

Benefit-Cost Analysis of Non-Wires Alternatives (NWAs): Reflecting Uncertainty in Electric Distribution System Planning

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ABSTRACT

Electric utilities typically make investment decisions based on point estimates from econometric forecasting models, yet these forecasts are necessarily uncertain, which may result in sub-optimal investment decisions if that uncertainty is not considered. In this paper, we show that failure to account for uncertainty may result in undervaluing non-traditional infrastructure investment and illustrate a model that correctly internalizes the value of non-wires solutions by accounting for expected value and option value through analogy and hypothetical examples. Traditionally, utilities have relied on deferral value, the economic benefit from delaying an investment in traditional ‘poles and wires’ infrastructure, to assess the financial viability of non-wires alternatives (NWAs), such as targeted deployments of energy efficiency, demand response, and distributed energy resources.

Deferral assumes a traditional investment will be deferred for a specific period of time if an NWA is deployed, usually based on a best estimate for local load growth, while deferral value is based on the avoided revenue requirement of a traditional investment. This paper applies the well-established economic concepts of expected value and option value¹ to move away from a single ‘best estimate’ for the length of time a traditional investment will be deferred and the size of the infrastructure need. The paper also describes a step-by-step playbook to help stakeholders looking to implement these concepts within their jurisdictions.

Applying an expected value framework allows distribution system planners to account for a range of potential future scenarios, including those where the traditional investment is avoided rather than deferred. Option value captures the flexibility to re-assess traditional investments over time as future scenarios become clearer, improving the economics of NWAs and reducing infrastructure costs for ratepayers.

Introduction: What Are Non-Wires Alternatives (NWAs)?

As demand, generation, and natural disaster risk change over time on an electric grid, issues such as capacity constraints, inadequate resilience, and frequency and voltage variation can threaten the reliability and stability of the system. System operators use forecasts to predict when and where these issues will arise on their systems and are expected to proactively address these issues before they negatively impact the grid. Historically, traditional infrastructure upgrades (referred to herein as ‘wires’ alternatives) such as enhancements to substations, transmission and distribution lines, or transformers have been the primary solutions considered

¹ See for example the body of economic work related to choice under uncertainty (e.g. as described in Mas-Colell, Whinston, and Green 1995; Kahneman et al 1982; and Burkett 2006). For a description specific to energy economics, see Bhattacharyya 2019.

(Lazar 2016). However, today, a larger variety of technologies and services such as energy efficiency, demand response, distributed generation, energy storage, and grid software and controls are widely available and can be cost-competitive with traditional infrastructure solutions. These alternatives are often referred to as “non-wires alternatives” (NWAs), but may also be described as “non-wires solutions” (NWSs) or “non-transmission alternatives” (NTAs) (E4TheFuture, PLMA, and SEPA 2018).

Compared to traditional infrastructure, NWAs can provide additional societal benefits such as reduced greenhouse gas emissions, improved energy security, lower energy cost burden for customers, and avoided transmission and distribution costs. The market opportunity for NWA projects is also continuing to grow, driven in part by mandates like those in California, Rhode Island, and New York that require utilities to consider NWA opportunities during grid planning (Frick, Price, Schwartz, Hanus and Shapiro 2021; Cooke, Homer, and Schwartz 2018). In 2020, over 320 NWA projects were documented in Wood Mackenzie’s U.S. NWA database, totaling approximately 850 MWs in identified or implemented NWA opportunities (Wood Mackenzie 2020).

However, Wood Mackenzie also reported that NWAs proposed in the U.S. only move forward about 40% of the time on average, with cost and reliability concerns acting as the primary barriers (Wood Mackenzie 2020). This finding – especially the fact that NWA costs are often reported as higher than traditional infrastructure investments even when common NWAs like energy efficiency are often touted as least-cost resources (ACEEE 2021) – encouraged this project team to closely review the NWA cost-benefit analysis (BCA) practices of several U.S. utilities and regulators.

In reviewing these BCA practices, we discovered a common failure to account for forecast uncertainty, which results in the undervaluing of NWA investments. After walking a reader through current distribution system planning practices, this paper then proposes a model and implementation playbook that corrects this undervaluing by capturing uncertainty to better compare the value of NWAs to wires alternatives using two established tools from economic analysis: expected value and option value.

Current Practice: Point Estimates of Grid Needs and Estimating Deferral Value

The objective of this section is to describe at a high-level how distribution system planning works and how NWAs are typically assessed for prudence. This process is summarized in Figure 1. The description below is general; in practice, there is some variation between utilities in how they model their distribution system, project needs, and determine solutions. Regulatory variation across states also means that there are different levels of visibility into such analyses and investment planning protocols.²

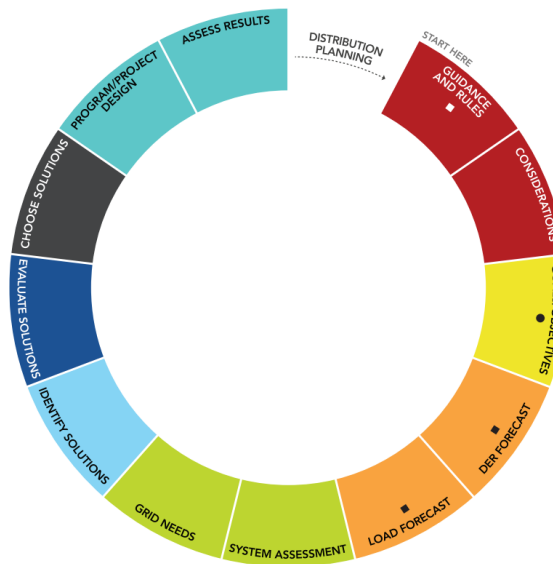
Current practice for distribution planning typically follows a common trajectory of analyses.³ First, the electric distribution company forecasts load growth out to 10-15 years. This

² The NARUC-NASEO Task Force on Electricity Planning maintains a thorough resource library on distribution system planning for interested readers (NARUC-NASEO Task Force n.d.)

³ For commonalities in distribution system planning, see NARUC-NASEO Task Force n.d. For a specific description of distribution system planning in Rhode Island, see National Grid n.d. *Rhode Island System Data Portal – Company Reports*.

forecast is typically done using an econometric model with covariates related to macroeconomics and weather or climate. The forecast is then adjusted for additional known changes, if any, and other factors like energy efficiency, demand response, renewable energy, and increasingly electrification of transportation and heating sectors. The result is a point estimate for electricity consumption at peak times based on certain extreme weather standards and estimated at an annual level for a relatively large portion of the electric grid (for example, by county or by defined electrical area).

Figure 1. Summary of distribution system planning steps.
Source: NARUC-NASEO Task Force on Comprehensive Electricity Planning 2021.

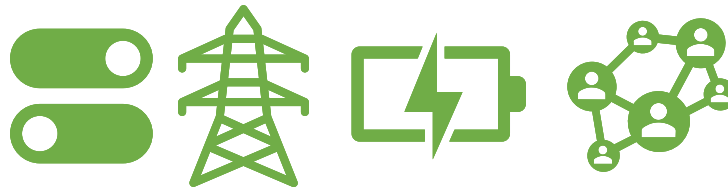


Next, this load and expected generation is input into distribution system modeling software, which uses pre-determined electrical and physical algorithms, and additional assumptions and inputs, to model how the electricity moves around the electric grid. Results of this modeling show when an issue arises on the electric grid, called a ‘violation’. A grid violation is any instance where grid conditions are not within predefined operating parameters. For example, a thermal violation occurs when the temperature of a conductor exceeds a range specified by the American National Standards Institute. A violation may be related to a handful of issues. If the modeling software sees that physical and electrical dynamics result in any parameter outside of a predetermined standardized range, then the modeling software will flag a violation.

Violations can potentially be resolved by a variety of changes including, but not limited to, re-routing electricity load using pre-installed switches (operational changes), physical investment in the electric grid to upgrade components (wires alternatives), strategic deployment of distributed energy resources (NWAAs), or demand-side incentives to reduce electricity demand

(pre-emptive outreach for energy efficiency and demand response). These types of solutions are summarized in Figure 2.⁴

Figure 2. There are at least four types of targeted solutions for grid needs: operational changes, investments in the equipment that comprises the electric distribution system, NWAs, and pre-emptive outreach to increase customer adoption of distributed energy resources in strategic locations.



Such solutions are then filtered based on technical and economic screens. First and foremost, a solution must resolve the problem in a way that is safe and reliable. Then, among all safe and reliable solutions, electric distribution companies can choose the solution or set of solutions that is the most economical. Determining economic value entails making two comparisons. First, the non-wires solution must be less costly than the value of deferring or avoiding the wires alternative. Second, the NWA should ideally have more benefits than costs, or at least a better benefit-cost ratio than other alternatives. The benefit-cost assessment entails a comparison of costs (e.g. upfront costs, maintenance costs) to benefits (e.g. cost savings); however, there is variability in how narrow or broad these costs and benefits may be. Each jurisdiction is likely to develop its own jurisdiction-specific test (JST) that may, at its narrowest, only consider those costs and benefits that are incurred by or accrue to the utility system. At its broadest, a JST may also include costs and benefits that occur to society writ large, such as environmental benefits and economic development benefits, among others (National Energy Screening Project (NESP) 2020).⁵

Importantly, comparing costs and benefits across a menu of option(s) requires making assumptions about the longevity of each option. In the case of non-wires alternatives, one might assume that investing in the non-wires alternative today defers a larger wires investment for some finite number of years. The benefits of this deferral – commonly referred to as deferral value – can be quantified based on the amount of revenue requirement that is saved by putting off the larger investment.

⁴ Figure 2 summarizes solutions that have traditionally been considered within a utility’s control or sphere of influence. However, other solutions such as local policy changes (e.g., zoning or ordinance changes) may be equally as effective.

⁵ For more information on benefit-cost analyses used for utility applications, we refer interested readers to the National Standard Practice Manual: <https://www.nationalenergyscreeningproject.org/national-standard-practice-manual/>

But What if Projected Grid Needs or Assumptions about Deferral Value are Incorrect?

Critically, the general process described above presumes deterministic modeling⁶ even though actual load growth is very much subject to stochasticity and statistical imprecision. We can infer some probability that load growth will be more or less than what is forecast in the point estimate. These probabilities should inform an ‘expected valuation’ that better characterizes the likely level of investment. Current practice’s philosophical difference in modeling approach may obscure critical insights about the electric grid which then risks sub-optimal investment levels and sub-optimal action portfolios.

Furthermore, there is value to preserving all choices until additional insights have been uncovered, called ‘option value’. The past several decades have seen relatively little change in how our electric grid needs to function, but the next few decades are likely to bring drastic changes with two-way power flow and substantial load growth. Simply buying time to see whether these changes manifest is of value. Failing to account for this option value will result in sub-optimal investment, particularly in non-wires alternatives that are nimbler than wires solutions.

Rhode Island: A Foundation for Applying Expected Value and Option Value

The State of Rhode Island’s primary investor-owned electric distribution company has collaborated with regulators and stakeholders to develop a model process for fairly assessing the viability of non-wires alternatives. This defined process provides the necessary foundation for exploring further improvements, like integrated concepts of expected value and option value. Specifically, this electric distribution company incorporates four notable features into its process.⁷

First, there is a single group within the electric distribution company that is responsible for distribution planning. This ensures that all grid needs are determined holistically and comprehensively, and that all grid needs are reviewed for the potential of non-wires alternatives through a pre-set and regulator-approved set of filters, the second notable feature of this process. These filters include type of grid need to be resolved (currently, only system capacity issues can be addressed with non-wires alternatives within this process; things like replacement due to asset condition cannot), total load mitigation need (if the amount of load mitigation is too large, then there are few non-wires alternatives the electric distribution company will consider reliable), and total anticipated cost (too small of a cost has been shown to result in little interest from the market of third-party solution providers). These filters attempt to remove subjective assessment

⁶ As defined in the 2005 Encyclopedia of Social Measurement, “Deterministic models assume that known average rates with no random deviations are applied to large populations... In stochastic models, in contrast, there are random variations due either to uncertainties on the parameter or to small population sizes for which it may not be reasonable to apply average rates” (Artzrouni 2005).

⁷ For more details on Rhode Island’s non-wires assessment process, we refer readers to National Grid’s non-wires alternatives webpage (National Grid n.d.)**Error! Hyperlink reference not valid..** For more details about Rhode Island’s regulatory review of non-wires proposals, we refer readers to the Least-Cost Procurement Standards (State of Rhode Island Public Utilities Commission 2020).

of grid needs and allow non-wires alternatives to be considered for all grid needs that pass screening.⁸

Third, the electric distribution company is technology agnostic. If a grid need passed screening and is deemed to potentially have a viable non-wires alternative, then the electric distribution company issues a public request for proposals that does not specify a distinct technology. Instead, bidders can propose any technology – or combination of technologies – it feels it can justify as safe, reliable, technically viable, and economically feasible (i.e. less costly than the wires alternative). Being technology agnostic is important because it allows the competitive market to innovate on solution sets, which may result in lower costs for ratepayers.

Finally, the State of Rhode Island follows a societal benefit cost assessment that is open to including additional costs and benefits as they can be defined and quantified or qualified.⁹ This benefit cost framework allows stakeholders to identify gaps and improve comprehensiveness of the assessment.¹⁰

Together, the elements of this distribution planning process provide the necessary foundation to not only consider non-wires alternatives, but to precisely estimate their true value.

What’s missing from Current Practice: Accounting for Uncertainty¹¹

Current practice fails to properly account for two types of uncertainty: uncertainty in projected load growth and uncertainty in how long wires solutions may be deferred.

A case in point is the example of Rhode Island’s non-wires alternative pilot, which held the express goal of reducing 1 MW of electric load in order to defer a \$13M substation upgrade. This pilot project was pursued in multiple stages. From 2012-2017, the electric distribution company offered enhanced incentives and increased outreach for certain energy efficiency and demand response measures, developed a utility-scale solar project, and in partnership with the state energy office offered an enhanced incentive for rooftop solar PV that faced West such that production better coincided with peak demand (Cadmus 2018). At the end of the pilot only about a third of the peak load reduction goal was achieved, illustrated in Figure 3 below (Opinion Dynamics 2018).

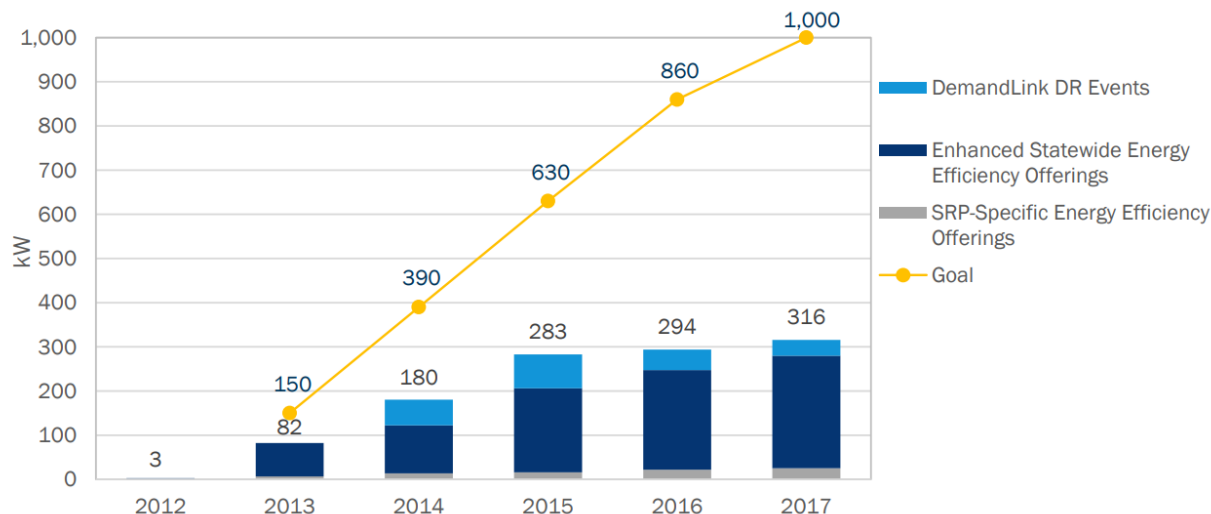
⁸ Since these screens and filters are implemented by human decision-makers, they are inherently subject to heuristics and biases. For more discussion, we refer interested readers to Kahneman et al 1982 and Camerer, Lowenstein, and Rabin 2004.

⁹ We refer interested readers to Docket 4600 of the Rhode Island Public Utilities Commission generally and Order 22851 specifically for more information about Rhode Island’s benefit-cost framework, development, and application (State of Rhode Island Public Utilities Commission 2018)

¹⁰ A fifth notable feature is Rhode Island’s revenue decoupling statute, which requires ‘An annual infrastructure, safety, and reliability spending plan for each fiscal year and an annual rate-reconciliation mechanism that includes a reconcilable allowance for the anticipated capital investments and other spending pursuant to the annual pre-approved budget’ (Rhode Island General Laws 2016). This feature is important because it is one avenue of visibility into the solutions examined. For jurisdictions without such a requirement, regulatory oversight may be able to influence a utility’s process for assessing non-wires alternatives through prudence review of cost recovery proposals.

¹¹ Beyond accounting for uncertainty, there are a variety of other issues for NWAs that are not addressed in this paper. To learn more about these other issues we refer interested readers to the following resources: (E4TheFuture, PLMA, and SEPA 2018; Prince, Waller, Shwisberg, and Dyson 2018)

Figure 3. Cumulative Load Impacts Compared to Goal



The figure shows the gross impact of a non-wires alternative pilot in Rhode Island. *Source:* Opinion Dynamics 2018.

In 2018 and again in 2019, the electric distribution company went out to procurement for a third-party provided non-wires alternative. Both procurements were ultimately unsuccessful. However, between 2012 and 2019, a combination of unrealized load growth and naturally occurring adoption of solar PV remedied the projected capacity constraint, and the electric distribution company was able to defer the substation upgrade for a substantially longer period.

There are two takeaways from this example. First, in its cost comparison, the electric distribution company compared the cost of the non-wires alternative to the deferral value of the substation upgrade – implicitly embedding the assumption that the substation upgrade would absolutely be needed in the foreseeable future. Had the electric distribution company factored in a non-zero chance of lower load growth, and therefore longer-term or permanent deferral of the wires alternative, the deferral value of the substation upgrade would have been larger, making more non-wires alternatives economically feasible. Applying the concept of expected valuation here could remedy this short-coming by including a non-zero probability of long-term or permanent substation deferral within the analysis.

Second, buying time allowed for conditions to evolve such that the electric distribution company had more certain information from which to model distribution system needs. However, the electric distribution utility failed to account for the value of preserving the option to forego the wires alternative in its benefit-cost analysis; if it had done so, nimbler solutions like non-wires alternatives would have been assessed as being more cost-beneficial than they otherwise were. Applying the concept of option value here could remedy this short-fall by including a non-zero estimate of the value of keeping future options open.

Infrastructure Planning with Uncertainty in Mind: A ‘Concrete’ Example

An example from a non-energy infrastructure investment decision helps with the intuition around why it can be beneficial to proactively plan with uncertainty in mind. The 2019 article, *Adaptation thresholds and pathways for tidal flood risk management in London*, published in *Climate Risk Management* by Hall, Harvey, and Manning reviewed the decision-making process for investing in a new levee for the Thames River in London, England. The challenge facing the infrastructure project planners was the high degree of uncertainty regarding the future average water level of the Thames. Climate models showed a range of possible water levels over the coming decades, which would demand levees of varying heights to hold back the water and keep London and its surrounding areas safe from flooding. For our purposes, let’s consider two possible future water levels, ‘high’ and ‘low’. If the planners knew with certainty that the future water level would be ‘low’, they would naturally choose to build a modestly sized levee with relatively low-cost, no taller than needed to ensure low water levels don’t leave the river channel. Conversely, if the planners knew with certainty that the future water level would be ‘high’ the planners of course would want to build a larger levee at a greater cost to avoid flooding even with high water levels.

Since the future water level is uncertain, the planners were faced with a choice in which significant risks seemed unavoidable at first glance. After all, if they build a smaller, less expensive levee and the water levels turn out to be high, lots of homes and businesses might be subjected to dangerous and costly flooding in the future – or, equally bad, the planners might have to tear down the small levee and build the big levee in the future at significant expense. Conversely, if they build a large, expensive levee and the water level turns out to be low, they will have wasted significant resources. In either case, the planners seem forced to risk incurring unneeded costs for society.

However, in the case of the Thames River levee, planners came up with a clever third option. They elected to pour a foundation large enough to support a large levee, but put up a smaller, less expensive levee wall. Though this option was undoubtedly more expensive than a small levee with a small foundation, it was also certainly cheaper than the large levee. Critically, the choice to invest a bit extra today in a large foundation also enabled the planners to avoid



[This wall](#) is part of the Thames river levee system.

either of the pitfalls summarized above. After all, thanks to the large foundation, they can always just add to their small wall if the water level turns out to be high in the future.

Choosing to build a large foundation in this example provides the same service to planners as investment in a non-wires alternative that defers a more costly wires investment – it gives the planners the flexibility to respond in the future once they have more information, and the future becomes less uncertain. The comparison is particularly apt in the sense that the planners in both cases are spending some additional money today to avoid higher-cost outcomes.

The specific parallel between the levee and a non-wires alternative is this: building a large foundation today (selecting a non-wires investment over a potential wires investment) leaves open two future scenarios, one in which the planners still build the larger wall, but at a later date (the ‘wires’ investment is deferred but eventually still implemented) and one in which the larger wall never turns out to be necessary (the ‘wires’ investment is permanently deferred, which is to say it is entirely avoided). Additionally, a poor outcome is removed from the set of possibilities: a larger-than-necessary levee wall is constructed, since water levels turn out to be ‘low’ (the wires investment is made but the forecasted grid need fails to materialize).

Better Practice: Expected Valuation

The intuition from the prior section is straightforward enough: if planners make investment decisions today with uncertainty about the future in mind, they can often reduce costs. This sounds great in principle, but how can a distribution system planner explicitly consider uncertainty? The economic concept of expected value is a great place to start.

Expected valuation is a framework in which different possible future scenarios are defined as part of setting up a planner’s decision-making process. Each scenario is then assigned a probability – think of this as the percent chance that that particular scenario comes to pass – and assigned a value, typically in terms of the present value of the net benefits that are expected to accrue in that scenario¹². The expected value is calculated as the probability-weighted average of the values across all scenarios. As shown in the equation below, expected value is equal to the sum of the value of each scenario multiplied by the probability of that scenario, for all scenarios. Note that probabilities must sum to unity.

$$\text{Expected Value} = \sum_{\text{scenario } 1}^{\text{scenario } S} \text{value}_i * \text{probability}_i$$

Let’s continue with the simple distribution planning example that was illustrated above; namely, that there are two possible outcomes for a distribution system need for which a NWA investment is being considered: the wires investment is deferred but eventually installed, or the wires investment is permanently deferred and so entirely avoided. A simple numeric example is illustrated in Table 1.

¹² Investopedia has an approachable introduction to the topic of calculating net present value using cash flow examples: <https://www.investopedia.com/ask/answers/032615/what-formula-calculating-net-present-value-npv.asp>

Table 1. Example of two-scenario expected value calculation

	Probability of Scenario	Net Present Value (NPV)	Probability Weighted NPV
Wires Investment Deferred	80%	\$1,000,000	\$800,000
Wires Investment Avoided	20%	\$1,500,000	\$300,000
		Expected Value	\$1,100,000

Probability weighted net present value (NPV) is determined by multiplying the net present value by the probability of a given scenario. Expected value is calculated by adding all probability weighted net present values. Note that all probability of scenarios must sum to 100%.

In this example, a hypothetical distribution planner knows that if their wires investment is deferred, the net present value will be \$1,000,000, whereas if the wires investment is entirely avoided, the net present value will be \$1,500,000. However, the distribution planner also thinks there is an 80% that investing in a non-wires alternative today will result in a deferral. If that system planner is operating in the current paradigm that relies on a single ‘best estimate’ future scenario, the planner will understandably select this relatively high probability scenario as their best estimate, and consequently plan as though a non-wires alternative is anticipated to produce \$1,000,000 in benefits from deferring the wires investment. However, this approach ignores the scenario in which the wires investment is entirely avoided – the best possible outcome of the non-wires investment!

If the system planner is instead operating in an expected valuation framework, they will appropriately consider the scenario in which the wires investment is entirely avoided, and perform the expected value calculation shown in Table 1. This system planner would then plan as though a non-wires investment is anticipated to produce \$1,100,000 in expected net benefits from either deferring or avoiding the wires investment. In practical terms, this means that the total cost of the non-wires alternative can be up to \$1,100,000 and still produce positive net benefits, a 10% increase in the range of costs for non-wires proposals that should be supported by the system planner.

Another way to think about the current planning paradigm is that it assigns a probability of 0% to all scenarios but the ‘best estimate’ scenario. By choosing not to consider the expected value of all scenarios, a system planner might incorrectly choose not to invest in a non-wires alternative that would be expected to produce net benefits, and instead default to a wires solution that would ultimately result in higher costs to ratepayers.

Defining the Scenarios to Include in your Analysis

We can build from the current practice for NWAs, which estimates the deferral value for an NWA based on the number of years for which a wires alternative will be deferred. It is conceptually straightforward to define each possible deferral length as a different scenario, up to and including permanent deferral. In practice it is not necessary to define an arbitrarily large number of scenarios to benefit from using an expected valuation framework to explore uncertainty around deferral length. We suggest starting by choosing no more than a handful of deferral lengths, including at a minimum the best estimate deferral length and permanent deferral, and determining the appropriate total number of scenarios to consider based on the specific needs and data availability of the particular system need in question.

Assigning a Value to Each Scenario

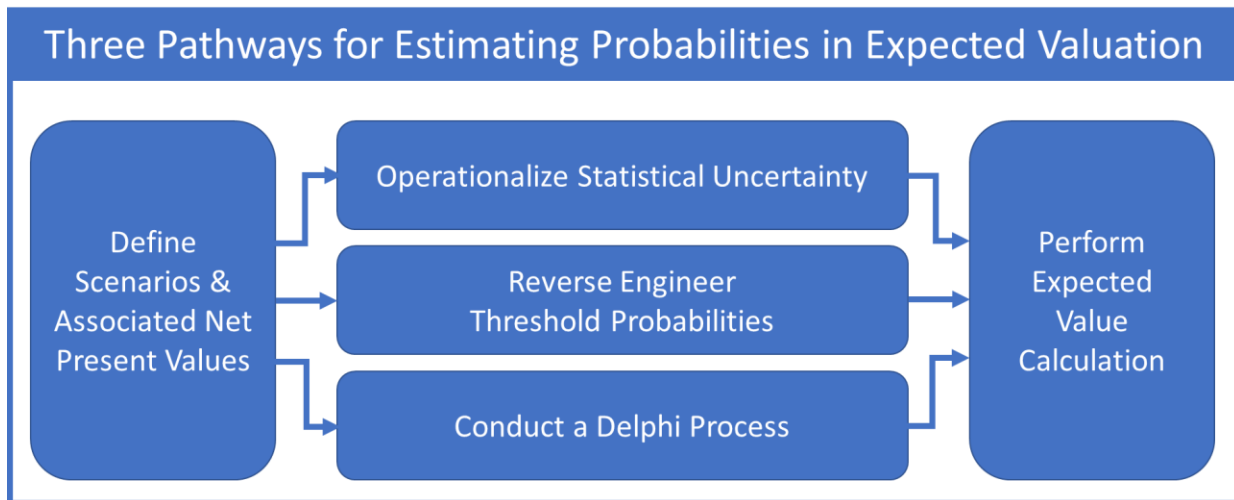
The specific set of benefits and costs to consider in assigning a specific value to each scenario in consideration are of course dependent on the regulatory framework and policies in the jurisdiction where a non-wires alternative is being considered, and so are beyond the scope of this paper.¹³ Once the benefits and costs to consider are determined, they need to be analyzed to determine a single net present value for each scenario. Because the financial calculations for discounting future costs and benefits are well established, we will not cover them in this paper.¹⁴

Assigning a Probability to each Scenario

Before providing a review of several methodological starting points, we wish to remind the reader that the current approach to distribution system planning already does assign a value to all but one scenario – zero percent! The fact that this decision is implicit makes it no less real. This fact also establishes a yardstick with which to measure other approaches to estimating these probabilities: we do not need a perfect method, just one that is superior to assigning a zero percent probability to all but one possible future scenario.

With that in mind, we briefly review three pathways for assigning probabilities, as shown in Figure 4. First, drawing upon measured statistical uncertainty in the econometric and distribution system models used to identify grid needs, such as load growth forecasts; second, relying on known information about wires and non-wires investment options to reverse engineer key ‘threshold’ probabilities which can then be assessed for reasonableness; and third, surveying experts, such as through the use of a Delphi panel.¹⁵

Figure 4. Three Pathways for Estimating Probabilities in Expected Valuation



¹³ See footnote 2 for a reference to the National Standard Practice Manual which provides further valuation guidance.

¹⁴ See footnote 6 for a simple introduction to discounted cash flow accounting and net present value calculations.

¹⁵ A Delphi process is a consensus-building survey tool used to estimate uncertain or contentious values. A thorough description of a Delphi process is included later in this paper.

Pathway 1: Operationalize Statistical Uncertainty. Utilizing statistical uncertainty to inform an expected valuation comparison could take many forms and should depend on the specifics of the forecasting methodology in question, as well as the specific system need for which solutions are being contemplated. Proposing a specific conversion from statistical uncertainty to estimated probabilities for an expected valuation calculation is thus beyond the scope of this paper. However, this is a ripe opportunity for future methodological refinement. An illustrative example might be using the results of several predictive scenario analyses of a regression model. A base case scenario might utilize the specific point estimates for regression coefficients, while a low case might set one or more key coefficients at two standard deviations below the point estimate, and a high case might set each at two standard deviations above the point estimate. Similarly, it is possible to retain the point estimates of the coefficients while exploiting the quantification of uncertainty in the predictive inputs used for forecasting. For example, an analyst could exploit uncertainty in forecasts of future economic growth rates or utilize the variability around average weather conditions.

Regardless of the specific approach, if only a few scenarios were examined, this could inform whether any scenarios result in a load forecast low enough to generate a permanent avoidance of the wires solution, and therefore inform whether assigning a probability of 0%, as is the current practice, is reasonable. In contrast, with a sufficiently large number of appropriately defined scenarios, the fraction of results in which the load forecast is sufficiently low to generate a permanent avoidance of a wires solution could be used as a proxy for the probability that the non-wires alternative will result in a permanent avoidance¹⁶.

Pathway 2: Reverse Engineer Threshold Probabilities. In an exercise conceptually similar to the first of the two approaches discussed above, but with lower data demands, it is possible to reverse engineer the threshold probability of permanent avoidance by exploiting the known (or expected) difference between the total costs of the traditional wires investment and the costs of a particular non-wires alternative. By arranging a simple expected value calculation similar to that presented earlier in this paper and manually varying the probability of permanent avoidance, an analyst can discern the threshold probability above which the non-wires investment provides the higher expected net present value, and below which the wires investment is preferred. Expert judgement would then be needed to determine if that threshold probability was realistic. A simple decision rule might be that if all experts consulted agree the real probability of permanent avoidance is above the threshold, then the NWA is preferred, and if the experts agree that the real probability is below the threshold, the wires investment is deferred. In fact, a Delphi process could be one way of obtaining the expert judgement needed to operationalize this approach.

Pathway 3. Conduct a Delphi Process. A Delphi process is a consensus-building survey tool used to estimate uncertain or contentious values. Conducting a Delphi process entails sending the same survey to each participant or a panel of experts. Each participant then fills out their best estimates for each survey question and gives some indication of their reasoning. The survey manager then compiles all answers together and sends the compiled answers along with the

¹⁶ This process for estimating the probability of avoidance is essentially a form of Monte Carlo simulation, where various inputs to the predictive model that identified the system need (such as a load growth forecast) are set at different levels, informed by the quantified uncertainty in those inputs, to generate a large number of outcomes and assess their distribution.

survey back for a second round. In this round, each participant has the opportunity to adjust their responses based on the responses and reasonings of the other participants. The survey is done anonymously, so that the loudest voices do not have disproportionate influence on the other members of the panel. The idea is that, after two or three rounds, the answers from each participant will converge on a consensus estimate.

In our proposed application, a distribution system planning manager may send such a survey to distribution system planning engineers and/or other subject matter expert stakeholders to build consensus around probabilities of various lengths of deferral or permanent avoidance, or to answer the reasonableness question asked as part of Approach 2.

Playbook: How Do You Start Doing This?

A variety of stakeholders may wish to advance the use of expected and option value in their evaluation of non-wires alternatives. The following steps and resources are recommended for those looking to jumpstart conversations with their utilities and/or regulators.

Step 1. Review your jurisdiction’s current practices for identifying opportunities for non-wires alternatives and evaluating the economics of non-wires investments relative to wires investments. You may be able to find an example benefit-cost assessment by reviewing infrastructure investment dockets and/or grid planning dockets at your state’s public utilities commission (PUC) or public service commission (PSC). Commissions may also be able to point you to relevant standards or regulations governing economic analyses of investment portfolios.

When reviewing benefit-cost analysis examples or governing standards and regulations, these questions may help determine if expected value and option value are being incorporated:

- Are probabilities of more than one future state presented?
- How is uncertainty shown or described for the input assumptions and results?
- Is there a discussion of how uncertainty may change over time or with more data?

Step 2. Make sure that all relevant stakeholders are aware of the benefits of using expected value and option value. Relevant stakeholders may include local utilities (especially forecasting teams, system planning teams, energy efficiency teams, demand response teams, and grid operations teams), regulatory staff, consumer advocates, state energy offices, distributed energy resource solution providers, and environmental organizations.

Step 3. Advocate to test an expected value and/or option value approach during the next non-wires alternative screening process or infrastructure investment regulatory proceeding. Make sure the results are presented in a public forum so others can learn from the experience.

If screening for a non-wires opportunity is already underway, the following questions may help to encourage the use of expected value and option value:

- By how much does a critical input assumption (such as projected load growth) have to change to eliminate or significantly change the forecasted grid need?
- Is there a possibility that a critical input assumption (such as projected load growth) turns out to be wrong? Can this uncertainty be incorporated into the analysis and results?

- Will input uncertainty diminish with more time or more data? If so, how is the value of decision-deferral incorporated into the benefit-cost analysis?

Note that the use of expected value and/or option value may not change which investment is selected, but both will likely showcase how forecast uncertainty can have a significant impact on non-wires alternative value estimates.

Step 4. Encourage regulators to update guidance for utility benefit-cost frameworks such that expected and option valuations are utilized, and analysis outcomes are compared with the jurisdiction’s previous approach.¹⁷

Future Consideration: Option Value

Option value can be defined in loose terms as the value associated with keeping your options open by choosing not to undertake an irreversible or highly costly decision today. Since the choice to invest in electric infrastructure certainly fits this description, it follows that the concept of option value can be brought to bear. There are a few different flavors of option value that exist in the environmental economics literature, but for this paper we will adhere to a single version, often referred to as quasi-option value (hereafter ‘option value’).¹ A full elucidation of the application of option value in the same manner as we have presented the application of expected value is beyond the scope of this paper but may be a fruitful further development of this framework.

In brief, option value derives from the fact that delaying an irreversible decision until more information is available allows a decision-maker to choose more optimally and under reduced uncertainty. In the context of the expected valuation framework presented in this paper, the option value quantifies the financial benefit from a non-wires alternative *deferring the decision* regarding whether to pursue the traditional wires investment into the future until such time as the uncertainty around future conditions may have been reduced or resolved. This ensures that the utility system planner can either pursue or not pursue the wires alternative with confidence. Harkening back to the River Thames levee example, pursuing a non-wires alternative can act much like the choice to invest in a large foundation with a small levee wall – it can be cheaper than the alternative and keep your options open in the future.

Conclusion: Expected Valuation is Likely to Help

To paraphrase Nobel Laureate physicist Neils Bohr, forecasting is hard, especially about the future of electric load growth. Current approaches to benefit cost analysis of non-wires alternatives resolve the inherent uncertainty about future system needs by selecting a best estimate and treating it as a guaranteed outcome. As shown by the illustrative analysis in this

¹⁷ In some jurisdictions, similar steps may be applicable for bringing expected and option value concepts into non-pipe alternative (NPA) discussions for natural gas distribution.

paper, using an expected valuation approach can enable system planners to explicitly account for a range of possible future scenarios, improving the realism of the analysis. If implemented with realistic scenarios, net present values, and probabilities, this approach is likely to help system planners select the least (expected) cost solution to anticipated system needs, and ultimately reduce costs to ratepayers. In some scenarios, the implementation of non-wires alternatives may also direct more benefits back to ratepayers in the form of investments in energy efficiency, demand response incentive programs, and even residential solar rooftop installations.

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