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International Journal of Current Research
Vol. 9, Issue, 12, pp.63159-63161, December, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

A GUIDE TO ELECTRICAL POWER SUBSTATION FEASIBILITY STUDY

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ARTICLE INFO

Article History:
Received 27th September, 2017
Received in revised form
23rd October, 2017
Accepted 14th November, 2017
Published online 31st December, 2017

Key words:
Substation, Feasibility, TELOS.

ABSTRACT

This paper presents a simple guide to conducting feasibility study for a proposed electrical power substation. The concept of feasibility study is described, generally. The paper also describes what a substation is. Thereafter, the paper presents a prototype procedure for conducting a substation feasibility study.

Citation: Osunbor, O. C. and Ezechukwu, O. A. 2017. "A guide to electrical power substation feasibility study", *International Journal of Current Research*, 9, (12), 63159-63161.

INTRODUCTION

"Look before you leap" is a common cliché. And that is what is achieved by performing a feasibility study before undertaking any proposed project.

A. What is a Feasibility Study?

A feasibility study is an assessment of the practicality of a proposed project (https://en.wikipedia.org/wiki/Feasibility_ study). It considers all factors associated with the project and determines if the investment of time and other resources will yield the desired result. A feasibility study is not a plan. The separate roles of a feasibility study and a plan are frequently misunderstood. A feasibility study provides an investigating function that should answer the question of "is this a viable electrical power substation project?" whereas the electrical power substation plan provides a planning function that outlines the actions needed to take the proposal from "idea" to "reality". Feasibility studies are very important. They should be carried out any time a new project or the expansion of an existing one is considered. Although it takes time and costs money to perform feasibility study, performing one saves much more in the long run.

B. Factors of Feasibility

Five broad areas of feasibility have been identified, with the key factors represented by the acronym TELOS, which means – Technical, Economic, Legal, Operational and Scheduling (https://en.wikipedia.org/wiki/Feasibility_ study).

1) Technical Feasibility: This assessment determines the availability of the required technical expertise and materials to handle the proposed project to completion.

2) Economic Feasibility: This area does, primarily, the cost/benefit analysis of the proposed project. On a broader note, this area of feasibility also assesses the availability of resources required to carry the proposed project through to completion. Furthermore, this area also considers if there will be ample market for the product upon completion of the project.

3) Legal Feasibility: This feasibility factor determines if the proposed project violates any legal requirements.

4) Operational Feasibility: This assessment determines the degree to which the proposed project will thrive in the existing business environment. It considers how well the proposed project will solve problems and take advantage of opportunities that are presented in the course of the project running.

5) Scheduling Feasibility: This assessment estimates how long the proposed project will take to be completed. It considers how reasonable the project timetable is.

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Electrical power station

Electrical power substations are the interface between parts of an electrical power system. The electrical power system referred to comprises generation, transmission and distribution. At some point or other along the power system chain from generation point to the consumer, there is need for one function or another. These functions include voltage step-up or step-down, power factor correction, rectification/ conversion/ inversion, switching and others. To perform these functions, substations are used. Based on the several different functions, different types of substations may be distinguished.

A. Transmission Substation

Where it is required to connect two or more transmission lines, the type of substation used is called a transmission substation. In cases where all transmission lines have the same voltage, transmission substations use high-voltage switches that allow lines to be connected or isolated for fault clearance or maintenance. Transformers are needed in cases where there are different voltage levels. For synchronization purposes, the voltage levels have to be the same. The necessary voltage step-up or step-down is achieved using appropriate transformers. Other equipment like voltage control/power factor correction devices such as capacitors, reactors or static VAR compensators and phase shifting transformers to control power flow between two adjacent power systems are also found in a transmission substation.

B. Distribution Substation

The consumer voltage level (between 2.4 kV and 33 kV) differs from the transmission voltage level (115 kV and above). The main work of the distribution substation is to transfer power from the transmission system to the distribution (the consumer side) system of an area. Additionally, fault isolation (on either transmission or distribution sides) and voltage regulation are also done in the distribution substation.

C. Collector Substation

In distributed generation projects such as a wind farm, power flows from several wind turbines up into the transmission grid. A collector substation is required to 'collect' power from the several wind turbines and pump same into the power grid. Collector substations also exist where multiple thermal or hydroelectric power plants of comparable output power are in proximity. Usually for economy of construction the collector system operates around 35 kV and the collector substation steps up voltage to a transmission voltage for the grid.

D. Converter Substation

Converter substations may be associated with HVDC converter plants, traction current, or interconnected non-synchronous networks. These stations contain power electronic devices to change the frequency of current, or else convert from alternating to direct current or the reverse.

E. Switching Station

A switching station is a substation without transformers. It operates only at a single voltage level. A switching station may also be known as a switchyard, and these are commonly located directly adjacent to or nearby a power station. In this case the generators from the power station supply their power into the yard onto the Generator Bus on one side of the yard, and the transmission lines take their power from a Feeder Bus on the other side of the yard. The function of the switching station is to isolate the faulty portion of the system in the shortest possible time. De-energizing faulty equipment protects it from further damage, and isolating a fault helps keep the rest of the electrical grid operating with stability.

F. Railways / Traction Substation

Electrified railways also use substations, often distribution substations. In some cases a conversion of the current type takes place, commonly with rectifiers for direct current (DC) trains, or rotary converters for trains using alternating current (AC) at frequencies other than that of the public grid. Sometimes they are also transmission substations or collector substations if the railway network also operates its own grid and generators (https://en.wikipedia.org/wiki/Electrical_ substation).

Elements of a substation

Generally, substations have:

- Switching devices
- Protection and control equipment
- Transformers
- Power electronic devices

Conducting an electric power substation feasibility study – Procedure

A. Determine the Type of Substation

A good start is to determine the type of substation required. Section II describes various types of electrical power substation. Innovations giving rise to what has been described as the substation of the future can be found in (Sakis and Meliopoulos, 2010).

B. Determine the Required Equipment

Having determined the type of substation required, it follows to determine the required component equipment based on the type of substation and the specific functions the substation should perform.

C. Evaluate the Proposed Substation Project According to TELOS and Overall Assessment

1) Technical Assessment: This assessment determines the availability of the required technical expertise – competent electrical, mechanical, civil engineers; and the social scientists. The engineers take care of decisions on technological aspects ranging from design through site selection processes to completion of the proposed substation project. The social scientists handle issues relating to human behavior and welfare – community acceptance and social impacts on the potential host and neighbouring communities.

2) Economic Assessment: This assessment evaluates the cost implication of the proposed project – from the design through procurement of substation equipment, transportation of

personnel and materials to proposed substation site, labour, corporate social responsibility etc. The potential benefits (including profits) to derive from the completed power substation are also evaluated. This cost and benefit data are used to do cost/benefit analysis with a view to determining if the proposed substation project will be worth undertaking.

3) Legal Assessment: Due to the potential hazards (like electrocution, electromagnetic radiation/interference, transformer noise) associated with electrical power substations it may be prohibited by law to site electric power substations in some locations. There may be other legislations associated with power substation projects. The purpose of the legal assessment is to ensure that the proposed substation project does not violate any legislation.

4) Operational Assessment: Everything put together, this assessment answers the question "will the proposed substation operate as expected?"

5) Scheduling Assessment: The proposed substation project should take ample time to be thoroughly executed. That notwithstanding, the project should be completed in time so as to operate profitably. The scheduling assessment determines the right timing for the project.

Overall Assessment: This is the point where all feasibility study aspects are reviewed. The review should make the "go/no go decision" (www.asha.org/practice/feasibility) on the proposed substation project. A good feasibility study must be objective, as it should reveal the strength and weaknesses of the proposed project, the resources required for implementation of the project and the prospects for success (Justis and Kreigsmann, 1979; Georgakellos and Marcis, 2009). In simple terms, two criteria are required for the overall assessment of feasibility. These criteria are the cost implication of the project and benefit to come from the project (Young, 1970).

D. Prepare the Feasibility Study Report

Generally, proper documentation of the feasibility study is necessary. The documentation may be termed the feasibility study report. For proposed projects that – by the overall feasibility assessment – pass the "go decision", the feasibility study report serves as an invaluable guide to the project planning, implementation and operation.

Conclusion

This paper has described what a feasibility study is, on the one hand; and what an electrical power substation is, on the other hand. A prototype procedure for conducting feasibility study for electrical power substation has been presented. Following the presented procedure will lead to an overall analysis of the TELOS assessment of a proposed project, which analysis determines if the proposed project is worth investing time and resources in.

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