Planning and Management Concepts

3

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Contents

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3.1 Introduction

In the management of a Transmission line from conception to decommissioning it is important to realise the nature of the line as a device (or system) and to ensure management structures do not compromise any aspect of the life cycle.

This chapter covers the various management concepts that should be employed as well as the process for line design, construction and maintenance with role clarity provided.

The organograms or management structures (hierarchy) have deliberately been excluded as the concepts may be met in many different ways depending on the utility structure and the insourcing or outsourcing of resources.

3.2 Management Concepts up to Commissioning

A Transmission line, as defined in Chapter 14, is a device that transmits power over long distances. It should be seen as a single device (or system) with electrical properties that contribute to power transmission within the supply grid. Chapter 14 outlined how a line can be “tailor made” to meet the system planner’s requirements within the grid.

A line can also be regarded as a large mechanical structure (system) spanning many kilometres over many terrain types that must endure varying adverse weather conditions. It is therefore a device requiring mechanical, civil, environmental, geotechnical and electrical consideratons in the design of the line.

This section deals with the different possible management concepts for the line from planning to commissioning.

3.2.1 Management Concepts for Preliminary Design and Optimisation Studies

3.2.1.1 Series Model

It is often the case that the tower designs are done separately from the conductor selection and the electrical parameters which are normally determined up front often from standard configurations. This is either outsourced or performed in house by a separate division. The tower design is determined from the phase configuration and bundle configuration supplied and is considered fixed. Likewise the foundation design is then determined based on the loadings provided by the tower designers and is also considered fixed.

In this model the tower designers do not consider or question the reasoning behind the conductor bundle and phase configuration but convert the requirements into loads for a tower to withstand. Likewise the electrical engineers who determine the conductor bundle and phase spacing maybe ignorant as to the effect their requirements have on the mechanical aspects of the line.

The series model and distance between the disciplines is often further exacerbated with outsourcing of tower and foundation designs. This often requires a specific scope and specification which has little flexibility.

The series model will result in sub optimal designs in most cases. It is a more simple model to manage than the iterative model described in the next section.

3.2.1.2 Iterative Model

In order to optimise the design, either for a specific line or to develop new or revise standard designs, the electrical, mechanical and civil engineers need to work as a team to ensure iteration of the design components. This is because each aspect affects the other. For example an electrical engineer may specify a 6 bundle Zebra conductor with a certain phase spacing for a 765 kV line. The tower designer will design accordingly without comment in the series model. However, if the iterative model is applied, it may be found that a quad bundle with a lower steel content conductor with slightly wider phase spacing could be used at a reduced cost due to the lower mechanical forces (wind load and guy wire for example).

If the line is to be optimised as proposed in Chapter 14, then the design of the line cannot be performed in series with the planner determining the conductor type and the tower being designed based on the conductor specified followed by foundation design.

The iterative model is more difficult to implement from a management viewpoint as it involves engineers from different disciplines working together and understanding each other's field with regard to transmission lines. This can be achieved in a number of ways:

- In house design (insource): a line design department is established with different disciplines under one manager. The aim is to create a group of line design engineers with in depth knowledge in one of the disciplines. Tower detailing and detailed foundation design can still be outsourced after the tower outline is optimised and conductor bundle and type chosen.
- In house management (outsource): in this case the company employs one or two experienced line designers who manage an outsourced team of engineers of different disciplines. The contracting of the engineers may be done on a time basis and not on an output based using a defined scope.

3.2.2 Management Concepts for Route Selection and Property Acquisition

The route selection and acquisition may form a separate project as the time duration is normally far longer than the construction period. However, a project management approach with designer involvement is recommended. This team may include a variety of environmental, legal, negotiators and technical experts some of which may be outsourced.

It is important that the negotiator understands the line design as well as the implications of certain concessions made with the land owner. An additional strain tower to avoid a certain point in the land or to follow the border of the property can increase the line cost overall.

It is important that the line designers are part of the team to advise on technical matters as well as to be aware of the agreements reached. For example in certain areas of the line route, guyed structures maybe prohibited or existing servitudes (right of ways) used requiring narrow servitude multicircuit multi voltage pole structures.

In addition to all the permits required for a line to be built, it is also important that the team include wildlife experts for flora and fauna as well as bird experts to ensure flight paths and nesting grounds are catered for.

The project team for the route selection and property acquisition is often the largest and most diverse of teams required to realise a final constructed line. It is also the longest serving. For this reason the handover to different Project Managers needs to be well managed with decisions clearly documented.

3.2.3 Management Concepts for Construction

The construction phase consists of construction activities and handover for operation.

This phase is best managed by a team under a project manager using matrix management whereby the team members are seconded to the team from management. The Project Manager decides on the timelines and outputs and informs the team members. There may be a sub structure in the team for environmental, design, construction elements.

The team can be outsourced or insourced to varying degrees depending on the company. If the team is totally outsourced from various suppliers it is important not to duplicate the structure with in house staff. This could result in an in house project manager managing the outsourced project manager with duplication of work, conflicting instructions to contractors etc. If the project manager is outsourced the in house resources need to manage the outputs and milestones by exception and not interfere with the team below the Project Manager.

It is also important that the project manager be appointed as early in the project life cycle as possible so that he understands the reasons for the design chosen, issues with line route and stakeholders. It is also desirable that one project manager be accountable from the start to the end of the project to avoid handover points with possible misinformation arising. It is also necessary to have one person accountable for time, cost and quality to avoid blaming later in the project.

3.3 Responsibilities

In any management structure it is important that roles and accountabilities are clearly defined. The three main role players in the establishment of a line are the Network Planner, Project Engineer and Project Manager. These may work for different companies and be contracted separately. They do need to fulfil the responsibilities as listed below.

The following roles are responsible for the design and construction of overhead lines-

- Network planner
  - Responsible to ensure the line requirements (R,X,B, loading for AC lines) are correct.

  - Responsible to ensure the project is released for preliminary design timely.
  - To ensure correct targeted in service dates are communicated.
- Project Engineer
  - To assist in the route selection process
  - To ensure the consultative process is followed relating to the design options and selection of the optimum design.
  - To ensure full understanding of all aspects of the line design as well as how to implement this on site.
  - To assist the Project Manager in the construction phase of the project.
- Project Manager
  - To ensure milestones are set and resources are arranged so that target dates are met.
  - The project manager is to understand the nature of lines and the types of problems and issues that may result from the line design and construction process.
  - To take charge of the programme (target dates, milestones), from the pre-engineering stage to final commissioning.
  - The project manager is to authorise all costs to the line. This is to include over-heads which are normally accrued without the project manager being aware of them.

3.4 Life Cycle Process up to Commissioning

The life cycle of a transmission line commences with the system planner and is completed when the line is decommissioned. This section deals with the planning, design and construction aspects.

3.4.1 Planning Requirements

As mentioned in Chapter 14 the planner is to provide information on the electrical requirements of the line. This can be submitted in the form of a table as indicated below. Note that even if standard designs are used, it is useful to have the requirement specification from the planner to check whether the proposed standard design will meet the requirements.

The planner should provide the information to the line designers as indicated in Table 3.1. A few fields may need explanation.

- *The* ***profile of the proposed line load on a yearly and daily basis*** *is essential for the designer to determine the templating temperature of the line. If the load profile shows a morning peak and a winter peak it may be possible to use a smaller conductor as the temperature reached under peak load may be relatively low. If the daily load profile is very peaky, it may be possible to use small conductors with a higher templating temperature. If the load profile is flat it may be necessary to use larger conductors with a lower templating temperature.*

Table 3.1 Information required to be supplied by Network Planner.

Project Name	Project name and number of line to be built.																							
Start Sub	Substation at which the line starts.																							
Finish Sub	Substation at which the line terminates																							
NDP ref.	(Name and reference of Network development plan)																							
Planner	(enter name of planner responsible)																							
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
Load MVA																								
Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Profile																								
Month	1	2	3	4	5	6	7	8	9	10	11	12												
Profile																								
Imped.	R		X		B		R (Z)		X (Z)		B (Z)													
Max																								
Min																								
Cost/km																								
Environ	(Include possible environmental constraints)																							
Time	(Include cost to utility for every Month delayed from preferred due date)																							
Voltage	Preferred	Second option																						
kV																								

- *The **load growth** is necessary to determine the optimum aluminium area of conductors.*
- *The **impedance** is necessary to determine the optimum bundle and phase configuration (AC lines). The designer needs two values, a minimum and maximum value to ensure the optimum impedance to the network.*
- *The **voltage** of the line is often fixed and cannot be altered, however, in certain cases the costs can be such that the lower voltage option provides a major cost saving. For example a 10MVA load required to be transferred at 132 kV may prove far more effective at 66 kV (sub transmission)*
- *The **time** the line is required is often exaggerated by the planner who expects a certain load growth, however, there are times when the utility can lose substantial amounts of revenue should the line be delayed. In these cases it is often cost effective to utilise more than one contractor and fast track the project.*

In addition to the above the maximum voltage level and fault level needs to be specified. The reliability level also needs to be specified by the system planner. Line ratings (normal, emergency) also need to be known (these may be a minimum and the line designer must ensure these are met).

3.4.2 Route Selection and Property Acquisition

The selection of a line route is often a very time consuming task that could take many years (in some cases over 20). In the management of the line route acquisition it is important that the route of "least objection" is not always obtained. It is often required that the route chosen is along the border between properties or along a road. In this case there is normally a large amount of bends and angle structures required which results in an increase of the overall line cost. Management needs to be cognisant of these issues when appointing consultants to obtain route or when using in house resources.

In contracts for negotiators, if they are outsourced and in house resources are not utilised, the payment method should include the cost of the line as a result of the route chosen. This could include for example a ratio of tangent (suspension) to angle or strain towers. If the contract is time based the negotiation process may be extended, if the contract is a turnkey for the servitude/easement to be signed up it may result in a large number of bends.

A project management approach is also recommended for this process as it covers many years, different resources and involves many public forums which require knowledgeable presenters. The project team may include environmentalists, negotiators, surveyors, marketers, design engineers and even health professionals if the electromagnetic field issues are raised.

As the process is a long one, the decisions and concessions taken need to be clearly documented and stored in an organised manner to ensure that no concession is overlooked in the design and construction phase. Concessions may be made to land owners in the early stages of the route acquisition. However, the nature of the concession may be overlooked in the design and construction stage resulting in rework or lengthy delays.

Chapter 6 and Cigré TB 147 cover the requirements for property route selection, consultation models and property acquisition.

3.4.3 Management Process for Preliminary Design and Optisation Studies

As proposed in Chapter 14, the purpose of this stage is to determine a group of design options (ten options provide a wide range that will ensure possible optimisation) and, via the use of optimisation tools, to select the final group options for further analysis. The number in the final group may be around 3 or 4 depending on whether an option is obviously superior.

The project engineering team is to be formed under a knowledgeable line design expert. The team should include members knowledgeable in conductor, tower and foundation issues. This encompasses electrical, mechanical and civil disciplines. As mentioned in section 3.2.1, these team members can be from the same or different companies.

Possible routes can be determined from the digital terrain map or from the Environmental Impact Analysis. If this is not possible the design team should select a profile similar in nature to that expected in the line that they are designing.

The line route can seriously affect the overall cost of the line. It is imperative that the line design leader approves the line design route prior to final negotiations and servitude acquisition.

The possible conductor and bundle options are then considered.

The tower family can then be determined from the selected terrain (either the actual terrain or a sample selected from terrain that is similar in nature) using the conductor families selected and the available tower families.

The planners are then to be consulted again to ensure that the proposed set of line design options is in line with the planner's requirements.

The Appropriate Technology Indicator (ATI) (covered in Chapter 14) is then to be determined for the options. The best (approximately four) options are to be taken to the next stage. This can be achieved by using the programme (spreadsheet) that determines the scores for each option.

The ATI takes into account the initial cost, cost of losses, MVA thermal rating and MVA surge impedance loading.

The motivation for project finance (may be made in the preliminary design phase) is to be completed. This is to include the following:-

- A design document which should contain the following information:
  - Reason for the line including extract from the planning proposal documentation. This normally includes the Net present value cost benefit analysis.
  - Information from planners on line requirements including time and cost constraints.

  - Possible routes with cost options if possible.
  - Environmental Impact Assessment (EIA) details (extract from the EIA produced if possible. This may vary from country to country).
  - Options selected for analysis.
  - Appropriate Technology Indicator (ATI) analysis and results.
  - Design options to be analysed further.
- A cost estimate of the following
  - Labour cost to complete the detailed design stage.
  - Cost of the geo tech survey
  - Cost of tower development (if required).

The cost estimate is to be added to the project costs for approval via the relevant governance procedures.

Note that the geo tech survey is often overlooked. It is a critical aspect of the detailed design stage. It determines the suite of foundation options that should be used on the line. It assists in determining the numbers to specify in the enquiry document or for construction. It also highlights the type of foundations that need to be designed or developed.

3.4.4 Management Process for the Detailed Design Phase

The detailed design phase precedes the execution phase. The output of this phase is a detailed design and costing which is then presented to management for execution approval.

In some cases the utility may decide to go to market to obtain actual tendered prices for submission to management. In other cases estimates may be made from previous projects. In the former case the risk of error in costing is lower.

Approval is normally required from management for the detailed design phase to commence. The output of the design phase is a detailed cost of the line (90 % or higher) accurate. This can only be achieved if the following are known:

- The line route and line profile.
- The tower positions and types per position.
- The detailed bill of materials including conductor, towers, insulators and fittings.
- The contract prices for the erection phase as well as material costs.

It should be noted that the construction and material costs can be very volatile and depends on the exchange rate, the availability of materials and labour. It can vary from line to line even if they are in the same geographical area.

The line route and actual line profile (as accurate as possible) needs to be used to determine the optimum tower, conductor and foundation combination.

The options short listed from the ATI analysis are to be used to determine the optimum combination. These are to be used using the actual line profile and line route chosen. Tower spotting packages should be used to determine the best option in relation to the ATI. This will mean that network planners have to be consulted once again to determine the best option including the R, X, B values as well as the cost of losses.

Note that the best design combination is to be determined together with Maintenance staff. Preferably there should be a technical governance structure which will assess the proposed design option. This committee should consist of maintenance and operation staff as well as line designers and system planners. These may be from different companies. If new towers are to be designed, it is necessary that the maintenance and construction staff are to be involved. This could mean engaging with contractors who are likely to be involved in the construction of the line.

Once the best combination is determined, it is necessary to optimise the tower selection for each tower position using a tower spotting programme. This is best performed by a "peg walk" of the route. A "peg walk" or "tower staking" is a walk down the line by the line designers to determine if the proposed tower selection in the proposed tower sites are optimal. This also includes accessibility, constructability and proximity to roads, drains or even unmarked graves that may not have been known about when the line was profiled.

In order to determine the type of foundation to use at each site, it is necessary to perform a detailed geotechnical survey at each tower site. This can only be performed after the tower, foundation and conductor combination has been chosen and the first selection of tower types per site is completed.

The peg walk can be conducted at the same time as the geo tech survey. The peg walk will determine if any tower position changes are required or if a different tower needs to be placed at a specific location. In addition access roads can be planned as well as farm gate positions and types of gate (e.g. game gates).

The information gained from the peg walk and geo tech survey can be used in the finalisation of the Environmental Management programme which is essential for each project.

The information available at this point is the full tower schedule, the detailed bill of materials, the line profile with tower types, the access road locations and gate locations and types.

This information may then be compiled into an enquiry document. The document is then sent to prospective contractors for tender.

Once the tenders are received it is necessary to analyse the tender in detail. The services of a quantity surveyor should be used at this stage.

Once the appropriate tender has been selected the price and motivation needs to be submitted for approval (this will depend on the utility governance requirements), it may be permitted to proceed if the tendered prices are within a certain percentage of the estimate.

The design document should now be updated to include:

- Planning information
  - Reason for the line including extract from the planning proposal documentation.
  - Information from planners on line requirements including time and cost constraints.
- Survey and Environmental
  - Possible routes with cost options if possible.
  - EIA details (extract from the EIA produced if possible).
  - Route and profile
- Initial tower, conductor, foundation combinations
  - Options selected for analysis.
  - ATI analysis and results.
  - Design options to be analysed further
- Towers
  - Tower design chosen with reasons
  - Tower schedule summary
- Conductor and earthwire
  - Final conductor or conductor bundle chosen with reasons.
  - Final earthwire chosen with reasons.

Note the earthwire selection is dependent on the fault level as well as the fault dissipation in the towers and ground. This analysis is to be performed as part of the earthwire selection. In addition the interference criteria for telecommunication lines are to be taken into account and described here.

- Foundations
  - Geotechnical survey results
  - Foundation designs for each soil category and tower type
  - Schedule summary of foundation types
- Hardware
  - Outline of suspension and strain assemblies
  - Damping system used
  - Clamps and fittings
- Insulators
  - Analysis of pollution and other requirements
  - Insulator options that could be used
  - Final insulator selection and reasons
- Performance assessment
  - Performance analysis of other lines in the vicinity
  - Lightning performance studies
  - Environmental impact studies such as bird pollution/interaction with the line, veld or cane fires

- Contracts (tenders received)
  - Summary of tenders received with technical analysis as to their suitability.

Once the overall project is approved by management, the contractor responsible for construction may be appointed.

3.4.5 Project Execution (Construction)

An overhead power line is unlike a substation in that there are many factors that **cannot** be taken into account before construction begins. Items such as access to site, soil types and tower erection methods may necessitate that the tower type, foundation type, equipment used or tower location be changed on site subsequent to the design being approved. This includes right of way clearing requirements and stringing specifications (location of equipment, drums).

3.4.5.1 Pre Construction Planning

The Project Manager responsible for the project is to set up a pre-construction meeting to plan the construction activities with the contractor, clerk of works and Project Engineer (who may include design staff). The following items should be discussed:

- Material arrival and storage

> ***Note that the control of material on site is critical to the success of the project. Nuts and bolts as well as spacer dampers, and insulators should be kept in a clean environment preferably off the ground. Composite insulators should be handled in accordance with the Cigré composite insulator handling guide*** (Cigré TB184 2001) ***(TB 184). There must also be a system whereby the material issue is controlled and the stock levels are known. A person should be placed in charge of the store which should be fenced off.***

- Project plan for construction including possible dates for line and road crossings.

> ***Note that line and road crossings need detailed up front planning. In the case of line crossings the permission to take the line out needs to be obtained from the Operations authority. The detailed bill of material, tools, and procedure needs to be drawn up and agreed to well in advance. Special items such as cranes, helicopters etc may also be required. This activity occurs after the permission has been obtained from the relevant authorities relating to the crossing.***

- Environmental Management Plan (EMP) issues and plans as to how the EMP will be met. The EMP is a plan to meet the environmental requirements of the line. It includes the rehabilitation of the environment.

Note that this will include the formation of access roads, the clearing of the servitude and whether tyre or track vehicles are to be used.

- Foundation design issues and tools to construct the foundations.

Note that it may be possible that certain foundation designs will need to be done or modified. There may, for example be a large rock area and rock piles may not have been designed. Or the contractor may not have the drill bits for the type of rock foundation required. This needs to be taken into account and resolved up front.

- Safety

Note that this is a standard item on all site meetings. It includes the safety procedures and equipment required and available to staff.

3.4.5.2 Foundation Nominations

The foundation types are to be nominated by an experienced person other than the contractor. This is due to the fact that the contractor is likely to err on the conservative side or on the side of higher financial returns.

The foundation types need to be documented per tower installation.

3.4.5.3 Backup Technical Support

Issues may arise on a daily basis that require urgent solutions. An example could be a drain or grave that is found to be in the foundation location. In these cases where a tower needs to be moved or a plan made on other matters, it is essential that competent backup available for assistance. The Project Engineer is to ensure that this back up is available.

3.4.5.4 Change Control Process

The resulting solution from the back up support may result in a tower move or other modification from the original design. These changes must be controlled in the following manner:

- The Project Engineer is to examine the proposal and agree to the change if applicable.

- The Project Engineer is to ensure the design document as well as line profiles or other drawings as appropriate are updated (once approved and executed).
- The cost of the change is to be determined by the Project Engineer.
- The reason for the change as well as the cost is to be submitted to the project manager for approval.
- The Project Manager needs to sign off the proposal and update the project costs and, where applicable, the projections (both cost and time).

Note that in order for the Project Engineer to understand the issues relating to problems on site he is to visit site regularly and have a very good understanding of the requirements of the project and the final design option chosen.

3.4.5.5 Clerk of Works

Clerk of Works need to have the skills and knowledge to oversee the following activities:

Note that Clerk of Works (COWS) are key to the success of the construction stage. The COW are the "eyes and ears" of the customer on site. They need to have knowledge of what is required to be done on site to ensure that the contractor is executing the work correctly.

- Excavations and foundation confirmation/selection
- Foundation cementing including testing (slump and cube test) as well as the correct method to vibrate the concrete.
- Assembly and erection of structures.
- Stringing of conductors including running out, regulating and clipping in.

In some cases it may be necessary to have more than one COW on site at one time and certain COW's may be specialised different areas such as foundations, tower erection and stringing.

3.4.5.6 Tests Required During Construction

There are a number of tests that are required during the construction process on site. Examples of these include:

Foundations: Cube and slump tests for concrete
Pull out tests for guy anchours

Tests may also be required in the laboratory such as tensile tests for compression fittings and Guy anchor assembly tensile tests.

Tower footing resistances need to be measured per tower and documented.

Impedance measurements should be conducted on the completed line to compare them with the designed values as well as to update the planning and fault level parameters with exact values thereby enabling a more robust planning database to be created.

3.4.5.7 Inspection Prior to Commissioning

A walkdown to each structure should be performed by the COW, Site Manager, the Project Manager and the asset owner representative. A list of defects need to be created which needs to resolved within a specified time.

3.4.5.8 Site Access Control

The design staff should be permitted to visit site at any time. However, they must inform the Project Manager who needs to make arrangements. The design staff must not communicate directly with the Contractor unless the Project Engineer or a representative of the Project Manager is present.

3.5 Forms and Records (Including Accreditation)

The following staff that are involved in the following activities need to be accredited to perform these functions:

- Design document – It is assumed that the design team would have sufficient knowledge to conduct the design process. The Design document needs to have each section signed by the designer and a person who is checking the section. The latter needs to be a registered professional (Professional or certificated engineer depending on the country).
- Tender evaluation – The technical evaluation of tenders needs to be performed with the presence of at least one expert in the field of line design. This needs to be a Professional engineer or registered professional.
- Foundation nomination – A technician approved by the foundation designer or member of the design team assigned to foundations (must be a registered professional) should carry out nominations.
- Clerk of Works – the clerk of works needs to have had training and experience in each of the fields mentioned before he may oversee the work in these areas.
- Records of site visits by the design engineer as well as the findings must be recorded on site together with the required actions.

3.6 Summary of Process

The process comprises the following steps:

1. Planning proposal (concept) release of project and pre-engineering funding is obtained to conduct the concept design. The output is the conductor, tower and possible foundation combinations.

2. Obtaining of servitude and Environmental approval. In some cases this may take up to 20 years. In cases where it is likely to take longer than 3-5 years a separate project may be commenced. Often, however, the negotiations may require a final tower design to be presented. In this case the concept design will need to be conducted.
3. Perform pre-engineering design and determine a short list of options that could be investigated further.
4. Submit the project for detailed design stage approval and funds for detailed design.
5. Obtain route and line profile.
6. Determine the optimum conductor, tower, foundation combination.
7. Determine tower positions and types per position.
8. Conduct geotechnical survey, peg walk to determine gate positions, foundation types and access road.
9. Complete Environmental Management Plan.
10. Complete and issue enquiry documents based on results of optimisation and geotech survey.
11. Evaluate tenders (using line design experts and quantity surveyor)
12. Compile and submit request for permission to construct line to Investment committee or management structure
13. Conduct pre-construction meeting
14. Construct line.
15. Process for inspection and commissioning.

Note that in some cases the steps 10 and 11 take place after the step 12. This is due to the time required for step 12. This is not ideal, however, as the cost of construction submitted by contractors is difficult to determine upfront and depends on workload, competition and cash requirements of contractors.

It is critical, that the step 5 is obtained before steps 6–12. The temptation is to begin construction or issue the tender before the route or line profile has been completed. As the line is useless until completed, by commencing the line too early may result in a weaker case for obtaining the route (right of way or servitude) or standing time claims from contractors. In cases of extremely long lines it may be prudent to commence construction on a section if the line route on the remaining sections can be altered if need be.

It is a fallacy that the quicker the tender is issued the quicker the line is completed. It is preferable to have all permissions approved prior to commencement of construction.

3.7 Management of Maintenance

3.7.1 Involvement at Design Stage

It is critical that the maintenance staff are involved in the design of the line irrespective of whether the towers and conductors are standard or not. This is to ensure access to towers is mutually agreed prior to construction as well as maintenance methods.

In the case of Live line maintenance the maintenance staff must be involved in determining the live line maintenance methods prior to design finalisation. Special tools may need to be developed or insulated cranes or personnel lifts purchased. In cases of new tower designs it is necessary to determine the adequate spacing by using dummy objects with full scale electrical impulse tests. This will determine whether the spacing proposed is adequate.

3.7.2 Information Required and Handover (Submission)

It is critical that the asset owner and maintenance staff be involved as early as possible in the construction of the line. his will allow for all issues to be resolved prior to handover from the construction company. A detailed handover check sheet needs to be established and agreed to prior to the commencement of construction. This should include checks per tower.

Maintenance of the constructed asset may be contracted out to a number of external suppliers. It is important for the asset owner to ensure that, prior to taken over the line, all information is available on the line that has been constructed or refurbished. This includes:

- Line as built profiles
- Map of line route with landowner details
- Tower type per tower position
- Conductor details (supplier, type, contract, numbers etc)
- Earthwire and OPGW details (supplier, type, contract numbers etc)
- Hardware details (supplier, type, contract numbers etc)
- Drawings of towers and assemblies.
- Foundation types per tower leg (this is particularly important with large tower footing areas such as the cross rope suspension)
- Results of concrete slump and test cube (compression) tests.
- Tower footing resistance per tower.
- Earthing used especially if additional earthing has been applied.
- Accessories such as aerial warning spheres, bird guards.
- Insulator types per tower if different (composite and glass may be used on one line for example), information to include creepage, material, insulator profile.
- Location of conductor joints as well as the compression tool number to perform the joint (if such joints were installed).

3.7.3 Information for Maintenance during Operation

In addition to the above it is important that the maintenance required is also provided. This includes the type of inspections to be conducted and the time interval. Items such as retensioning guy wires should also be included.

Regular line inspections should be conducted with focus on the following:

- Tension in guy wires
- Evaluation of the earthing system at the towers
- Structure condition
- Vibration and spacer damper – condition and orientation
- Aircraft warning spheres, condition
- Condition of guy anchors
- Insulator damage
- Servitude condition and access to towers – poor maintenance of servitudes could inhibit effective restoration of lines as well as affect line performance depending on the vegetation below the line.
- Thermal imaging of the line for potential electrical hot spots
- Periodic assessment of the conductor – especially in corrosive environments – this may entail taking physical conductor samples and testing them in a laboratory
- Records should be maintained with the fault information for each line so that analysis and performance improvement projects can be undertaken if necessary.

3.8 Conclusion

The current utility structure often differs from vertically integrated to fully outsourced with many different companies involved in the life of the asset. This chapter highlights the concepts for management of the line in the different stages. The organogram or management structure can vary between utilities and companies and still comply with the proposed concepts. As a result the management structures have not been discussed.

The aim is to make the utility aware of the management concepts to be applied and to apply these in the best manner that befits the company structure and insourcing or outsourcing policy.

3.9 Highlights

The management of the line life cycle is consistent irrespective of the structure of the company or companies involved with different stages of the life cycle.

It is important for the asset owner and operator to be aware of the management concepts and process to ensure all stages are well catered for even if they fall outside the domain of the company.

The concepts highlighted in this chapter have been proven over many years and, although they may vary from country to country in detail (for example it may not be practice for the planners to provide the information as suggested and only state a conductor type), each stage must be covered to some extent.

3.10 Outlook

It is likely that the planning, design, construction, maintenance and operation of overhead power lines will be conducted by different companies with different goals, make up and skills compared to the past. In this case it is important that the process through the life cycle of the line is not compromised. This can be achieved by the role players being aware of the process as described in this chapter.

The risk exists that the more independent the role players are the less the overall planning and management concepts will be understood and executed. it is possible that each stage is seen in isolation to the detriment of the overall line design, operation and maintenance. This risk is likely to increase in future as the role players become more segregated.

References

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