

Analysis on the Importance of Cost Driving and Cost Reduction Using Life Cycle Cost Analysis in Distribution Power Systems

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Abstract – The life cycle economy of the power distribution network arranging plan is winding up increasingly more significant in power markets. As we as a whole known, the distribution network is one of the primary segments of the power system and takes the substantial obligations of social and economic improvement. The distribution network arranging is basically a discrete, nonlinear, multi-organize and multi-objective combinatorial advancement issue, and its point is to fulfill client need under the reason of searching for a lot of ideal decision variables (sort of feeder sorts and ways and the switch position, and so forth.), limiting the venture arranging, network misfortune costs and the client power blackout misfortune. For quite a while, researchers have completed a ton of research on this issue. The idea of Life-Cycle-Cost intends to consider the assembling cost, yet in addition to consider the operational and transfer costs. For this situation the technique underpins the cost appraisal of gear, while empowering a correlation of various hardware highlights. Power age is the key factor to decide the economic development and modern improvement of any nation. An electric power industry is in the mid of a basic period in its development. Enormous scale changes in both transmission and distribution levels are required to happen sooner rather than later. In this paper, a Life-Cycle-Cost analysis is performed covering a total 110 kV overhead transmission grid with air insulated substations.

Keywords: Electric Power System, Life Cycle Cost, Transmission and Distribution etc.

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I. INTRODUCTION

So as to settle on reasonable decisions about vitality strategy, arrangement makers should probably look at the costs and advantages of various sorts of electricity-producing advancements on a like-for-like premise". Because of life-cycle stages, frequently the genuine costs of the venture or hardware, either to the decision creator or the cost conveyor, are not reflected by the forthright once-off capital costs. The life-cycle costing approach is researched as a way to improve decision making on the economic practicality of vitality systems. The choice of power transformer is critical to power segment. Most techniques are used by the underlying cost and don't consider the artificially assessment of economy and innovation. The distribution transformer is the most significant single bit of electrical gear introduced in electrical distribution networks with a huge effect on the network's general cost, effectiveness and dependability. Life cycle cost (LCC) is a procedure to appraise the all-out cost of proprietorship. It is an organized methodology which tends to every one of the components of this cost and can be utilized to

deliver a spend profile of the product over its foreseen life-range.

II. ELECTRICAL POWER SYSTEM

Electrical utility has three utilitarian territories specifically generation, transmission and distribution. Electricity is created at the producing station by changing over a primary wellspring of vitality to electrical vitality. In the distribution network there are two fundamental distribution network lines to be specific, primary distribution lines (33kV/22kV/11kV) and secondary distribution lines (415 volts line voltage). The power plants commonly produce 50 cycles/second (Hertz), exchanging current (AC) electricity with voltages somewhere in the range of 11kV and 33kV. At the power plant, the 3-stage voltage is ventured up to a higher voltage for transmission. High voltage (HV) and additional high voltage (EHV) transmission is the following stage from power plant to transmit AC power over long separations at voltages of 220 kV, 400 kV and 765 kV. The transmission of high voltage direct current is favored, where the

transmission line lengths are more than 1000 km to limit losses in India. Sub-transmission network at 132 kV, 110 kV, 66 kV or 33 kV establish the following connection in the transmission network.

Primary distribution lines feed the HT purchasers and distribution transformers. The distribution transformers feed the low voltage distribution networks which are the secondary distribution lines. Subsequently low voltage distribution network (LV network) is the last connection associating the shoppers. The square outline of electric power system is as appeared in Figure 1. The business doing all these or any of these business forms, Generation, Transmission and Distribution is named as Electrical utility.

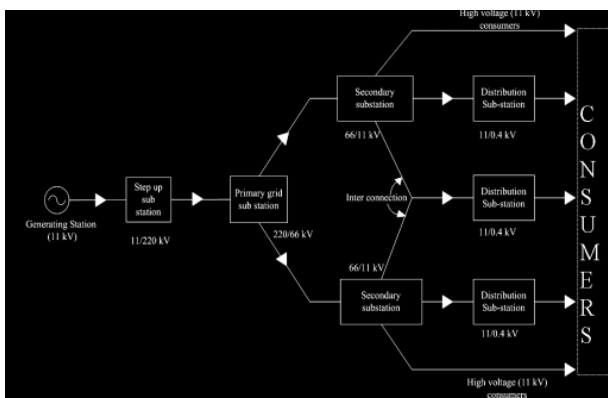


Figure 1: Electric Power System Framework

2.1 Distribution System

The power network, which for the most part concerns the regular man, is the distribution network of 11 kV lines or feeders downstream of the 33 kV Substations.

Every 11 kV feeder (High Tension Feeder) which emanates from the 33 kV Substation branches further into a few subsidiary 11 kV feeders to convey power near the heap focuses (territories, modern zones, towns, etc.). At these heap focuses, a transformer further decreases the voltage from 11 kV to 415 V to give the last mile association through 415 V feeders (likewise called as Low Tension feeders) to singular clients, either at 240 V (as single stage supply) or at 415 V (as three stage supply).

The primary piece of distribution system incorporates:

- ▶ Sub-transmission lines.
- ▶ Service mains with metering arrangement.
- ▶ Receiving Substation.
- ▶ Secondary circuits on the LV side of the distribution transformer.

- ▶ Distribution substation located closer to the load center.

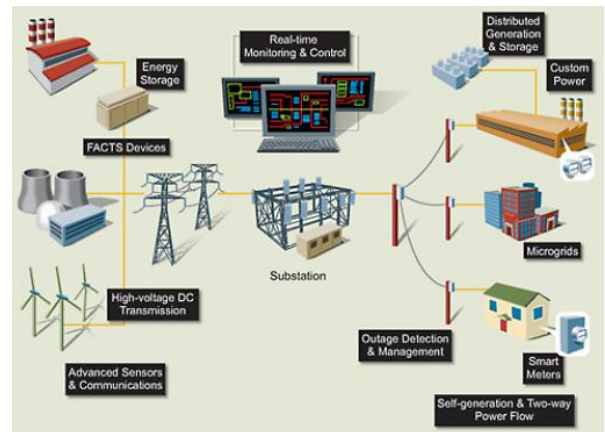


Figure 2: Electricity Transmission and Distribution Framework

The fundamental issue in distribution systems or rather more fittingly the issue going up against the power division overall, is the decrease of transmission and distribution (T and D) losses to adequate least levels. The All-India T and D losses (www.powermin.nic.in) were about 15% till 1966-67. During the most recent couple of years, electrical utilities the nation over have assessed the losses in the scope of over 20% to 40% higher than the first years. T and D losses in created nations are around 7-8% as it were. Thinking about the Indian conditions, for example, far away country regions, nature of loads and distribution system setup the sensible admissible (specialized) vitality losses ought to be about 10%-15% in various states. While the losses in EHV network are about 4%-5%, main part of the losses happens in the T and D system.

The Distribution system requires more consideration as it is extremely hard to institutionalize because of its unpredictability. As it includes shoppers, power quality ends up fundamental thought in feeding the power supply. With a quality power there is requirement for continuous supply of power. Supply and Demand needs to coordinate for continuous supply of power to the buyers. Henceforth for better performance of the distribution system the necessities are quality power and dependable power at sensible cost. To keep away from deficiency of power one significant thought is decrease of transmission and distribution losses. Transmission and distribution losses (T and D losses) in India have been reliably on the higher side between the scopes of 21–25%. Out of these losses, 19% is at the distribution level in which 14% is contributed by specialized losses. This is because of insufficient investments for system improvement work.

III. LIFE CYCLE COST ANALYSIS

Life-cycle cost analysis (LCCA) is a strategy for evaluating the absolute cost of office ownership. It considers all costs of acquiring, owning, and disposing of a building or building system. LCCA is particularly valuable when undertaking choices that satisfy a similar performance necessities, yet vary concerning beginning costs and operating costs, must be contrasted all together with select the one that augments net investment funds. For instance, LCCA will help decide if the joining of an elite HVAC or coating system, which may expand starting cost yet result in drastically decreased operating and support costs, is cost-compelling or not. LCCA isn't valuable for spending allotment. Lowest life-cycle cost (LCC) is the most clear and simple to-translate proportion of economic assessment. Some other usually utilized measures are Net Savings (or Net Benefits), Savings-to-Investment Ratio (or Savings investment-to-Cost Ratio), Internal Rate of Return, and Payback Period. They are predictable with the Lowest LCC proportion of assessment on the off chance that they utilize similar parameters and length of study period. The first and most testing assignment of a LCCA, or any economic assessment strategy, is to decide the economic impacts of elective plans of buildings and building systems and to evaluate these impacts and express them in dollar sums. The motivation behind a LCCA is to gauge the general costs of undertaking choices and to choose the structure that guarantees the office will give the lowest by and large cost of ownership steady with its quality and capacity. The LCCA ought to be performed from the get-go in the plan procedure while there is as yet an opportunity to refine the structure to guarantee a decrease in life-cycle costs (LCC).

LCCA can be connected to any capital venture decision in which moderately higher beginning costs are exchanged for diminished future cost commitments. It is especially reasonable for the assessment of building plan choices that fulfill a required level of building performance yet may have distinctive beginning venture costs, diverse operating and support and fix costs, and perhaps various lives. LCCA gives an essentially better evaluation of the long haul cost-viability of a venture than option economic techniques that emphasis just on first costs or on operating-related costs in the short run. Decisions about building-related investments ordinarily include a lot of vulnerability about their costs and potential reserve funds. Playing out a LCCA incredibly improves the probability of picking a task that sets aside cash over the long haul. However, there may in any case be some vulnerability related with the LCC results. LCCAs are typically performed right off the bat in the plan procedure when just gauges of costs and reserve funds are accessible, instead of certain dollar sums. Vulnerability in info esteems implies that real results may vary from assessed results.

3.1 Life Cycle Cost Method

As indicated by IEC 60300-3-3, the life cycle of a component will be sub-isolated into the following six cost-causing stages:

- ▶ design and development
- ▶ concept and definition;
- ▶ installation;
- ▶ manufacturing;
- ▶ disposal
- ▶ operation and maintenance

The Method forever Cycle Cost computation in this paper is performed in agreement to IEC 60300-3-3 "Trustworthiness management Part 3-3: Application guide – Life cycle costing". Much of the time it bodes well to join the fore referenced various components of costs into:

- ▶ operating,
- ▶ Recycling costs.
- ▶ investment,

For a progressively exact cost evaluation, a further qualification among operational and maintenance costs must be made. Such a qualification allows a simpler benchmarking of various maintenance strategies, as these end up being the primary cost drivers for the analysis. The investment costs (idea/definition, plan/improvement, manufacturing, establishment) are in return to the operating costs (task, maintenance), costs, whose level is noticeable before the investment is made. If there should arise an occurrence of the establishment costs these costs can be tallied to the investment or the operating costs. Further information must be utilized for the computation of the lifecycle-cost, for instance:

- ▶ inflation rate
- ▶ useful lifetime of the equipment
- ▶ interest rate

IV. 110 KV NETWORK DATA

The utilized 110 kV network is sustained by a 380 kV system by means of 380/110 kV transformers and comprises of air insulated substations (AIS). The topology of the network speaks to a blend of wide open and a metropolitan zone. The parts which are contemplated are recorded in Table 1.

Table 1: Number of System Components

Equipment	Number
Circuit-Breaker	334
Substation	66
Disconnecter	393
Power Transformer	83
Shunt Inductor	5
Secondary Equipment	252
Transmission Route (Km)	523
Instrument Transformer	168
Overhead Line (Km)	1.151
Steel Tower Incl. Insulators	2.093

The Life-Cycle-Cost analysis expect that the network is assembled recently. That implies that all investments of the network are contributed at the year zero. The investment costs utilized for the figuring can be removing from Table 2.

Table 2: Investment Costs of Equipment (Exemplary)

Equipment	Cost of the Investments
Circuit-Breaker	34.000
Substation	558.000
Disconnecter	19.000
Power Transformer	675.000
Shunt Inductor	225.000
Secondary Equipment	26.000
Transmission Route (Km)	198.000
Instrument Transformer	17.000
Overhead Line (Km)	65.000
Steel Tower Incl. Insulators	26.000

Table 3 speaks to the risk rates of the utilized system parts. These rates influence substantially the failure costs of the segments and have been utilized for the computation of the outage costs every year.

Table 3: Failure Rates of Different Network Components

Equipment	Per Year Minor Failure	Per Year Major Failure
Circuit-Breaker	0,00407	0,00067
Substation	---	0,00218
Disconnecter	---	0,00035
Power Transformer	0,01138	0,00569
Shunt Inductor	n/a	n/a
Secondary Equipment	0,00228	---
Transmission Route (Km)	n/a	n/a
Instrument Transformer	---	0,00025
Overhead Line (Km)	0,01913	0,00051
Steel Tower Incl. Insulators	0,00478	0,00013

The fix costs (major just as minor deficiencies) contingent upon the various segments are recorded in Table 4 and these costs present the outage costs. The costs for not conveyed energy and sales losses of the organization were not considered. The danger rate of the overhead line (for this situation steel towers and overhead line) is divided with a proportion of 20% steel towers and 80% overhead line (overhead conductors).

Table 4: Repair costs for major and minor failures (exemplary)

Equipment	Per Year Minor Costs	Per Year Major Costs
Circuit-Breaker	9.400	12.400
Substation	13.400	34.800
Disconnecter	4.200	8.300
Power Transformer	29.300	77.000
Shunt Inductor	86.400	61.600
Secondary Equipment	3.400	14.600
Transmission Route (Km)	n/a	n/a
Instrument Transformer	5.200	22.400
Overhead Line (Km)	3.000	0
Steel Tower Incl. Insulators	19.000	75.000

Other than the fix costs the costs for updates and investigations are considered by Table 5 and 6. In these tables it is likewise conceivable to locate the diverse maintenance interims.

Table 5: Inspection intervals and costs

Equipment	Costs in a	Interval in a
Circuit-Breaker	200	2
Substation	2.300	1
Disconnecter	100	2
Power Transformer	200	2
Shunt Inductor	200	2
Secondary Equipment	n/a	n/a
Transmission Route (Km)	n/a	n/a
Instrument Transformer	200	2
Overhead Line (Km)	200	2
Steel Tower Incl. Insulators	100	1

Table 6: Overhaul intervals and costs

Equipment	Costs in a	Interval in a
Circuit-Breaker	3.400	5
Substation	6.800	1
Disconnecter	2.000	10
Power Transformer	10.000	10
Shunt Inductor	2.000	10
Secondary Equipment	500	5
Transmission Route (Km)	n/a	n/a
Instrument Transformer	10.000	10
Overhead Line (Km)	3.000	6
Steel Tower Incl. Insulators	500	1

V. ECONOMIC DATA CALCULATION

The present value is a synopsis of all installments which emerge over a fixed time-span limited for example for the time of the establishment. The following information are utilized for the estimation:

- ▶ inflation rate 1,5%
- ▶ interest rate 8%
- ▶ outage costs table 3 and 4
- ▶ useful life time 20 to 50 years depending on components
- ▶ maintenance interval table 5 and 6
- ▶ maintenance costs table 5 and 6
- ▶ calculation time 50 years

VI. RESULTS AND DISCUSSIONS

Figure 1 demonstrates the pieces of the total present estimation of the total system (498512,08 k€) identified with the various parts. As on account of nearer thought gets clear, the present estimation of the entire overhead line has the best impact on the present estimation of the total network (59 %). Inside the substation the power transformer gives the best share, while different parts impact the outcome (e. g. instruments transformers, disconnectors and the secondary equipment). It must be referenced that the transmission route still exist, and on this reason no license methodology, route arranging and so on is essential and accordingly these costs are not considered ascertaining the present value.

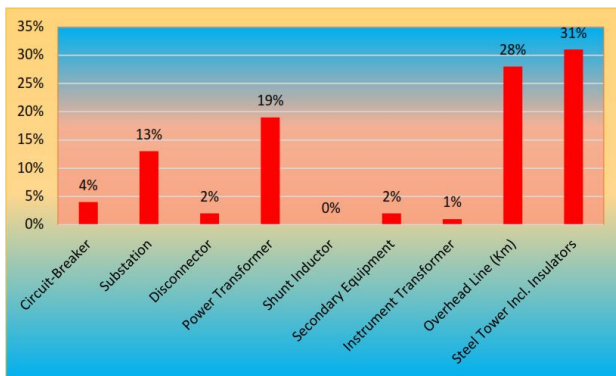


Figure 1: 110 kV network Present Value

Figure 2 (power transformers) shows, that the upgrade costs for all intents and purposes don't impact the present value. On account of the steel tower incl. insulators it gets clear that the redesign costs (11%) qualifies the impact on the present value without question and in outcome of this the outage costs are pretty much irrelevant.

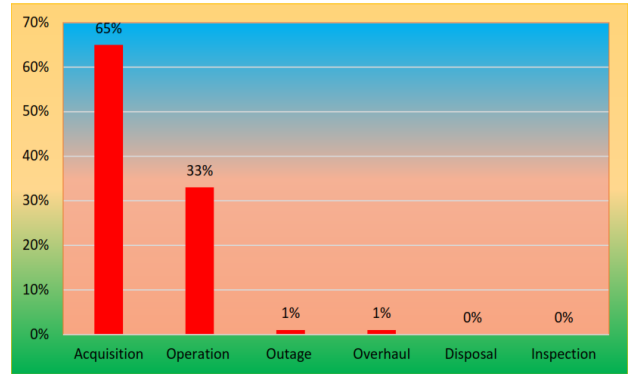


Figure 2: Power transformers Present Value

The present values of two distinct segments are exemplarily appeared in Figure 3 (steel towers incl. insulators 156503,68 k€) and 3 (power transformers 94027,52 k€). In view of the case of the power transformer it winds up straightforward, how much the operating costs impact the present value this case.

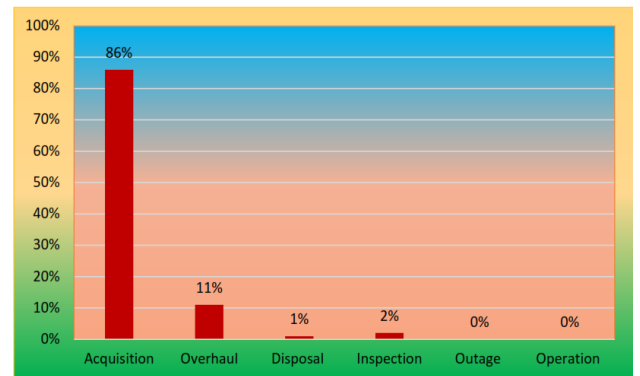


Figure 3: Steel towers incl. insulators Present Value

The distribution of the outage costs of the network (3521,99 k€) can be received from Figure 4. This Figure demonstrates that steel towers, overhead lines and power transformers cause together 83% of the outage costs of the total system. In this manner it just bodes well, to introduce extra equipment for the condition equipment to decrease these costs at overhead lines incl. towers and power transformers. Be that as it may, regardless the economic bit of leeway of the introduced observing systems must be determined in all respects cautiously, as the extra costs for the condition appraisal ought not to surpass the outage costs of the equipment group.

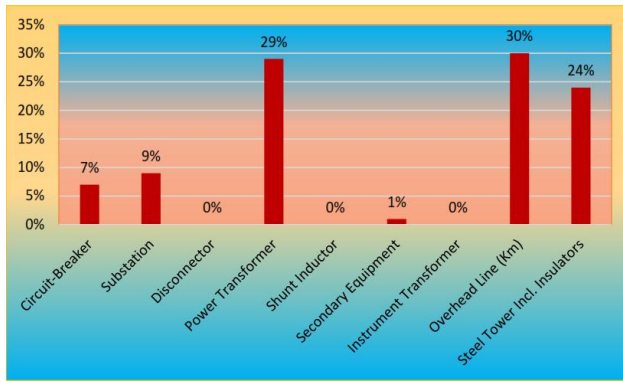


Figure 4: All components of Outage Costs

For this situation the costs for not conveyed energy because of an outage are not included. These costs speak to the economic ramification for the purchasers and can be assessed to 5 €/kWh which may change the outcomes.

VII. CONCLUSION

Additionally, the Life-Cycle-Cost strategy can be utilized viably for looking at changed network topologies and equipment types. For this situation the technique can rapidly find the cost-driving components. The outcomes portray the principle cost-driving or most significant components of the system. On this premise, diverse maintenance strategies have been connected and explored into. At long last, these components are especially considered by a weighted hazard analysis. It very well may be abridged, that the Life-Cycle-Cost Analysis is a helpful instrument to distinguish the principle cost drivers of a network and to take up there suitable activities to diminish the costs. The computation of the outage costs has a urgent impact, if the system administrator expects to change the maintenance strategy, for instance a progress from a period based to a condition based maintenance strategy. Since it is conceivable to look at the present value of every segment, these set screws still can be refined. Because of the low failure rate of present day system segments the advantage for extra condition appraisal gadgets must be determined in all respects cautiously.

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