WOOD POLE NEWSLETTER

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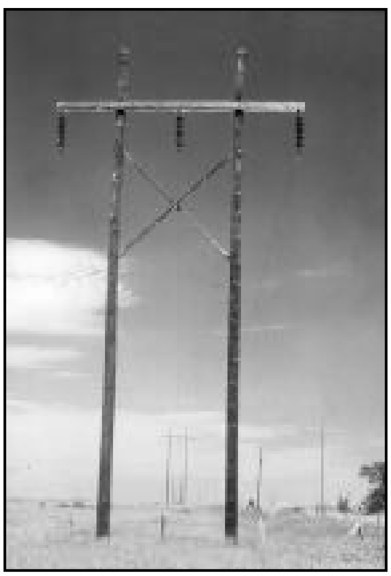
Western Wood Preservers Institute

LIFECYCLE STUDY PROVES WOOD IS THE BEST INVESTMENT

Structure material selection is normally the outcome of some form of economic analysis. Prices of pole materials are usually the first factor considered in any analysis; however, today's utility purchasing practices commonly include many other factors as well.

Pole materials represent only 10 to 20 percent of the total cost of building a new power line. In a recent economic analysis conducted by Engineering Data Management, Inc. (EDM) of Fort Collins, Colorado, the economics for the following types of poles were examined:



Wood
Light-duty Steel
Fiberglass (FRC)
Spun Concrete

In the study, the significance of other installation costs was reviewed along with various post-construction costs for inspection, maintenance, repair, replacement, and disposal. By properly considering all of these factors, utilities can accurately and equitably make economic evaluations as part of their material selection process.

INITIAL LINE CONSTRUCTION COST FACTORS

Several factors contribute to the initial cost of building an overhead power line. The most obvious is the purchase price of the structures themselves. However, structure costs represent only a portion of the total cost of a typical line:

Structure costs	15%
Engineering	8%
Right-of-way preparation (including survey)	25%
Wire and insulators	25%
Line and guy hardware	7%
Construction labor (including foundations)	20%

The above percentages are approximate and will change from line to line depending on the numerous variations encountered in line design and construction. Normally, structure selection has little impact on any of the factors other than structure cost. However, there are certain situations in which structure selection will affect one or more of the other factors.

RIGHT-OF-WAY, PERMITTING, AND ENGINEERING

The legal process of obtaining permission to build a new overhead line is often both time consuming and costly. The simplest project would allow for line construction along an existing utility easement and thus require only the approval of the state agency which governs the activities of the utility. In this scenario, the planning and design cycles tend to be very short with decisions made based on routine economic analyses.

Projects are seldom this simple, however.

When new lines require the acquisition of new ROW, and especially in the case of new transmission circuitry, the permitting process can be very lengthy and complex. First, the utility must often prove the need for the line before starting the permitting process. Given a certificate of need, the utility then must obtain approval from all the various local and state agencies which have jurisdiction over line construction. Also, if the subject line proposes to cross any federal land or waterways, the process becomes much more involved as there are several federal agencies which must provide consent.

When the permitting process shows promise of being completed, acquisition of the needed ROW becomes high priority. This process is often delicate, requiring artful negotiations, and sometimes takes several years to complete. In past years, utilities could often use the "right of eminent domain" to obtain particular parcels of land from uncooperative landowners. Today, this right is granted less frequently and thus negotiations have become much more sensitive to the desires of the landowners.

Final line engineering and survey work costs are relatively independent of the structure material selection. Only when structure configurations change or guying requirements differ between materials will cost variations be introduced.

PURCHASE COST FACTORS

Pole prices are affected by several different factors including:

- Raw material cost
- Raw material availability
- Supply quantity
- Order quantity
- Delivery lead time
- Material-to-labor cost ratio
- Transportation

For wood poles, the West Coast species such as Douglas-fir or Western Red Cedar service a wide range of pole heights and load class demands and offer a sustainable supply of poles from 35 ft. Class 05 through 125 ft. Class H2.

CONDUCTOR, INSULATOR, AND HARDWARE COSTS

These items are very significant cost factors in the construction of an overhead line and usually represent more dollars than the structures themselves. Their costs are impacted only slightly by structure material selection. Conductor costs generally are totally independent of structure type, but insulator costs may vary. Because wood itself is an insulator, less line insulation is required than would be for either steel or concrete structures. Many utilities, however, size insulators based on structure type unless they are designing for higher voltage circuitry (i.e. 230 kV and above). Those utilities which base insulator size on structure material type can save between $1 and $3 per insulator on a typical distribution line when using wood poles.

While different pole types utilize different styles of hardware, the end result is that hardware costs from material to material tend to be approximately the same and thus have no significant impact on pole material selection.

POLE INSTALLATION LABOR COSTS

Field labor costs for the different pole materials will vary depending on the following:

- Ease of ROW access
- Pole preparation
- Construction techniques used
- Construction and lift equipment available
- Foundation requirements
- Logistics of pole delivery
- Climbing requirements

For many overhead line projects, these variables result in only small differences between materials and are often considered negligible. However, there still remains a significant number of projects in which these variables cannot and should not be ignored.

Providing suppliers with adequate lead times helps utilities hold down costs.

Generally, through-drilled holes are used for most line hardware connections. While wood poles are frequently furnished with pre-drilled framing holes, field-drilling is often necessary. Because wood poles have been in use much longer than any of the other types, they are the most familiar and are normally considered the most "user friendly" with regard to field drilling. Tools and procedures for the field adaptation of wood poles are well established and are the standard against which the ease of use of the other materials is measured. Fully pre-drilled poles are generally only practical when they are ordered project specific. More often, poles are ordered as a commodity for stocking purposes or for projects in which engineering has not yet been finalized.

The majority of projects utilize conventional construction techniques. That is, line beds and / or cranes are used to lift and set poles. However, concrete poles will typically require heavier equipment. In some instances aerial construction techniques (helicopters) are mandated and weight can have a significant impact on construction costs.

Structure material choice generally has little effect on foundation costs. Direct embedment is the foundation of choice for all materials. And since all poles are essentially the same size and are carrying the same load, the necessary depth for embedment and augured hole diameter are normally the same. Differences are only introduced in situations where special protection must be provided to one of the material types to protect it against an unusually harsh subterranean environment or where high groundwater creates a buoyancy problem for one or more of the pole types. In the latter case, heavy pole weight is considered an asset as it facilitates pole setting.

Trucking is the most common means of pole transportation. Rail transport is normally only used when distances from origin to delivery site are long. Rail transport only becomes a cost variable when there is no rail siding at the selected pole yard(s). In those situations, additional handling costs are incurred to transport poles from the nearest available siding to the pole yard(s).

Years ago, pole climbing provided the only practical means of access to the overhead lines for construction and maintenance operations. Linemen climbed poles everyday as a normal part of their work regimen. As such, ease and safety in climbing were important issues to all construction personnel. Wood poles were normally favored over the other materials because they were familiar and afforded complete versatility in climbing without any added expense. All the other materials require added appendages to accommodate climbing and, even then, do not provide the same flexibility for worker positioning atop a pole. Today, bucket trucks have, in many situations, eliminated the need for linemen to climb any pole. However, climbing provisions are still normally required on the alternative material poles as emergency means of access. Consequently, climbing provisions can still remain an added cost for steel, FRC and concrete poles.

POST-CONSTRUCTION COST FACTORS

The least sophisticated cost evaluations consider nothing beyond initial cost. Purchase decisions of the past were sometimes based strictly on delivered cost of the product. As utility purchasing practices evolved, more and more factors were added to purchasing equations. The previous section described some of the factors which would be a part of a "total installed cost" equation. This type of equation has been used by most utilities for many years, but does not necessarily provide as complete an analysis as possible.

Today, there are post-construction cost factors which are also being considered. Inclusion of these factors will occasionally alter the outcome of material selection evaluations. In order to fairly evaluate the impact of factors which represent moneys expended at later points in time, present-value comparisons become necessary. A description of the technique used for the purposes of this study follow. In general, the initial installation costs usually represent the largest portion of total expense, but in situations in which comparisons of "as-installed" costs between material types is close, post-construction factors can impact the outcome of an evaluation.

Some wood fir poles have been in service for eighty years.

INSPECTION COSTS

The frequency of line patrols and time spent in inspection are priority matters dictated by a line's importance. A recent survey of the inspection techniques used by various utilities reveals tremendous variations within the industry. Techniques used include both aerial surveys, using either airplanes or helicopters, and ground patrols which may or may not have included some climbing inspection. All cases differed significantly in the amount of time spent on average at each structure. While no two utilities operate the same way, on average it appears that lines are patrolled and poles inspected approximately every five years.

On average, most utilities inspect poles every five years.

Inspection and maintenance programs will ensure maximum service life from wood pole structures.

Inspection techniques, especially for wood poles, have improved dramatically in recent years. These newer techniques provide vastly improved information quality at very reasonable costs.

MAINTENANCE COSTS

Pole maintenance requirements are normally dictated by the environment. Harsh environments can sometimes place strenuous demands on maintenance crews. However, an environment which is deemed particularly harsh for one material may not be for another.

None of the materials is immune to all of the various forms of degradation, but some perform better than others in certain environments. Any pole placed into a hostile environment will usually require periodic maintenance to enable it to perform properly throughout its expected life. The type and extent of maintenance will vary, but for the alternative material poles the maintenance generally relates to surface restoration. Should the galvanized finish or paint coatings, which are used to protect steel poles from corrosion, deteriorate or be damaged, repair or refinish work will be necessary. FRC poles also rely on protective coatings plus UV inhibitors to protect against resin decomposition and the subsequent blooming of glass fibers. Damage to any of these coatings needs to be repaired. Concrete poles need to maintain good surface continuity as well, so that the underlying steel is protected against exposure to the elements and possible corrosion. Concrete poles which show signs of deterioration need to have cracks filled and their surfaces resealed. These types of remedial action are necessary to ensure continued good performance by the poles.

While surface protection is of primary concern for the alternative material poles, the primary cause for wood degradation is biological attack. Most environments harbor multiple agents capable of causing damage to wood poles. Preservative treating of wood is necessary for combating fungal, bacterial, and insect attacks. As poles age, the effects of initial treatments tend to weaken and remedial preservative treatments become necessary to prolong the life of the poles. Some environments have been found mild enough that remedial actions have proven unnecessary. However, the majority of wood poles in service today has received, or is scheduled to receive, remedial treatment.

Pole maintenance costs will vary with the severity of the environment. Thus, for the purpose of doing an economic evaluation, differing environments were studied. The maintenance assumptions and costs used for each are discussed later.

REPAIR AND REPLACEMENT COSTS

Situations arise in which more than simple maintenance activities are needed to prolong the useful life of a pole. Any of the pole types can become damaged beyond repair. Where damage to a pole diminishes its strength beyond an acceptable level, some type of corrective action becomes necessary. In the most extreme cases, pole replacement may be the best or only practical solution. However, where reasonable caution is exercised and good inspection programs are in place during the life of the line, it is highly unlikely that any of the alternative material poles will warrant replacement as the result of progressive degradation. Catastrophic natural events, such as hurricanes or tornadoes, are the usual causes for alternative material poles needing to be replaced.

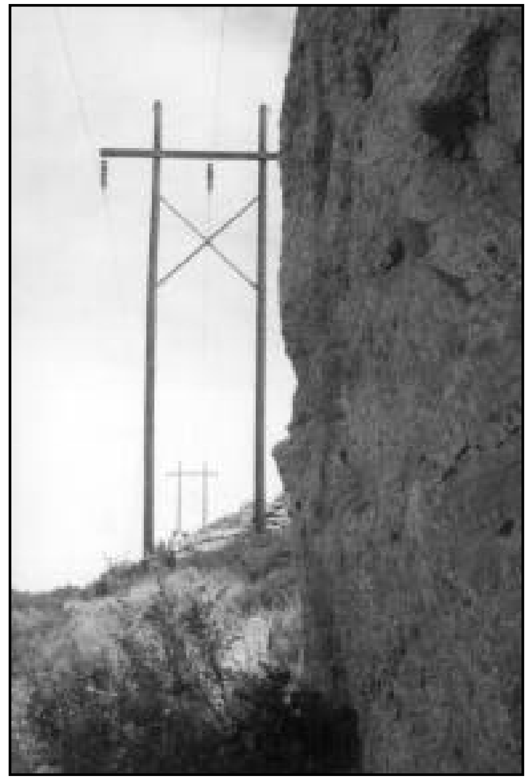
Wood poles require replacement on the average of 2 to 4% every ten years starting at twenty years. These replacements are the result of advanced deterioration from natural causes. Wood poles also need proper maintenance to ensure life longevity.

Certain forms of damage might be corrected via mechanical repair which can save money and should always be considered as an option. However, because these types of repair are often associated with damage caused by forces outside of nature, there is no way to predict the frequency of such occurrences. Thus, costs of pole repair have not been factored into the economic analyses which follow.

DISPOSAL COSTS

When a line is decommissioned, materials are removed so that the land can be reclaimed for use by a new line or another purpose. Old poles will either be reused or discarded. If discarded, several options exist for the material's final disposition. Steel is commonly recycled; in many instances new line applications can be found for the steel poles and they are returned to service on a different project. When no new application is found, steel poles are typically sold for scrap and thus generate a small amount of revenue. Similarly, FRC and concrete poles are also candidates for reuse. When recycling is not a viable option, then landfill disposal is normally used since these materials are not considered hazardous to the environment.

Wood poles removed from service are also candidates for reuse if they are still in sound condition. However, the disposal of wood poles is a slightly different issue. Because the vast majority of wood poles are treated with some type of chemical preservative, there is some concern for how best to handle their disposal. Wood poles removed from service are often either given away (accompanied by a material safety data sheet) or used for fuel in certain types of power plants. A few years ago the practices for disposing of treated wood were studied by various governmental agencies and there was concern that it might be reclassified as hazardous waste. However, after careful review by the governing environmental regulatory agencies, its classification as a solid waste remained unchanged. The EPA did formulate Toxicity Characteristic Leaching Procedure (TCLP) regulations which now govern treated wood disposal. CCA-treated wood is currently exempt from these regulations and all other current wood pole treatments pass the TCLP requirements by a significant margin.

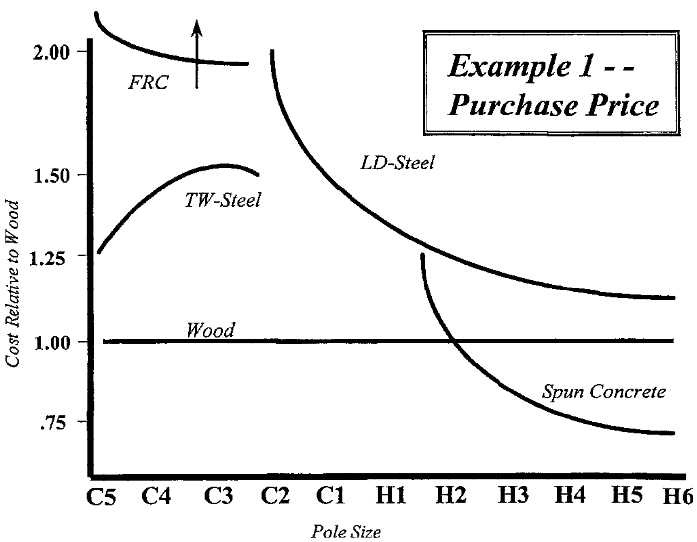


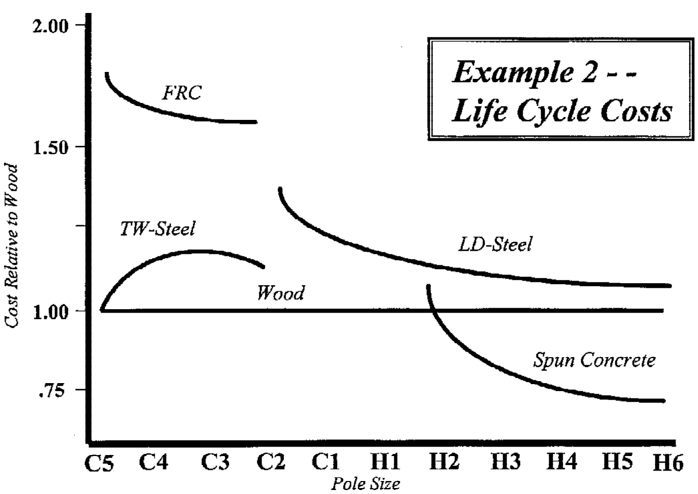
Long service life equals significant dollar savings.

COST COMPARISONS

When making a cost study of the various material options, any or all of the previously discussed factors may be considered. The following graphs show the results of two distinctly different studies. The first graph measures the cost differences between the different pole materials based simply on purchase prices and the second graph shows the relative cost differences based on a complete study of life-cycle economics.

Graphs illustrate the cost relationship between wood and the other materials, setting wood costs as the benchmark of 1.0.





In both examples, the pole prices used were taken from current industry surveys and reflect equivalent pole designs based on NESC Grade B design criteria. The prices include freight costs which assume equal shipment distances and pole quantities for all pole types. (Note: a customization of these studies to reflect the actual geography of a particular utility company will alter the results one way or another, depending on pole quantities used and relative distances from individual pole suppliers.)

While the first graph provides an example of the cost relationship between materials based solely on purchase prices, the life cycle economics example looks at all the factors and gives consideration to the time value of money based on a "present value" analysis. The approach of using present value, life cycle costs is often considered the fairest means of comparison because it considers and properly weighs all the material variables. This life cycle cost study gives consideration to the following:

- Environmental conditions
- Material costs and availability
- Construction costs
- Projected service life
- Inspection costs / Inspection frequency
- Maintenance costs / Maintenance frequency

For the purpose of present value calculations, a 4% inflation rate and a 10% discount rate are assumed. The equation used for computing the present value (PV) of a single expenditure is given below. The present value for multiple project expenditures is a simple summation of all the individual PVs.

$$PV = \frac{(Cost) \times (IF)^N}{(DF)^N}$$ where,

PV	=	Present Value
Cost	=	Today's Value
IF	=	Inflation Factor [1 + inflation rate]
DF	=	Discount Factor [1 + discount rate]
N	=	Year No [no. of years from present]

The useful life of any pole is directly dependent on the care and maintenance it receives while in service. For the alternative material poles, pole life can be expected to equal or exceed the life of the line. For wood, biodegradation will cause a certain number of poles to be replaced over time. However, when a good wood pole inspection and maintenance program is followed, the number of poles needing replacement is typically limited to two to four percent every ten years after twenty years of service. For the purpose of this example, a three percent replacement rate is used. A moderate environment, typical of the majority of line sites, and an 80-year line life was assumed when establishing the inspection and maintenance criteria shown below:

Criteria	Moderate Environment
Effective Pole Life	• 3% wood replacement every 10 years beginning @ 20 years • 80+ year life for alternative poles
Inspection	• Line patrol and pole inspection @ 5-year intervals
Maintenance	• Wood - treatments @ 20 years and every 10 years thereafter • Alternative poles - none required

The frequency of line patrolling is normally a matter of prioritization. A utility will often use a “line importance” factor as part of their equation in determining type and frequency of inspection. The more important the line, the more rigorous is their inspection program. There are no industry standards for said practices. For the purpose of this example, a five year interval between inspections is used.

Good maintenance programs include pole inspection as a routine part of their ground patrols. A complete visual inspection is normal for all pole types, with wood poles requiring additional groundline NDT. Based on recent data collected, costs for this type of inspection average $9 per pole for wood and $3 per pole for each of the other materials.

Depending on the severity of the environment, certain remedial actions may be necessary to restore a poles protection system. Concrete poles require very minimal maintenance in most environments. In harsh environments, steel and FRC poles will typically need some touchup to their original coating system on the average of once every twenty to thirty years. However, for the moderate environment used in this example, it was assumed that no maintenance would be required for either steel or FRC poles. Since the effectiveness of wood preservatives diminishes over time, wood poles normally need some form of remedial treatment after twenty years of service and at ten year intervals thereafter. Costs for said treatments generally range from $25 to $40 for wood poles (all environments) and $20 to $30 for steel and FRC poles (harsh environments).

SUMMARY

Many different conclusions can be drawn from the examples. Most notable is the fact that the maintenance and inspection costs, which are incurred several years following initial line construction, are not extremely significant to “present worth". As a general rule, wood pole lines tend to be the most costly to maintain. Even so, this example shows that the costs of future inspection, maintenance, and pole replacement add only 5%-11% to the present value of a wood pole installation and 0%-1% to the present value of an alternative material pole line. While this does narrow the margin of cost difference between wood and the alternative materials, it is less of a difference than often perceived. The actual calculated difference in post-installation costs between wood and the alternative materials only ranged between 5% and 10% of the initial installation cost. This equates to between $30-$90 per pole for most distribution lines and between $100-$300 per pole for most transmission lines.

Final analysis shows that the major factor in the economic evaluation for pole selection is the initial cost for materials and labor, and wood poles tend to be the lowest cost construction for most pole sizes. “Future” costs have only a minor impact on the evaluation. This relationship holds true in most normal economic environments. A lowering of discount rates will increase the importance of “future” costs, while a rise in rates will lessen their importance. Thus, while these rates can be manipulated to influence an economic evaluation, the rates used for this example represent realistic values for today’s economy. Only major economic swings, beyond what we have experienced in recent years, would affect discount rates to a degree which would have any significant impact on this type of cost comparison.

EDM's analysis demonstrates that for most overhead line applications, treated wood, compared to steel, fiberglass or concrete, remains the most cost-effective material in terms of initial costs as well as total life-cycle costs.

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