substation project. The Asset Owner would leave detailing of this documentation to the successful Service Provider. In this case it becomes imperative that the selection of the Service Provider must consider their previous experience with such projects and references from other users.

This section of the brochure summarizes the most important technical requirements which should be included in the technical documentation for a “turnkey” project.

In general, the technical documentation package for a turnkey project should contain the following:

- Technical Specification,
- Environmental and Safety Specification,
- Major Equipment Specifications,
- Building Specification,
- List of Referenced Standards and Drawings,

6.2.1 TECHNICAL SPECIFICATION

The Technical Specification document shall contain all the technical requirements the Asset Owner wants to convey to the Service Provider.

In general, the Technical Specification shall comprise the following major Sections:

6.2.1.1 GENERAL REQUIREMENTS

This section shall provide an overview of the project with emphasis on the following issues:

Description Of Project – presents a description of the project, the major parameters, and what the Service Provider is required to deliver in the project. As an example, for a distribution substation, the description should include the available land area for the substation, the high and low voltage of the substation, the number of incoming high voltage lines (and their length), the number of feeders expected to deliver distribution power and maximum short circuit level acceptable by the distribution customers, the installed MVA in the substation, the projected ultimate short circuit level, the delivery mode of the high/low voltage (by cable or overhead lines), the preference for the switchgear (GIS, metalclad switchgear or AIS). Information may or may not include a suggested 1-line diagram, but must include information relative to protection, control and metering requirements and communications (e.g. microwave, fibre-optics, phone lines, etc.),

Facility requirements that affect future maintenance must also be specified: requirements for control buildings, battery rooms, washrooms, maintenance/storage rooms, Fire Protection, HVAC requirements, AC/DC power supply requirements, diesel sets, if applicable facilities for compressed air

This section should also contain all information available to the Asset Owner related to the site of the new substation (or existing facilities if the project deals with refurbishment/retrofitting of an existing one). If not all information are available, the Asset Owner shall indicate in the document which party in the project will be responsible to obtain them,

Site Location and Environmental Data – presents the data related to the exact location of the future substation and provides the environmental data needed for the Service Provider to perform the work.

The Environmental Data shall contain, at a minimum the following information:

Condition:	Value:
Altitude Above Sea Level	m
Average Annual Rainfall	mm
Extreme Rainfall	mm
Max. Relative Humidity	%
Min. Relative Humidity	*%
Max. Outdoor Temperature	°C (dry bulb)
Max. Outdoor Temperature	°C (wet bulb)
Max Daily Average Outdoor Temperature	° C (dry bulb)
Min. Outdoor Temperature	°C (dry bulb)
Pollution (ref. To IEC/TR 60815 or C57.19.100)	salt, particles, etc.
Hourly Wind Pressure 1/30	kPa
Hourly Wind Pressure 1/100	kPa
Snow Load	kPa
Snowfall (maximum drift and cross depth)	mm
Ice Load (radial thickness)	mm
Max Solar Constant	kW/m ²
Rain Load	kPa
Seismic Data Za, Zv, v	G

Scope Of Work - lists Scope of Work responsibilities for the Service Provider and the Asset Owner and specifies the demarcation between the Service Provider's and Asset Owner's Scope of Work. It stipulates that project shall be executed as a turnkey contract per the Scope of Work and Technical Specification, Commercial Conditions and Terms and other documents that are a part of the tendering documentation and that the Service Provider shall be responsible for the design, engineering, fabrication, supply, delivery, erection, installation, required system studies, training of staff, testing commissioning, field verification of the complete substation.

This section of the document also specifies who will be responsible for the production of all necessary studies associated with the project (insulation coordination study, lightning protection study, short circuit study, EMF study, protection coordination study, grounding study, legal survey, topographic survey, noise study, etc.).

One very important aspect of the Scope of Work is the environmental component. Today environmental compliance is a must and it takes considerable work and effort to meet the environmental requirements. The list below gives a typical overview of the environmental activities/services required for a substation project:

- Environmental Assessment (Environmental Study report),
- Acoustic Assessment,
- Certificate of Approval for Noise,
- Certificate of Approval for Drainage,
- Site Approval,
- Chemical Soil Investigation,
- Environmental Specification for Construction,
- Environmental Monitoring During Construction

Information to be provided in Tender Submission – lists significant characteristics of all major components of the substation. This information is important for the Asset Owner in order to evaluate the level of compliance of the Tender with the requirements.

Project Schedule – contains the required preliminary project schedule which the Service Providers have to comply with. It also provides information related to the time frame for submittal of the Critical Path Method (CPM) Work Control Schedule required for meeting the substation in-service date, of the proposed detailed project and major equipment production schedule, a factory inspection plan, a design and production test program, construction plan and list of drawings, a list (by subsystem) of the major assembly and erection activities to be performed by the Service Provider's civil/structural, mechanical and electrical disciplines to complete the installation of the substation.

Quality Control And Assurance – contains the required level of quality assurance the Service Providers have to comply with. It usually requires that the Service Providers supply a general Quality Assurance Manual in the bid describing the quality assurance procedures routinely carried out at the Service Provider's works. In connection with this Manual the Service Provider shall submit certificate according to Quality Standard ISO 9001. In addition the Service Provider shall submit a Quality Plan for the proposed delivery - the Quality Plan shall define the systems and procedures which will be used by the successful bidder to ensure that the delivery will comply with the requirements of the contract.

Spare Parts And Serviceability – specifies the Asset Owner's requirements related to what spare parts shall be part of the contract, their availability for the required period of time and what level of service will be required and for how long from the successful bidder,

Drafting And Documentation – specifies the level of technical documentation related to Scope of Work. The documentation shall consist of all relevant civil/structural/mechanical/electrical/P&C/telecom drawings, all equipment manufacturer drawings, bills of material, cable list, technical description and applicable calculations, inspection, test & acceptance plan and installation, operating and maintenance instruction for equipment. This section also specifies the drafting practices, drawing review process to be followed by the Service Provider and the way "As Built" drawings and documents are to be handled.

Construction Site Organization – specifies what facilities the Service Provider has to supply at site for proper execution of the project. Such facilities might include: own temporary site offices, warehouse, lunchrooms, change-rooms, sanitary rooms, required utilities, security services and any other required facilities. The Service Provider shall provide forklifts, cranes, lifting and transportation equipment, tools, machinery and any other required equipment. This equipment and machinery shall be operated by qualified personnel, only. It also stipulates what facilities the Asset Owner shall provide to the Service Provider to allow the Service Provider to perform the work (i.e. power supply).

This section also should specify that the Service Provider has to be the holder of the Notice of Project and shall obtain all necessary permits for the work to start and to be done in accordance with all applicable bylaws and regulations.

Health, Environmental and Safety (HES) – provides the Asset Owner's health, environmental and safety requirements based on which the Service Provider shall conduct construction work. In addition to its own HES rules and policies, the Service Provider shall comply with local Occupational Health and Safety regulations, prepare HES program and submit it to the Asset Owner for approval and assign its own HES Coordinator and oversee all issues relating to health, environment and safety.

Also, the Service Provider is required to carry out and provide construction force with protective equipment, risk assessment specific to work sequence, safety meetings, safety procedures for specific hazards, on-site first aid, environmental protection, training relevant to local work protection codes, monitoring and auditing and reporting of major incidents to the appropriate authorities. It also specifies that special attention to be given for work safety in the vicinity of energized equipment, respecting limits of approach per the Asset Owner's requirements. For safe work in the vicinity of energized equipment the Service Provider shall evaluate risk, and, if necessary, build physical barriers around unsafe areas.

The **Environmental and Safety Specification** for the project shall be produced by the Asset Owner and should be part of the technical documentation package.

Power Outages – specifies the power outages which will be required for safe construction of the substation and for connection of the new substation to the system.

Project Coordination – specifies how the project shall be managed by the Service Provider. Usually, the Service Provider provides a Project Manager to manage the contract and be the single point of contact, develops a Project Execution Plan and submits it to the Asset Owner for approval before the award of Contract and participates in the Asset Owner's periodic project meetings.

6.2.1.2 MAJOR EQUIPMENT

This section lists all major electrical equipment and its ratings to be installed in the substation. Major equipment includes:

- Power transformers,
- Gas Insulated Switchgear,
- Mixed Technology Switchgear,
- HV Circuit Breakers,
- Disconnect Switches and Grounding Switches,
- Instrument Transformers,
- LV Circuit Breakers (or Metalclad Switchgear),
- Surge Arresters,
- Reactors,
- Capacitor Banks,
- Line traps,
- Special Equipment (i.e. Static Var Compensators, etc.),

If these pieces of equipment have to comply with international standards, these standards should be referenced in this section and all additional technical data to be included. However, if the Asset Owner has its own equipment specifications and requires compliance of the equipment with its standards as well with international ones, then Asset Owners detailed specifications shall be attached to the technical documentation package as separate documents under the heading "**Major Equipment Specifications**".

As an alternative, the Asset Owner may chose to allow the Service Provider to use existing blanket contracts for major equipment. The advantages of such decision are that:

- Standardization of equipment through the utility is desirable,
- Delivery lead times for major equipment under blanket orders are shorter, as no additional tendering and evaluations are necessary,
- The utility often benefits from preferential prices for long term contracts, which the Service Provider cannot obtain for one-off contracts. The savings can be passed on to the Asset Owner,
- Major equipment has already been technically evaluated and its reliability found acceptable. It is being manufactured to existing specifications and quality control,
- The manufacturers are familiar with the Asset Owner's customized requirements,

6.2.1.3 GENERAL DESIGN REQUIREMENTS

This section provides general guidelines and instructions to the Service Provider related to the design component of the contract. It requires that the performed work and supplied equipment, material, devices, hardware and software for the project shall meet or exceed, in regard to quality, ratings, reliability, functionality, integration to electricity network, future expansion ability, serviceability, maintainability, health, safety, environmental and ergonomics the requirements given in the technical specification and applicable international, national standards, Asset Owner's standards and guidelines, prevailing legislation and best engineering practices. It also requires that physical layout and equipment shall conform to the latest state-of-the-art design practices and that all materials used for equipment, steel structures and accessories shall be of high quality, while satisfying all functional requirements under any possible combination of environmental conditions, the objective and providing simplicity, reliability and safety while ensuring high economy and low maintenance cost. Personal safety and all required precautions and provisions necessary to make the works safe, shall be considered a paramount requirement of the design.

The design and construction of the substation shall comply with the requirements of national and local legislations and by-laws.

6.2.1.4 CIVIL/STRUCTURAL WORKS

This Section provides basic identification of the Civil/Structural Works for the Service Provider to determine upfront the nature of the Civil/Structural Works involved in the project. It provides all labour, products, equipment and services necessary to complete the Civil/Structural Works of the project. Legal Surveys and Topographic Surveys required for completion of the project are usually included in the technical documentation package. If not, the turnkey project contract specifies who is responsible for the surveys to be done.

Civil Works deal with:

- Removal of trees, shrubs and any other objectionable materials and dispose of off site,
- Relocation of existing underground services as necessary,
- Removal of topsoil and stockpile at designated areas,
- Design, building and commissioning of storm sewer systems, site perimeter ditches, subgrade, rough grading, site access and station service roads,
- Design and installation culverts,
- Installation of temporary construction roads,
- Design, building and commissioning of spill control systems for transformers,
- Obtaining all necessary permits, approvals or clearances. This will include but is not limited to: Building Permits from local municipality, and Certificates of Approval,

Structural Works deal with concrete foundation, footings, anchor bolts & shear, anchor & piles, outdoor steel structures and substation safety fence. Structural works also covers design of any sound barriers / enclosures around power transformers / reactors required to meet local guidelines for noise,

6.2.1.5 MECHANICAL WORKS

This Section provides the requirements for mechanical works to be provided by the Service Provider. It specifies all labour, products, equipment and services necessary to complete the Mechanical Works component of the project,

The following issues have to be addressed by the specification:

- Water supply and sewer facilities. Usually, outdoor substations require water supply and sewer only for the relay building. Indoor substations have more elaborate water supply and sewage systems,
- Fire detection and protection systems. Such systems have to be installed mainly in indoor substations around power transformers, high voltage cable terminations, switchgear rooms, etc. All components of such a system shall be interconnected and controlled by a central HVAC panel which also controls the ventilation and air conditioning. The level of fire protection is dictated by international standards and by local bylaws,

6.2.1.6 BUILDINGS

This Section provides the Architectural, Civil, Structural, Mechanical and Electrical requirements that have to be met by the Service Provider for erection of buildings associated with the substation. This section could be quite extensive. Therefore, the [Building Specification](#) is usually covered by an Appendix to the Technical Specification. See [chapter 6.2.2.](#) in this brochure for more details,

6.2.1.7 ELECTRICAL WORKS

This Section gives the Service Provider the design requirements for the entire electrical installation of the substation. Depending on the degree of control the Asset Owner wants to exercise over the turnkey project, the contents of this section can be more or less detailed. The Asset Owner has the option of requesting the Service Providers to include in their submissions their own proposals for the basic electrical elements. It usually covers the requirements for the following major topics:

- **Single Line Diagram** – this diagram conveys to the Service Provider the desired diagram of the substation with electrical location of all major electrical equipment to be installed. The Single Line Diagram shall be done for the initial as well as for the ultimate stage of the substation, Alternatively, the Asset Owner can request proposals for the 1-line diagram and evaluate them against reliability requirements, total built cost and substation maintenance costs over expected life-cycle.
- **Basic Layout** – this subsection covers location of all major electrical equipment, structures, buildings, roads, etc. in the substation with emphasis on maintaining the required electrical and safety clearances for the specified voltage levels and Lightning Impulse Level (LIL), accessibility to various components of the station, reliability requirements, maintainability, constructability, etc. The Basic Layout of the substation shall be developed for both the initial stage as well as for the ultimate stage. Basic Layout drawings might be developed by the Asset Owner based on their internal standards and requirements or might be part of the turnkey project, Again, as an alternative, the Asset Owner can request proposals from the Service Providers for an optimal Layout and evaluate them as part of the total package.
- **Grounding** – this subsection covers permanent, temporary, cable shield and P&C facilities grounding. All these grounding installations shall be capable of carrying the ultimate maximum ground fault current for the substation fault magnitude and duration, without causing any hazardous potentials, potential gradients, interference to other systems, or damage,

Grounding shall include:

- grounding of all conductive enclosures that may be touched by personnel thereby eliminating shock hazards,
- grounding to limit voltage in the substation to definite fixed values of step and touch potentials to ensure personnel safety,
- appropriate grounding around surge arresters and lightning protection masts to create a low resistance path to earth,
- grounding of all metallic fences and gates around the perimeter of the substation and inside it,
- grounding around the buildings located inside the substation,
- **Lightning Protection** – this subsection specifies the required protection of the substation against direct lightning strokes. Lightning protection shall be designed such as to provide adequate shielding from direct lightning strokes taking into account the iskeraunic level of the area where the substation will be built.

- **Buswork & Insulators** – this subsection provides details on the characteristics of rigid buses, strain conductors and insulators to be specified by the Service Provider for the entire buswork of the substation. The Service Provider shall provide the calculations based on which the entire buswork of the substation has been selected,

Usually, the substation buswork consists of strain and rigid buses, bushings, insulators, conductors and connectors. Buses, connections and bus supports shall be designed to withstand worst case scenario of forces resulting from combination static and dynamic forces created by:

Static pressure of a specified wind speed on tubular conductors, insulators, bus support, connectors and conductors,

Static pressure of a specified wind speed on tubular conductors, insulators, bus support, connectors and conductors, all covered with a specified layer of ice (where applicable),

Dynamic pressure of wind for above speeds with a specified gust factor,

Dynamic forces of momentary ultimate short circuit current at installation location,

Automatic re-closing,

The tubular rigid conductors and stranded conductors shall be sized for maximum mechanical stresses for the worst case scenario, the conductor temperature rise during ultimate short circuit current for the predicted duration of the fault (usually 3 sec.) and nominal continuous current for specified environmental conditions (aluminium conductors may operate continuously at 90°C, utilizing welded, compression and implosion connectors; copper conductors may operate continuously at 70°C, utilizing either bolted or compression connectors),

Rigid buses in high voltage installations (230 kV and over) shall be provided with damping conductors inside the buses to reduce wind generated vibrations. Also all buswork used for installations above 230 kV shall be certified for Corona free operation at these voltage levels,

Insulators shall be selected such as to meet the specified environmental conditions (level and type of pollution) and to withstand the combined stresses imposed by worst case scenario short circuit and wind/ice conditions. A safety factor for sizing of insulators on mechanical loads, for maximum static loads and for combined maximum static and maximum dynamic loads shall be included for the selection of the mechanical characteristics of the insulators.

- **AC and DC Station Services** – this subsection specifies the requirements for the auxiliary AC & DC station services (AC SS and DC SS) needed for the substation. The Service Provider is responsible for designing the AC & DC SS power supply distribution system such as to facilitate safe, reliable, correct and accurate operation of the substation.

The AC and DC SS's Conceptual Single Line Diagrams shall be included in the documentation; these diagrams shall reflect the reliability requirements of these station services based on the importance of the particular substation in the system. The Service Provider will develop the detailed diagrams once the real AC & DC SS loads will be available.

- **AC SS:**

- All critical loads as determined by the Asset Owner (AC loads which must have uninterrupted AC power supply, e.g. transformer cooling, thyristor valve cooling pumps and radiator fans, SF₆ dead tank breaker tank heaters, etc) shall have redundant AC power supply, i.e. shall be equipped with automatic transfer switches,
- The most critical loads, as determined by the Asset Owner shall have a third source of AC power supply. It shall be supplied by a DC/AC inverter that should automatically takeover the AC power supply in case of total loss of station AC power supply,
- Adequate power receptacles shall be provided in the substation for supply of SF6 handling carts, power tools, etc. Lighting fixtures have to be provided for safe navigation through the substation and for checking of proper position of load interrupter and disconnect switches during and after operation,
- Grounding requirements of the entire AC SS supply system shall be specified,

- **DC SS:**

- The size and rating of the DC SS equipment shall be based on the DC SS load profile. This load profile shall take into account the load to be supplied in the initial stage and shall allow for future expansion of the substation and addition of supplementary loads.

- Location of the DC SS equipment shall be such as to prevent total loss of DC SS in case of a major failure in any of the components (i.e. location of batteries in separate dedicated rooms, separation of switchgear and battery chargers belonging to DC SS system “A” from the one belonging to system “B”, etc.),
- The voltage of the DC SS shall be selected such as to avoid significant voltage drops during operation,

For all of the above subsections, applicable international, national and Asset Owner’s standards have to be listed and drawings referenced which have an impact on the design of a particular component of the substation,

6.2.1.8 PROTECTION & CONTROL DESIGN REQUIREMENTS

This Section provides the requirements for design, installation, programming, and commissioning of all required protection and control functions. It also stipulates that performance characteristics of the protection and control hardware and software systems to be installed. This Section usually covers the requirements for the following major topics:

- Protection and Controls of all major equipment,
- Redundancy - dual redundant protection and fully redundant control systems might be required to meet required availability and reliability,
- Number and size of P&C racks for the initial and ultimate stage of the substation,
- Physical separation of the protection systems to mitigate single point failures – i.e. level of separation between P&C racks containing relays associated with “A” and “B” protection schemes (in some jurisdictions racks with relays associated with “A” protection scheme have to be located in a separate room from the ones associated with “B” protection scheme),
- Additional requirements of the Protection and Control systems – i.e. requirements for effective shielded against electrostatic and electromagnetic interference, grounding of control cables, etc.
- Telecom facilities,
- Power And Control cable systems,
- Protection and Instrumentation wiring and cable specification,
- Protection, Control and Instrumentation wiring and cable connection, routing and grounding requirements,

6.2.1.9 TELECOMMUNICATION REQUIREMENTS

- Communication system required for the substation to meet the requirements of the Asset Owner, including the dc power supply system. The system should be integrated with any system the Asset Owner presently might have or plans to have in the future. This information should be coordinated with other relevant design groups.
- Visual impact of any towers that are required as part of the new communication system at the substation,
- Mitigation required of any interference that a new communication system associated with the substation will have on any existing systems, such as nearby radio towers or airport communications, as required by national codes or standards,
- Size of communication equipment the ultimate substation will require, including separate dc supply. This information should be coordinated with the civil design group so that the area required for this equipment can be taken into account in any buildings required,
- Ultimate ac loads the communications equipment will require. This information should be passed on to the electrical design group to aid this group in the sizing of the ac station service required for the substation.

6.2.1.10 TESTING REQUIREMENTS

This Section provides the requirements for testing of all components of the substation. The section shall specify all testing to be performed in accordance with applicable international, national, Asset Owner’s standards and additional tests as requested by the Asset Owner. It also shall state that where standards are not suitable or applicable, the Service Provider shall recommend other common industry procedures and test methods which shall be approved by the Asset Owner.

The Section shall also cover the conditions under which:

- the Service Provider must replace or repair any piece of equipment that doesn't pass a test or is damaged and the conditions under which the Service Provider must redo the tests previously done on any equipment which is replaced, repaired or modified.
- the Service Provider can perform field verification tests when the tested equipment/component is connected to the power system.

6.2.1.11 TRAINING REQUIREMENTS

This Section covers the training requirements for the Asset Owner's personnel. The training shall be comprehensive to enable the Asset Owner to operate and successfully maintain all major equipment of the substation and the personnel providing the training shall be knowledgeable and well qualified. The Section shall also require that a description of the training program to be submitted to the Asset Owner for approval.

6.2.2 BUILDING SPECIFICATION

This specification supplies the Service Provider with the technical requirements for the building(s) to be installed in the substation. Buildings in outdoor substations usually house protection and control equipment as well as part of the AC & DC SS. In large outdoor stations such buildings are larger and they provide space for maintenance activities and for storage as well. High voltage Gas Insulated Switchgear might also be located in a building in an outdoor substation.

Specifications for such buildings are quite elaborate. Some of the issues to be addressed in the specification are:

- Type of building required - usually an industrial, low maintenance and energy efficient building is required for a substation environment. Load bearing masonry, flat roofed buildings or pre engineered steel framed buildings, clad with siding and with sloped gable roofs are two acceptable alternatives for such a building,
- Details on wall panels, roof assembly, floors and raised floors, ceilings, doors and openings, windows, exterior steps, conduits and cable ducts, etc.
- Loadings on the building components (roof, walls, floor, etc.) based on specified environmental conditions and on dead and live load to be installed in the building,
- Requirements for roof and washroom drainage as well as for water supply to the building,
- Requirements for the heating, ventilation, and air conditioning system (HVAC) and for the fire detection, protection and security system of the building,
- Requirements for the electrical services of the building (interior, exterior and emergency lighting, power receptacles, cable raceways, distribution panels, etc.) as well as for the data/phone/LAN connections,
- Requirements for grounding and lightning protection of the building,

6.2.3 ENVIRONMENTAL AND SAFETY SPECIFICATION

The Environmental and Safety Specification supplies to the Service Provider the requirements of the Asset Owner related to all environmental and safety aspects of the project. Significant requirements that should be included in the document are:

- **Due Diligence** - the Service Provider must demonstrate due diligence by:
 - Preventing adverse environmental impacts, i.e. prepare emergency plans, complete training, wear personal protective equipment, use adequate equipment and materials, eliminate unnecessary contaminants, recycle, etc.,
 - Mitigating adverse environmental impacts that do occur, at the earliest possible time, i.e. clean up at sites where contaminants/pollutants have been released into the natural environment, report internal/external stakeholders, restore sites, etc.); and
 - Complying with all of the Asset Owners policies and procedures, and all laws and regulations regarding work operations (i.e., site supervision, government agency notification, record keeping, etc.).
- **Daily Introduction/Review of Environment (and Safety) Issues** – the Service Provider shall provide documented job planning activities (which shall include job steps, hazards, barriers and environmental issues) and these must be communicated to, and understood by all personnel on the job site. Also, the Service Provider shall conduct daily reviews with all personnel, regarding potential site contaminants as they may relate to both worker health and environmental impacts,

- **Environmental Incident Management** – the Service Provider shall:
 - prepare a project specific Emergency Preparedness and Response Plans (EPRP),
 - prepare an Environmental Incident Response (which usually consists in retaining the services of Spills Emergency Response contractor),
 - prepare an Environmental Incident Report – the Service Provider shall follow the Asset Owner’s reporting procedure which will be supplied for incorporation into the Service Provider’s EPRP.
- **Waste – Management** – these include:
 - Conventional Waste, Liquid Industrial Wastes, Hazardous Solid Wastes and Sediment and Erosion Control,
 - Pumped-out Waters - ground waters/pump-out waters shall be managed in accordance with all legislated requirements. The Service Provider must arrange for all necessary testing well in advance of pumping operations to have water sample(s) collected and tested.
 - Scrap Metals - all scrap metals must be recycled,
 - Dangerous Goods/Hazardous Products Management
 - Non-Hazardous (and Non-Recyclable) Solid Industrial Wastes - these wastes comprise soil, spoil, gravel, road building materials, concrete and any other materials that are NOT commonly considered to be recyclable,
- **Soil Contamination and Disposal** – the Service Provider shall test for contamination and until the required soil testing is completed, all station spoil will be treated as if it was contaminated. The Service Provider must ensure that composite soil samples are taken for soil testing from all excess spoil which must undergo both bulk and leachate testing. The results of these tests will determine how the material can be disposed,
- **Transporting Dangerous Goods (TDG)** – the Service Provider must ensure that dangerous goods are managed (handled, stored, transported and shipped) in full compliance with all legislation. “Manage” shall include, but shall not necessarily be limited to:
 - Use only those dangerous goods that are absolutely necessary on-site,
 - Maintain current inventory of all dangerous goods stored on site,
 - Ensure all dangerous goods stored on-site are in marked containers/facilities,
 - Maintain all records and documentation as required,
 - Complete all required documentation (Bills of Lading) for all dangerous goods transported/shipped; and
 - Ensure all personnel involved in transporting dangerous goods activities adequately trained – provide training as required.
- **WHMIS** – the Service Provider shall ensure that all requirements of the Workplace Hazardous Materials Information System (WHMIS) Regulation of the Occupational Health and Safety Act are met. The WHMIS Regulation applies to all dangerous goods, toxic products and any product that has, or should have, a WHMIS or Workplace label.
- In addition to its own Health, Environmental and Safety (HES) rules and policies, the Service Provider should conduct construction work according to the applicable local laws, regulations, by-laws, rules and policies.
- The Service Provider should prepare HES program and submit it to the Asset Owner for approval.
- The Service Provider should assign its own HES Coordinator and oversee all issues relating to health, environment and safety.
- The Service Provider should carry out and provide construction force for the following:
 - Risk assessment specific to work sequence,
 - Site equipment maintenance,
 - Personnel protective equipment,
 - Safety procedures for specific hazards,
 - Safety meetings,

- Occupational health,
- On-site first aid,
- Environmental protection,
- Monitoring and auditing HES,
- Reporting of major incidents,
- The Service Provider should pay special attention to work safety in the vicinity of energized equipment, respecting limits of approach as per the Asset Owner's requirements or as per established national/international standards. For safe work in the vicinity of energized equipment the Service Provider shall evaluate risk, and, if necessary, build physical barriers around unsafe areas.

6.2.4 MAJOR EQUIPMENT SPECIFICATIONS,

The Equipment Specification provides the technical requirements for all electrical equipment to be installed in the substation. Given the volume of information required for presentation of these requirements and due to the fact that most requirements would be covered by standards, the section only makes reference to the appropriate standards.

The Asset Owners standards related to the equipment to be installed (if available) shall be included as Appendices to the Section as "[Major Equipment Specifications](#)",

6.3 PART III – FORM OF TENDER

A good tendering document is a prerequisite for the proper evaluation of tenders. The tendering document should, in addition to the technical, commercial, reliability and maintainability requirements, also include a well designed Form of Tender that contains clear and detailed instructions on what should be included in the tenders. The submitted bids filed on the Form of Tender must allow the Asset Owner to compare all tenders on an equal basis.

6.3.1 DECLARATION

This section contains basic information that includes:

- The identification number of the RFT or RFP, e.g. Requisition number, or Contract number, depending on the Asset Owner's procurement system used,
- The name of the Tenderer and his coordinates (full address, telephone number, e-mail address, web site, etc.),
- Tenderer's reference number for this particular tender,
- A formal Statement of Offer, with sufficient space to be filled with the Tenderer's offer.,

6.3.2 SCHEDULE OF PRICES

This section is the most important in the Form of Tender. It contains a listing of the items being tendered and space to be filled by the bidder for the prices associated with each item. If multiple items are tendered, with delivery/completion spaced over a number of years, the form should contain multiple columns, to allow for prices for each year.

Each item description must be detailed enough to avoid any confusion between different items, and the determinant value (e.g. minimum temperature withstand at -30°C versus another item for -50°C, or short circuit capability, or number of feeders, etc), should be in bold lettering.

The Schedule of Prices should include add/delete items (e.g. feeders or instrument transformers, etc.) and items such as Training Courses (for Major Equipment maintenance) at site or in the plant, Service Provider-offered site maintenance, etc.

It is also advisable to allow space under each price (expressed in numbers) for the price to be filled in letters as well, to avoid any possible confusion that could lead to wrong interpretation of the price, or even invalidation of the tender.

It is recommended that the Schedule of Prices include a price list of components and spare parts, to be filled at the same time with the prices for the main items of the tender. This price list validity should be the same as that for the main items and allow for optional purchase during the life of the contract at a fixed price.

Under the same section, a page should be provided for the bidders to submit price reductions for quantity discounts or for deletions or certain features specified in the main bid.

6.3.3 PROOF OF ABILITY

On this page the tenderer is requested to provide information pertaining to their organization and experience with similar projects. Specific questions can be formulated to ask for such info as:

- Number of design engineers in the organization,
- Number of experienced draft persons and supervisors,
- Experienced project engineers/managers,
- Affiliated construction contractors and their experience and number of personnel,
- Experienced testing and commissioning staff,
- Similar projects performed in the past and rough value,

6.3.4 MAJOR EQUIPMENT SUPPLY SOURCES

Questions related to the source of Major Equipment to be installed in the substation need to be detailed and must cover various aspects such as:

- Ordering (to the Technical Specification),
- Manufacturing processes and schedules,
- Quality assurance implementation and verification in the manufacturers' plants,

- Factory testing and acceptance criteria,
- Inspection and test witnessing prior to shipping,
- Shipping to site and installation,
- Need for specialised erection consultants,
- Site testing, commissioning and acceptance by the Asset Owner,
- Warranty of Major Equipment,
- Support from OEM during the equipment life,
- Maintenance manuals, training videos, parts lists, etc.

6.3.5 MASTER SCHEDULE

This section contains a table incorporating the key events (milestones) of the contract and space for dates to be filled in by the Tenderer (a sample for a circuit breaker is attached in [Table 6.1](#). – it can be adapted and used for a turnkey substation). For turnkey substation contracts master schedules are required for all major equipment as well as for the project site construction phase.

6.3.6 DRAWINGS AND DATA SUBMISSION

Under this heading statements from the Tenderer are required to indicate the firm dates for submission of the drawings for approval and the Major Equipment type test dossier for evaluation by the Asset Owner.

6.3.7 PRICING INFORMATION

This section must provide the space for the Tenderer to advise if the prices for the various items and freight to site are subject to escalation (changes in the cost of labour and material over a longer period), and in such case if they are tied to specific indexes or tariffs.

In the same section, the Tenderer must indicate if the prices are subject to foreign exchange adjustment. If they are, then the Tenderer must indicate:

- the currency (in the country of origin),
- the percentage of content that is subject to foreign exchange adjustment,
- the base rate of exchange (at the time of tendering),
- the date when such adjustments should be calculated (e.g. delivery to site of the piece of Major Equipment which is subject to adjustment),

6.3.8 TERMS OF PAYMENT

This section should allow the Tenderer to indicate if it accepts the terms of payments offered in Part I by the Customer, or alternatively, if progress payments are required and in such case insert a proposed schedule for progress payments based on specific milestones.

6.3.9 VALIDITY OF PRICES

On this page the Tenderer can confirm the validity of the prices submitted for the required tendering period or beyond (30 to 90 days usually). Occasionally, though not recommended, the tenders validity may have to be extended beyond the initially scheduled period necessary for evaluation. In such case it is necessary to request confirmation from all original tenderers that the price validity is extended.

6.3.10 TABULATION OF TECHNICAL DATA

Technical Data tabulation for a turnkey substation will need to contain such tables for all Major Equipment required for the substation. These tables are under normal circumstances very detailed, requesting in addition to nameplate and test data various critical information for each type of Major Equipment and associated auxiliary equipment that may be required.

6.3.11 SIGNATURES PAGE

This page has legal significance and contains space for the required signatures of Tenderer's designated persons authorized to submit a tender on behalf of the Service Provider, as well as for their title and position in the company and the date and place of signing.

It should also contain space for the Company seal, as required.

TABLE 6.1.

MASTER SCHEDULE
(Contract Key Events)

Project/Station:	Work Order:	Requisition No:	Date:
Equipment Description:	Purchase Order:		
Manufacturer's Name:	Tender Ref. No:		
Contract Administrator:	Title:	Telephone No:	

KEY EVENT	KEY EVENT	REQUIRED DATE (1) (2)	GUARANTEED DATE (1) (2)	ACTUAL DATE(1)	REMARKS
	Release Purchase Order Issued				
	Manufacturer Contract Schedule				
	Submission:				
1a	Civil Drawing Package				
1b	Outline Drawing Package				
1c	Diagram Drawing Package (excl. CWD)				
1d	Connection Wiring Diagrams				
	Approvals:				
2a	Civil Drawing Package				
2b	Outline Drawing Package				
2c	Diagram Drawing Package (incl. CWD)				
	Reproducible:				
3a	Civil Drawing package				
3b	Outline Drawing Package				
3c	Diagram Drawing Package				
4	Design Review Meeting				
5	Pressure Vessel Registration (if applicable)				
6	Release or Engineering				
7	Ordering of Materials				
8	Submission of Equipment Manuals				
9	Approval of Equipment Manuals				
10	Design Tests Complete				
11	Design Test Reports				
12	Approval				
13	Start of Significant Manufacture Activity				
14	Completion of Assembly:				

15	Factory Acceptance Tests Complete				
16	Delivery Dates (Site)				
17	Site Acceptance Tests				
18	In-Service Dates				
19	Min. Lead Time From Issue of Release Purchase Order to Delivery at Site.				

Notes:

1. Calendar date format shall comply with SI system, i.e., year-month-day.
2. Tenderer shall complete the column and may add new key events as required.

7. P REQUALIFICATION OF SERVICE PROVIDERS

7.1 INTRODUCTION

An essential step for a Turnkey project is the procurement process, and as part of it, the selection of reputable Service Providers. The Service Providers must be able to provide all or most of the following services: plan, engineer, specify, procure, manage the project, build and commission the substation, as well as integrating the new substation(s) into the utility system. They must also provide performance guarantees for a period of time that can vary, but should extend to a minimum of 2 years after completion.

Because of the wide range of services required and the risks associated with non-performance on any of these tasks, it is highly recommended to proceed in two steps:

- The pre-selection process should limit the pool of suitable Service Providers to a number that is lower than 5 but no less than 2 candidates. This chapter is addressing the pre-selection process and associated activities.
- The actual selection, via a Request for Proposal, should include the preparation of the specifications and tendering documents, issuance of tenders, evaluation and award to the most suitable candidate. This process is dealt with in [Chapter 8](#) of this brochure, "Tendering Process".

The Prequalification Process is somewhat different for extensions or refurbishments, where the Original Equipment Manufacturer (OEM) has a definite advantage in the process, due to obvious expertise and skills at maintaining and repairing the equipment originally manufactured by them. In some cases however, there may be possible to include other Service Providers, sometimes run by or employing former OEM staff on the list of acceptable potential bidders.

7.2 THE PRE-SELECTION PROCESS

The starting point of the Turnkey Project is the preparation of the Procurement Plan, covering both the Pre-selection Process and the actual Tendering, Evaluation and Award.

The Pre-selection Process should include:

- Preparation of a Brief Functional Specification.
- Preparation and issuance of a Statement of Intentions that should attach the Brief Functional Specification.
- Development of a set of qualification criteria to be applied in the Pre-selection Process.
- Identification of potential vendors and products that have the capability to meet the functional requirements specified and preparation of a list of such vendors.
- Preparation and issuance of an Invitation for Expressions of Interest to the vendors identified above.
- Evaluation of the Expressions of Interest received, based on the qualification criteria developed earlier.
- Selection of the qualified vendors – a minimum of two, maximum four – that will receive the Request for Proposal (RFP) documents.
- The issuance of the RFP (covered under [Chapter 7](#)).

Details of these steps are outlined below.

This document is a skeleton of the future Functional Specification (to be prepared for the RFP) and should outline the number and location of the planned turnkey substation, and minimum data related to each of them, such as:

- A proposed time frame for the building and in-service dates of the proposed substations.
- The number of proposed transformers and the required MVA
- The number of high voltage lines connecting each substation to the system
- The number of immediately required and future feeders planned for each substation,
- Basic Protection & Control (P&C) and telecommunication requirements necessary to integrate the substation into the system
- Other pertinent details (e.g. power entrance and exits via cables or overhead lines), geographical and road access details, environmental and seismic requirements, etc.

A complete functional specification defining all aspects of the projects must be prepared for the RFP. The full functional specification must include:

- System performance requirements (installed MVA, ampacity values, fault withstand capabilities, BIL, etc.
- Base design drawing
- A full list of Standards to which the substations must conform
- Project schedule information
- Training requirements
- Documentation requirements
- Installation and commissioning requirements
- Maintenance requirements
- Project management requirements
- Safety requirements
- Interfacing requirements with existing system/facilities detailing demarcation responsibilities for all points of interconnection including electrical, telecommunication, P&C
- Performance measurement criteria.

The objectives of the Statement of Intentions are:

- To make the Asset Owner's intentions known in the market place
- To allow the potential Service Providers to form alliances (e.g. between consulting engineering firms, contractor service organizations and electrical equipment manufacturers), pool resources and prepare for the Expression of Interest process, based on the brief functional specification issued with the Invitations for Expression of Interest.

The objectives of the issuance of Invitations for Expression of Interest are to:

- Identify potential vendors and products that demonstrate the capability of meeting the functional requirements for the planned substations.
- Minimize the time and cost required to evaluate full proposals.
- Maximize the quality of the pre-selected vendors responses

The qualification criteria must be developed prior to the issuance of the Invitations for EOI's. These criteria must insure that potential bidders have adequate resources and the necessary experience to complete the projects successfully and within the proposed time frame. Some of the criteria that address financial and technical capabilities of the potential suppliers will be of a "pass/fail" nature. Others will be on a "points" system to allow the selection of preferred bidders in the case of a large number of qualified candidates. Examples of these criteria include:

- Financial health of the bidder – does the company have sufficient financial resources for a project of the scope intended?
- Project performance – can the company demonstrate a record of satisfactory schedule and cost performance on similar projects undertaken in the past? Is the company involved in any legal action for non-performance on previous projects?
- Technical capabilities – can the company demonstrate familiarity with the functionality required for this project? What is the track record of the electrical equipment the company intends to offer?
- Maintenance capability – can the company offer maintenance contracts for the duration of the warranty period and beyond?
- Claims management – has the company been involved in claims on previous contracts? What sort of claims needed settlement and to what extent did the company show flexibility in the claims settlement process?

The Asset Owner can obtain information and compile a list of potential vendors using a variety of sources, such as:

- Past providers of contractual services
- Major electrical equipment manufacturers
- National and international engineering companies

- References from other users of Turnkey services that have successfully completed such projects.

The preparation of the Invitations for Expression of Interest has been discussed above. Depending on each Asset Owner's legislative status, the issuance can be distributed widely via advertising in major news publications, on its websites, etc., or to a select list of potential Service Providers. If the Asset Owner has limited resources available for the evaluation process, it is advisable to limit the number of Invitations to a short list of strong bidders that are known nationally and internationally for previously successfully completed turnkey projects.

Once the submissions are received, copies must be distributed for evaluation by the various functions: Engineering, Finance, Procurement, Legal and Maintenance. A tight schedule to provide comments must be observed and all comments should be channelled to the authority in charge of the Turnkey project.

In addition to a thorough evaluation of the documents submitted by potential vendors, it is recommended that individual meetings with the most promising suppliers be conducted. During such meetings various functions of the Asset Owner will have a chance to detail some of the requirements of the projects, such as technical, commercial, legal and project management aspects. The meetings would require the attendance of the vendors' top technical personnel and as such would allow a more intimate assessment of the companies' technical strength and capabilities.

Evaluation of the received materials and the impressions from the meetings with the vendors must be summarized and weighed appropriately before the short list of Service Providers is finalized.

A proposed sample Evaluation Form for the Expression of Interest, containing evaluation categories, scoring and weighting factors, is attached.

Once decisions on the short list of Turnkey Service Providers are finalized, the vendors must be informed in writing and the second stage – the actual issuance of the Request for Tenders (RFT) or alternatively of the Request for Proposals (RFP) must be undertaken immediately.

The RFP's offer some advantages over RFT's as they allow for greater flexibility to the Service Provider in offering alternate solutions to the one requested in the RFP. This allows sometimes for application of new technologies or non conventional approaches to the tasks at hand. RFP's usually require only functional specification, since it allows wider interpretation of the requirements,

The RFP that is issued at this stage in the Turnkey project must contain all information required to enable complete submissions by the short-listed Service Providers, including any innovative solutions they may propose.

RFT's are usually used by Asset Owners that wish to maintain standardized solutions in their system such as standardized single line diagrams, reliability criteria, maintainability requirements, low level of spare part inventory, low level of reliance on OEM (Original Equipment Manufacturer), etc.

Depending on the nature of the project (full new substation(s), addition of new bays in existing substation or refurbishment of existing installations), the RFP/RFT must incorporate the general and technical specification, the commercial terms and conditions and the Form of Tender.

The RFP Form of Tender, in addition to space allocated for description of the main proposal, should provide suitably marked-up space for submission by Service Providers of alternatives or innovative solutions.

EXPRESSION OF INTEREST EVALUATION FORM

Sub Categories	Reference*	Score (out of 10)	Weighting	Score Weighting	Respondent A	Respondent B	Respondent C	Respondent D
1 Organization Profile			Out of 15					
Overall Structure			3					
Project Management			2					
Engineering and Design Team			3					
Construction and Commissioning Team			1					
Quality Assurance Team			1					
Substation Maintenance Team			1					
Major equipment Suppliers			2					
Sub-Contractors			2					
2 Respondent Financial Profile			Out of 11					
Financial Statements/Profitability			11					
3 Technical Abilities and Experience			Out of 22					
Turnkey			5					
Design			5					
Equipment Procurement			3					
Construction and Commissioning			3					
Maintenance			2					
Project Management			4					
4 Manufacturing & Supply Capability			out of 20					
Manufacturing & Supply Capability			5					
Place of Manufacture			5					
Ability to Meet Schedule			10					
5 Safety			Out of 19					
Claim History			2					
Assessment Rating			7					
6 Environmental Stewardship			Out of 8					
Corporate Environmental Policy			2					
Environmental Records			6					
7 General Reputation in Industry, Past Experience			Out of 15					
Totals								

8. TENDERING PROCESS

8.1 RELEASE OF RFP'S/RFT'S

The process of assembling the tendering documents should proceed in parallel with other activities of the turnkey process, i.e. prequalification of Service Providers,

The entire tendering documents package must be ready by the time the prequalification of Service Providers is complete,

There must be a formal process of issuing the RFP/RFT documents to the pre-qualified Service Providers,

It is very important that sufficient time be allocated for the bidders to prepare high quality submissions in a detailed manner. If the time interval from the issuance of the RFP/RFT to closing is insufficient, the RFP's/RFT's submitted will lack the necessary quality and may actually result in delaying the RFP's/RFT's evaluation due to insufficient info.

The overall project schedule should be set up to allow a minimum of 6-8 weeks for RFP/RFT submissions, and another 2 weeks contingency in case any of the bidders requests an extension. Sufficient copies of the submissions (including some un-priced copies) from the Service Providers must be requested to allow for simultaneous evaluation by various departments.

Closing date for submission is legally binding and must be strictly adhered to.

Tenders received must be stamped with the date and time of submission,

8.2 TENDERS EVALUATION

The purpose of the tender evaluation is to review all the tenders or RFP's received and to select the Service Provider which offers the best value for the services offered, i.e. the optimum combination of the lowest life costs and the quality of the equipment and services offered to meet the specification.

Most issues that need to be addressed during the Tender Evaluation process for new turnkey substations are also applicable to turnkey extension or refurbishments of existing substations.

However, there are some differences that deserve to be highlighted and require special attention. Some of these differences relate to process, others impact liabilities, safety and security, or interaction between Asset Owner's personnel and the Service Provider (i.e. outage coordination, etc.).

One important difference resides in the fact that, an extension or refurbishment project may limit the number of bidders. The most obvious example would be the extension of an existing GIS installation, where the Original Equipment Manufacturer (OEM) would be considered the obvious choice, due to their expertise and knowledge on existing installations. However this situation is not necessarily universal. In some cases the OEM is no longer in business, giving all potential bidders equal standing. In other cases manufacturers can offer equipment for the extension, to be joined with transition pieces to the existing equipment, provided they are given sufficient information and drawings of the joint section

The strategy of how to obtain competitive bids for a refurbishment project must be given careful thought prior to tendering. It is highly desirable to avoid sole source situations, as only competition will work efficiently to reduce the overall cost of the project. In some cases, where the Asset Owner has a number of similar installations in need of refurbishment in more than one substation, it may be advisable to tender a multi-year project covering all such installations. This would enhance the Asset Owner's negotiating power and may result in lower project costs

The work on an extension or refurbishment of an existing substation implies work in the immediate proximity of energized equipment. Training of the Service Provider's workforce in safety requirements and practices specific to Asset Owner's installations becomes extremely important. As such, these requirements must be specified in the tendering documents, and must be acknowledged and accepted by the Service Provider in his tender. The process to adequately train and test the Service Provider's workforce must be agreed upon, ideally during the Tender Review meeting. The safety requirements must also cover protective equipment that may have to be worn by the workforce, and specific instructions for approach of energized installations (e.g. in dealing with possible arc flash from adjacent equipment).

Liabilities that can impact an extension/refurbishment project are also different, due again to the work in an energized installation. If the tendering documents have adequately covered them in the terms and conditions, this should be a moot point during the tender evaluation. Particular attention should be paid to any exceptions taken by the tenderers and such exceptions should be resolved prior or during the Tender Review meeting).

The Asset Owner should consider all the costs over the life of a substation in addition to its first cost. For major electrical equipment the lifecycle cost should include the first cost plus other costs such as transportation, installation, commissioning, warranty, losses over the lifecycle, maintenance, spare parts, reliability, users' engineering, disposal and salvage. It is essential that Asset Owners should have total commitment to the lifecycle cost evaluation during the tender review process. The selection of the bid on the basis of lowest lifecycle cost can contribute significantly to the profitability of an organization.

Usually, substation turnkey projects are large projects and the tender review requires detailed technical and financial evaluations. The tender evaluations should be performed by a team nominated by the Asset Owner. The team should comprise of staff knowledgeable of the technical aspects of the tender as well as procurement staff with expertise in the commercial terms and conditions of a contract. If the Asset Owner does not have the technical expertise in-house for the review, a Consultant with expertise in the field should be retained.

The tender evaluation consists of the following steps:

- Technical Evaluation,
- Financial/Commercial Evaluation,
- Tender Clarification Meeting,
- Overall Evaluation and Recommendation,

To assess tenders, a system of criteria intended to evaluate the competency of the Service Provider shall be used to rate their bids. Examination will focus on examining how each bidder proposes to deliver the project and establish the bid's price based on the life cycle cost of the project.

All relevant information requested in the tender documents and provided with the tender shall be used in the tender evaluation.

There are two major criteria for selection of the successful bidder – the [technical evaluation](#) which determines the suitability of the technical solution offered, and the [financial/commercial evaluation](#) which determines the overall price of the project and other commercial conditions.

However, additional significant criteria must also be considered in the tender review process. Some of these criteria are:

- Relevant experience,
- Past performance,
- Technical skills,
- Management skills and systems,
- Resources,
- Methodology;

The criteria must be relevant to the project, transparent and universally applicable to all tenders; the evaluating team must be able to use the criteria in a meaningful way by allocating a score to the tender submissions.

8.2.1 TECHNICAL EVALUATION

When evaluating the technical criteria, the Asset Owner shall ensure that any difference in scores between a good tender and a satisfactory one does not overshadow a substantial price difference. Tenders with substantial price differences must be carefully evaluated and solid justification has to be provided by the Asset Owner if the higher priced tender is chosen. At the same time, low cost bids must be also carefully scrutinized to ensure that the Service Provider fully understood the requirements and that the bid doesn't contain ambiguous terms which might translate in unexpected surprises during the project,

The technical evaluation is by far the most critical part in the evaluation process, and can result in go/no go decisions. The technical evaluation of a tender consists of the following:

- Compliance with specified technical requirements,

- Compliance with specified standards,
- Assessment of alternatives offered,
- Assessment of exceptions and costs to comply,
- Reliability considerations,
- Transportation to site and Installation,
- Commissioning and Acceptance testing,
- Operation and Maintenance Implications,
- Post-contract technical support from the Service Provider,

8.2.1.1 COMPLIANCE WITH SPECIFIED TECHNICAL REQUIREMENTS

The Asset Owner must use the technical specification as the basis for comparing the proposals and apply consistent criteria for evaluating all tenders. Each specified requirement has a cost component, therefore, the Asset Owner should make note of any omissions or exceptions to the specified requirements.

8.2.1.2 COMPLIANCE WITH SPECIFIED STANDARDS

The Asset Owner must ensure that the Service Provider complies with the specified standards since deviations from the standards have implications on the cost and schedule of the project,

8.2.1.3 ASSESSMENT OF ALTERNATIVES OFFERED

The Asset Owner should encourage the Service Providers to quote alternatives to the base bids. Such alternatives may be more economical and innovative and yet meet all the requirements of the specification. It is the Asset Owner's responsibility to evaluate the alternative bids with an open mind, as these can often result in substantial savings to the overall cost of the project. Alternatives should be rated against the specified requirements and assessed for their acceptability.

8.2.1.4 ASSESSMENT OF EXCEPTIONS AND COST TO COMPLY

The tenderers may take exceptions to some of the technical requirements for various reasons:

- a) some requirements add costs to the project but – in their opinion - do not add any significant value or add to their cost (e.g. requirements for plant inspection of major equipment by the Asset Owner),
- b) the Service Provider does not have the capability to either manufacture or test components of the project according to the requirements (e.g. Factory impulse testing of major equipment at a level for which the equipment manufacturer has no capability in his factory test lab, or high altitude conditions do not permit it). The exceptions have to be reviewed and may be acceptable in some cases. However, the costs to meet the specified requirements have to be included in the base evaluation so that all tenders are evaluated on consistent basis.
- c) The project schedule may be too tight, when major equipment (e.g. power transformers) has long lead time delivery and may have to be shipped from overseas. In such case the Asset Owner will have to determine the extra cost involved in stretching the schedule and consider it in the evaluation.
- d) The Asset Owner's tender specification, which was prepared as per the existing equipment's information, doesn't match with the Service Provider's standard product such as GIS, digital control and protection unit, etc. The Service Provider will have to clarify its exceptions in detail.

8.2.1.5 RELIABILITY CONSIDERATIONS

The Asset Owner needs to consider the reliability of the installations at two stages in the project: the Pre-qualifications of the Service Providers (see chapter 7) and at the tenders' evaluation level.

The second assessment involves a thorough review of the design offered, equipment and materials proposed, constructability review, proposed factory and site acceptance testing, and review of prototype features, if any. The tender review meeting is a venue to obtain some of the required info necessary for a suitable analysis from the Service Provider.

The Service Provider must be willing to reveal some confidential design data to allow the Asset Owner to properly review the proposed design (e.g. dielectric stress levels at critical points in HV compartments of major equipment).

The Asset Owner must fully respect the confidentiality of the information provided by the Service Provider. Both parties need to cooperate during the tender review to allow for critical information exchange.

The tender review may also establish a basic design. Any changes to the design, which occur after the review, should be mutually agreed upon. The tender review meeting sets a basis for the design review that may be conducted at a later date.

Failure statistics should be reviewed where available. Some items to be considered are:

- Failures/Shortcomings of the major equipment proposed by the Service Provider. The information may be in the form of number of failures, failure rate (MTBF), major failures, minor failures, forced outages and their duration, etc.)
- Repair time for the failed equipment, cost of repair, cost of transportation etc.
- Description of the failures of the major equipment proposed by the Service Provider that caused forced outages in the past,
- Field problems (not necessarily failures) and remedial actions taken to prevent them should be reviewed and discussed if needed with the Service Provider.
- The response (past and expected) of the Service Provider to any failures, warranty issues with their installations
- The ability of the Service Provider to learn from previous turnkey projects and apply the lessons to the project at hand

8.2.1.6 TRANSPORTATION TO SITE AND INSTALLATION

The Asset Owner must ensure that all the components of the project (especially large electrical equipment such as power transformers, GIS) can be transported safely to site and installed in the most economical way. The Asset Owner must communicate to the tenderer any road and access restrictions that may prevent delivery to site, e.g. bridge restrictions to high weights, tunnels, barge or ferry shipping, road inclines, etc. Failure to anticipate obstacles to delivery can adversely affect the project completion schedule. The availability of access roads to the existing substation may have been changed from what they used to be and special attention must be given for replacement or refurbishment projects as the transportation unit may be quite different from the ones used when the substation was erected,

During the tender review meeting ways to minimize the site installation effort should be discussed, e.g. shipping major equipment mostly assembled, with a minimum of parts to be removed for shipment and resulting in fewer site tests required.

Coordination issues during installation must be discussed in detail at the tender review meeting. Depending on the type of contract (total turnkey or partial – which may include some civil works performed by the Asset Owner), detailed schedules need to be reviewed.

Safety at the installation site, including training of the Service Supplier's personnel to the utility safety requirements, is the full responsibility of the tenderer. Hours of work and weekly schedules (which may be restricted by the utility activities) need to be acknowledged.

The Asset Owner must facilitate connections to his network by providing for the required outages.

8.2.1.7 COMMISSIONING AND SITE ACCEPTANCE TESTING

A list of commissioning and site testing requirements must be in the tendering document. The commissioning is normally part of the contract and performed by the Service Provider. However, the Asset Owner representative will be present and witness the site acceptance testing to ensure the functionality of the equipment and performance to specification. A record of the site tests performed must be produced and signed by both the Service Provider and the Asset Owner rep.

The procedure must be described in the tendering document and must be acknowledged by the Service Provider at the tender review meeting.

8.2.1.8 OPERATION AND MAINTENANCE IMPLICATIONS

The Asset Owner must obtain feedback from their operating and maintenance personnel on their experience with the equipment proposed by the Service Provider and their assessment of maintenance requirements. Costs for special maintenance and operating requirements should be added in the evaluation. Conversely, advantages (time saving or monetary) in operating and maintaining the proposed equipment must be included in the life-cycle cost evaluation.

8.2.1.9 POST-CONTRACT TECHNICAL SUPPORT FROM THE SERVICE PROVIDER

The Asset Owner must examine the historical records and experience that they or other users have had with a particular supplier of services and/or major equipment. The willingness of a tenderer/original equipment manufacturer (or successor company) to continue providing support for equipment throughout its life is very valuable and should be factored into the technical evaluation.

The factor used in the evaluation should be part of the evaluation criteria and its weighting must be disclosed in the tendering document.

8.2.1.10 RELEVANT EXPERIENCE

Previous experience of the tenderer needs to be assessed in relation to the fields of expertise required to achieve the intended outcomes of the project. Recent experience is more valuable than historical experience. The tenderer's previous experience in technical areas comparable to the tendered project, the scale of past projects and the role undertaken within those projects should be considered. The tenderer shall provide a list of relevant projects undertaken and for each project the following shall be included or be clarified at tender clarification meetings:

- Project name, description and relevance to the tendered project;
- Quality standards (target performance levels),
- Client's project manager,
- Role of the tenderer,
- Contracted price,
- Duration of project (any delays in schedule),

All the above factors need to be quantified, and their weighting should be shown in the tendering documents.

Extension to the contract completion date and claims for variations also give an indication of performance capability. Similarly, the satisfaction of previous clients regarding the management of the project and project outcome provide useful subjective information on performance of the tenderer. The tenderer shall provide following information on each project:

8.2.1.11 TECHNICAL SKILLS

The competence of key management, professional and technical personnel that the tenderer proposes to employ on the project needs to be assessed with particular emphasis on the skills and experience in technical areas comparable to the project. The tenderer shall include the following details of the proposed project team:

- Names,
- Functions/positions,
- Technical expertise,
- Curriculum Vitae of key staff,

8.2.1.12 MANAGEMENT SKILLS AND SYSTEMS

The availability within the tenderer's organisation of personnel with appropriate management skills together with effective management systems and methods appropriate to the successful management of the project should be included in the bid. The tenderer shall include the following information:

- Quality system;
- Project management tools;
- Program software;
- Environmental management system;

8.2.1.13 RESOURCES

The assessment should include the equipment (including facilities and intellectual property) which the tenderer proposes to use on the project. The Tenderer shall include the following information related to this subject:

- specialised equipment,
- labour, by trade skills,
- facilities.
-

8.2.1.14 METHODOLOGY

The tenderer shall be able to demonstrate its capability to bring the contract to a satisfactory conclusion by describing the methodology of approach to accomplish the project's required outcomes. The information required shall include the following:

- Program of works;
- Key performance indicators;
- Division of works into subcontracts;
- Innovative procedures to be used;
- Reporting and recording systems; and
- Quality Plan.

8.2.2 FINANCIAL/COMMERCIAL EVALUATION,

The overall cost of the project is the total amount that the Asset Owner will be required to pay to the Service Provider for the installed and ready to use substation or retrofit/refurbishment. This must include all costs over the duration of the contract. Depending on the contract, this could include:

- Fixed capital cost,
- Variable tender costs during the contract period,
- Special adjustments during the contract period,
- Maintenance costs,
- Operating costs,

The bids should be evaluated considering the following financial/economical evaluation formula:

$$FEE = IC + AOC + PMC + OC + PUC + UUC + EC + DC - B$$

where:

FEE – Financial/Economical Evaluation,

Investment Cost (IC)

- Quoted price from the Tenderer's Financing cost

Internal Costs (AOC)

- Planning, pre-qualification, inquiry preparation and bid evaluation costs; in-house or contracted project costs (supervision, training, etc.); costs per man-hour of in-house labour or of contracted labour (€/hr.) × number of people × supervision/training time (hr) - of course costs are also available in \$, Yen, £,...

Capitalised Costs for Planned Preventive Maintenance (PMC)

- This cost is based on the level of required maintenance for the new equipment (maintenance plans): for each maintenance task, the calculation is based on the cost per man-hour of in-house labour or of contracted labour (€/hr) × number of people × time to perform maintenance (hr) + spare parts (€) + rental or purchase of special equipment (€).
- These capitalised costs are calculated for each maintenance task all along the life of equipment considering required maintenance frequencies, and then summed up.

Capitalised Operation Costs (OC)

- Running losses in transformers, shunt reactors, etc. (€)

Capitalised Costs for Planned Unavailability (PUC)

- Loss of revenue from planned downtime: cost for power (□/kW) × power (kW).
- Cost for energy (€/kWh) × power (kW) × time (hr).
- These costs can be estimated from the maintenance plans, the necessary outages associated to each maintenance task, and based on the boundaries of the new substation (are there Customers directly supplied by the substation without an alternative supply?, etc.).
- Outage planning administration costs (€).
- Network constraints: Customer / generation constraint penalties (€).

Costs for Unplanned Unavailability (UUC), including costs for corrective maintenance

- Loss of revenue from forced downtime:

- The effects of each failure mode of each equipment on the substation are described in the FMEA (failure mode and effects analysis) process. It enables to calculate for each failure mode (based on load hypothesis):
- Cost for power (€/kW) × power (kW)
- Cost for energy (€/kWh) × power (kW) × restoration time (hr)
- Estimated corrective maintenance costs (€).
- The estimated failure rate of equipment should also be given by the Solution Provider (no. of failures / yr). This cost has to be combined with the probability of observing each failure mode during the considered time period (shorter or equal to expected life of the new equipment). Then, the associated effects of each failure mode on the substation enable to determine the outage costs.
- Network constraints: Customer / generation constraint penalties.
- The unavailability cost and the number of years to be considered are given by the Asset Owner and these will be multiplied by the unavailable hours/year given by the Solution Provider.
- Unavailability due to the substation equipment shall be considered here, not due to on external circuits (€).

Extension Costs (EC)

- The Solution Provider shall give an optional price for extensions of the substation valid e.g. for 10 years, taking into account also interest rate etc.

Capitalised Costs for Decommissioning (DC)

- Costs of dismantling, waste handling
- Salvage value of old equipment (income).

Bonuses (B)

- This consists of possible land or other bonuses the Asset Owner wants to use (specified in the technical specification)

The costs must be converted to an equivalent basis. This conversion should take the form of **capitalised cost calculation**, except for unplanned unavailability, extension costs and bonuses. The following information must be stated by the Asset Owner:

- time period for which cost should be calculated, this time is shorter or equal to expected life of the new equipment
- specific interest rate to be used in calculation.

Direct costs (such as parts) can be calculated based on previous work or estimated from past experience. **Indirect costs** (such as downtime), while difficult to assign a cost value, should also be considered in the equation.

In the commercial evaluation certain factors must be given specific weights based on historical performance of the Service Provider, such as:

- Performance to schedule,
- Claim management,
- Warranty observance,
- Reliability of major equipment provided,
- Reputation of the Subcontractors,

RECAPITULATIVE TABLE

Data to be given by the Asset Owner to the Tenderer	Unit	Data to be given by the Tenderer to the Asset Owner	Unit
Average cost per man-hour of in-house labour	€/hr	Cost of new equipment	€
Cost per man-hour of contracted labour	€ /hr	Installation time	hr
Cost per man-hour of installation supervision	€ /hr	Testing time	hr
Cost per man-hour of testing labour	€ /hr	Training time	hr
Training costs	€/hr	(Preventive) maintenance plans for each major piece of equipment :	
		frequency of each task	yr
		duration of each task	hr
Rental or purchase of special equipment for maintenance	€/hr	Cost of spare parts	€
Cost for running losses per circuit	€/kWh	FMEA (failure mode and effects analysis) for each major piece of primary equipment :	
		probability of each failure mode (reliability data for each equipment)	/yr
		effects of each failure mode on the bay / on the substation	/yr
Loss of revenue from planned downtime (cost for power per circuit)	€ /kW	Description of corrective maintenance tasks for each piece of equipment :	In manuals
		duration of each task	h
		special conditions if any	
Loss of revenue from planned downtime (cost for energy per circuit)	€ /kWh	Salvage value of equipment	€
Outage planning administration costs	€	Cost of dismantling and waste handling	€
Customer/generation constraint penalties	€	Extension cost for each circuit	formula
Loss of revenue from forced downtime (cost for power), to be considered for each circuit separately	€ /kW		
Loss of revenue from forced downtime (cost for energy), to be considered for each circuit separately	€/kWh		
Cost of land	€ /m ²		
Time period for capitalised calculation	yr		
Interest rate	%		

8.2.3 TENDER CLARIFICATION MEETINGS

Tender clarifications can be obtained in several ways such as phoning the tenderer (not recommended because of errors in interpretation), requesting clarifications in writing and requesting a tender review meeting.

The tender clarification meeting should generally be held with the tenderer(s) who is (are) likely to receive the business.

As preparation for the meeting, the Asset Owner should prepare an Agenda listing the items of concern from the tender that need clarification. The Agenda should be communicated to the Service Provider with sufficient advance notice to allow preparation time.

The meeting should be chaired by one designated person and this person should ensure that all the proceedings of the tender review meetings are properly recorded and action items are assigned.

The tender clarification meeting provides the opportunity for the Asset Owner to obtain needed design details and obtain feedback on the specification. The tender review meeting allows the tenderer to obtain information on why certain requirements are included in the specification and explain to the user how some of the requirements could be met by proposed alternatives without cost increases. A constructive and successful meeting could be achieved on the premise that the Service Provider is an expert in design, construction, installation and commissioning aspects of the project and that the Asset Owner has extensive knowledge of the system and reasons for special requirements.

The Asset Owner and the tenderer should record all action items arising out of the tender clarification meeting and minutes of meetings should be promptly issued – Service Provider should acknowledge receipt of the minutes and respond to action items promptly.

The Asset Owner should pay particular attention to any changes in the quoted price arising out of clarifications. Such changes may alter the financial standing of the bidders. The only price changes that are acceptable are those necessary to eliminate the exceptions that the tenderer had identified in the tender. This practice allows the user to compare tenders on a fair and equitable basis.

8.2.4 OVERALL EVALUATION AND RECOMMENDATIONS

The selection of the successful bidder is based on the Asset Owner's best judgment concerning whose services and expertise will provide the overall lowest lifecycle cost for the project.

The overall evaluation is a summary of technical, financial and commercial aspects of the submitted tender after all the clarifications are available.

The tender evaluation consists of collating the diverse information (such as costs, past experience and projected reliability) that form the basis for selecting a particular Service Provider.

Various departments of the Asset Owner which provide input into the evaluation issue recommendations to the Asset Owners decision making authority. The Asset Owner's technical departments provide the go/no go recommendation on technical specification compliance/non-compliance basis. These departments also evaluate issues such as reliability, maintainability, operability, OEM support and provide input in the final evaluation.

With input from the technical departments, the Asset Owner's Procurement Department completes the overall evaluation. Depending on the Signing Authority Register, the order may be placed immediately by the Procurement Department or referred to a higher signing authority for approval.

9. M ANAGEMENT OF TURNKEY PROJECTS

9.1 INTRODUCTION

Management of turnkey projects could be described as monitoring and checking of various items and activities in a turnkey project based on the contract document & specification. These include monitoring and checking of:

- Project Schedule
- Contract Scope of Work and Specification
- Variations / Additional Work / Claims
- Project Safety
- Quality Assurance
- Potential Difficulties and Trouble
- Labour, Environmental and Site condition

A good project management plan would contain standard procedures and guidelines such that the monitoring and checking of the above items could be planned and executed systematically.

9.2 PROJECT ORGANIZATION

An essential component of management of turnkey project is the setting up of project organisation structure. It is vital to remember that Asset Owner should have its own project organisation independent of the Solution Provider's project organisation. However in spite of having these individual project organisation, it is perhaps most important that constant interaction and information is shared between the Asset Owner and Solution Provider in order to manage the project successfully.

A typical setup of project organisation would typically consist of the following:

- Project Director
- Project Managers
- Contract Managers
- OSH (Safety) Officers & Supervisors
- Engineering Design Team Leaders
- Design Engineers
- Construction Team Leaders
- Construction Engineers
- Quality Assurance Manager
- Quality Assurance Engineers
- Project Planners
- Document Controllers
- Commissioning and Testing Manager
- Commissioning and Testing Engineers

The above is a sample of personnel whom would be needed as core members of a project organisation structure. Individual Asset Owner and Service Provider may already have its own project organisation structure. In any case, the function of each member within the project organisation should also be clearly defined. Proper lines of authority should be established in the project organisation and feedback channel is important.

9.3 COMMUNICATION CHANNELS & FORMAT

It is worthwhile to note that in turnkey projects, some of the project organisation members may be located at different geographical locations, for example, some may be in design office and some may be at site / factory and so on. Due to these varied locations, creating proper communication channels is all the more important to ensure that the project can be managed smoothly.

Therefore one of the most important aspects of project management is to establish strict guidelines for the communication channel and format for correspondence and documentation. The key components would include the following as a minimum:

- Title and Contract No. Of Project
- Format for correspondence between Asset Owner and Service Provider, including details for circulation copy (cc).
- Document Numbering / Referencing system for correspondence, drawings and all other documents related to the project.
- Procedure for document / drawing submission including no. of drawings to be submitted and returned, procedure for re-submission and approval
- Clear description and purpose of document approval status (e.g. Approved with Comments, Not Approved and so on).

9.4 PROJECT SCHEDULE

The project schedule is one of the most important document and information in the management of turnkey projects. Project schedules could range from simplistic to extremely detailed ones which include resource monitoring and timeline monitoring of key activities. Some even more elaborate project schedules may include critical path programming and baseline monitoring. In these days, project schedules are done by using advanced planning and scheduling software.

Asset Owners with Planning Departments may prepare the overall project schedule according to the milestones in the contract with the Service Provider. However it is important to note that where turnkey projects are concerned, Asset Owners are normally the passive party in the sense that all design, manufacturing, construction, installation, testing and commissioning activities are directly controlled and influenced by the Service Provider. Therefore, normally in a turnkey project, the Service Provider would prepare and update regularly the overall project schedule. The progress of the project should be indicated against a baseline of the overall project schedule.

In order to assess the progress illustratively and to provide a macro bird's eye view of the overall progress of the project, it is recommended to apply a cumulative S-curve as a measure of the progress of the project. In order to plot these S-curves, it is necessary to allocate weightage to each of the activities in the project schedule.

The end product of the S-curve would be to indicate whether the project is ahead or behind schedule on an overall basis.

9.5 PROJECT SCOPE OF WORK

Another aspect in management of turnkey projects is the application of contractual objectives and ensuring that work is done according to contract scope of work and technical specification. In this sense, it is necessary for the Asset Owner to establish rules for checking design / manufacturing / construction / installation / testing / commissioning activities by Service Provider. More often than not, this involves a huge amount of documentation which includes checklist forms, testing procedures, construction clearance forms, site test records, factory test reports, etc.

The compliance to scope of work and specification should be constantly monitored and checked. It shall be enforced during all stages of the project, from engineering design up to testing and commissioning. Therefore, it is essential for all project members to be aware of the contractual scope for the work within each individual's purview. There have been many instances when design engineers request for technical solutions which are beyond the scope of contract, hence leading to variations and claims.

9.6 PROJECT SAFETY AND QUALITY

Accidents, be it small or large are undesirable on any project. Accidents which occur are mostly due in a large part to human error. It is human nature that complacency and a lack of discipline where safety is concerned are breeding grounds for accidents to happen. Accidents unleash detrimental effects on the project as morale of the project organisation is affected which in turn lowers the work productivity of the project members. Therefore the cost of unsafe practices cannot be ignored in any project.

Hence, it is essential to recognise that safety is of paramount importance in any project, small or large. This relates to safety in design of equipment, safety in site construction works, safety in testing procedures, safety in transportation of equipment and numerous other aspects. It is essentially correct to state that each activity must be considered from a safety point. This is especially important if the project involves interface with "live" existing equipment. A safety checklist system should be established, requiring these checklist to be fulfilled before any related activity could be carried out

Apart from implementing safety in design and site procedures, it is essential that safety should be practised and enforced. This means that Safety Committees should be established in the project organisation structure. In addition, trained safety officers and supervisors should be delegated during site construction and installation works. Safety audits should be conducted regularly to ensure that all parties are properly up to speed with the necessary safety precautions, procedures and protection equipment.

As part of the safety culture, proper permit to work (PTW) system should be established for site construction and installation works. These kinds of permits are important especially when working in “live” environment or conducting potentially dangerous works such as welding. Establishing a PTW system ensures that all project members would abide strictly by a pre-determined set of safety rules. Safety regulations often differ based on local regulations, therefore it is imperative that qualified and authorised persons are appointed as members of the safety committees.

Regular safety audits must be carried out to ensure that any unsafe practices or situations are detected and rectified immediately. In some areas, local safety regulations stipulates that safety audits are required to be conducted by third party independent accredited safety auditors.

9.7 POTENTIAL PROBLEMS & DELAYS

Another important aspect of managing turnkey project is the ability to detect potential problems and / or delays in the project. This ability is dependent on the experience of the management personnel as there is no substitute for experience. In this sense, it is important for Asset Owners to engage competent and experienced personnel as part of the management team for the project. Asset Owners may also specify that the Service Provider must only provide experienced personnel in their project organisation.

It is important for the project management team to undertake the leadership of the project until the end of project. Many a time, quick and precise decisions are required in the course of turnkey project. In the event of problems and delays, the rule of thumb should generally be:

- Proceed with the activity or process that has the highest priority
- Activity or process with less priority should be postponed after making decision,
- Upon completing the highest priority item, review the situation of problem and delay again
- Repeat this in an effort to resolve and recover any problems and delays

Assembling a project organisation which is empowered to make such decisions is important; otherwise project schedule may be delayed while waiting for decisions to be concluded.

9.8 PROJECT MANAGEMENT DOCUMENTS

As part of project management tools to achieve the objectives discussed in the preceding paragraphs, documentation becomes the most important tool for organising the thoughts and processes that goes into a turnkey project. Some of the Project Management documents that are required include:-

- Project Organisation Structure,
- Project Schedule (including major equipment delivery time),
- Progress Reports,
- Site Safety Reports,
- Quality Assurance Plan,
- Project Safety Plan,
- Document Register,
- Document Submission/Approval Procedure,
- Progress Payment/Cash Flow/Milestones,

It is normal that some of these documents such as Quality Assurance Plan and Project Safety Plan are pro-forma documents / template which may be modified to suit the requirements and conditions of each individual project. On the other hand, Asset Owners may also require that Service Providers should prepare each of these documents specifically for the related project.

Proper documentation is important for efficient management of turnkey projects. In this sense a systematic method of indexing and archiving documents and drawings is necessary to facilitate quick retrieval of the correct documents. In this age, much of this archiving and indexing is computerised which allows complete access across a wider domain and number of personnel. For example, for an international project, it is always possible that the design office and site locations are geographically far apart. Such is the wonder of technology that by having a computerised and networked document management system, personnel from different locations will be able to have access to the correct documents and drawings quickly and accurately.

When developing a project schedule, some of the key categories which should be included in the project schedule are:

- Regulatory Submissions and Approval
- Engineering Design and Drawing Approval
- Procurement & Manufacturing
- Factory Test
- Transportation / Delivery
- Site Mobilization
- Site Construction
- Site Installation
- Interface with 'Live' Equipment, if any.
- Site Testing
- Commissioning / Energisation
- Project Clean-Up / Demobilisation
- Defects Liability Period

The project schedule should be reviewed regularly (normally on weekly and monthly basis) to ensure that the project is on schedule. If delays or potential delays are detected during these reviews, remedial action must be implemented to recover these delays. In this regard, regular project review meetings must be conducted to evaluate the progress of the project.

The demarcation of responsibilities between Asset Owner and Service Provider should be properly and clearly defined. This would ensure that all areas of scope of work are clearly covered and there are no missing items. This would help to eliminate claims for variations and missing scope later on in the project.

9.9 PROJECT VARIANCES / CLAIMS

In any project, it is inevitable that claims or variances will arise in the course of the project. This is also true of turnkey projects. Variances may arise due to many reasons, however in most instances, variances arise due to a combination of the following:-

- Incomplete specification
- Inaccurate scope of work
- Missing scope of work
- Delays caused by other reasons (such as regulatory approval) or other contractors
- Changes in substation layout
- Changes in technical requirement of equipment

Variances and claims must be kept up-to-date and regularly reviewed as this affects the overall budget for the project.

10. PROJECT EXECUTION

10.1 OBJECTIVES

In the execution of substation project, there are many objectives that need to be identified and set. The flowchart in Fig. 10-1 shows some of the typical processes and objectives in the turnkey project execution.

One of the most important aspects is achieving a balanced critical path management with the following key points in the project execution:

- Flow of work should not be reversed (Fig. 10-1)
- Work execution should be matching with Time Schedule (Fig. 10-2)
- Complete compliance with required interface engineering as substation package (Fig. 10-3)

During the normal execution of turnkey project, these three points may not be always planned / performed in series since the work are done by many concerned people, and restrictions of social requirement / regulation may apply. In the course of the project, there could be many natural gaps between planned activities as depicted in Fig. 10-1 and actual work sequence. A good project management plan must account for such gaps and miss-sequence of activities. The challenge in project execution is to consistently find a suitable way to minimize the gaps in activities and move the project forward.

Project management requires clear understanding, imagining and evaluating any influences that may arise due to the miss-sequence of events for the above three key points. In such instances, the success of the project depends on the ability to take leadership and re-align the project team efforts to the most effective path. In case it is difficult to determine the effective path, the priority of events should always be considered in the order of Flow / Time / Engineering.

Under the normal circumstances in a project, when there are more parties involved in a project, it is normally more difficult to proceed with the project smoothly and much more effort is required to coordinate the objectives of various parties. That is why turnkey project execution is advantageous as it makes it possible to allow the single responsibility approach to project execution. This changes the approach of managing the project and empowers the project team to make quick decisions, thereby making shorter completion time possible. Therefore, it is not surprising that among Asset Owners, turnkey project execution is becoming a preferred solution for substation projects.

In planning for a turnkey project, it is essential that clear objectives are defined for Asset Owner and Service Provider.

The project execution flow in Fig. 10-1 illustrates the flow of work that shall be done after Contract is awarded to the Service Provider. This flowchart is an actual example that was used in a real turnkey project. The visual presentation of using flowchart is important as it allows all parties to easily understand the work flow of the project.

The use of flowchart will also encourage all parties to adopt a common and systematic approach to the execution of the project. A good flowchart will also identify all the key activities which are contained in a turnkey project.

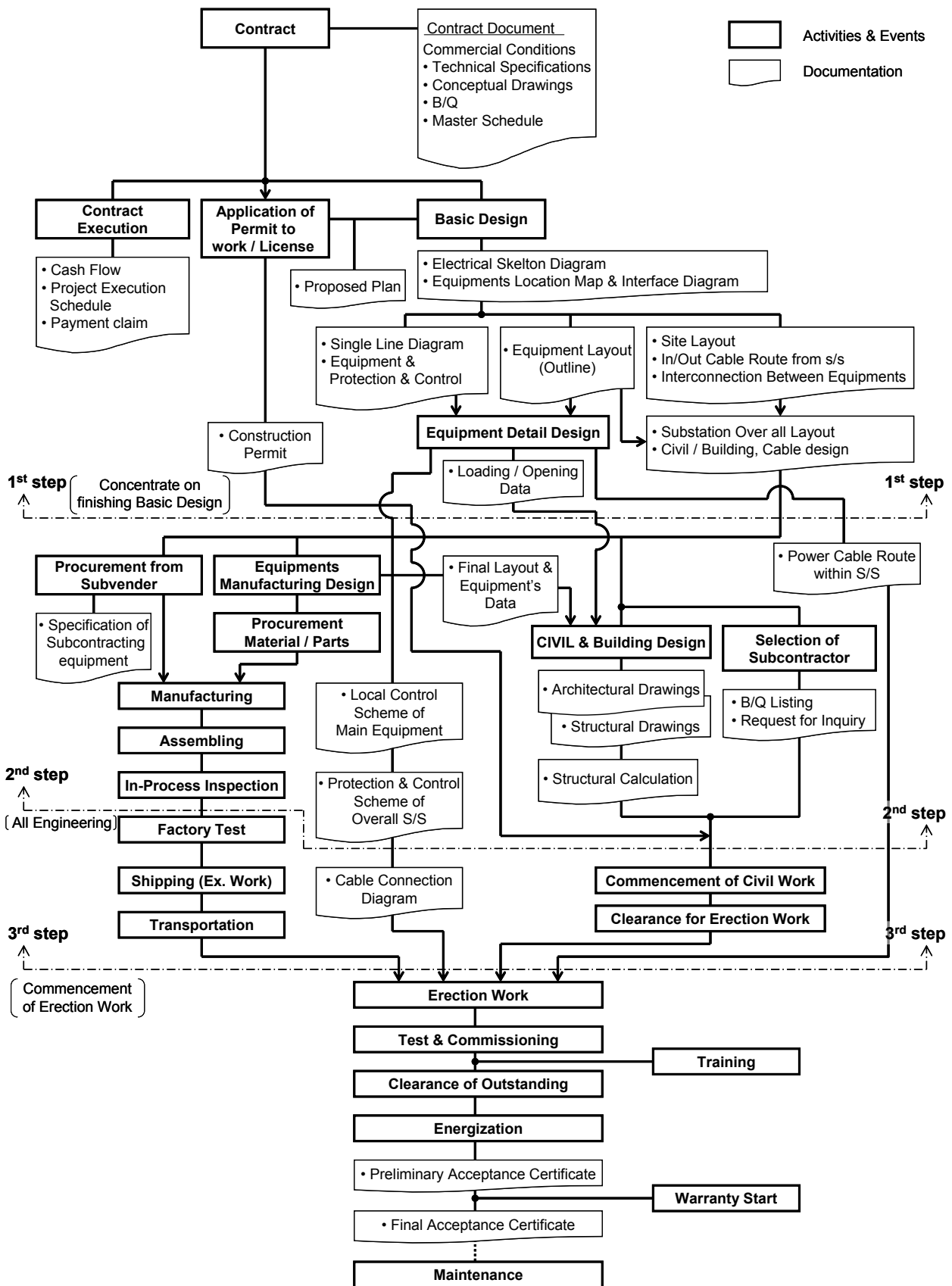


Fig.10-1 Example of Project Execution Flow

The flowchart in Fig. 10-1 shows several kinds of activities and events which make up the overall project execution. The completion of these activities and events are dictated and evidenced by documentations. For example, the event “**Application of Permit to work / License**” could be considered as completed when the document of “Construction Permit” has been issued and received.

By considering the above concept, we could understand the potential problem in succeeding events when the preceding events in the flowchart are not completed. For example:

- Without proper Contract document (as in Fig. 10-1), the potential of trouble in the project will remain till end of project and will interfere with the succeeding event. This causes a reversal of work flow as some or more time for rectifying the preceding event will be necessary. It is therefore better to wait and complete the work at the present stage before moving ahead to the next stage. It is acceptable to proceed with minor outstanding items; however essential items must be finished before embarking on the next stage.
- What is the most important point for proceeding with the event? The documents and flowchart shown in Fig. 10-1 are a typical style of proceeding with the work. In general, the document described in the flowchart should encompass and summarize all the knowledge and experience of turnkey project execution. This type of documentation serves as the tool for designing the activity and events in any given stage.
- By studying the flowchart, it is clear that one should not only wait until pre-events are completed but also prioritize the items for the next event in order for the project to move forward.

We can recognize from the flowchart in Fig. 10-1 that as the project moves forward, more and more events are executed in parallel. For example, if we look at the events after contract, there are three parallel events; i.e. “Contract Execution”, “Application of Permit to work / License”, “Basic Design”. At the points after Substation Over all Layout has been finalized, there are at least 4 events that are to be executed in parallel.

Hence, it becomes clear that the initial steps should be executed correctly and as perfectly as possible; otherwise this will lead to compounded problems later. In practice, all parallel management should be well organized before the installation work commences.

10.2 TIME SCHEDULE - MILESTONES

One of the most important tools of project execution is to have a time schedule which identifies the key milestones in the project. As an example, Fig. 10-2 shows the typical time schedule of site work execution for each style of substation project:

- AIS
- MTS
- GIS
- Removal of existing substation if required

It is generally common to consider that there are 4 key dates and milestones for site works:

- Commencement of site preparation / mobilization
- Commencement of civil building / foundation works
- Commencement of erection (Installation of Structures and Equipments)
- Energization

It is ideal to complete the engineering of each step before starting the site preparation, however this is not easy to achieve in practice. Therefore it becomes more important to prioritize the engineering events in order to execute the project smoothly. It is crucial to understand that the ability to recognize and prioritize events is the key guiding principle of project management.

Three steps listed in Fig.10.1 must be performed in progression according to the Time Schedule shown in Fig.10.2.

1st step – Concentrate on finishing Basic Design which enable the two major teams (the equipment / civil & erection) to start their own job in parallel,

2nd step – Prepare All Engineering for commencement of civil works including permission for construction and All Engineering for manufacturing equipment & delivery to site

3rd step – Commencement of Erection Work

After the 3rd step, the next target is an Energization. But it is important to recognize that the 1st step and 2nd step are the most important for overall coordination and management. The perfect finishing of 1st step and 2nd step will impact positively on the later events in the projects.

10.3 EXECUTION

As part of project execution, engineering plays a very important role to ensure the smooth implementation of the project during construction, installation and testing stage. Mistakes that are made or undiscovered during engineering stage will often cause problems during the latter stages of the project. Therefore, in order to minimize potential problems caused by engineering, the project engineering activities should be planned in a systematic manner.

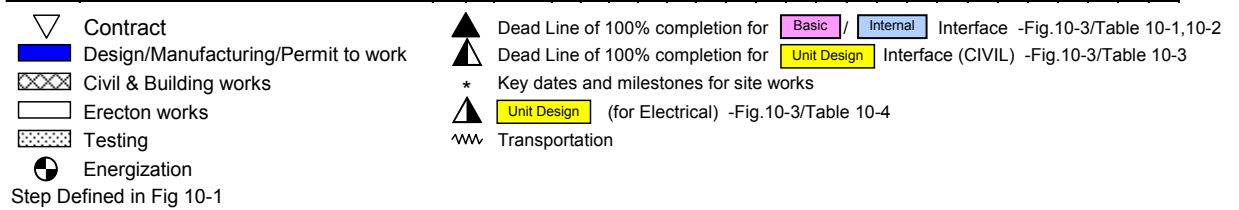
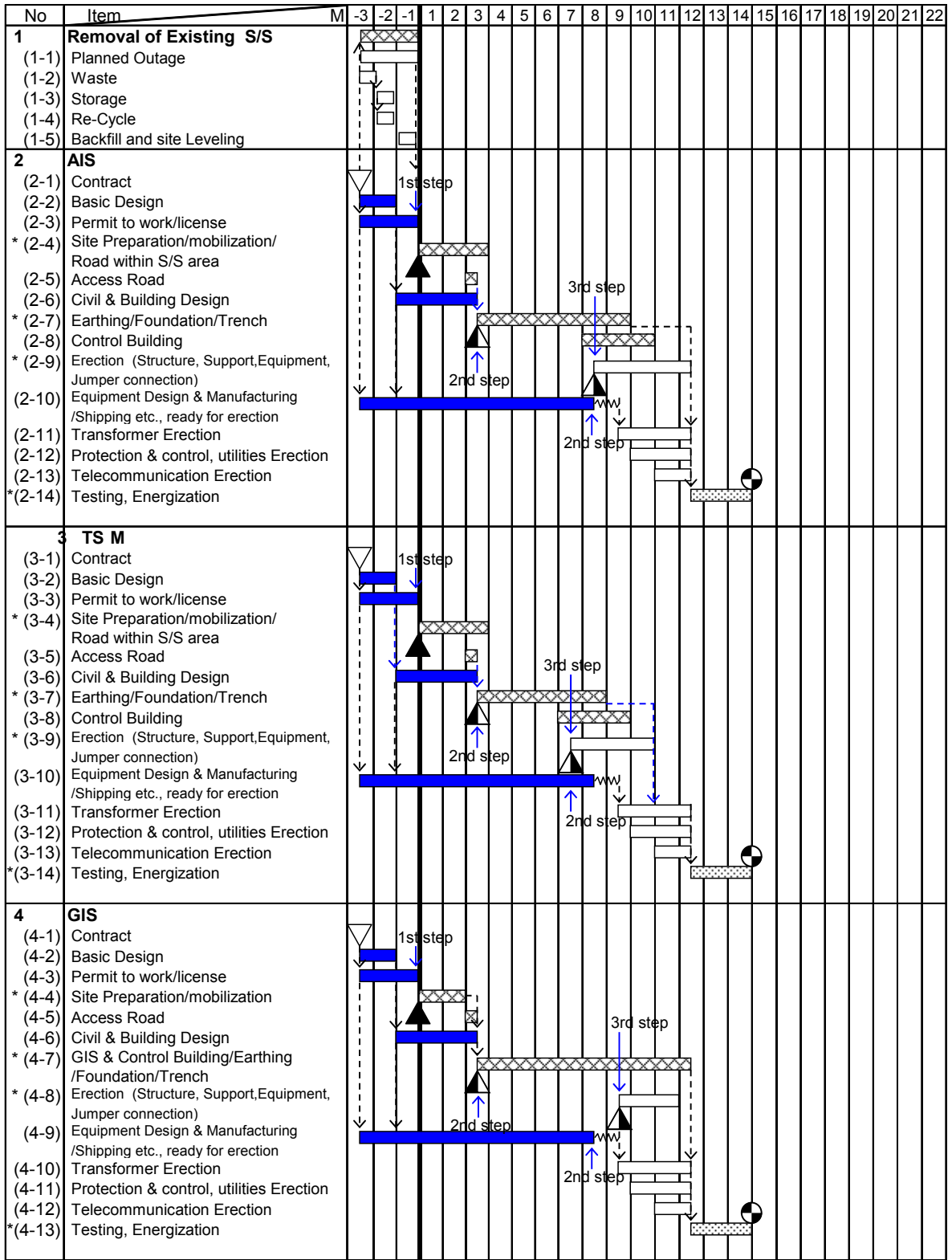


Fig.10-2 Example of Time Schedule

Fig.10-3 shows the necessary engineering works for a typical example of a turnkey substation project. Complying with Project Execution Flow & Time Schedule requirements described earlier, the priority of the engineering works can be classified as:

- Basic interface
- Internal interface
- Unit design interface

Basic interface and Internal interface items listed in Table 10-1/Table 10-2 should be fully completed without outstanding items at the latest before commencement of site works. Examples are:

Basic interface

- Substation Asset Ownership / Responsibility
- Geographical location and soil data of S/S and Future developing plan of surrounding area
- System short circuit current at each voltage level
- Overall Single Line Diagram
- Network Parameter (electric characteristics)
- Noise / Vibration limit at S/S Boundary
- Type of S/S (AIS, MTS, GIS)
- Future Extension Requirement
- Preliminary overall site layout matching with the orientation of Incoming and Outgoing feeder
- Diversion Plan of O/H (overhead) or U/G (underground) (Exchange of route and remote end substations to be linked)
- Allowable Maximum height and weight for transportation (specially for Power Transformer)

Internal interface

- Requirements (Size, Loading, Floor openings) of Civil / Building works
- Design of AC/DC Power supply to each equipment
- Crane, Hoist load and Lifting height / Crane travelling requirement
- Method of HVAC/DC testing
- HV Power Cable Route
- Alarm signal points and classification

Unit design interface (CIVIL) items are listed in Table 10-3 and should be completed before the commencement of foundation / building work. Examples are:

- The detail of embedded base and plate fixing
- Cable ducts, pit and tunnel requirements
- Final confirmation of cable route
- Final confirmation of Equipment Loading Data / Floor opening requirement / Outline of Equipment / Head dissipation of Equipment etc.
- Fire Wall and Oil Pit detail design

Unit design interface (ELECTRICAL) items are listed in Table 10-4 and should be completed before starting Factory Acceptance Test and the commencement of erection works Examples are :-

- Type of External Connection
- Location of panels and Layout of devices, relays on Panel
- Switching Cooling Method (ONAN – ONAF).
- Type of Relay and its coordination with remote-end for transfer trip of feeder
- Layout and accessible height to Operating switch, handle, meters from floor
- SF₆ Gas Sectionalizing and SF₆ os. of Gas Monitoring Device
- Status Indication / Annunciation Text and SOE Text
- Type of Control, Metering and Switching device, test switch
- Alarm Single Point
- Remote-Local Switching (Fan, OLTC)

- Parallel Operation Scheme
- Protection Scheme and Coordination with equipments and remote-end
- Interface with signalling equipments and interface with Telecommunication System
- Interface with Substation Automation Network along with protocol
- Factory Test Procedure
- Final confirmation of all items listed in “Before Starting Factory Acceptance Test”
- Cable Connection Diagram
- Site Inspection and Test Procedure
- Relay setting calculation
- Pre-commissioning Procedure for Energization

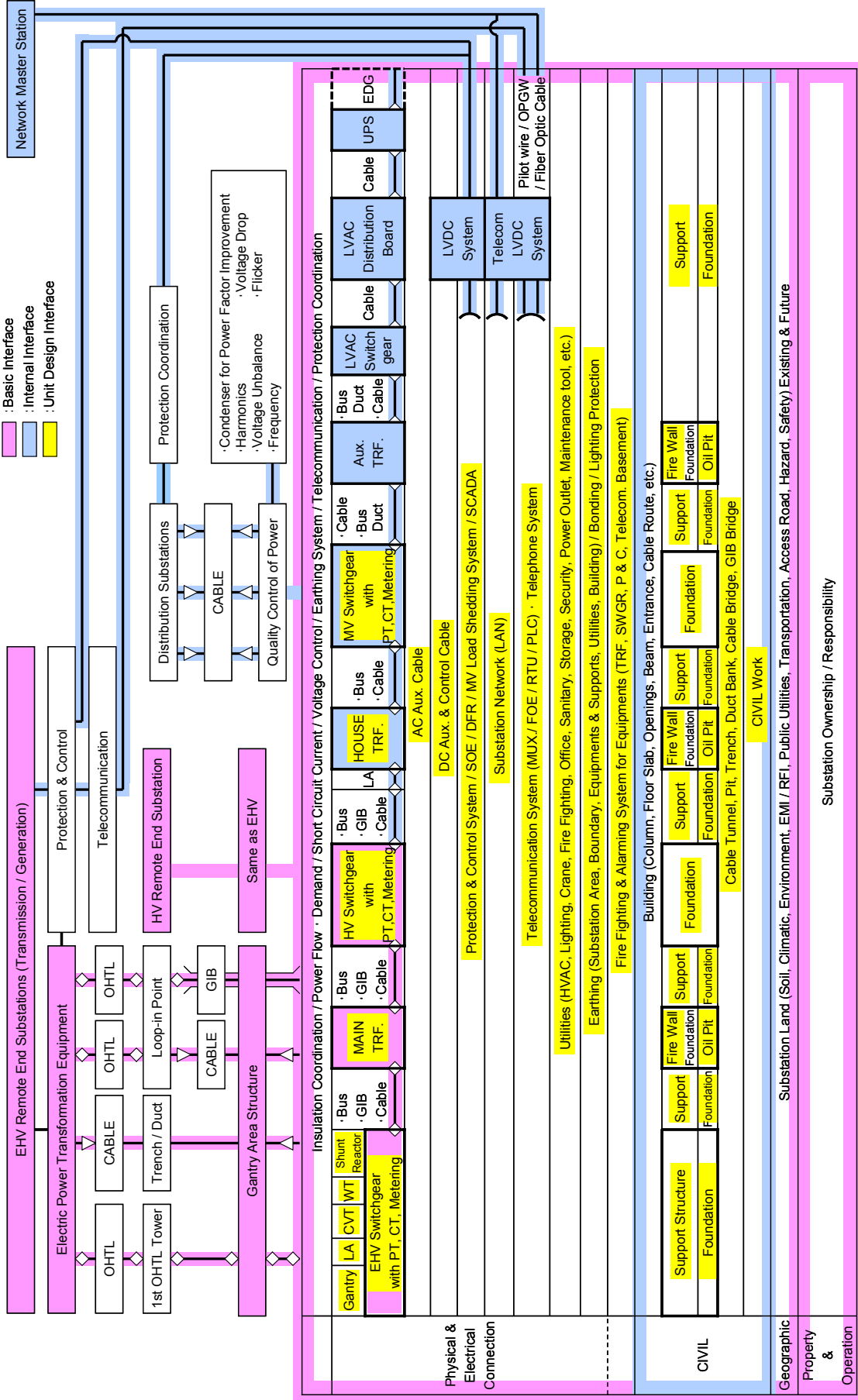


Fig.10-3 Example of Engineering Interface for a Typical Turnkey Substation Project

Table 10-1 - Example of Basic Interface Items

No.	Basic Interface Items
1	Substation Asset Ownership / Responsibility
2	Geographical location and soil data of S/S and Future developing plan of surrounding area
3	System short circuit current at each voltage level
4	Overall Single Line Diagram <ul style="list-style-type: none"> · Main Busbar Configuration (Double-Bus, 1 1/2 CB, etc.) · Auto Transfer Switching
5	Electric Magnetic Compatibility / Radio Frequency Interface requirement
6	Network Parameter (electric characteristics) <ul style="list-style-type: none"> · Parameter / Length (Cable parameter / Length)
7	Noise / Vibration limit at S/S Boundary
8	Type of S/S (AIS, MTS, GIS)
9	Future Extension Requirement
10	Preliminary overall site layout matching with the orientation of Incoming and Outgoing feeder
11	Diversion Plan of O/H (overhead) or U/G (underground) (Exchange of route and remote end substations to be linked)
12	Remote end S/S (ex. Protection / Telecommunication) modification or replacement
13	System Grounding method
14	Typical Protection Scheme Diagram
15	Fire Fighting requirement (Water, CO ₂ , Inert gas etc.)
16	Interface with outgoing feeder / Internal connection
17	CT calculation and coordination
18	Required Testing and Maintenance Space (such as HVAC test, Lifting space for OLTC inspection etc.)
19	Allowable maximum height and weight for transportation (specially for Power Transformer)

Table 10-2 - Example of Internal Interface Items

No.	Internal Interface Items
1	Requirements (Size, Loading, Floor openings) of Civil / Building Works
2	Design of AC/DC Power supply to each equipment
3	Crane, Hoist load and Lifting height / Crane travelling requirement
4	Method of HVAC/DC testing
5	HV Power Cable Route
6	Alarm signal points and classification
7	Requirement of Road Strength
8	Sizing Water Fire-Fighting Tank, Oil pit
9	Sizing of AC and Ventilation System
10	Final Single Line Diagram and Layout

Table 10-3 - Example of Unit Design Interface Items (CIVIL)

No.	Unit Design Interface Items (CIVIL)
1	The detail of embedded base and plate fixing
2	Cable ducts, pit and tunnel requirements
3	Access Road for each site work
4	Final confirmation of cable route
5	Final confirmation of <ul style="list-style-type: none">· Equipment Loading Data· Floor opening requirement· Outline of Equipment· Head dissipation of Equipment etc.
6	Fire Wall and Oil Pit detail design
7	Security System
8	Emergency Escape Route
9	Drainage
10	Floor Protection
11	Detail civil and building design

Table 10-4 - Example of Unit Design Interface (ELECTRICAL) (1/3)

Unit Design Interface (ELECTRICAL)			
No	Before Starting Factory Acceptance Test	No.	Before the commencement of erection works
1	HV/MV Switchgear Type of external connection - Bushing + GIB - Cable/Slip-on Cable	1	Final confirmation of all items listed in "Before Starting Factory Acceptance Test".
2	CT Characteristic Coordination	2	Specification of SF ₆ gas
3	Layout and accessible height for operating switch, handle, meters from floor	3	Site Inspection and Test Procedure
4	SF ₆ Gas Sectionalizing and SF ₆ Nos. of Gas monitoring device. (each compartment, or three-phase common etc.)	4	Precommissioning Procedure for Energization
5	Requirement of pressure relief valve		
6	Status Indication/Annunciation text and event text		
7	Metering (digital, multi, etc.), Display (mimic)		
8	Type of control, metering and switching device, test switch,		
9	Interlock CB-DS-ES in own S/S		
10	Interlock CB-DS-ES between Remote S/S		
11	Nos. of auxiliary contacts and its allocation for interlock, indication, protection,		
12	Diagnostic Sensor (type, position, Nos. of PDM, SF ₆ digital GD, etc.)		
13	Cable color identification,		
14	Substation Automation Interface with LCC (including IED),		
15	Remote-Local switching scheme,		
16	PT connection and ferro-resonant with stray capacitance of CB/GI,		
17	Final paint color		
18	Factory Test Procedure,		
19	Transportation Plan,		
20	Installation Procedure,		
21	Operation and Maintenance manual,		

Table 10-4 - Example of Unit Design Interface (ELECTRICAL) (2/3)

Unit Design Interface (ELECTRICAL)			
No	Before Starting Factory Acceptance Test	No.	Before the commencement of erection works
1	<u>Transformer</u> OLTC tap position and voltage range	1	Final confirmation of all items listed in "Before Starting Factory Acceptance Test".
2	Switching Cooling Method (ONAN – ONAF)	2	Specification of Oil
3	Overloading Capacity	3	Site Inspection and Test Procedure
4	Type of External Connection - Bushing - Cable / Slip-on Cable - GIB	4	Precommissioning Procedure for Energization
5	Alarm Single Point - Oil Level - Oil / Winding Temperature - Fan, OLTC		
6	Status Indication tap position display (Mimic), etc.		
7	Remote-Local switching (Fan, OLTC) scheme,		
8	Parallel operation scheme		
9	Final paint color		
10	Factory Test Procedure,		
11	Installation procedure,		
12	Transportation plan,		
13	Operation and Maintenance manual,		

Table 10-4 - Example of Unit Design Interface (ELECTRICAL) (3/3)

Unit Design Interface (ELECTRICAL)			
No	Before Starting Factory Acceptance Test	No.	Before the commencement of erection works
1	Protection and Control Location of panels and Layout of devices, relays on Panel	1	Final confirmation of all items listed in "Before Starting Factory Acceptance Test".
2	CT – detail coordination,	2	Cable connection diagram
3	Type of Relay and its coordination with remote-end for transfer trip of feeder	3	Site Inspection and Test Procedure
4	Protection scheme and coordination with equipments and remote-end,	4	Relay setting calculation,
5	Tripping, alarming point and indicating location	5	Precommissioning procedure for Energization
6	Status Indication/Annunciation text and event text		
7	Type of control, metering and switching device, test switch		
8	Interface with signalling equipments and interface with Telecommunication system (SOE, DFR, SCADA, PLC, FOE),		
9	Remote-Local monitoring and control for unmanned substation,		
10	Interface with Substation Automation network along with protocol,		
11	Redundant system to cover long access time of operator to S/S when fault,		
12	Compatibility of Busbar Protection Relay with future extension feeders,		
13	Human-machine interface with digital relays, test switch,		
14	Security system for network computer (fire wall etc.),		
15	Authentication for access to system		
16	Compatibility of operating software with upgraded version at future extension stage,		
17	Terminal block type and size for external cable connection,		
18	Final paint color		
19	Factory Test Procedure		
20	Operation and Maintenance manual,		

And all other related engineering points for Telecommunication, Aux. LVAC/DC System and outdoor equipment etc. shall be also considered as Unit Design Interface (ELECTRICAL).

The following are examples of the mismatching of the above engineering interface items, subsequent problems and countermeasures to amend the problems:-

- The orientation and position of line entrance structure and dead-end tower cannot be decided fully until O/H route design is completed. On the other hand, the minimum requirement for interface with power cable to HV switchgear is the orientation of the dead-end tower and sufficient space for the minimum distance between each feeder or phase to maintain the required conductor / cable rating / clearance. If there are substantial changes to the final location and/or orientation of dead-end tower later, it is difficult to change the route of the power cable as there may be restriction for space of cable reservation area. (Basic interface)
- The soil condition and soil resistivity have to be investigated at the beginning of the project as these soil parameters are important factors for the earthing system and foundation design. Mistakes in these soil parameters will lead to serious problems later if the earthing system becomes insufficient and the foundation works have to be rectified, resulting in delay to civil works. (Basic interface)
- The decision to cater for future extension space must be considered from the beginning of the project as this affects the overall substation plot area and civil works design (Basic interface)
- The required CT characteristics are also the key design inputs due to the interface to protection system at initial stage. Therefore, it is important to perform the CT calculations at the beginning of the design stage based on the selected protection scheme and protection relay. (Basic interface)
- In the case of a GIS extension project, the existing crane travelling area in the GIS building was not sufficient. Therefore, a separate temporary hoisting frame was constructed for the smooth installation of the GIS equipment. (Internal interface).
- Changes in size, location and nos. of wall and floor openings for cables and Gas Insulated Bus often result in additional civil work at a later stage. Therefore, it is most important to finalize the requirements of all openings before starting of civil work in order to reduce additional work later. Normally, changes are unavoidable however these should be kept to a minimum. (Internal interface)
- Miscalculation of AC and DC load requirements are another source of problems. If the AC / DC board has sufficient spare capacity, then it may be acceptable to use the spare feeders. Otherwise, it becomes necessary to provide additional AC / DC board which increases the cost to the project. On the other hand, sometimes the design of AC / DC board is too conservative with many spares provided, resulting in large and costly AC / DC board. Therefore, it is important to design based on optimum requirement. (Internal interface)
- The details of embedded base and plate fixing need be confirmed before starting of civil works for the advance fabrication of such steel items such that concrete works can proceed smoothly with installation of these embedded parts. The checking and re-checking of final level is required throughout the civil works stage for re-confirming the accuracy of civil works. Substantial delay may occur if final levels are not according to required design levels. (Unit design interface – CIVIL)
- In many cases, the interlock scheme of main equipment may change during the design stage which affects alarm signals and tripping scheme between local and remote side. Several modifications may be made until finalization. Some of these modifications may not be according to correct sequence of activity (e.g. change in tripping scheme after alarm signal list is decided) and hence is a source of mistake and error in wiring and cable diagram. Therefore, it is vital to conduct final confirmation study of interlock scheme (at local and remote side) such that correct information will be reflected in cable diagram (Unit design interface – ELECTRICAL)

These examples are some of the issues that arise in project execution when proper interface planning is not done at the engineering stage.

In the execution of turnkey project, the turnkey Service Provider is trying to coordinate all the planning, engineering and construction events instead of the Asset Owner.

It is necessary to emphasize the importance of prioritizing the various events and steps in the order of Flow / Time / Engineering as the key ingredient of project execution.

Fig.10-1, 10-2 and 10-3 may be used as checking tool by the Asset Owner to determine whether the project execution events or engineering steps have been on progress / completed smoothly, or not.

In case these items are clearly specified from the beginning based on the Asset Owner's standard specification and designs, Service Provider will be able to manage turnkey project without difficulties.

10.4 CLAIMS MANAGEMENT

Commercial Terms and Conditions which are issued with the Tendering documents must specify the venue for settling any claims by the Service Provider or Asset Owner. Failing that claims management could be a difficult process during and after contract implementation. The claims clause in the Commercial Terms and Conditions must specify that claims should be settled through binding arbitration and designate the binding arbitration authority.

In particular substation refurbishment/extension turnkey projects are likely to experience claims resulting from missing or not up-to-date site information. This will translate into additional claims which have to be addressed through the claims management system

The word "claims" is used interchangeably with the word "variances" in this chapter. In most cases, claims are always presumed to be additional work thereby resulting in additional cost. However, it is also possible that in some cases and circumstances that a reduction in scope of work may lead to less work and hence reduction in cost. In this aspect, the term "variances" would be more universally representative of the possibility of additional as well as reduced work.

Claims may arise due to several reasons; mainly claims about scope assignment including changes in scope assignment. Claims may also arise due to changes in the interface of project, however in most instances, claims and variances arise usually due to a combination of the following:

- Incomplete specification,
- Inaccurate scope of work,
- Missing scope of work,
- Delays caused by other reasons (such as regulatory approval) or other contractors,
- Changes in substation layout,
- Changes in technical requirement of equipment,

Claims may occur between the following parties:

- Asset Owner <-> Service Provider (contractor),
- Service Provider <-> other contractors,

Claims usually result in 2 main changes:

- Changes to the project schedule,
- Changes to the overall cost of the project,

In evaluating the claims, it is necessary to judge quickly whether claims are justified and warranted. If the claims are affecting the overall schedule and progress of the project, it is imperative that quick decisions are made to authorise the claims and proceed with the work. Contractual resolution could be duly worked out according to the provisions in the contract.

Whilst evaluating the necessity of the claims, it is also prudent to review the effect of the variance on the immediate activity/job flow in the project and ensuing delays that may occur if the variance is not resolved. If there are indications that the variance would result in delays to the overall project schedule, countermeasure must be implemented for recovery of the delay and job flow must be re-prioritised accordingly.

In addition to evaluating the impact of claims on the project schedule and work priority, it is also important to have a proper system for documenting and evaluating claims. This is all part of a comprehensive claims management system. Some of the components in a good claim management system should include the following:

- Guideline for Service Provider to raise variances,
- Method of documenting variances,
- Method of evaluating variances,

In the Contract Documents, there is normally a section which deals with variances; some contracts may specify that a cause for variance should be raised within 21 days of the event or circumstance occurring which may lead to a claim. In some instances, variances will only be considered if the related additional or reduced work scope is authorised by the Asset Owner or its representative according to the prescribed procedure in the Contract Documents.

From the Service Provider's perspective, it becomes extremely important to be fully aware of the contractual scope of work. Only with a full understanding of the contractual scope of work can the variances be correctly identified and raised to the Asset Owner by the Service Provider. The Service Provider must be fully aware that any request for work outside of the contractual scope shall be considered as a variance and thus brought to the attention of the Asset Owner within the specified period of time. By the same token, in order to minimise the variances, the Asset Owner must be fully aware not to request any unnecessary work which could be outside of the contractual scope.

One of the key aspects in claims management is the evaluation of variances or claims. Generally, the method for evaluation should be clearly defined in the Contract Documents. There are several methods to assess a claim, in this case a claim being claim for additional cost due to additional work. These methods include:

- Comparison of quotations,
- Unit rates basis,
- Cost plus basis,

In the cases of additional work which may be done by sub-contractors, Asset Owner may request Service Provider to obtain several quotations for evaluation by Asset Owner. The additional work would normally be ordered to the best suitable sub-contractor, considering cost, experience and quality.

Some Asset Owners may prefer to specify that standard unit rates for various equipment and work are to be included in the Contract Documents. In such cases, the additional work would be calculated based on the available unit rates from the Contract Document. This concept is more transparent as the unit rates could be negotiated before finalising the Contract. However, it is virtually impossible to include all unit rates for all eventualities. In some cases, Asset Owner may also decide that specific unit rates obtained from industry publications or authorities shall be used in the event of a variance.

Another complement for calculating the variation based on unit rates is to use a "cost plus" method where the Service Provider is compensated according to the actual cost of work plus a fixed amount for overhead and administrative cost that would be incurred by the Service Provider.

As mentioned earlier, the main outcomes of a variance are revision to the project schedule and project cost. After evaluating the variance, it is necessary to confirm whether there are any changes or effects to the project schedule and the project cost. If there are changes, then it is necessary to revise the project schedule accordingly. As for the project cost, this could be handled as a variation to the main contract sum.

10.5 TEST/ACCEPTANCE

The procedures for testing and acceptance are generally universal and do not distinguish between turnkey or non-turnkey projects. Hence the criteria for testing and acceptance should generally be the same, irrespective of whether the project is turnkey or non-turnkey.

What may represent a significant difference for turnkey substation, depending on the terms of the contract, is which party is responsible for the commissioning and acceptance testing. Under normal circumstances the Service Provider will perform commissioning and acceptance tests as part of the contract.

In such case, the Asset Owner's role in the commissioning and site testing process is limited to witnessing the tests and issuing the Commissioning Notice to Energize (CNE), which allows the new substation to be placed in service. However, it is incumbent on the Asset Owner to also perform the full review of the completeness of the project, including Engineering, Construction, Installation, Commissioning and Testing.

For any substation project, the site-acceptance testing represents the validation of the work performed and the successful completion of the tests provide the assurance that is necessary to allow the new installation to be energised and connected to the rest of the system. For turnkey substations, the process is even more important, as it confirms the work performed by the Service Provider is up to the contract's Technical Specification and provides evidence that the quality of such work matches the requirements provided in the tendering document.

Regardless of who actually performs the commissioning and testing, the process needs to be a rigorous one and must be properly documented from start to end. The responsibilities for the process are normally assigned to the Asset Owner's specialised group that performs commissioning and testing for new or refurbished installations. In large utilities, such specialised groups may perform other functions as well, e.g. periodic testing of major equipment, inspection and test witnessing of major equipment at the manufacturer's plant, QA assessment of supplier's plants, etc. Such a variety of activities has the advantage of providing the group with deep knowledge of various equipment types and testing methodology and prepares them well for a multitude of problems and situations that can arise in the field during acceptance testing of the new substations. Each Asset Owner has his specific procedures for site acceptance, so the following is only a suggested list of activities that need to be undertaken and documented as part of the Test/Acceptance process:

10.5.1 SET UP PROJECT FILE

Once the contract is signed up and the new project is started, the Project File is set up. This file will contain all relevant information relative to the new substation and will include the 1-line diagram of the new substation, a list of all major equipment to be installed with their main ratings and characteristics, sets of approved manufacturers' drawings for each piece of major equipment, proposed delivery and installation schedules, etc. As the job progresses, new information will continue to be added, e.g., factory test reports, specific technical data, equipment manuals, correspondence, etc.

It is expected that a person assigned for the site test/acceptance will read and get familiar with all info available in the Project File that is relevant to the specific job.

10.5.2 PROJECT TEST SUMMARY

A very important document that needs to be prepared is the Project Test Summary. It includes all the Equipment Test Summaries for each type of Major Equipment which in turn must contain the specific equipment ratings, the proposed test procedures, the range of acceptance criteria, any equipment manuals references where applicable.

Once reviewed and approved, copies of this document should be filed in the Project File and sent to the Service Provider, the project manager and the field coordinator.

10.5.3 ACCEPTANCE STANDARD

The Acceptance Standard for a turnkey substation must contain, in addition to specific acceptance standards for each piece of major equipment, acceptance standards for all elements of the substation, including substation grounding, civil works, bus and insulators, lightning and switching surge protection, protection and telecom equipment, fences and gravel, control cable trays, cable terminations/bushings, AC/DC power supply systems, fire protection and security systems, washroom and storage facilities, etc.

The Major Equipment acceptance standards should record nameplate data, serial number data, civil and structural inspection data, mechanical and electrical inspection data, temperature readings, insulating medium data, timing results, substation data and the installer/tester information.

The acceptance standards are normally drafted by an experienced installer or tester and must be reviewed and approved by a professional engineer. Once the test data is recorded on them, the data should again be reviewed and approved by an engineer.

The data measured and recorded during acceptance testing must be retained for future reference, as it represents the "footprint" against future maintenance data will be compared.

For turnkey substations, a copy of the Acceptance Standards must be submitted to the Service Provider, who will perform the testing and after recording the results submit the complete documentation to the Asset Owner.

10.5.4 ACCEPTANCE TESTS SCHEDULING

Scheduling the acceptance testing requires close coordination between the Service Provider and the Asset Owner, to minimize disruption in work that is still under way at the substation and the time required for testing, which often involves additional costs (e.g. the daily and travel fees for highly specialised testers, rental of HV test equipment, etc.). Any pre-testing meetings (for safety or personnel training) must also be planned in advance.

10.5.5 TRAINING OF MAINTENANCE PERSONNEL

It is highly recommended that the site acceptance testing be also witnessed by representatives of the future Maintenance personnel, as on-site training of the Maintenance crews offers obvious benefits for the Asset Owner. It is also recommended to synchronise any training courses that are planned for the new equipment with the site testing, for the same reasons. These requirements should be clearly spelled out in the contract and become part of it.

10.5.6 DEFICIENCIES, PROBLEM RESOLUTION

The Service Provider is responsible for any remedial action required as a result of site acceptance testing. Any parameters falling outside the acceptance criteria range must be explained and prompt action to rectify the problem must be taken to bring the results in the acceptable range. The “as found” data and the “as left” acceptable results must be recorded and reported to the Asset Owner’s representative witnessing the acceptance tests.

10.5.7 ENVIRONMENTAL RESPONSIBILITY

Special attention is required during the Acceptance Testing to avoidance of environmental incidents, specifically oil spill prevention for oil-insulated equipment (power transformers, reactors, capacitors) and diesel generators, and SF₆ gas leak prevention for SF₆-insulated equipment (GIS, GIL, circuit breakers or instrument transformers). Oil processing equipment and SF₆ gas reclamation carts are the responsibility of the Service Provider, but the Asset Owner’s representative should ensure the equipment is in acceptable condition and the probability of spills or leaks is minimized.

10.5.8 COMMISSIONING NOTICE TO ENERGIZE (CNE)

The final act in the acceptance process of the turnkey substation is the issuance by the Asset Owner’s representative of the CNE. The notice authorizes the Asset Owner’s Operating Authority to proceed with the energization of the new substation. An example of the CNE process, a CNE form and a list of conditions that must be met prior to issuance of the CNE are attached.

COMMISSIONING NOTICE TO ENERGIZE

Project	Year/Stage	Project Short Name
Project Scope		EAR No.
Equipment or Circuit Designation	Equipment or Circuit Details	
Associated outstanding items/restrictions/deficiencies(attach sheets as necessary)		
I give notice that the Protection and control Equipment Described above has been tested and is ready for initial energization	I give notice that the installation of the equipment described above is complete except as noted. This does not release me from any duties which I may have under safety practices regulations	
Protection and Telecontrol Date	_____ Date Site Construction Representative	
<input type="checkbox"/> I confirm all prior conditions and documentation are completed in accordance with BCTC standard requirements and that all equipment described above has been tested and is ready for initial energization	Effective _____ hours, Project Contollership over the equipment listed above is transferred to BCTC. This serves as written notice that this equipment or circuit is deemed to be on the power system under BCTC operating responsibility and authority	
_____ Date Project Manager (or Delegate)	_____ Date Project Controller	

Conditions to be met prior Authorizing Commissioning Notices to Energize

Project	Year/Stage	Project Short Name	
Project Scope			EAR No.
Prior Requirement	Date Completed	Completed By	Comments
Equipment or circuit installation completed in accordance with project drawings and specifications			
Equipment or circuit testing completed in accordance with approved test plans and test cover sheets approved (where applicable) and on file			
Operating One Line Diagrams Prepared or updated with copy to ACC			
LOO & SOO(where applicable; Including transmission rating Changes in 5T-10) created or Revised with copy to ACC			
Alarm assignments and responses Complete and included with LOO(if applicable)			
Initial energization sequence and switching orders reviewed with ACC (if applicable)			
_____ Date Delegate)		_____ Project Manager(or	
		I give notice that the above conditions have been met as a pre-condition for authorizing a CNE associated with this phase of the noted project. This does not release me from any duties which may have under safety practices regulations	

11. TURNKEY PROJECTS FOR NEW SUBSTATIONS

In real life most of the substation turnkey projects are likely to be for “green field (new)” substations. Some of the aspects related to new substation turnkey projects include:

- Availability of real estate in the required area may result in dictating the technical solution which may not be necessarily the lowest cost alternative,
- Choice of selecting the best/newest technical solution without being concerned with matching existing equipment,
- Design work is much simpler because all equipment, structures, etc. are new and all the documentation associated with them is available,
- Construction and commissioning is safer, faster and schedule is more predictable since most of these activities do not depend on operating outages and work methods are free from constraints of work near live installations,
- Grounding grid of new substation can be built to the ultimate projected fault levels and to the latest standards using copper replacement materials (copperweld material),
- Need for AC station services during construction and commissioning. This AC SS source might represent a significant expense depending on the location of the new substation,
- Latest environmental and safety standards are applicable and the Service Provider must comply which increases the cost,
- Labour relations are simpler for new substation turnkey projects,
- Potential neighbourhood opposition to the new substation could lead to considerable schedule slippage,
- Aesthetical issues, historical heritage and community acceptance may increase cost in built up areas,
- No unforeseen issues related to potential underground surprises (i.e. existing foundations, duct banks, cables, etc.) during construction phase,
- Routing of new HV circuits to the substation might require lengthy approvals due to opposition from the public,

12. TURNKEY PROJECTS FOR SUBSTATION REFURBISHMENT/EXTENSIONS

Substation refurbishment and Substation New Bay turnkey projects are types of projects in which changes/additions have to be performed in an existing energized substation.

- A Substation Refurbishment turnkey project is a project in which parts of an existing operational substation major equipment (transformers, circuit breakers, disconnect switches, metalclad switchgear, etc.) are at their end-of-life and they have to be refurbished to extend their life; or their technical characteristics no longer meet the latest system requirements and they have to be replaced with new equipment, e.g. refurbishment of hydraulic mechanism only of circuit breakers in a GIS installation, replacement of circuit breakers only in a GIS, etc.
- A Substation New Bay turnkey project is a project in which an existing operational substation is extended by addition of new facilities to meet the increased requirements (i.e. new air insulated bay in a high voltage switchyard, new high voltage GIS bay, new medium voltage metalclad switchgear section or GIS bay, etc.)

The fact that the substation exists in an environment in which changes/additions affect the neighbourhood as well as the presence of existing live equipment creates a series of restrictive conditions for these types of turnkey projects,

These special conditions have to be clearly defined and they have to be included in the Tendering Documents before the tendering process starts. Special attention has to be given to the alternative solutions offered by the Service Provider to ensure that they comply with the restrictive conditions issued in the technical specifications.

Some issues to be considered for such projects are:

- Site survey needs to be conducted to establish the state of original equipment and site condition which may have changed from the original construction stage. Some of the points for checking during site survey are:
 - Applicable type of Equipments or New type may be required.
 - Availability of working space/access road/cable and O/H line route, increased surrounding building or residential housing, etc.
 - Existing obstacles such as Piping, Telecomm line, Drainage, Cable duct / trench, etc.
 - Availability of common cable rack, opening, cable duct / trench, etc,
- Functionality of the substation during the construction or service work has to be maintained. This involves cooperation between the Asset Owner and the Service provider to implement the necessary measures to guarantee personnel safety, installations stability and continuity of operation,
- Security of installations - given the environment prevalent after 9/11, most utilities will require a background check of the Service Provider's workforce. This issue must be completed before the contract is awarded. Access into the Asset Owner's substation will be closely controlled, to prevent intruders and metals/materiel theft during construction. However, if the Service Provider will be general contractor, it must accept liability for break-ins or theft during their stewardship of the substation – an issue that must be factored into the evaluation).
- Interaction by the Service Provider's staff with the Asset Owner's workforce must also be considered. The Asset Owner will need to provide staff that facilitates required outages, depending on the project may assist with some dismantling of existing equipment, need to witness commissioning and site acceptance tests. The costs to cover these activities may differ from one bidder to another as a function of the proposed solutions and must be factored into the evaluation.
- In an existing installation it is often difficult to obtain extended operational outages required for the project. Even approved outages are sometimes cancelled due to unexpected events elsewhere in the power system. It is recommended to allow for flexible schedules which take into consideration such situations.
- Hours of work offered by the Service Provider must be checked to ensure that they synchronize with the hours of work mandate by the Asset Owner's labour agreements. Failure to do so could result in significant schedule slippages and unwanted Labour relations strains,

- The quality, accuracy and completeness of as-built drawings is a key factor which will affect the engineering process flow. Mistakes in as-built drawings (such as incorrect CT ratios, incorrect relay settings) will lead to problems at the later stage of the extension work. Therefore, it is most important that all previous modifications are incorporated and latest actual status must be checked and confirmed against site conditions. To mitigate such situations, cushions should be built into the schedule and additional costs can be dealt with through the claims management system.
- Often, when old technology is being replaced with new one this may result in unexpected changes to existing protection and control wiring and to protective relaying annunciation. Additional wiring might also result in the need for new cable trenches/trays due to the fact that existing ones are already used up to full capacity,
- There may be space constraints imposed by the layout of the existing installations. Such limitations may be overcome by the innovative use of new technologies such as Gas Insulated Switchgear, Mixed Technologies Switchgear, Insulated Cables or Gas Insulated Busduct, reconfiguration of switchyards to accommodate new equipment, etc.
- The basic parameters of the system (rated voltage, rated frequency, fault current levels, continuous current ratings, neutral point grounding, basic insulation levels) are fixed and cannot be modified. Other parameters, such as orientation or direction of the overhead lines or underground power cables in the neighbourhood of the substation could be modified in order to achieve the new technology.
- For substation refurbishment/extensions turnkey projects it is important to release all existing civil and structural details (e.g. site preparation, drainage system, foundations and supporting structures, spill containment, internal roads, rails, fencing and control buildings) to allow the Service Provider to properly blend in the new installation into the existing ones,
- Seismic conditions – which may not have been considered at the time the existing installations were built, must be followed now. Legislative changes since the original installation may now impose tougher seismic requirements.
- Sometimes, unexpected designation of certain existing buildings in substations as “historical heritage” surfaces only during detailed design stage with significant additional costs and delays in the project,
- Primary and secondary systems such as basic control system functions and its interfaces with upper and lower levels, protection schemes, communications by power line carriers or by optical fibre or other means, could be modified according to the new technology.
- Specification and selection of secondary equipment, covering protection, control, instrumentation and metering circuits and telecommunication and telecontrol systems. Implementation of IEC 61850 port will allow the development of the substation telecommunication system.
- Reference must be made to the environmental aspects such as noise levels, electrical and magnetic fields, corona levels, which must be reduced in accordance with newer prevailing restrictions.
- Depending on the project site, archaeological restraints that constrain the civil works might exist. Other restrictions cover oil spills, PCB content of insulating liquids, venting into atmosphere of greenhouse gases (e.g. SF₆), asbestos removal and disposal regulations, lead and mercury exposure and other safety requirements governed by local and national laws and international standards that have to be respected.
- New environmental regulations would require more stringent designs to be applied. Some jurisdictions ask for retrofitting with spill containments of all transformers in a substation when a new one is installed,
- In some jurisdictions legislation requires that when refurbishment/extension is undertaken in an existing substation, existing facilities have to be also updated to meet the latest standards - especially environmental and safety standards (e.g. retrofitting of existing transformers with spill containments when adding another unit or when replacing it),
- Substation layout and bus design, covering the single line diagram, the arrangement of the bays and the main buses, circuit entries, main equipment location, electrical and safety working clearances could pose additional restrictions,

- In an extension project, the auxiliary AC/DC supply is normally taken from existing spare feeders of AC/DC boards. It is important to ensure that sufficient spare feeders and capacity are available for the extension, otherwise it may be necessary to provide additional AC/DC supply source. It is also important to establish whether it is possible to modify the existing auxiliary AC/DC supply panelboards for extension without shutdown of the existing ones..
- It is a common request in extension projects that some of the new equipment/parts to be the same or compatible with existing equipment. An example of this would be the busbar protection relays. It is important to confirm that such equipment/parts are available; this kind of checking is especially vital for substations which are more than ten years old as some equipment may not be available any more,
- It is often useful to find out whether previous extensions or modifications were done or not. This may give an insight whether there are any difficulties of technical issue and required prevention for safety work etc.
- Due to the numerous interfaces with existing equipment, an insurance policy must be undertaken by the Service Provider to cover existing substation portion required for refurbishment/extension work, such as modification, connection, partial replacement and testing to be affected by extension work.
- The warranty of extension parts/portion shall be clearly defined. This implies that the terminal points between existing and extended parts have to be clearly defined. Warranty conditions for refurbishment projects must be as strict as for new equipment and must cover both labour and parts and time frame between reporting of damage to repair.
- In substation refurbishment projects, scrap and recycle work should be carefully planned, as per [Table 12-1](#) which outlines a general guide and requirements when executing refurbishment projects. There may be other criteria to consider which are geographically specific such as local permits, local weather, local terrain and local transportation restrictions for disposal of equipment.

Table 12-1 - Requirements for Scrap and Recycle work before Refurbish

	Items	Activity
1	Scrap and Recycle Plan of Existing substation as per regulations	1. Scrap Yard plan 2. Disposal Plan (1) De-oil from transformers, (2) SF ₆ gas recycling from GCB, (3) Cooling gas recovery from Heat Ventilation and Air Conditioning System, (4) Porcelain Insulator of Gantry Yard, (5) Bushing of transformers/reactors, (6) Gas Cylinder recovery from Fire Fighting, (7) Copper/aluminium solid conductors, (8) Insulated Auxiliary Cables; Non flammable/flammable, (9) Power Cables (oil filled/ XLPE), (10) Stored oil and water in pit, (11) Steel support structure, (12) Battery, (13) Gantry structure,
2	Scrap and Recycle Plan of Existing Civil construction as per regulations	1. Concrete foundations, 2. Gravel in transformer oil pit, 3. Asphalt pavement, 4. Sanitary, 5. Building structure, 6. Earthing mesh,
3	Transportation of removed equipment	1. Transformer (1) To be kept as emergency spare after re-filling with oil, (2) To be used for other substations, 2. Others (1) To be decided as required,
4	Protection of Environment	1. Isolation of scrap work area to avoid environmental hazard, (1) Dust, fumes (shielded by fence/net if required), (2) Sound/noise (shielded by fence/net if required), 2. Prevention of oil spill out and contamination,

13. CLOSING THE PROJECT

13.1 INTRODUCTION

The end of the project starts after the successful commissioning of the substation. The Asset Owner takes possession of the finished substation. Before an Acceptance Certificate is transferred typically a close inspection takes place.

A defects list is created by the Asset Owner. The Service Provider is then required to rectify all the defects as soon as practical usually during the project warranty period.

At this point final resolution of the steps listed below are necessary to keeping cost low and any additional cost creep due to labour cost or tax considerations.

13.2 DOCUMENTATION

Documentation is the accounting of all meetings, agreements and intellectual communication of the project between the Asset Owner and the Service Provider. It is essential that project documents are prepared correctly and compiled in a systematic manner to allow easy retrieval in the future.

Over the life of the project, hundreds or in some cases, thousands of documents such as drawings, specifications, test records, material data sheets, calculations, etc are generated.

Modifications made during construction shall be marked on the relevant document for final updating and incorporated into as-built documents. As-built documents are an integral part of project documentation as they reflect the actual constructed details of the substation installation.

As-built documents are important to facilitate proper operation of the substation. These drawings are necessary for cost tracking and change order review. Improperly recorded as-built drawings will lead to mistakes on additions or modifications.

A typical summary of documents are as follows

- Substation plan drawings and layout drawings,
- Foundation drawings,
- Architectural, civil drawings and calculations,
- Ground Grid drawings and calculations,
- Equipment layout,
- Power cable route's layout,
- SCADA / Relay Panel layout, manual,
- Equipment instruction manual,
- AC power supply single line diagram,
- DC power supply single line diagram,
- CT calculations,
- Control cable connection drawings,
- LV AC/DC calculation,
- Power cable current calculation,
- Insulation coordination study document,
- Assembly drawings for steelwork,
- Equipment detail drawings,
- Protection and control schematic drawings,
- Relay Protection and Control settings,
- Ground Grid Readings,
- Test reports of all equipment,

During the course of the project, all of the major substation equipment will be subjected to different levels of factory inspection acceptance. Some of these tests may be conducted in the presence of an independent testing authority or Asset Owner's representative. Often this is done on items that have long lead times, expensive or are difficult to transport. The inspection of equipments condition, packaging or blocking before shipping is necessary to prevent delays and insure quality on delivery. Site Test Records are necessary as well for confirming the site equipment conditions before completion and energizing substation equipment. A check list should accompany the projects schedule to improve speed and accuracy during commissioning.

On site test data will be compared with the data of factory inspection and the data from site testing to ensure quality control during transportation and site installation were satisfactory. An example of this might be impact recorders. Proper care and proper storage of these documents will aid to minimizing the life cycle cost from strategic maintenance philosophy. Attention to detailed records is a big influence in cost reduction for the project.

Make sure the format of the documentation is consistent and meets standard recording formats. The format should be compatible with the Asset Owner's normal records. An example might be electronic drawings are in a format the Asset Owner can view or make revisions, AutoCAD or Microstation. Attention to these types of detail reduces errors and speeds up the approval process.

Instruction Manuals should be part of the drawing approval process. If additional training is required for a substation site, the manuals should be issued as part of the training. Both electronic and print versions should be provided.

Proper instruction manuals coupled with effective training will lead to more efficient maintenance of the substation by operation maintenance staff. The substation design should be considered to optimize the strategic maintenance of the new facility which will result in significant cost reduction impact to the Life Cycle Cost. It is important to allocate sufficient time and resources for mutual discussions between Asset Owner and Service Provider about future planned maintenance as instruction manuals are useful only for normal maintenance, not for strategic maintenance. In many cases the Service Provider may be hired to perform maintenance on the new facility such as a FACTS (Flexible Alternating Current Transmission System) device.

13.3 SITE CLEAN-UP

Clean up should take place as part of a continual process and not just at the end of the job. Unused material should be returned to stock to prevent material overcharges. Clean up is also a safety issue. Poorly controlled job sites can be a safety hazard and could lead to accidents. Extra man hours and expense can result.

Temporary construction facilities such as trailers, sanitary facilities, temporary service or generators and water supply facilities should be removed. These events should be coordinated so all other events have been concluded. In many cases local standards and permits require these facilities until all work has been completed.

All construction debris should be removed and disposed of in the safe and approved manner. Burning of construction trash may violate local ordinance and should be discouraged. Recycling of conductors and cables and other materials are strongly encouraged. Often shipping containers can be reused. Minimizing the volume of debris and scheduling the time of removal depend on the how remote the job site is and what arrangement have been made.

In some cases, general landscaping such as re-planting of trees is implemented around the substation area. Often a boundary fence is installed around the substation area for beautification, but also for safety and noise mitigation. In urban areas, surrounding disturbed existing land marks (such as access roads, adjacent properties, etc.) which have been disturbed during construction may be required to be brought to original conditions.

13.4 FINAL WALK THROUGH

The Asset Owner will need a final inspection of the construction site

Any outstanding issues are recorded by means of a defects list with target completion dates. Any warranty or revenue agreements should be finalized at this time. All outstanding work orders should be closed once repairs are completed to prevent additional overhead charges. All assets should be recorded as soon as possible to allow earnings on new capital facilities. Any delays can be costly since money often is borrowed to construct the project.

13.5 LESSONS LEARNED MEETING

After completion of the project each coordinator and project manager and purchasing coordinator should have an opportunity to record any anomalies or opportunities to improve performance for the next project. Mistakes can be costly and any attempt to improve the processes will result in savings.

14. CONCLUSIONS

The scope of this brochure is to be a guide for Asset Owners of various sizes (large and small) in how to approach and how to successfully complete a turnkey project for new substations or for refurbishment/retrofitting or extension of existing ones.

Turnkey project for substations is a viable alternative to the in-house approach and more and more Asset Owners are taking this option.

The decision of opting for a turnkey project approach versus the in-house solution must be carefully evaluated. There are both benefits and drawbacks in using the turnkey method and this brochure has endeavoured to highlight most of them.

The brochure guides the reader through the full turnkey process from conception to completion and its intention is to enable the reader to adapt the turnkey process to the particular project they are about to embark upon, from single bay extension to building a full new substation.

Success or failure of a turnkey project depends to a significant degree on the quality and completeness of the documentation package assembled by the Asset Owner at the onset of the project. This documentation package must cover as clear and complete as possible the scope, deliverables and time frame assigned to the project, so that Service Providers can offer an accurate cost estimate and additional extras can be avoided during the life of the project and after completion. Besides detailed technical information, the documentation package must be very specific on the commercial terms and conditions, payment schedules, quality assurance during construction, warranties, performance measures after in-service and liabilities that survive the Handover Day,

Selection of the Service Provider for a turnkey project is a very important aspect and may determine the success or failure of the endeavour. Prequalification of potential Service Providers, their financial viability, past experience, technical merit of the solution offered, full cost as well as commitment to deliver the project on time are important factors in the decision of the Asset Owner on which Service Provider to retain,

The project execution process and assurance of the expected quality during construction is of vital importance during turnkey projects and the Asset Owner must include in the contract with the Service Provider detailed requirements related to the process of quality control and monitoring of expected deliverables and deadlines, The terms and conditions of the contract must also clearly indicate the responsibilities of both Asset Owner and Service Provider during the commissioning and acceptance testing. Under normal circumstances the Service Provider will perform commissioning and acceptance tests as part of the contract, but the Asset Owner retains the responsibility of providing the criteria for acceptance and of final acceptance of the work prior to placing the substation in-service.

Turnkey projects for new substations present significant differences from turnkey projects for refurbishment/retrofitting or extensions of existing ones and the differences are highlighted in the brochure,

Case studies included in the brochure provide the reader with real life examples of turnkey projects from different parts of the world. These case studies underscore the particularities of each case with emphasis on the benefits of the turnkey approach, as well as listing any "lessons learned" for the particular case.

15. CASE STUDIES

DUBLIN 110 kV GIS TURNKEY SUBSTATION PROJECT

1 BACKGROUND

At the end of the 1990's and early in the new millennium, many multinational companies, including some high profile IT companies, were attracted to Ireland. Within a relatively short period of time a large number of applications were made to the Irish Electricity Utility, ESB (Electricity Supply Board) for connections to significant point loads located at Industrial Parks within the greater Dublin area. The load requirements for these "Webfarms" ranged from 20 MW to 40 MW. A feature of installations of this type is that the load factor tends to be very high because they operate on a 24 hour basis. For this reason, coupled with the fact that there was a booming economy in Ireland and a large number of construction projects being planned, the available capacity on both the transmission and distribution networks was depleting rapidly.

The proposed stations were to be located in new "high-end", landscaped, industrial parks many of which were located in urban areas. It was specified by the local planning authorities that open AIS stations would not be acceptable. Space was at a premium and the buildings were to blend in with the surrounding buildings.

In Ireland, the distribution voltage level is 10 kV in urban areas stepped down from 38 kV but in the Greater Dublin area the distribution voltage level is stepped down directly from 110 kV. ESB Networks decided to look at available options to meet this challenge.

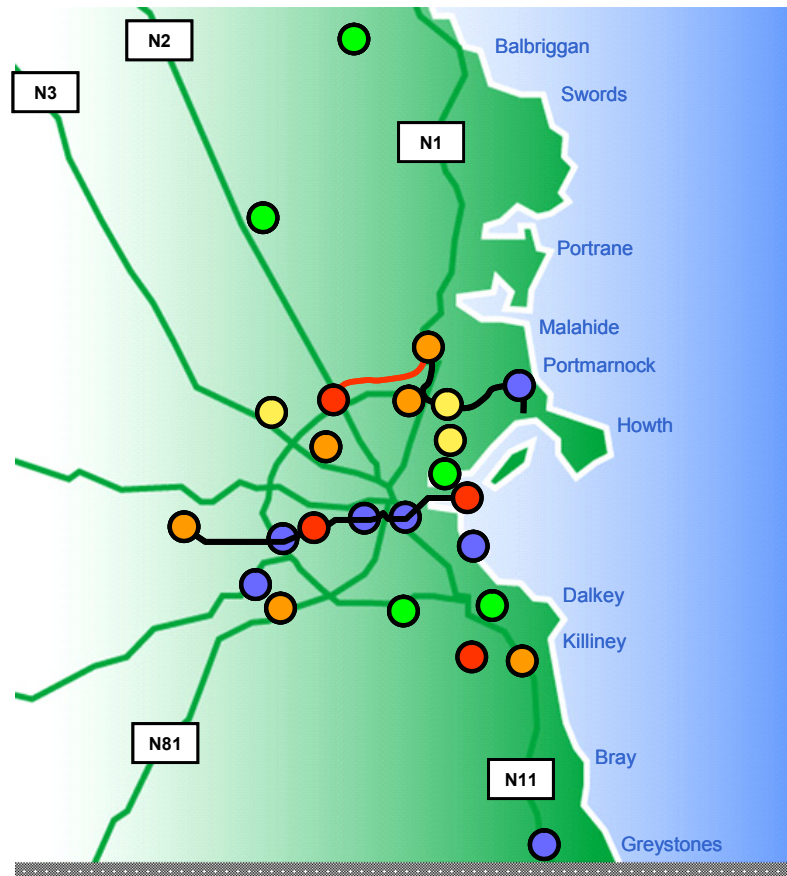


Fig 1 Map of Greater Dublin showing proposed station locations

2 CONSIDERATION PROCESS

Up to this point, ESB designed and built this type of station using their own in-house technical services. However, at a very early stage of planning it became obvious that ESB's engineering and technical resources could not handle the level of work required due to the proposed timescale and scale of the workload while maintaining the normal Operation and Maintenance services on the Network.

Following initial discussions between the Client, ESB Networks and their Consultant, ESBI (ESB International), a wholly owned subsidiary of ESB, it was decided to implement this project using a turnkey option. This option was considered appropriate due to the large risks involved and the short timelines required. It was believed that the turnkey option would enable the Client to hire a reputable and proven Contractor with appropriate experience and a track record in such a role.

The two main factors in the decision to use a turnkey solution were that this approach would overcome the resource issue and also make the Contractor responsible for deliverables. It would also remove the risk of meeting the tight schedules required from the Client and place that risk on the contractor. The arrangement would have the further advantage that the large Contractors tend to be closely linked to or are part of the big companies that manufacture transformers and switchgear and hence should be in a better position to negotiate for production slots which suit the required programme.

After much deliberation it was eventually agreed that the project would be awarded as split turnkey. Split turnkey was decided because ESB wanted to keep control of the civil design and the civil project management. ESBI have a well established civil department who have had many years of experience in the civil design of AIS and GIS substations. The plan was that once the civil programme was completed each substation would be handed over to the successful electrical Contractor.

It was also decided that a separate enquiry would be issued for the civil works for each substation rather than a single enquiry covering all of the planned substations. This decision was feasible due to the large number of qualified and experienced Contractors within Ireland and was intended to encourage more competitive rates and also to allow different Contractors to propose more efficient and shorter construction programs.

In a number of cases the substations were constructed adjacent to the construction site of manufacturing plants for which the bulk of supply from the station was to feed the load required in that plant. In many of these cases the main civil Contractor on these sites was also the successful tenderer for the construction of the substation presumably due to the advantage of being already mobilised on the site.

It was further decided that telecoms was also to be separated from the turnkey Contractor's scope of work because ESB has a telecoms department., and for familiarity and consistency reasons it was agreed that this department would be responsible for the majority of telecommunications work including the supply and laying of both fibre and pilot wire cable, the supply, installation and connection of the optical multiplex equipment in each station and the provision of phone, fax etc. The telecoms department was also responsible for the integration of each new substation into the existing ESB SCADA system using the signal list provided by the turnkey Contractor.

The Consultant, ESBI, set up a dedicated project team to operate in the Owner's Engineer role and this team produced the tender documents and a scope of work for the turnkey contract. The various Contractors then quoted a price along with a proposed programme. The submissions from each of the tenderers were evaluated primarily on price but also on the experience and technical capabilities of the Contractor along with proposed program and ability to deliver on time. (i.e. factory production rates along with committed projects etc.)

3 PRACTICAL CASE

During the financial approval process the scope of work was confirmed as fifteen 110 kV/MV GIS substations. The tender enquiry documents were prepared by ESBI and issued in November 2000. Fourteen stations of the contract were awarded to a globally recognized firm for power and automation technologies. This company was already established in Ireland and it was this companies' Irish office that project managed the overall project. The transformers, switchgear and plant were supplied by the various factories operated by sister companies of the Contractor from around Europe.

One station was awarded to the second lowest tenderer as a strategic decision by the Client to have an alternative source in place in case of delivery problems from the selected contractor.

From the beginning it was planned to keep a standard design for the construction of the substations. The initial civil design was a replica of an indoor GIS station design which ESBI had used previously in the Middle East. Following construction of the first three stations it began to prove very difficult to maintain this design. This problem arose from the fact that these stations were located in a new breed of landscaped business parks and urban residential development areas and both developers and local authorities insisted on architecturally designed buildings to match the general design of adjacent buildings. This led to an increase in the planned civil works costs.

The turnkey Contract was a contract between the Client and the Contractor to deliver “ready to energise”, fully functional and commissioned stations. Once it was determined by the Clients planning department that a Customer connection was required from the 110 kV network, then an order was issued to the turnkey Contractor and the Contractor began to place orders for the transformers, switchgear and various plant.

The responsibilities of the three main stakeholders in this project were broken down as follows:

Client – ESB Networks

- System planning, load forecasting and identifying if each application for a major supply point could be fed from the existing distribution network or if a new substation was required to supply the forecasted load to the Customer.
- Contract award to the turnkey Contractor as well as the individual civil contracts and payment of engineering certificates upon recommendation by the Consultant.
- Safety auditing on the construction sites.

Consultant – ESB International

- Preparation and evaluation of the turnkey contract tender documents as well as clarification meetings with successful tenderers and preparation of recommendation of award of contract to the Client.
- After contract award, ESBI prepared (for each substation) the Single Line Diagram, Scope of work, overall budgeted costs (including land purchase and civil construction) and expected completion programme (based on the Contractors fitout programme) for Capital Approval.
- Identification of possible sites as near as possible to the particular load centre, dealing with developers and local authorities
- Once a suitable site was determined, ESBI then prepared and submitted the planning application for each site.
- Full civil design, tendering and evaluation and project management of the civil phase.
- Reviewing and approving all project documents, switchgear layouts and protection designs for each substation as well as ensuring projected costs were in line with the original tendered costs and project programmes were acceptable.
- Chairing all progress meetings and dealing directly with the Contractor on all day-to-day issues.

Turnkey Contractor

- Following the acceptance of an order for each substation, the Contractor then submitted a full package of station electrical designs for approval to the consultant.
- Ordering of Plant and materials with various suppliers and ensuring that the programme of deliveries was met.
- Liaising with the civil contractor and verifying transformer plinths and switchgear support steelwork were within tolerances.
- On completion of the civil works, taking control of the substation site, setting up the site services and adhering with H&S requirements.
- Coordinating the subcontractors for the mechanical & electrical services and installing and testing the security, ventilation, heating, fire detection and protection, watermist, earthing and lighting systems.
- Managing the offloading, installation and erecting of all electrical plant, in this case the 110 kV GIS switchgear, the 10 kV metalclad switchgear, 20 MVA transformers, Control and protection cabinets, LVAC, DC, Batteries and chargers
- Managing the project progress in relation to the project programme and submitting engineering certificates at agreed stages along with claims if necessary.
- Answerable to both the Client and Consultant on all aspects of the project through a single point of contact who had full knowledge about all projects and the progress of each.
- Coordinating the precommissioning and commissioning staff and ensuring that all obstacles and difficulties encountered were dealt with swiftly and efficiently to provide a fully functioning and “ready to energise” station.

Fig 2 and Fig 3 below show a plan drawing and a photograph of one of the substations completed as part of this contract.

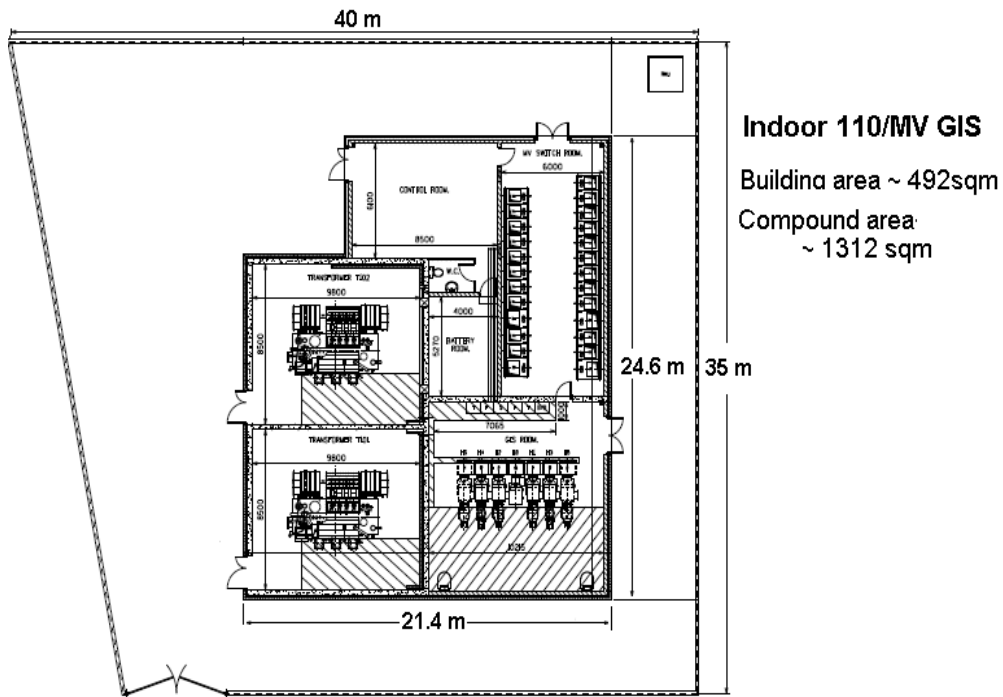


Fig 2. Typical 110kV/MV GIS substation – Original Design Plan



Fig 3. Typical 110kV/MV GIS Substation – After Completion

4 BENEFITS

The immediate benefits of deciding to go turnkey on this project were that a reputable Contractor with experience in this field took control of the day to day running of the project and ensured that resources to carry out this work were readily available.

The electrical Contractor took responsibility for the coordination of sub-Contractors, materials, lead times etc. This allowed early reservation of production slots for long lead items i.e. GIS and Transformers. One very relevant benefit that was found when comparing this project to non-turnkey projects was that improved lead times on material delivery were obtained as the Contractor was ordering equipment from the parent company.

An added benefit for a Client in this type of contract is that the Contractor is a single point of contact that is accountable for quality, performance, workmanship, defects etc. This should allow the Client easier control over the project. To achieve maximum benefits all of the substations should have been identical. However as this project to date has a project duration of more than seven years, external influences and network changes have impacted on this ideal.

Also beneficial to the Client should be the fact that the project management role is principally assumed by the Contractor. However it was found that this could not be assumed so project management was closely monitored by both the Client and Consultant.

An undeniable benefit is the speed of implementation when a contract is awarded to a turnkey contractor. When a utility is responsible for delivering a project, it is one of many other projects that are ongoing but when an external Contractor is appointed, this Contractor is eager to ensure that the project progresses steadily because the project costs only allow a certain period of time and, in theory, the quicker the project is completed the higher the profit. Also in most cases, the Contractor is eager to impress the Client in order to be favoured for future contracts.

The size of this particular project allowed for economies of scale. As the substations were constructed and energised, the experience of all parties involved increased. Civil and electrical reviews were carried out on completion of each substation. This allowed improvements in design and in some cases, programme when planning the next substation.

Standardisation of solution was a key benefit, especially for this contract, where multiple projects were ongoing over a period of time. By standardising station designs, switchgear and protection designs, the Client, Consultant and Contractor were fully aware of the functionality and capability of the stations and this in turn reduced design time, design approval time, installation and commissioning time and also allowed the system planners to adopt a "one size fits all" approach when dealing with applications from developers and planning future network strategy.

5 DISADVANTAGES

Along with benefits to all types of projects, there are inevitably going to be disadvantages and turnkey projects are no exception.

In this case, the single biggest disadvantage of the decision to go turnkey was cost. It has been proven in the past that it is considerably more expensive to utilise a turnkey solution on medium to large scale projects. For this project the Client has estimated that almost half a million euros per station was the increased cost for choosing to go turnkey. Contractor evaluation & selection needs to be a thorough process which can be expensive to implement and may not be carried out in sufficient detail to avoid subsequent claims.

Another disadvantage which was recognised a number of times during this project was that the Contractor will design and build the installation to the Client's specification. The Client must have a clear view of how much design discretion will be allowed to the Contractor. This may range from using a basic functional specification and accepting whatever technically compliant approach the Contractor provides and accepting an impact on operational staff. The alternative is to be quite prescriptive in various areas e.g. protection scheme design in the interests of overall standardisation on the network which is the approach ESB followed.

To be cost effective and avoid large claims and variations the technical specifications and Client requirements need to be specific and detailed. As ESB was defining the protection schemes this meant that appropriate drawings had to be available which defined ESB's requirements fully but avoided overspecifying in areas where ESB had no mandatory requirements. This also means that the risk of ensuring the specification is complete is the responsibility of the Client/Consultant. If the specification changes over the duration of the contract, then variations and claims will be submitted by the contractor unless this is accounted for in the contract.

Sometimes the reasoning behind a particular protection function/scheme can be misinterpreted or the depth of understanding of this scheme may vary between the Client/Consultant and Contractor. Care is required in the area of design review where the Client or Consultant may assume a greater degree of understanding than actually exists, even in the case of repeated designs. It is essential that overall design responsibility remain with the Contractor for the turnkey concept to work.

Split turnkey between the civil and electrical elements as in this example results in the responsibility for design compatibility between the two elements of the project returning to the Client/Consultant thereby losing some of the benefits of a full turnkey approach.

The turnkey contract may place the responsibility of meeting the tight schedules required upon the Contractor but Client-related dependencies (i.e. relay settings/ configurations/SCC links etc) and other risks assumed need to be managed strictly to avoid consequential delays to the main Contractor and in turn further claims for delays. To avoid this, the Client must ensure that all information is readily available and this may need to be flagged well in advance.

Another area which may cause delays is in the case of interface work in existing substations where the Client accepts responsibility for provision of material to match existing schemes. It is better for the Client to avoid this situation as far as possible. The respective responsibilities in this area must be clearly defined in the project Scope of work.

As the Client will be the end user, sometimes it is impossible for the Client to avoid interfacing with other parties e.g. in many cases the responsibility of dealing with local and government authorities still lies with the Client.

Duplication of supervision, support & management should be considered in the overall project cost. Turnkey implies full project management by the Contractor but this is not always the case and in the case of this contract, both the Client and Consultant along with the Contractor frequently attended the progress meetings.

In general, turnkey contract is used as a term but the contract may not be implemented as a 'pure' turnkey. The benefits of the use of nominated sub-contractors, suppliers and methods should be considered as trade offs against the benefits of a pure turnkey arrangement.

6 CONCLUSION

In the case of the Dublin GIS turnkey substations project, the decision to go turnkey was necessary because of a lack of internal resources to realise the project in the required timeframe. The objective was successfully achieved. However this success was achieved at a cost in that financial costs were considerably higher than if the design and management of this project was executed by an in-house service.

There were a number of important lessons learned and this project helped to shape the way projects of this nature will be run in future.

Due to the impact of the customised civil design required in a number of the substations on the cost of the project, the connection policy was modified to minimise the cost to ESB of such customisation.

To alleviate the impact of changes to the control and protection designs a revision control policy was introduced to reduce the frequency of such changes. This allowed a number of blocks of identical stations to be built which resulted in reduced engineering and design approval costs.

As much of the mechanical and electrical work was carried out by sub-contractors it was found to be necessary to insist that the main contractor provide a full time project manager for each individual project who was located on site full-time. This appointment streamlined communications between the Consultant and the Contractor to deal with any issues which arose on site.

The importance of planning ahead and adhering strictly to the programme cannot be stressed enough. At various times during the construction, fitout and commissioning of these substations, specialists were required for short to medium periods for different tasks. These specialists needed to be booked well in advance and when the programme slipped it proved very difficult to secure the services of these specialists for the new dates. In addition to the commitments made to the Customers for supply from these substations, this factor emphasised the importance of planning ahead and constantly reviewing the programme with the turnkey contractor to ensure the potential obstacles were avoided.

Overall this project was successful and despite various scope changes, improvements in physical and electrical designs and many issues arising on both the civil and electrical stages within the last seven years, it was completed to budget.

Despite taking longer than the originally envisaged five years, all agreed commitments to Customers were met.

The use of a turnkey solution for a project of this scale can be recommended. As stated previously if budgets, scopes and programmes are planned in detail and executed efficiently then it can be a successful outcome for all parties involved.

A STATIC VAR COMPENSATOR TURNKEY PROJECT IN FRANCE

1 BACKGROUND

In 2002-2003, system studies by the French TSO Réseau de Transport d'Electricité (RTE) revealed severe voltage drops could potentially occur in the Brittany area by 2006-2007. Located in the western side of France, the region is an electrical peninsula with few generating plants ; its rising power demand is currently supplied by remote plants through long and heavily loaded EHV lines (400 & 225 kV).

The prospects of severe voltage constraints led to a decision, in 2003, to install two Static Var Compensators (SVC) in Poteau Rouge and Plaine Haute substations in Brittany. The project was completed in 2005, under a turnkey contract. Technical aspects of the project, including a more in-depth account of the rationale for the initial decision, have been reported in the CIGRE 2008 session¹. This case study will focus on the choice and lessons learned from the turnkey approach for this project within RTE.

2 CONSIDERATION PROCESS

While the SVC solution was satisfactory from technical considerations, engineering teams within RTE had very limited experience with this particular technology. The SVCs in Poteau Rouge and Plaine Haute were the first two devices of this kind to be installed on the RTE network, and, as of 2003, no additional SVCs were to be built within the next few years. The isolated character of the project, together with a relatively tight schedule and the absence of prior experience led to the consideration of a turnkey approach.

Historically, due to its strong in-house expertise, RTE has had only limited recourse to the turnkey solution. For almost all projects, detailed site-specific technical specifications are provided to the service providers; project execution and on-site work are closely supervised by RTE engineers. For the SVC project discussed here, the choice to go turnkey was motivated not only by a relative lack of prior technical experience (which could be well overcome in an in-house approach) but also by the opportunity to experiment a larger use of the turnkey solution, and thus assess its prospects for wider use in subsequent projects to be commissioned by RTE.

3 PRACTICAL CASE

The project followed the sequence indicated in the brochure. Since the SVC devices were an extension to existing air insulated substations, specific difficulties with turnkey extension projects were also encountered in addition to more general aspects.

Among these difficulties:

- Striking the appropriate balance between detailed and functional specifications:

When designing an extension to an existing substation, it is essential to take into account the practices and safety procedures used by the Asset Owner personal for maintenance and operation. Indeed, the new components must be integrated into a system designed, maintained and operated according to specific rules and practices. The service provider must be given the appropriate information to take these constraints into consideration when designing the extension.

On the other hand, functional specifications are necessary to benefit from the service provider's experience and technological know-how. Flexibility in choosing equipment characteristics can lead to higher performance and cost reduction.

From RTE's experience on this project, a key point is to involve technicians and engineers familiar with the site-specific maintenance and operations procedure very early in the project specification stage and in exchanges with the service provider. Engineers in central design offices may miss some site-specific constraints at these early stages, with a risk of costly design adjustments later on or of obtaining a final non-optimal design.

For example, in this SVC project, the service provider chose to lay the transformers directly on a concrete slab according to its usual practices. All other transformers at RTE are supported by rails or concrete beams so as to avoid contact between the oil-filled tank and the concrete. This allows visual inspections of the base of the tank and prevents corrosion. Hence, with regards to widespread practices at RTE, this approach was not optimal ; the technical specifications written by the engineers for the turnkey project were not detailed enough to address this issue.

¹ "Operational performance of two static VAR compensators to support the voltage in Brittany", B4 202, presented in CIGRE Session 2008

- Defining the proper level of oversight at the design and project execution stage:
The project team assembled by the service provider teams may not be equally skilled on all aspects of the project; there are also numerous specific national rules and regulations about which an internal team may not be familiar.

Hence, it appears essential that the asset owner recognizes as early as possible any such difficulty and determines with the service provider the best course of action. The resources on the asset owner side must be geared to perform this form of oversight. This includes : timely feedback on the technical documents, especially on issues related to established practices and regulations, direct exchanges between experts and with personal in charge of operation and maintenance, close monitoring of the project schedule and compliance with expected deliverables, etc...

In the SVC project discussed here, environmental considerations led to the service provider to enclose the reactors in a building in Poteau Rouge and surround the components with soundproof walls. During the testing period in 2005, one of these walls in Plaine Haute caught fire. Investigations into the cause of this incident revealed a series of issues concerning the civil engineering design and the erection of the walls and building structure. In particular, standard practices to avoid magnetically induced currents in the structures and earthing network had not been followed in Poteau Rouge and Plaine Haute. These problems were not identified by the service provider; they could not be caught by the RTE teams either, which considered detailed oversight was not necessary in a turnkey project, especially since RTE had worked with the civil engineering subcontractor in the past.

From RTE's experience, it is not sufficient to require that the service provider works only with subcontractors qualified by the asset owner and familiar with its specifications.

Under the turnkey contract, the service provider was bound to modify the structures in order to resolve the issue. After unsuccessful and, in some cases, hazardous attempts from the service provider, RTE imposed a complete reconstruction of the building in Poteau Rouge under guidelines from a firm of architects approved by RTE.



The Static Var Compensator in Poteau Rouge before (left) and after (right) reconstruction

- Ensuring sufficient transfer of knowledge for later maintenance activities by the asset owner :
Training sessions for the asset owner maintenance teams were to be conducted by the service provider under the turnkey contract. Both these sessions and the operational documents supplied at the end of the project proved insufficient to ensure a good transfer of knowledge. The engineers in the central design offices were not able to provide the same level of support as in in-house projects since they had not followed the design process of the service provider very closely and were not familiar with the technology in the first place.
Such a situation creates a certain form of reliance on the service provider for maintenance activities. A closer oversight from the asset owner engineering teams can allow a better transfer of knowledge. The writing of the operational documents must also be monitored closely.

4 BENEFITS

From a technical point of view, the overall performance of the two SVCs built under this turnkey contract is quite satisfactory. The devices meet their technical specifications and their availability is high. The overall conclusion is that the performance of the service provider in its core competency area was good.

The project was initially completed on schedule (although the incidents mentioned above during the probation period delayed the final acceptance).

5 DISADVANTAGES

On the other hand, the difficulties discussed above show some drawbacks of the turnkey approach:

- Close oversight from the asset owner appears necessary during the project execution stage, to offset any potential deficiencies of the service provider outside its main area of expertise. Such problems may be hard to detect in the tendering process.
- Service providers may have difficulties in capturing site- or country-specific operation and maintenance procedures, which leads to a less than optimal technical solution. A good transfer of experience from the asset owner to the service provider is required, and good communication channels must be established very early in the project, which may prove hard under pressure of contractual deadlines and commitments.
- The proper balance between detailed and functional specifications can be difficult to find.

6 CONCLUSION

RTE engaged in the SVC project above with high expectations concerning the turnkey approach. While the overall project execution proved satisfactory, some difficulties were encountered and led to a mixed experience.

This project showed that the turnkey solution can indeed spare in-house resources, but not as much as was initially expected. In order to ensure a satisfactory outcome for the project, technical specifications must be written with care, the project design and execution must be monitored closely, and specific steps must be taken to ensure sufficient transfer of knowledge for subsequent maintenance and operation of the components.

MONTHLY REPORT FOR LARGE FULL TURNKEY PROJECT

1 BACKGROUND

This study case is the background regarding necessary monthly reporting between contractor and utility in case of large contract full turnkey (some 100's millions of €, and tens of substation are concerned in this study case). The aim is to covers all points, in a synthetic document & meeting in order to ensure a good follow up, risk management of the project communicate and take decision.

2 CONSIDERATION PROCESS

The monthly progress report is a meeting, with a dedicated template, having the same form along the contract for better understanding and follow up. The paper support is updated every month by the contractor and structured as follow:

- An EXECUTIVE SUMMARY, with highlights of main activities of the month, of next month and decision on major issues,
- The project control figures in order of have an overview of the activity progress, regarding Engineering, Procurement, transportation, civil works, EM (Electro Mechanic) installation and commissioning,
- A particular focus is made on design and detailed engineering, on document transmission, approval and comments, on procurement, on construction, commissioning, planning, quality assurance, quality control,
- Safety aspects,
- Cost control, including invoice details, variations register, bank guarantees,

3 PRACTICAL CASE

This is the actual process for reporting between Utility and Contractor

A. EXECUTIVE SUMMARY

A.1. HIGHLIGHTS

A.1.1. MAIN ACTIVITIES OF THE MONTH

1. Design

- Review of layouts & single line diagram of substations with Customer & Consultant Engineers,
- Technical review meeting for drawing approval, mainly fast track approval requirement,
- Submission of Equipment document for approval, or for information,

2. Civil Works

- All civil works subcontractors for all packages have been assigned,
- Three out of the four subcontractors are approved by utility, last remaining one awaiting for approval by utility,
- Subcontractor for civil works detailed design has been submitted for utility approval for all packages,,
- Site topographical surveys have been carried out and reports have been submitted to Utility for approval,
- Soil investigation points are submitted,

3. Execution Program

- Master Time Schedule consolidated for all substations,
- Progress report finalized for 400/220kV substations,
- Presentation of Execution Program to & consultant Engineers,

A.1.2. NEXT MONTH ACTIVITIES

1. Design:

- Remote Station Technical surveys,
- General Layout of remaining Substation,
- Technical review meeting of the substation control system with Utility & Consultant,
- New revision of Single line diagram,
- Interlocking Principles,

SECTION OF WORK	Weight	Accomplishment in %								
		Previous period			This period			To date		
		Planned	Actual	Variance	Planned	Actual	Variance	Planned	Actual	Variance

XX

X

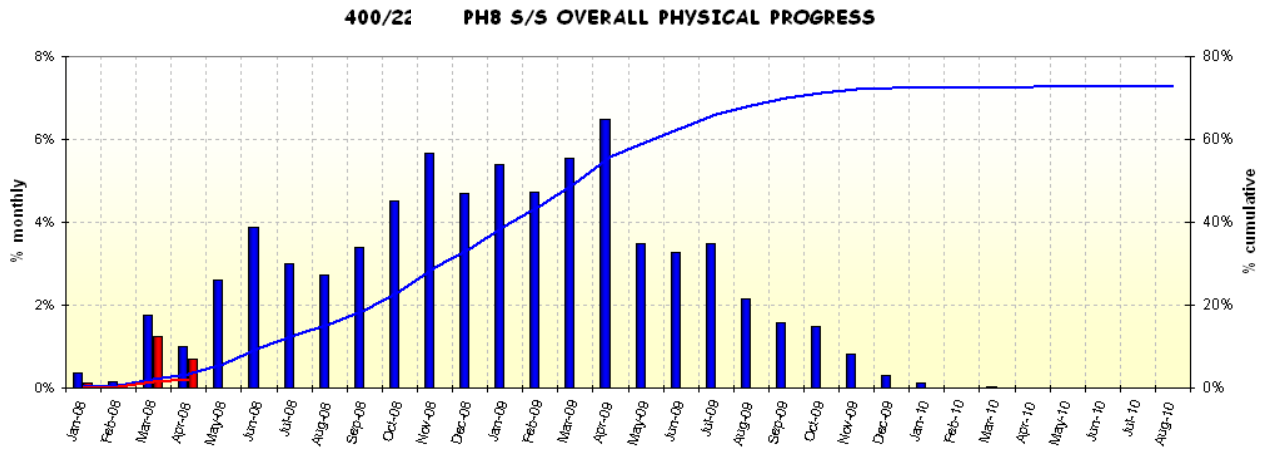
Substation B

SECTION OF WORK	Weight	Accomplishment in %								
		Previous period			This period			To date		
		Planned	Actual	Variance	Planned	Actual	Variance	Planned	Actual	Variance

XX

X

Level 1: Overall S-Curve



Level 2: Activity Status & Curves

Engineering Status Progress Table & S-Curve

For Each substation, progress is analysed

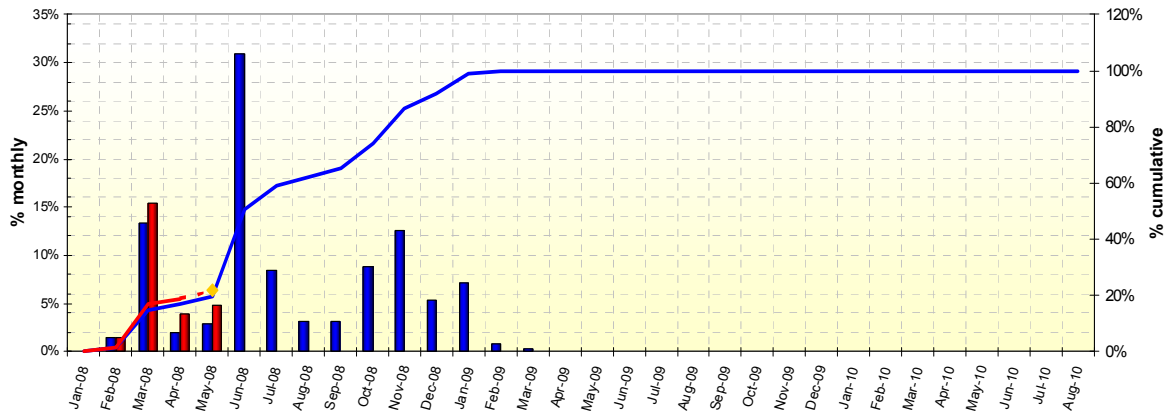
**System Engineering
Progress Report**

Reporting Period: May-08

SUBSTATION	ACTIVITY	Weight	Accomplishment in %								
			Previous period			This period			To date		
			Planned	Actual	Variance	Planned	Actual	Variance	Planned	Actual	Variance
Contract name	Overall progress	100,0%	16,1%	17,5%	1,5%	20,4%	24,3%	3,9%	41,2%	41,1%	0,0%
substation A	TOTAL ENGINEERING	25,6%	19,1%	19,0%	-0,1%	21,8%	23,7%	1,9%	41,0%	40,0%	-0,9%
	- LV Engineering	8,5%	14,8%	15,0%	0,2%	15,2%	19,0%	3,8%	30,0%	34,0%	4,0%
	- HV Engineering	17,2%	21,3%	21,0%	-0,3%	25,1%	26,0%	0,9%	46,3%	43,0%	-3,3%
substation B	TOTAL ENGINEERING	22,0%	19,2%	19,4%	0,2%	22,1%	24,0%	2,0%	41,2%	43,4%	2,2%
	- LV Engineering	7,2%	14,8%	16,0%	1,2%	16,0%	18,0%	2,0%	30,8%	34,0%	3,2%
	- HV Engineering	14,7%	21,3%	21,0%	-0,3%	25,1%	27,0%	1,9%	46,3%	48,0%	1,7%
substation C	TOTAL ENGINEERING	52,4%	13,3%	16,0%	2,8%	19,0%	24,7%	5,7%	41,2%	40,7%	-0,5%
	- LV Engineering	17,3%	14,8%	12,0%	-2,8%	16,0%	20,0%	4,0%	30,8%	32,0%	1,2%
	- HV Engineering	35,1%	12,5%	18,0%	5,5%	20,5%	27,0%	6,5%	46,3%	45,0%	-1,3%

Engineering shown in below table includes System Engineering only. Products and SUBSTATION CONTROL SYSTEM engineering activities are included in Procurement activities as defined through the present WBS (Work Breakdown Structure).

400/220KV S/S SYSTEM ENGINEERING PHYSICAL PROGRESS FOR xxx



	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	
PLANNED																																	
Monthly	0%	1%	15%	2%	3%	31%	8%	3%	3%	9%	13%	5%	7%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
Cumul	0%	1%	15%	17%	19%	22%	53%	56%	59%	68%	81%	86%	93%	94%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	
ACTUAL																																	
Monthly	0%	1%	15%	4%	5%																												
Cumul	0%	1%	17%	19%	22%																												

(Please note that this type of table and progress curve, could be used for all activities)

Procurement Status Progress Table & S-Curve

Procurement includes main equipments procurement considered as turnkey activities (from dedicated studies to Free On Board- FOB - delivery),

Transport Status Progress Table & S-Curve

Transport includes transportation of all equipments from Free On Board -FOB- to sites,

Civil Works Status Progress Table & S-Curve

Civil work includes total scope of the Civil work sub-contractors and is considered as turnkey activities (from dedicated studies to construction),

Electro mechanic Installation Status Progress Table & S-Curve

Installation activities shown in below table includes only Electro Mechanic installation,

Commissioning Status Progress Table & S-Curve

Commissioning activities includes commissioning of complete substation,

Comments on General Progress

To speed up the late finalization of Layouts approval, specific meetings with the Engineers and Utility were organized during the month,

To speed up approval of the GIS layouts, single line diagrams and digital control system architecture specific meeting was organised with GIS representatives this month, specific workshop to be settled for digital control system issues next month,

Design and Detailed Engineering

Correspondence and Data Transmission Sheet,

List of Correspondences issued by Utility,

No.	From	Subject	Letter ref.	Letter Date	Date Received	Reply to Contractor letter
1	XX	Provisional Letter of Award	xxxxxxxxxxxxxxxxxxxx	27/12/2007	27/12/2007	3135 TG 094
2	XX	Your Letter of Confirmation of Provisional Letter of Award PLOA	xxxxxxxxxxxxxxxxxxxx	01/01/2008	02/01/2008	GTC144-06/08/003
3	XX	Final Letter of Award (FLOA)	xxxxxxxxxxxxxxxxxxxx	13/01/2008	14/01/2008	

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3	XX	Final Letter of Award (FLOA)	xxxxxxxxxxxxxxxxxxxx	13/01/2008	14/01/2008	

Procurement / Manufacturing

Procurement for main items finalized.

Item	Description	Expected order date	Actual order date
9	Transformer 800MVA from XXX T&D ATT unit (Turkey)	5/3/2008	5/3/2008
8	Transformer 315MVA from XXX T&D ATT unit (Turkey)	5/3/2008	5/3/2008
11	Transformer 200MVA from XXX T&D TCT unit (Brazil)	5/3/2008	5/3/2008
10	Transformer 160MVA from XXX T&D TCT unit (Brazil)	5/3/2008	5/3/2008
7	Transformer 60MVA from XXX T&D ATT unit (Turkey)	5/3/2008	5/3/2008
6	Transformer 40MVA from XXX T&D ATT unit (Turkey)	5/3/2008	5/3/2008
12,13,14,15	Shunt Reactors from XXX T&D TCT unit (Brazil)	5/3/2008	5/3/2008
5	11kv Switchyard from XXXXX T&D unit	5/3/2008	5/3/2008
18	Telecom from XXX T&D AUTOMATION unit	5/3/2008	5/3/2008
16,17	CCS, DCS from XXX T&D AUTOMATION unit	5/3/2008	5/3/2008

Factory Acceptance Tests (FAT), proposed agenda

Item	Description	Original proposed date	Duration	Location	Site
6	40MVA 66/11kV transformer	6-jan.-08	3d	Turkey	
17	Digital Control System	22 oct 08	3d	Dubai	
11	200MVA 220/66kV transformer	11-nov.-08	3d	Turkey	
10	160MVA 132/66kV transformer	9-decc.-08	3d	Brazil	
15	66 kV 30MVAR Reactor	5-jan-09	3d	Brazil	
21	Earthing transformers	15 jan-09	3d	Turkey	
9	800MVA 440/220kV transformer	2-febr.-09	3d	Turkey	
7	60MVA 132/11kV transformer	16-march-09	3d	Turkey	
8	315MVA 220/132kV transformer	16-march-09	3d	Turkey	
13	400 kV 60MVAR Reactor	10-apr-09	3d	Brazil	
12	400 kV 150MVAR Reactor	21-apr-09	3d	Brazil	
14	220 kV 60MVAR Reactor	4-may-09	3d	Brazil	

Construction, Pre-commissioning & Commissioning

Planning

Safety Aspects

Site safety and security Program as well as Fire prevention and protection program have been transmitted for approval.

Costs Control

Invoice details

Invoice N°	Amount	Currency	Invoice date	Payments Due date	Payments Received date

Variations register

Bank Guarantees

Advance Payment Guarantee

Currency	
N°	
Amount	
Issued date	
Validity date	

Performance Bond

Package	
Currency	
N°	
Amount	
Issued date	
Validity date	

Contractual Matters

Variation Orders

Received :	Currency 1	Currency 2
N°1		

Taking Over Certificates

To be filled at a later stage.

Contract Substation Name And Other Substation(s)	Certificate N°	Access to substation	Commissioning Date

Contract Substation Name And Other Substation(s)	Certificate N°	Access to substation	Commissioning Date

MONTHLY PROJECT SAFETY REPORT

S.N°	DESCRIPTION	Contractor 1	Contractor 2	Contractor 3	Total
1).	a) Total Office employees-Daily average				
	b) Total site employees – Daily average				
2).	Total First Aid Cases – (F.A.C)				
3)	Total Reportable Accidents – (R.A)				
4)	Total Dangerous Occurrences – (D.O)				
5).	Total No. Of Lost Time Accidents –(L.T.A)				
6).	Total Hours Lost – Reportable Accidents only)				
7).	Total Man-hours worked (Sub-Contractors)				
8).	Total Tool – Box meetings (Workforce)				
9).	Total Weekly Safety Meetings (T/Foreman)				
10).	Total Weekly Safety Meetings (Staff)				

4 BENEFITS

The main benefit is to have clear 360° and periodic status for all point dealing with the project, It is possible to compare on a periodic basis, design progress, site activity, finance, safety, The aim is to ensure the expected project progress, promoting the communication and decision tools, This type of periodic report using in this case for turnkey management could be used to improve internal reporting in case of in-house contract management, For this type of very large contract using turnkey mode is, the most of times the more accurate method, due to the unusual, important, resource mobilisation to manage this unusual, important load,

5 DISADVANTAGES

This type of contract follow up report could be the main communication axis, but not the only communication tool between the partners, Detailed discussion regarding all necessary point should be done separately, with all concerned people for Utility and contractor, Even if the proposed report is exhaustive, vicinity of teams should ensure that regular technical meetings take place and that they include all contract partners.

6 CONCLUSION

The proposed reporting between utility and contractor is a main management tool for necessary communication, reporting and decision process for very large full turnkey contract. Company management can take advantage of this document to have a synthetic view of the project, to observe the contract progress, the remaining activities and the main risk.

In house project management process could also partially take advantage of this proposed reporting.

Direct positive relationship between partners will be supported by the proposed exhaustive project report.

TURNKEY REPLACEMENT OF 4-500kV GIS BAYS AT A BC TRANSMISSION GENERATING STATION SWITCHYARD

1 BACKGROUND

The Mica Generating Station is located on the Columbia River system in British Columbia (Canada) and has a capacity of 1800 MW. It is situated in a remote location and is not normally manned. Contractors and BC Hydro (Generating utility) crews who perform work in the plant are transported weekly to and from the plant from Revelstoke, approximately 150 km South from Mica. The Mica town-site provides temporary accommodation for the crews during their four day work week. The adjacent 500 kV switchyard is the terminal station for Mica Generating Station and is maintained by BC Transmission Corporation (BCTC).

The 500 kV Gas Insulated Switchgear (GIS), commissioned in 1977, is used to connect the output of the generators to the 500 kV transmission system. This was the first GIS system installed on the BC Hydro transmission network. Since then, numerous technological advances have been made to GIS systems resulting in improved performance, extended life expectancy, and reduction of SF₆ leakage. One new technology that was adopted for this project is the addition of high energy absorbing surge arresters and “point on wave controllers” which control the circuit breaker closing operation, replacing the maintenance-intensive closing resistors.

The Mica 4-500 kV Double-pressure circuit breakers and associated equipment experienced chronic SF₆ gas leaks. It recorded leaks of 695 kg of SF₆ in 2006. This replacement project was expected to eliminate the loss to the atmosphere of an equivalent of approximately 16 million kg of CO₂ annually.

The Mica GIS system had encountered numerous maintenance issues such as internal flashovers, failed disconnect switches and unreliable circuit breaker performance as well as difficulties to obtain obsolete parts and technical support from the OEM successor company. Bottled-up generation resulted in significant financial loss.

The Project was initiated to address the leakage and maintenance issues, and return the reliability of the switchgear to acceptable levels. The project involved the replacement of four 500 kV circuit breakers, 8 sets of disconnect and ground switches and associated gas insulated SF₆ bus.

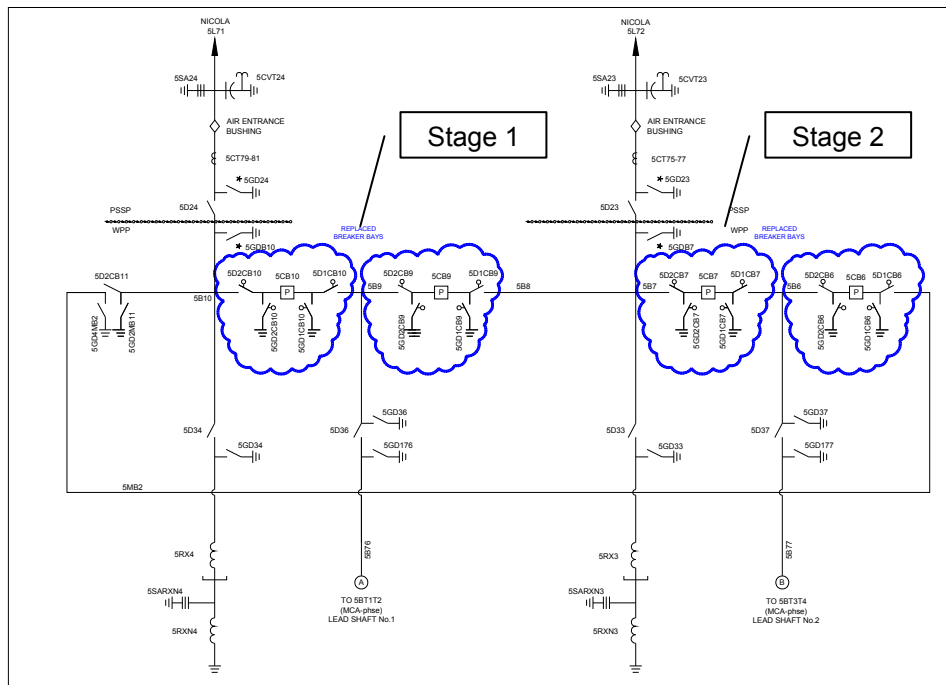


Figure 1: Mica 500 kV GIS Single Line Diagram

2 CONSIDERATION PROCESS

Due to Mica Generating Station Switchyard remote location and BCTC lack of internal Engineering and Construction resources, the decision to proceed with a turnkey contract was relatively straightforward. BCTC retained BC Hydro Engineering to produce the technical specification for the

replacement equipment, issue the Request for Tenders, evaluate the tenders and issue a recommendation for award.

The project was tendered as a 'supply and install' turnkey contract and was awarded to a GIS equipment manufacturer in November 2005 for a fixed price, on the basis of lowest tendered price for technically acceptable equipment. In turn, the GIS manufacturer provided some project management, but subcontracted installation of the equipment to a local contractor, retaining supervision of erection and commissioning of the equipment only.

In order to address the complexities of interfacing the new equipment to the existing station and Transmission System, in October 2005, prior to contract award, a scope change was approved by BCTC to assign additional project management including system integration on behalf of the utility and engineering services to BC Hydro Engineering. This increased the project cost by approximately 6%.

3 PRACTICAL CASE

The project was divided into two stages to be executed over two years to coordinate with generation requirements and outage restrictions. These restrict the construction season to narrow windows between mid-April and mid-August of each year.

Stage 1 was executed and completed in 2007, and Stage 2 in 2008. Each stage of the project involved the replacement of two breaker-bays (circuit breakers and the associated disconnect switches). The 2007 work was completed in October 2007, with some delay mostly due to late delivery by the GIS manufacturer of the equipment to site.

Stage 2 commenced in April 2008 and was completed by mid-August, 2008. Equipment for stage 2 was delivered from Europe to site on time before the scheduled outages in April 2008.

4 COST ESCALATION OF THE PROJECT

This project was approved at a planning level (accuracy +/-30%) in July 2005 for a fixed amount.

A cost estimate revision was approved in October 2005, increasing the authorized expenditure by 6% (accuracy +/-10%). This increase was required to cover project management and engineering services by BC Hydro.

In February 2007, a further cost increase of 7% over the original estimate was required to cover additional costs for contract and project management, mid line surge arrestor design and construction (which were not in the initial plan) and design issues with the "point on wave controller" (which was still under development by the GIS manufacturer).

The cost for project completion eventually came at 37.3% over the February 2007 estimate and 43% over the original July 2005 estimate. The reasons behind these over expenditures, and the actions taken with the contractor are described in Table 2 and below.

The project has experienced cost escalation due to the following factors:

- Insufficient accuracy in the initial project plan,
- Contractor non performance,
- Integration issues of new equipment with original equipment, and
- Inexperienced project management.

Further detail on each of the cost escalation factors is provided below, in percentage relative to the original estimate:

Table 2: Root Causes of the Cost Escalation and Associated Costs

Root Cause	Associated Details	Costs
Insufficient accuracy in the original project plan.	Underestimated BC Hydro Field Operations and Engineering costs in the project plan for commissioning, contract management, and project management	8.6%
Deficient performance by the supply and installation contractor in the areas of communication, design, quality and construction coordination. BCTC had to negotiate with the manufacturer to recover some of these costs.	1. The contractor did not recognize the significance of updating, producing and filing drawings.	3.8%
	2. The contractor did not supply an operating Point on Wave Controller for the circuit breakers	4.2%
	3. The contractor did not recognize the complexity of Mica site management	1.7%
Subtotal		9.7%
Integration of new equipment with original equipment.	Unexpected costs to manage contractor claims associated with a warped flange on interface with old equipment, drawings, and schedule delays and to carry out detailed project cost review by an outside consultant	3.8%
Inexperienced project management and lack of appropriate cost control processes for the BC Hydro project personnel.	Insufficient Project Management experience - i.e. failure to control BC Hydro resources for issues including surge arrestor installation and point on wave controller design and drawing management.	6.2%
	Poor estimating in the original Project plan – i.e. failed to recognize and estimate costs to obtain and commit BC Hydro field resources	6.6%
Subtotal		12.8%
Increased Interest and Overhead costs.	Resulting from overall project cost increase.	2.4%
Total	Cost	37.3%

Most difficulties listed above were experienced during the first phase of the project, and mitigation measures for the second phase were decided upon during the “Lessons Learned” meeting held after the completion of the first phase.

A project management specialist consultant was retained to complete a review of the project’s Stage 1 costs. In conjunction with Management, the consultant developed a risk matrix and mitigation plan for Stage 2.

A lessons-learned meeting was held with the primary contractor (the GIS manufacturer) and BC Hydro contract managers, BC Hydro project team leaders and the BCTC project team to identify key risk areas and develop the mitigation plan. Residual risks that were identified for Stage 2 and the proposed mitigation were identified as follows:

- *Schedule delay for Stage 2 construction start due to system operational constraints.*
Mitigation: Outage plans were submitted to BCTC Real Time Operations and coordinated with BC Hydro’s planned generation outages. Last minute delays could have increased risk of further cost escalation due to contractor delay claims. This was considered a moderate risk. A contingency funding was provided for this.
- *Schedule delay for Stage 2 due to delay in supply of equipment from the GIS manufacturer’s facility in Europe.*
Mitigation: Regular production schedule meetings were held with the manufacturer to monitor equipment production and delivery. Contract remedies to recover costs for vendor caused delays would mitigate the higher costs.
- *Technical issues associated with integration of the new point on wave controllers into the BC Hydro system could result in increased BC Hydro Engineering costs to*

resolve. Mitigation: The contract required the GIS provider to supply a functioning device to BC Hydro Engineering for evaluation and in advance of Stage 2 start. Additional costs for re-work associated with this installation would be recovered by contract remedies. If the GIS supplier failed to deliver a functional point on wave controller, BCTC would delay the installation until the supplier could develop their own controller.

- *BC Hydro personnel not available at optimal times to complete switching and commissioning activities resulting in increased costs for travel and overtime.*

Mitigation: Weekly activity planning with next week look ahead scheduling was identified from the Stage 1 lessons and was implemented on site during Stage 2. This was considered a moderate risk and a contingency funding was provided for this event.

- *Insufficient identification and quantification of the project costs and risks for Stage 2 could continue to present cost risk.*

Mitigation: The revised estimate for Stage 2 had the benefit of the lessons learned from Stage 1 and had undergone a more rigorous risk assessment. This was considered a low risk.

- *Deficient performance by the supply and installation contractor could persist in Stage 2 and present cost risk.*

Mitigation: The contractor fully participated in the lessons learned session and committed to putting in place improved processes for on site management and weekly reporting. The contractor was motivated by the desire to increase the volume of Turnkey EPC contracts in Canada. Contract remedies were available to recover costs and would have been vigorously pursued in Stage 2. This was considered a low risk.

- *Inadequate project management and cost controls for the BC Hydro resources employed on the project could continue to present cost risk.*

Mitigation: The BC Hydro Project Manager was replaced for Stage 2. The cost review of Stage 1 highlighted specific areas for closer scrutiny during Stage 2. Advance commitment for critical Protection & Control resources required during commissioning was arranged with BC Hydro Field Operations staff not directly involved in the Generation projects. There was no further transmission line work required in Stage 2. This was considered a low risk.

5 BENEFITS

BCTC is a Transmission System Operating and Asset Management company. As such, BCTC has no Construction or Engineering resources. Hence the need for BCTC to rely on such resources from third party providers. BCTC routinely retains BC Hydro Engineering to provide Engineering services for both new and retrofit projects. Similarly, the construction portion of the contracts is tendered, either separately from the major equipment supply, or – such as in Mica project case – as a turnkey contract with the equipment supplier.

The “other” model, i.e. engineering, installation and commissioning of the equipment by BCTC, was not an option in this case.

The Mica project was an early project undertaken by BCTC shortly after its set-up as a separate company from BC Hydro (in 2003). As such, it offered a learning experience, with lessons that were subsequently successfully applied to other, considerably larger projects. Within the Mica projects, by applying close scrutiny and mitigation as required, the second stage was fully successful, with no further delays in the in-service date, or additional costs.

6 DISADVANTAGES

Due to the fact that there was no other option open to BCTC, it is difficult to list any disadvantages that accrue from using the turnkey model. Such disadvantages may only be speculated in this case.

7 CONCLUSION

Overall, the project achieved the replacement of 4-500kV GIS bays, using modern circuit breakers in an operational major generating station at a remote location. The point-on-wave controllers and high energy absorbing surge arresters allow the switching of the circuit breakers without closing resistors which would be maintenance-intensive. The project was accomplished with minimal generation loss and overall at a very reasonable cost, even after the additional costs are factored in.

Since the completion of the Mica project, BCTC has continued to use the turnkey projects as a means to achieve its ambitious system refurbishment and expansion program.

The key to the successful completion of such difficult projects rests with close scrutiny and evaluation of options and suppliers before the turnkey contract is placed, tight contractual requirements and close supervision of the project during execution.

The list of items under the “lessons learned” chapter is a useful list of advice to follow in any turnkey project.



MICA GS Switchyard – Old Breakers



MICA GS New Switchyard

CONTRACTOR'S EXPERIENCE OF REFURBISHMENT TURNKEY PROJECT

1 BACKGROUND

In this case study, two projects with similar backgrounds are presented. Both of these projects arose due to equipment failures in the respective substations. Equipment failure, are unexpected events and as a result, urgent replacement was required to minimize the interruptions to the transmission network system. Hence both projects were executed on urgent basis. For clarity, these two projects will be referred to in this case study as Project A and Project B. A general outline of both projects is presented here.

Project A

- This project is related to a 275 kV substation in Asia where the project commenced urgently at the end of 1999 after the equipment failure. In the existing 275 kV substation, there were three generations of existing GIS and the failure was located in the 2nd generation of GIS.
- The 2nd generation of GIS was commissioned in 1979 and due to damage from the failure, urgent replacement was required. The existing substation building would be re-used including power cables and building facilities such as the overhead crane.
- New equipment for the project consisted of new 275 kV GIS, Protection and Control systems, a new Substation Computer System, low voltage AC/DC systems and a new Power Transformer,
- The project was implemented on a tender basis and executed on a fast-track program with the 1st diameter being energized in 5.5 months.
- The working conditions on the project included working in energized as well as de-energized areas of the substation,

Project B

- This project is related to a 345 kV substation in the Middle East where the project commenced urgently at the end-2005 after an incident destroyed the existing GIS in the substation which was commissioned in 1982.
- Due to the extensive damage, urgent replacement was needed and parts of the existing substation building had to be re-built. The existing substation building mainframe was re-used, however the basement columns and the ground floor slab had to be re-built.
- Due to the urgency of the project, it was not possible to manufacture all the new GIS in time; hence some spare GIS bays were re-located from other existing substations. In addition, new equipment for the project consisted of a new 345 kV GIS and new power cables. Existing Protection and Control systems and the low voltage AC/DC systems were re-used.
- The project was implemented on a negotiation basis and executed on a fast-track program with the substation energized in 6.5 months.
- The working conditions of the project included working in energized as well as de-energized areas of the substation ,

2 CONSIDERATION OF THE PROCESS

The failures created extensive damage to the primary equipment, causing severe implications to the transmission networks. In the case of Project A, the 275 kV substation was located in a power generating plant, hence its importance as a node in the entire transmission network. As for Project B, the 345 kV substation is a major system substation for the transmission network and it was crucial to re-commission the substation before the summer season as loads tend to peak during the summer in the Middle East. In light of this, it was necessary to rectify the damage and re-commission the substations as soon as possible.

In the selection of the project execution method, several key factors were considered:

- Track-record of the solution provider,
- Manufacturing duration of the new GIS,
- Time schedule for re-commissioning of substation,
- Engineering information of existing equipment,
- Duration of engineering and design activities,
- Integration with existing equipment / systems,
- Total cost of refurbishment,
- Total project delivery time,

Based on the premise of short delivery, it soon became clear that a turnkey approach would be the best solution as this would minimize the total project delivery time. In a normal project execution

process, the Customer could have executed the project in the following sequence:

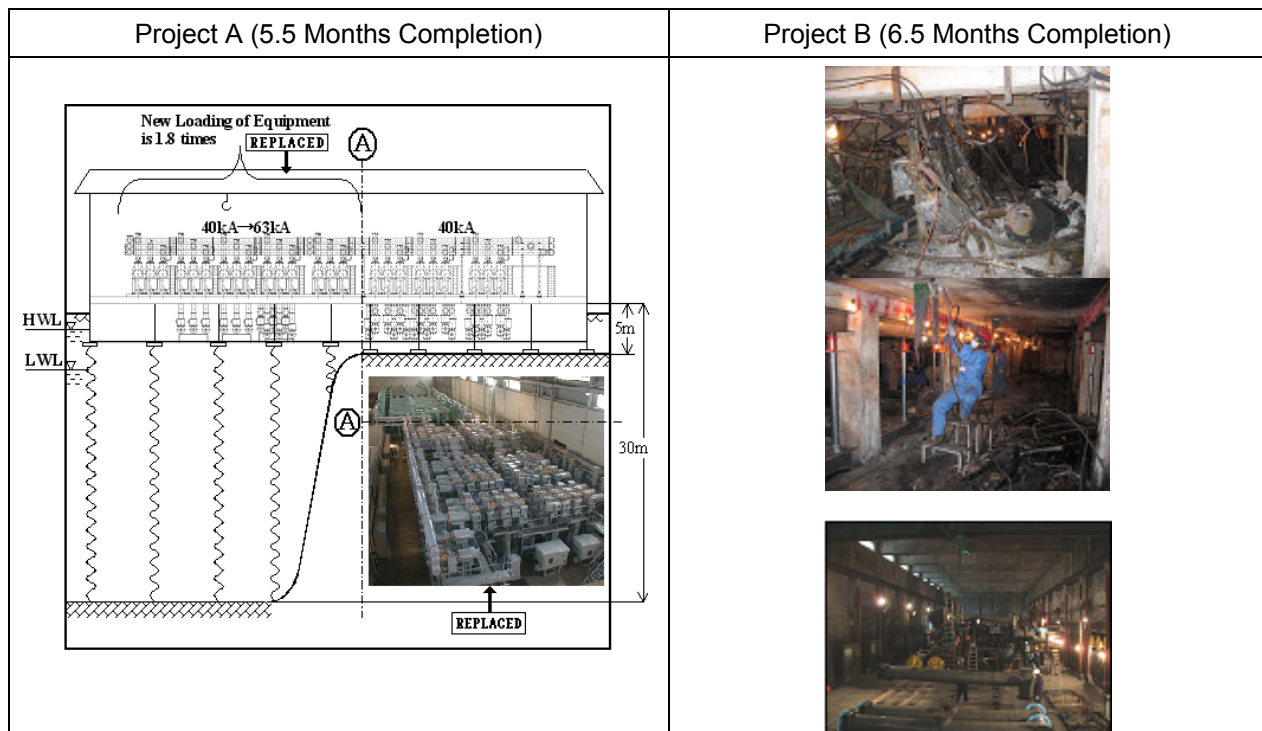
- In-house engineering or outsource to consultant,
- Upon completion of engineering, prepare specifications, Bill of Material and tender documents,
- Call for tender,
- Evaluate tender,
- Award contract,
- Review and approve equipment design and manufacturing,
- Site delivery,
- Site installation,
- Site testing and commissioning,

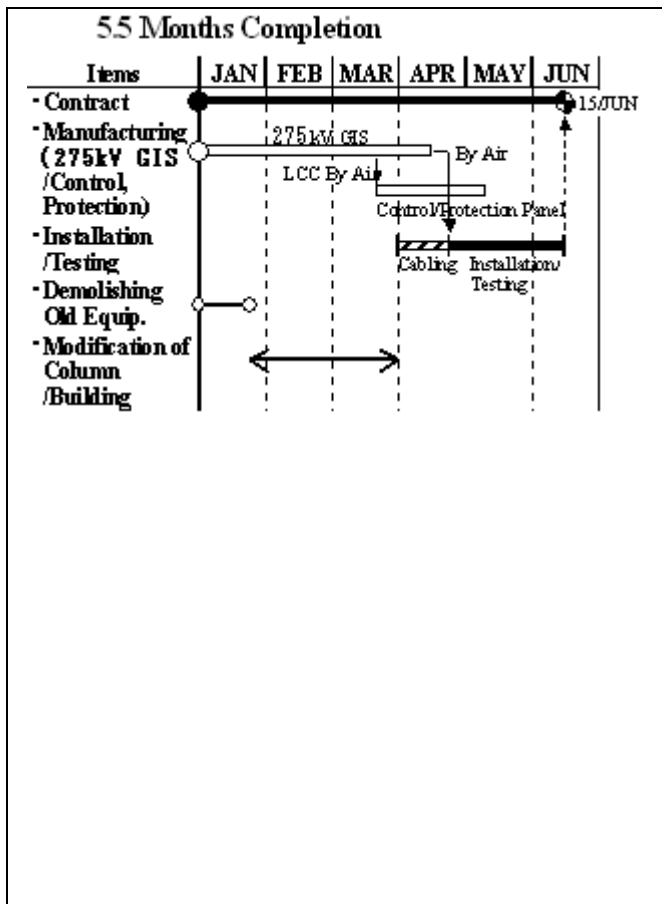
This general sequence would have resulted in a minimum project delivery time of 12-15 months which was totally unacceptable in these emergency conditions. Due to the urgency, the Customer decided that the turnkey model with equipment from the OEM (Original Equipment Manufacturer) was the most feasible method to restore the affected substation into the transmission network at the earliest possible time.

By adopting a turnkey approach, initial engineering was no longer necessary as this work would be done by the solution provider in tandem with the OEM design and manufacturing. Depending on the format of the turnkey contract, the time for preparation of tender documents could also be reduced as detail specifications would not be necessary. It was clear that the turnkey model would be best suited for the urgent refurbishment work. Since the refurbishment work would be best accomplished by the original OEM or solution provider of the existing system, the Customer could also consider the option of a negotiated contract instead of open tendering.

For project A the OEM / solution provider for the damaged GIS was not available; hence the Customer decided to implement the project on a tender basis by preparing general specifications tailored for refurbishment work. For project B as the original OEM / solution provider for the damaged GIS was available, the Customer decided to implement the project on a negotiated basis directly with the OEM / solution provider. Such contracts are normally more expensive than other types of contracts, but the situation was such that urgency of putting the substation back in service outweigh the cost issue.

3 PRACTICAL CASE





Most Helpful Support from Customer

- Customer assisted to provide the details of busbar coupling for the 1st generation GIS which is more than 25 years old by obtaining the necessary information and design data from the OEM. This information was essential to develop the coupling for the interconnection between the busbars of new and old GIS.
Customer provided interface information of existing substation auxiliary systems and main control systems. This helped to minimize the time for site investigation during the emergency refurbishment work.

Most Helpful Support from Customer

- Customer assisted to expedite the removal of spare GIS bays from other existing substations.
- Customer assisted and coordinated the application for obtaining construction permits and related licenses from government authorities such as Fire Brigade department and other government Ministries.

Technology Specially Used

- As the up-rated and new GIS was substantially heavier than the old GIS, special equipment was used to monitor the structural deflection of the floor slab and beams
- The new GIS needed to be interconnected with 1st generation GIS of another OEM, hence special design was made for the interconnection of coupling between the busbars of the different GIS type

Technology Specially Used

- Temporary support was provided in the basement of the damaged substation building for safety to prevent collapse of the GIS floor
- Due to the substantial damage to the substation building, expert assessment of and conditional survey of the substation building was done to determine the integrity of the damaged substation building.
- Special tests such as ultrasonic pulse velocity were conducted to analyse the cracks in the structural beams, columns and slab of the building.
The structural design for re-construction of the column and floor slab included special

	consideration for the margin of reduced concrete strength in the existing building.
<u>Lessons Learned</u> <ul style="list-style-type: none"> Accurate, clear and updated records and drawings of existing substation systems is vital. Without this accurate information, numerous problems would arise during the project execution. 	<u>Lessons Learned</u> <p>The most difficult point was the re-location of spare GIS bays from other substations as this involved the dismantling of spare GIS bays in a live substation</p>

4 BENEFITS

Project A	Project B
<ul style="list-style-type: none"> By using a turnkey project model, the refurbishment could be completed successfully within a very short period of time. Otherwise, this would not have been possible. Quick completion means that the substation could be introduced back into the transmission network earlier. At the same, this provided economical benefit to the Customer as they could fully utilise their generation capacity again for injecting power into the transmission network. 	<ul style="list-style-type: none"> By using a turnkey project model, the refurbishment could be completed successfully within a very short period of time. Otherwise, this would not have been possible. Early completion before summer season means that potential supply problems in the transmission network were averted.

5 DISADVANTAGES

Project A	Project B
<ul style="list-style-type: none"> Information of existing systems (of more than 20 years old) was not fully available. This created numerous problems for the interfacing between old and new GIS and related systems <p>Without the time for detail engineering, especially for the interface with existing systems, it was necessary to conduct ad-hoc design and engineering on site whenever problems were encountered during site installation and testing. Due to the rush work, this occasionally resulted in confusion due to the mismatch of engineering design and site work</p>	<ul style="list-style-type: none"> Information of existing systems (of more than 20 years old) was not fully available. This created numerous problems for the interfacing between old and new GIS and related systems

6 CONCLUSION

Based on the experience of the above two projects and considering all aspects, it is clear that the turnkey project model was the best solution for the emergency refurbishment work. Without adopting the turnkey project model, it would have been impossible to achieve energization of the substations in Project A and B within 5.5 months and 6.5 months respectively.

Although some disadvantages occurred due to the lack of detailed engineering, the benefits of adopting the turnkey project model far outweighed these disadvantages.

Without the strong support from the Customer, it would not have been possible to execute these refurbishment projects successfully. Considering the general flow of turnkey project execution, there are three key components as shown in Fig.10.1 (See Chapter 10.1):

- Contract Execution
- Application of Permit to Work / License
- Basic Design

As already presented under “Most Helpful Support from Customer”, in the area of Contract Execution and Application of Permit to Work / License, these required strong and committed teamwork and cooperation between Customer and OEM / solution provider, due to the necessity of coordinating overall fast-track schedule, shutdown schedules and working in live condition. Substantial amounts of time are normally needed for the application and approval from various authorities of the necessary permits and licenses; which were expedited by the support from Customer. The Basic Design process could be shortened with the availability of accurate and updated data and information from Customer as this reduced the time and tedious process of site survey to re-confirm the condition of existing systems for the interface between the old and the new equipment.

The above points required the dedicated cooperation and support from the Customers which are vital and important ingredients to the success of the refurbishment projects.

JOAIRAM: A NEW METROPOLITAN SUBSTATION IN THE BRAZILIAN NORTHEAST TRANSMISSION SYSTEM.

1 BACKGROUND

The South Region of the metropolitan city of Recife, in the State of Pernambuco, Northeast of Brazil, is supplied by the 69 kV distribution system of the Regional Distribution Company CELPE. This 69 kV System is fed by the Bongi and Pirapama Substations of CHESF (Transmission Company of the Brazilian Northeast). The Pirapama and Bongi substations are supplied by the Recife II 500/230 kV substation.

The necessity for reinforcement in the supply of this region has been detected and mapped for a long time. Both the distribution and transmission companies have studied the issue and made this recommendation. However, regardless of the recommendation, there were many constraints such as lack of available land, environmental restrictions and unclear regulatory responsibilities that resulted in construction and operational delays in implementation.

The recommendation stated that the best reinforcement was construction of the new Joairam substation, with two new 230/69 kV transformers of 150 MVA each, sectioning the three 230 kV Bongi – Recife Transmission Line circuits, as can be seen below, in Figure 1.

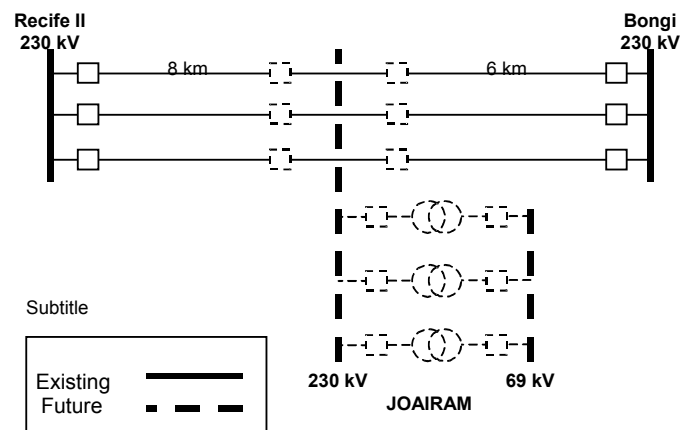


Figure 1 – Joairam Substation Diagram

2 CONSIDERATION PROCESS

This conventional, outdoor substation was planned to have in its first stage two transformers of 150 MVA, totalling 300 MVA, and another transformer in 2010. This concession was given to the CHESF Transmission Company by the Brazilian Regulatory Agency.

The Joairam Substation comprised the following:

- ✓ (6) Transmission line bays: Bongi C1, C2, C3 and Recife II C1, C2 and C3.
- ✓ (1) 230 kV interconnection bays.
- ✓ (2) 230 kV transformer bays
- ✓ (2) 230/69 kV, 150MVA transformers,
- ✓ (1) 69 kV interconnection bay.
- ✓ (2) 69 kV transformer connection bays
- ✓ (1) Grounding reactor bay.
- ✓ (1) 69/13.8 kV, 1 MVA auxiliary transformer bay

As the Regulatory Agency spent an extended amount of time to give the concession to the Transmission Company, this company had to construct the substation in a shorter period of time to service all the loads connected to this new substation. To construct the substation on time the decision was to proceed by way of a turnkey project.

3 PRACTICAL CASE

During the study phase of the basic project by the Asset Owner various particularities were identified which usually arise with an open installation of this magnitude that is situated in the suburbs surrounded by residential homes and near an industrial complex. The basic fire protection system using the installation of a nebulizer water system for the power transformers was considered as an additional safety measure, as already used in another CHESF installation.

The project budget included the project services, construction, equipment assembly and installation, testing, commissioning, assisted operation, training as well as supply of materials, equipment, spare parts, special tools, and the associated indirect costs. CHESF received six technically acceptable proposals, from which the lowest bid was chosen. The leader of the consortium was a well known manufacturer of high voltage equipment who had previously also supplied power transformers on another contract.

After the release of the contract, activities were delayed for nine months, due to the following aspects:

- Detection of rocks during the preparation of landscaping (carried out by another company) – although surveys characterizing the site had been previously carried out – which extended the time period necessary for conclusion of this stage of the process;
- Review and change of the initial project during this same period caused by the identification of a ground water aquifer in the area, which led to repositioning of the substation and to revision of the project for the 230 kV lines that would be selected;
- Difficulties getting the environmental license from the relevant environmental organization to execute the project in an urban area.

The main variable points during the execution were:

- Cancellation of the consortium that was originally assembled, due to the major scheduling changes required. Only the leading company remained as the supplier of the turnkey substation and this company was authorized to subcontract other service companies to do the construction;
- Alteration to the scope of the project, including the supply and assembly of 4 entry lines of 69 kV. The responsibility for their execution was not defined when the contract was issued; however, the basic project already included these 69 kV lines, anticipating these events. This alteration also represented an added element to the contract in relation to the initial value;
- Additional 69 kV current transformers due to the revision of the project;
- Problems with testing and commissioning of the 230 kV and 69 kV switchgear in the field, which led to the alteration of the project and became part of the follow-up work that had to be concluded after energization;
- In parallel to the alterations above there were also various additional contract deadlines and new deadline definitions for the supply of some equipment and spare parts, caused sometimes by necessity to provide repairs.

The differences of opinion regarding the project were negotiated and discussed among the contractual parties.

Since being placed in-service the substation has performed well. It has security signs in all areas and it is a frequent site for technical visits. Periodically the installations receive equipment accessories. It is considered as a recent pilot project that is situated near the company's office and it is subjected to continuous technical monitoring.



Figure 2 – Aerial view of the terrain



Figure 3 – Aerial view of the Joairam Substation - CHESF

4 BENEFITS

The contract of this project initially represented, from the commercial point of view, a reduction of 25% of the cost estimated in the initial budget, and made possible the participation of a company with the necessary experience and capital to guarantee its satisfactory conclusion. Another advantage of the turnkey application is the change of one or more subcontracted companies for others, with more experience in the specific service. In this case, this happened and it was very important for the success of the project

Although the service provider and the subcontractor had been clients of the Asset Owner before (on other projects), the specific experience associated with the turnkey project created new learning opportunities through the exchange of technical and administrative knowledge.

The proximity of the substation to the subcontractor's central office, as well as to CHESF's central office, also facilitated the execution of activities and inspections.

5 DISADVANTAGES

The construction of this substation did not include great technological or project innovations, due to the lack of alternatives to the defined basic project. This could have been provided through a more detailed analysis, presented for approval during the project concept phase.

The partial payments schedule in the contract was not very flexible, associating the payments to the completion of the major events, which forced the service provider to anticipate the application of resources. For example, the completion of foundations for the equipment of a line entry could only be compensated after the completion of the foundations for support structures of all equipment and bus bar. Some changes to the payment schedule to split events were carried out in the first contract renegotiation, but this did not completely resolve the problem.

6 CONCLUSIONS

During the execution of Joairam substation turnkey there were six authorized contractual deadline alterations, which represented a significant delay. Moreover, although the Service Provider was committed to constructing the substation following the project turnkey conditions, efforts could have been put into place to avoid delays through better risk management, of the project schedule.

The use of the turnkey solution was successful, realizing a reduction of 25% of the original budget estimate.

Using this experience we can propose the following for other turnkey projects:

- In the contract: Detailing the cost of each service by activity to allow the payment when possible in the same month of the completion of the respective key event. The technical descriptions of the services should be clear, to avoid misunderstandings;
- In the tendering process: Exigency in certification of turnkey project participants for all companies involved in the consortium;
- Revision of some technical specifications, mainly for switchgear which in this case presented many operational problems;
- Allowance for revision of the basic design after the contract is signed, to allow for new technology developments.
- Claims: The Service Provider should present a technical and administrative report with a complete description of all activities affected by project changes, their new deadlines and priorities considered with at least two alternative options, to help the authorization of the project or contract review when necessary.

Currently the authorization to construct new substations is defined in the transmission installation concession bid [1]. These processes have been conducted by the Regulatory Agency responsible for publishing the technical data that forms part of the tendering documents, collaborating also with development of the basic project.

[1] In Brazil, new substations are constructed, operated and maintained by the winner of the bid process. It is called transmission installation concession bid.

THE FIRST 150 kV ELECTRIC POWER SUPPLIES TO THE RAILWAY GRID - ERMIDAS-SADO AND MONTE DA PEDRA TURNKEY SUBSTATION PROJECT

1 BACKGROUND

Most installations of REN – Rede Eléctrica Nacional, S.A., which is the National Electricity Transmission Grid (NTG), are intended to feed the High Voltage Grid (60 kV) of the National Electricity Distribution Grid (NDG) and / or link together the Grids of Very High Voltage (150 kV, 220 kV and 400 kV) of REN. All these facilities are of the uniform type and in general well adapted and unified.

Grid Planning Division has to study the location of new facilities, their interconnection, taking into account the needs of supply, as well as the location of the new Generation Power Plants, always with a view to optimize resources and a high level of security of energy supply.

2 CONSIDERATION PROCESS

Major Customers or loads, including some heavy industries, as well as railway transportation are fed directly from the High Voltage Network of NDG or from the Very High Voltage Network of NTG.

In the nineties, REFER, the Concessionaire of the National Railway Grid has decided to electrify the existing “Southern Line”, connecting Setúbal, near Lisbon, the capital, to Algarve, in the south of the country, needing for that, to have several points to supply the planned traction substations.

Since the “Southern Line”, through the province of Alentejo, is an economically weak area and therefore with a high voltage transmission network also somewhat long and with a low short-circuit power, except in SINES area where REN has a major substation, the power infeed of National Railway Grid traction substations would be achieved from the 150 kV Very High Voltage network in the area.

Therefore, it was defined by Grid Planning Division and in accordance with the needs of traction substations and their locations, that the supplies would be provided by using an existing 150 kV overhead line and by construction of a substation with two two-phase feeders. The most economic solution was to install side by side a traction substation 150/25 kV (REFER traction substation) and power feeding 150 kV substation (REN power substation) and, simultaneously, install each set as close as possible to the 150 kV overhead lines, while respecting its relative location to the electrified railway line “Southern Line”.

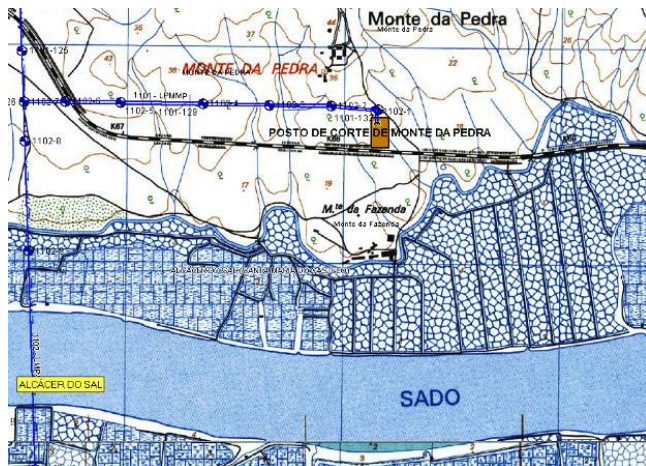
For reasons of maximizing use of existing resources it was also decided that REFER would provide all the civil work for the two substations (REFER traction substation and REN power substation).

It is important to point out that the scheduled time for energization of both substations was the same.

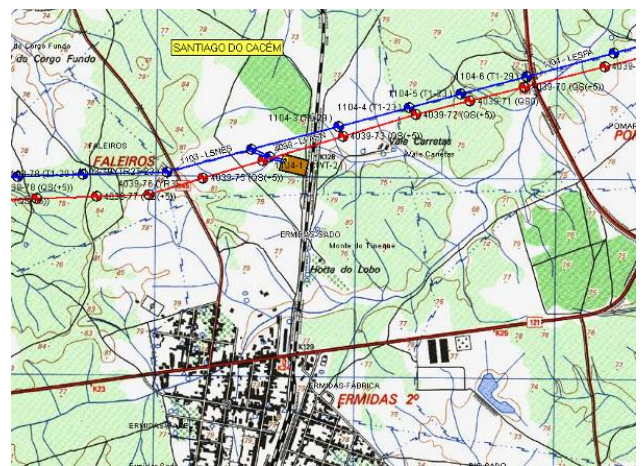
REN was faced with the need to build two smaller facilities, located relatively close to each other (about 60 km), with configurations which were not in the usual patterns of REN (REN pattern is usually more complex and with a greater number of bays given the functional requirements associated).

Furthermore, REN was developing a new design concept for the Substation Technical Buildings, with a new and simpler architecture and, above all, with new requirements for operation and maintenance and new characteristics for easier construction.

Given this set of situations and the fact that the facilities were comparatively simpler, it was decided to contract out the entire project as a Turnkey Contract. This one hand provides a pilot experience with such an approach to a project and free up internal resources for other projects.



Monte da Pedra Substation location



Ermidas – Sado Substation location

3 CONFIGURATION

The tendering process for the turnkey project included two 150 kV substations of the conventional outdoor air insulated type, called "Ermidas - Sado" and "Monte da Pedra", with the following configuration:

- A single main busbar;
- Two overhead line bays;
- Two two-phase "feeders".

4 INFORMATION PROVIDED BY THE ASSET OWNER

For the turnkey tendering process, the Asset Owner provided the following technical documentation, besides the General Tendering Documents:

- Main Electrical Project of the installations which included the following issues: Substation layout (primary circuits), rated and short-circuit currents, electrical and safety clearances, insulation coordination describing the overvoltage and insulation levels, specification of the main high voltage equipment and specification of the complementary high voltage equipment such as aerial connections and type of conductors, specification of the substation grounding (buried earth grid) and the direct lightning strikes shielding, the auxiliary services scheme, specification of control and protection system, data concerning the civil works including the Detailed Specification for the Control and Auxiliary Services Technical Buildings.

5 SERVICE PROVIDER'S SCOPE OF WORK

- Studies:
 - Primary and Secondary Circuitry Detailed Specification, including Auxiliary Supply Services and Control and Protection;
 - Execution Projects of Civil Works – substation rainwater drainage, internal roads and paving, steel structure foundations and guttering and cable seals Specification for Civil/Structural Works:
 - Storm drainage;
 - Technical buildings including water supplies and sewage facilities;
 - Rough and finish grading and internal roads;
 - Steel structures foundations (for gantries and high voltage supporting structures);
 - Substation buried earth grid,
- Equipment, materials and systems:
 - High Voltage main equipment: circuit-breakers, insulators, instrument transformers and line-traps;
 - Auxiliary Service Supplies: auxiliary service transformers, emergency generators, batteries and rectifiers, direct current (D.C.) and alternate current (A.C.) distribution panels;
 - Steel structures, conductors and clamps, insulator chains, insulator supports, low voltage isolated cables, optical fibres and buried grid conductor;
 - Control Systems;
 - Protection Systems;

- Telecommunication Systems;
- Metering.
- Tests:
 - Substation commissioning tests: FAT and SAT (Factory Acceptance Tests and Site Acceptance Tests)

The following works and supplies were excluded from the tender:

- Soil movements and access;
- General substation platform rainwater drainage;
- Gates and Fences.

6 TECHNICAL SPECIFICATIONS

Besides the studies already mentioned, Asset Owner produced the following technical specification:

- Main high voltage Switchgear (circuit-breakers, insulators, instrument transformers, line-traps);
- Control and Protection Systems;
- Complementary Equipment such as aerial conductors, insulating supports, clamps, tubes for rigid busbars;
- Auxiliary Power Supply (batteries, rectifiers, emergency generators);
- Steel structures and gantries;
- Standard Plans for Civil Works

The Service Provider was responsible for delivering the project and for coordination of work with other activities included in the project. The Service Provider was the in charge of Construction Supervision with direct reporting to the Asset Owner.



Monte da Pedra Substation

7 DIFFICULTIES

There were no major difficulties during the turnkey project process. There were minor problems, mainly linked to the relative lack of experience of the Service Provider, with regard to timely coordination of deliveries, including those of less value, but which have relatively long delivery periods (such as high voltage clamps). In these cases, the Asset Owner with its own experience was attentive and drew the attention of the Service Provider to pay attention to some of the more critical supplies, and the result was very satisfactory. Fortnightly coordination meetings with all parties involved in the project helped avoiding significant negative effects of the issues mentioned above.

8 BENEFITS

One can consider weighting all the pros and cons, that this type of contract was very positive and has met all the deadlines for implementation and the budgeted costs:

- Deadline for completion: 12 months
- Award Date: 23-12-1998
- Energizing Date: 07-12-1999 (sixteen days in advance of the deadline)
- Amounts budgeted ("in-house"):
 - Ermidas – Sado: 1.840,00 k€
 - Monte da Pedra: 1.840,00 k€
- Final values (turnkey):
 - Ermidas – Sado: 1.620,00 k€ (-11,9%)
 - Monte da Pedra: 1.615,00 k€ (-12,2%)

Taking into account the fact that the model normally and often used in REN is the "in-house" project, this model of contract ("turnkey") revealed a very interesting final cost. From technical point of view there were no significant negative points and we have experienced some minor problems with the quality of steel structures galvanizing, but these were corrected in time.

It is also worth noting that there was any release of REN human resources, although lower than expected.

9 DISADVANTAGES

At the time, the only disadvantage was associated with the relative lack of experience of the Service Provider in the overall management of the work, despite being one of the most qualified suppliers. This forced REN to provide more resources than those who were "a priori" assigned. We would also list as a potential disadvantage to the model ("turnkey") reduced control of some aspects of the design process (but little apparent in these two facilities).

10 CONCLUSION

The main conclusion is that the model ("turnkey") is very beneficial if the Asset Owner carefully prepares the specification in which the basic design is very well defined and characterized.

THE NEW 150/60 kV GIS TRAFARIA TURNKEY SUBSTATION PROJECT

1 BACKGROUND

Mainly due to liberalization of the electric power market, the National Electricity Transmission Grid (NTG) has, in the last decade, significantly increased construction of its Very High Voltage Infrastructure, both in overhead lines and in high voltage substations. The following case study concerns the turnkey project for the construction of a new 150/60 kV Gas Insulated Substation (GIS) - Substation of Trafaria, installed in an urban environment, which thus becomes a new node in the National Transmission Grid (NTG).

The 150/60 kV GIS Trafaria substation is located very near the city of Lisbon, on the southern shore of the River Tagus within walking distance of the sea and is designed to meet the growing needs of consumption of electricity in the region of the Peninsula of Setúbal and strengthen the capacity of power to the councils near Lisbon, compared to consumption that have been, thus, improved the quality of provision of service - power supply - an area in great urban expansion.

2 CONSIDERATION PROCESS

The 150/60 kV GIS Trafaria substation had to be designed using a technical solution without applying the conventional outdoor air insulated substation (AIS) alternative, in order to minimize the environmental impact of the installation, while improving their local integration and public acceptance. Therefore, taking into account the above criteria, the substation comprises the following technical solutions:

- GIS 150 kV Substation, SF6 insulated, indoor, integrated in a technical building;
- AIS 60 kV Substation, air-insulated, indoor, compact, integrated in another building.

This project consisted in building a platform with an area of about 1.4 ha, including access road on a 6.3 ha piece of land belonging to REN, SA, the Concessionaire of the National Electricity Transmission Grid (NTG). Beside the technical buildings, including the Control Building and the 150 kV and 60 kV Switchgear Buildings the substation was provided with means of access to the facilities with a length of about 135 m. On the outdoor platform of the substation there are internal roads, storm and sanitary drainage systems, the power transformers area with acoustic enclosures and foundations and steel structures for support of the incoming 150 kV circuit and for support of some equipment.

The land of REN, SA, around this facility was landscaped in order to recreate the original conditions of the area.

Considering the specificity of this project and in order to reduce the involvement of the Asset Owner in the development of the project and in coordination of work, it was decided that the most appropriate type of contract was the turnkey substation model.

For that, a procurement process was initiated for selection of the Service Provider. This one was chosen through a Tendering Process in which the number of bidders was limited. It was decided that the Tendering Process would only include the 150 kV GIS Main Equipment Manufacturers. The Asset Owner provided however the power transformers, using their usual suppliers for this type of equipment, and was involved, directly and indirectly, in supervision of the work performed by the Service Provider and in coordination of security and environmental monitoring.

For this venture the Asset Owner has developed and provided a Main Electrical Project, leaving to the successful Service Provider the development of this project, particularly regarding the technical building which would house the GIS 150 kV equipment, the building of the 60 kV compact substation and the Control and Protection System Project in accordance with the specification of the solution presented by the Service Provider and approved by the Asset Owner.

The decision by this solution seemed to be the best one, considering that the Main Electrical Project would inevitably change to be adapted to the Service Provider solution, therefore avoiding the possibility of transferring to the Asset Owner a set of responsibilities resulting from additional work which could be difficult to account.

3 CONFIGURATION

The tendering process of turnkey project included one substation with the following components:

- construction of the platform;
- manufacturing and installation of five (5) 150 kV GIS bays, SF6 insulated type;
- manufacturing and installation of seven (7) 60 kV AIS bays, compact air-insulated type;
- construction of the GIS 150 kV and 60 kV buildings, which includes electrical installations, air conditioning installations and facilities for telecommunications;

- construction of maintenance roads inside the substation,;
- construction of the storm and roof drainage and sewage;
- foundations and structures for support of electrical equipment to be installed on the platform and of the 150 kV and 60 kV technical buildings;
- construction of the Control and Protection Building assigned to the 150 kV and 60 kV electrical equipment; the building includes space for housing the batteries, the emergency generator and the auxiliary station service transformers;
- implementation of the Control and Protection Systems as well as of the Telecommunication Systems.



150/60kV GIS Trafaria Substation – Design phase: 3D Building Simulation

4 INFORMATION PROVIDED BY THE ASSET OWNER

For the turnkey tendering process, the Asset Owner provided the following technical documentation, besides the General Tendering Documents:

- Main Electrical Project of the installations which included the following:
 - architecture of the installation (including diagrams and drawings with plans and elevations of the building elements),
 - Required rated and short-circuit currents,
 - insulation coordination with overvoltage and insulation levels,
 - specification of the main GIS high voltage equipment,
 - specification of the substation grounding (buried earth grid),
 - auxiliary services diagram,
 - specification of control and protection system,
 - specification of communication systems,
 - lighting and surveillance systems,
- Civil Works Design Project including:
 - design of the platform and access to the substation,
 - design of maintenance roads and drainage,
 - design of the power transformers foundations, of the firewalls and acoustic barriers, the steel structure foundations, the guttering and cable seals, fences,
 - design of the control and auxiliary services building,
 - design of the 60 kV switchgear building,
 - design of the GIS substation – Asset Owner provided the architecture of the building and its general layout and major dimensions.

All the Civil Works Design Projects included list of measurements except for the 150 kV GIS building which did not include measurements relating to the structure of the building (reinforced concrete).



Construction phase of the substation main buildings

5 SERVICE PROVIDER'S SCOPE OF WORK

Beside development of detailed planning of the entire project, as submitted at the tendering stage, the Service Provider supplied:

- Studies:
 - Preparation and submission for approval by the Asset Owner of the technical documents presenting location and arrangement of various equipment in the appropriate buildings and in the outdoor area of the substation,
 - Development of the Detailed Project for installation of the 150 kV GIS and of the 60 kV AIS part of the substation based on the specification provided by the Asset Owner,
 - Execution Projects for the Technical Buildings Civil Works – Detailed design of the buildings which will accommodate the 150 kV GIS and the compact AIS 60 kV equipment. This design includes not only their structural components but also all their mechanical, electrical, HVAC, sanitary and storm drainage. Telecommunication facilities as well as other facilities are part of this design,
- Civil/Structural Works:
 - Storm and roof drainage,
 - Construction of the three technical buildings (150 kV GIS building, 60 kV AIS building and the Control Building assigned to the 150 kV and 60kV electrical equipment, including water supplies and sewage facilities);
 - Construction and paving of maintenance roads inside the substation,
 - Implementation of a landscaping project for the integration of the substation in the surrounding environment,.
- Equipment, materials and systems:
 - High Voltage GIS 150 kV main equipment;
 - High Voltage AIS 60 kV, compact, air-insulated main equipment;
 - High Voltage 150 kV Surge Arresters;

- Auxiliary Service Supplies: auxiliary service transformers, emergency generators, batteries and rectifiers, direct current (D.C.) and alternate current (A.C.) distribution panelboards;
- Steel structures, conductors and clamps, station post and suspension insulators insulator supports, low voltage isolated cables, optical fibres and grounding conductors and connectors,
- Control Systems;
- Protection Systems;
- Telecommunication Systems;
- Metering.
- Tests:
 - Substation commissioning tests: FAT and SAT (Factory Acceptance Tests and Site Acceptance Tests)

6 DIFFICULTIES:

Some difficulties appeared during construction of the substation:

The first one was related to the construction of the overall substation platform. There were initial difficulties with the existing soil conditions (there was winter with frequent rain). Not wanting to stop the construction and wait for better weather conditions a solution was for further work in those conditions. However, this solution required additional costs and the Service Provider claimed that they were not part of the contract. After discussions with the Asset Owner a consensus was reached to share costs.

Another activity that has generated some conflict was the construction of the switchgear buildings.

As mentioned previously, the Asset Owner provided the general architecture of the buildings while the Service Provider should adapt them to receive the GIS and AIS equipment, including the correct size and implementing the stability design of the buildings. The Civil Works Design Project for the GIS 150 kV building did not include guidelines related to the structure of the building (reinforced concrete). The Service Provider claimed the costs for these elements but the Asset Owner believed that these costs were included in the Contract since it was the Service Provider's project. In the end and after some discussion the Contractor agreed.

Some smaller difficulties appeared in some cases due to lack of details in the specifications such as the size of the batteries room, definition of the communication system needs for control and protection systems, etc.

During the commissioning tests of the installation there was a need to make some adjustments in the control system cabinets in the control room and with the extension of the uninterrupted AC supply system.

Also some difficulties were encountered in implementing the exterior lighting and integrated system of surveillance and access control.

In summary, the main difficulties that appeared were due to:

- Implementation of Civil Works mainly due to the weather conditions,
- Overlap of some activities, including installation of equipment, cabinets, GIS equipment, cables while civil works activities were not yet completed;
- Omissions in the description of design elements that were submitted for Tender.



150/60 kV GIS Trafaria Substation. Buildings.

7 BENEFITS

The major benefit taken from this kind of project when compared to the normal “in-house” project, currently used in REN, S.A. was reduction of the Asset Owner’s human resources, since there was significant less involvement of the Asset Owner in coordination and development of the project.

For this case study, when comparing the “turnkey” solution with the “in-house” project estimates, the final costs were:

- Amounts budgeted (“in-house”): 12.500,00 k€
- Final values (turnkey): 9.850,00 k€ (-21,2%),

which demonstrates the economic benefits which can be achieved with the “turnkey” project model.

8 DISADVANTAGES

Since the Sub-Contractors and Sub-Suppliers involved in this project and contracted by the main Contractor were firms included in the list of qualified suppliers of REN, one can consider that there were not great disadvantages. The difficulties already mentioned above and which appeared during the work, must be considered as normal challenges of a project like this one, not disadvantages. The Asset Owner in a regular and normal way kept monitoring and controlling the project through work regular meetings and by the approval of the solutions presented by the Contractor.

9 CONCLUSION

For projects in which not all details of the infrastructure can be set during the design phase and which have a significant development component, such as the GIS equipment, it seems that the “turnkey project” solution is more advantageous.

EXTENSION OF THE EXISTING SUBSTATION 220/110 kV LAGISZA BY A 400 kV SWITCHYARD

1 BACKGROUND

The existing substation 220/110 kV Lagisza was built in the 70-ties of the 20th century and is used for power evacuation from the power plant Lagisza, which has the power of 7x120 MW, it is also connecting the 220 kV transmission grid with the 110 kV distribution network. The structure is situated in the South of Poland in the industrial region of Silesia.

In the year 2002 the power plant Lagisza decided to build a new power unit having the power of 460 MW. For this investment the Transmission System Operator issued some attachment conditions according to which the unit was to be connected to the 400 kV transmission grid. This kind of a solution involved the necessity of extension of the existing substation 220/110 kV by a 400 kV switchyard.

2 CONSIDERATION PROCESS

Due to limited possible space to locate the new structure it was adopted to put up a 400 kV SF6 GIS. The building of the new switchyard was to be situated in the direct neighborhood of the new power unit. Moreover there should have been a possibility of free 400 kV overhead line connection from the area where the switchyard would have been placed.

3 PRACTICAL CASE

In order to provide appropriate standard of reliability for the power evacuation from the new power plant an adoption was made to build a 400 kV switchyard with a two breaker circuit configuration. In the direct neighborhood of 400 kV switchyard transformers 400/220 kV, 500 MVA and 400/110 kV, 330 MVA were located. They were meant for combining a new junction 400 kV with 220 kV and 110 kV grid.

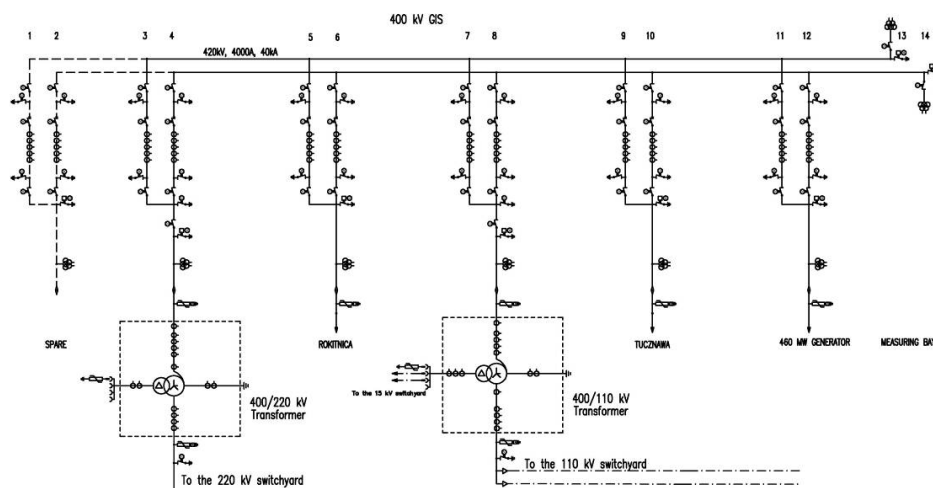


Fig. 1. 400 kV switchyard – single line diagram

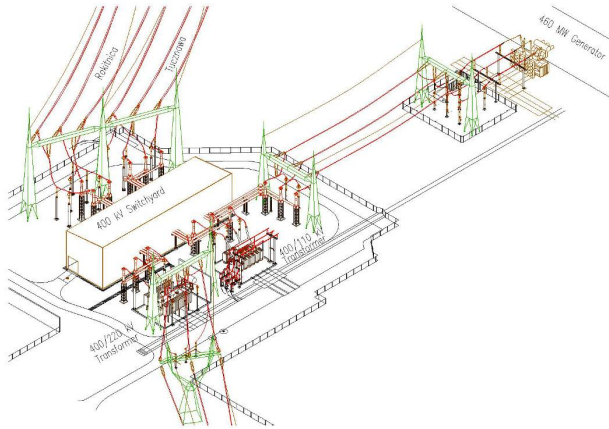


Fig. 2. 400 kV switchyard – 3D layout

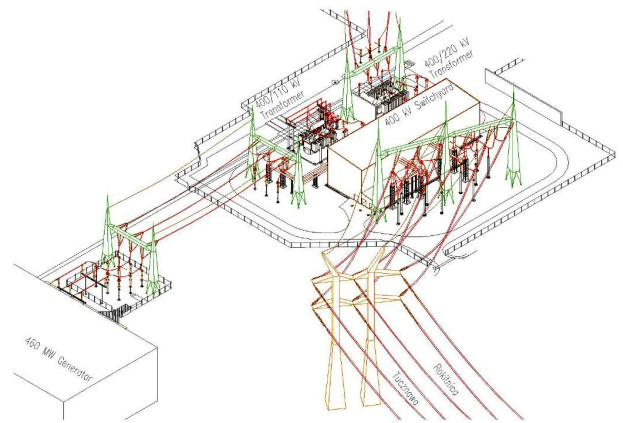


Fig. 3. 400 kV switchyard – 3D layout



Fig. 4. 400 kV GIS



Fig. 5. 400 kV GIS

4 BENEFITS

400 kV switchyard was built and commissioned in the period of 12 months starting from the moment when works began. So as to obtain such a result it was necessary to simultaneously design and carry out the realization works. The service provider was responsible for the whole undertaking. By reason of excellent work organization and convenient selection of workers it was possible to realize the agreement considering the launching of power for the time of the activation of the new power unit.

5 DISADVANTAGES

On the basis of experience gained during the construction of 400 kV switchyard it is possible to state that the realization of tasks with the turnkey delivery method is proper in case of new objects only.

Problems appear when considering modernization of existing structures. If the agreement states that the realization of a task must be consistent with an accepted schedule and terminated in exact time and limitations concerning necessary outages appear during the realization process, its period may be extended by the cause of what the service provider has to bear additional expenses. This kind of a situation is rather hard to predict at the stage of agreement preparation and may be the reason of further arguments between the asset owner and the service provider.

Realizing the work in a way to meet to expectations of the asset owner is achievable only when all the demands are precisely stated in the materials for the tender. In order to reach that, it is essential to put great effort into preparing the investment and also spend a lot of time on it. That time is not to be won back during the realization. It should be well thought over whether another model of realizing investments would not be more profitable, especially when it comes to short period of realization.

6 CONCLUSION

The turnkey delivery method of realizing investments is an interesting solution. It isn't possible to state though, that this system is going to definitely work under all circumstances.

In the case of new investments the system is one of the best building techniques.
For the works connected with modernization or extension of existing substations it should be considered whether a different system of realization would not be a better choice.