

the power to help you succeed.

Report Produced by PSE's Performance
Benchmarking and Statistical Research Group

Cost-Benefit Evaluation of Underground versus Overhead Power Lines

July 6, 2010

Contact: Steve Fenrick
1532 W. Broadway
Madison, WI 53713
Direct: 608-268-3549
Mobile: 608-334-5994
Fax: 608-222-9378

Email: fenricks@powersystem.org
Web Site: www.powersystem.org

**Power System
Engineering, Inc.**

Madison, WI · Minneapolis, MN · Marietta, OH · Indianapolis, IN · Sioux Falls, SD



About Power System Engineering, Inc.

Founded in 1974, Power System Engineering, Inc. (PSE) is a full-service consulting firm serving the utility industry with offices in Wisconsin, Minnesota, Indiana, Ohio, and South Dakota. PSE's benchmarking experience includes research for regulatory purposes and utility management improvement applications. In addition to our statistical cost research, PSE has expertise in the areas of Demand-Side Management (DSM) involving demand response and energy efficiency, merger valuations, load forecasting, transmission and distribution system planning and design, resource planning, communication technologies, smart grid investment planning, rate design, alternative regulation, and cost of service studies.

About the Performance Benchmarking and Statistical Research Group

PSE's Performance Benchmarking and Statistical Research Group researches the cost and reliability performance of electric utilities relative to their peers. This research enables managers to identify performance levels, locate areas of potential improvement, and set realistic yet challenging goals. A byproduct of this research is the ability to evaluate certain investment options and estimate their impacts on cost and reliability. These estimations are based on historical data and the impacts these investments have had on PSE's sample of electric utilities.

Table of Contents

1	Introduction.....	1
2	Operation and Maintenance Cost Savings	3
3	Reliability Impacts of Underground Lines	5
	3.1 Economic Damage Cost (or Benefit) Estimation.....	6
4	Other Considerations and their Value.....	8
5	Conclusion	10

Figures

Figure 2-1: Average Impact of Undergrounding on O&M Costs per Meter	3
Figure 3-1: Average Impacts of Undergrounding on SAIDI.....	5

Tables

Table 5-1: Undergrounding Decision by Feeder	11
--	----

Equations

Equation 5-1 Net Present Value	10
Equation 5-2 Difference in Economic Value.....	10

1 Introduction

What is the best balance between low rates and high reliability? This is a central question that most electric utility managers struggle with. Although higher reliability increases homeowners' satisfaction and reduces business owners' economic losses due to power outages, it usually requires capital investments and increased O&M spending that eventually requires funding from increased rates.

Given this challenge, distribution utilities looking to increase reliability often consider whether to bury a power line underground. Construction costs associated with undergrounding are typically higher than those of constructing an overhead line. However, the increase in reliability, O&M cost savings, and aesthetics of underground lines should be considered.

This paper's objective is to provide a cost-benefit evaluation framework for underground power lines. Since each circumstance is different, PSE will not offer a "one size fits all" recommendation, but this report will offer some important insights which should not be overlooked when evaluating each individual situation.

Value-based planning methodology for distribution facilities assumes that consumers' preference for service reliability is measurable and that the measured preference can be used to set economically justifiable targets for distribution facility investments. For optimum reliability planning and investment decisions, it is essential to estimate the economic damages caused by service interruptions. Decisions should be made with the intent to maximize the aggregate welfare of all stakeholder groups.

The magnitude of economic damage caused by a given power outage at a utility will vary, not only among the customer classes but also at the substation and feeder levels. For example, a feeder serving primarily residential loads will typically have lower economic damage compared to a feeder serving commercial and industrial loads. These differences should be recognized in a proper cost-benefit evaluation framework.

Important inputs into the cost-benefit framework are:

- Initial investment costs of underground lines.
- Initial investment costs of overhead lines.
- Operation and maintenance (O&M) savings resulting from an underground line.
- Reliability value of the underground line compared to an overhead line mile.
- Aesthetic value to residents of underground versus overhead line miles.
- Safety issues related to underground and overhead power lines.

A cost-benefit framework is provided below. This framework attempts to answer the question of whether a line mile should be constructed underground or overhead.

Benefit or Cost	Present Value (2009 dollars)
Initial Investment Cost of the Underground Line Mile	\$U
Initial Investment Cost of the Overhead Line Mile	\$O
O&M Savings of the Underground Line Mile	\$S
Reliability Value of the Underground Line Mile	\$R
Other Considerations Regarding the Line Mile	\$C
Net Present Value of Undergrounding Decision (NPV)	$(O + S + R + C) - U$

If the net present value (NPV) of the undergrounding decision is positive, the decision should be made to underground the line. If the NPV is negative, the line should be constructed overhead. While the equation is straightforward, filling in the values for U, O, S, R, and C can be a difficult task.¹

Managers are typically well-suited to estimate the initial investment costs of an underground and overhead line-mile (items U and O in the cost-benefit framework). While it is generally understood that underground construction will cost more than overhead, these cost estimates will vary depending on utility-specific items such as customer density (urban, suburban, and rural), soil conditions, labor costs, design and construction techniques, vegetation, and, voltage and load levels. Managers will usually be able to make accurate estimates by factoring in these circumstances.

Thus, the following sections will discuss the items which are more challenging for managers to quantify, namely the O&M cost savings of underground lines, reliability impacts and their economic value, and other considerations. The final section offers a hypothetical case study of how a manager might go about determining whether a line-mile should be placed on poles or buried underground.

¹ Other input values include the proper discount rate, expected inflation, expected life spans of investments, and risk associated with future requirements and requests. In our case study in the last section, we assume a discount rate of 6% and an inflation rate of 3%. Underground lifetimes may be less than overhead's (30 years versus 50 years). However, this will not significantly impact the present value calculations. We will therefore eliminate this added complexity and assume the lifetimes are equal between underground and overhead lines.