**COST-BENEFIT FRAMEWORK**

**Introduction**

**Cost-Benefit Framework Scope and Objectives**

In the Commission’s Order, the Collaborative was tasked with developing cost-benefit concepts to be applied to smart grid investments. Language in the Order asks for recommendations on the definition of “methods of estimating, calculating and assessing benefits and costs, including evaluation of non-quantifiable benefits (and costs).” Based on its understanding of the Order, the Collaborative agreed on the following objective: to develop a standardized cost-benefit framework for proposed smart grid investments so that future debates about the cost-effectiveness of potential smart grid investments in Illinois can center on the reasonableness and supportability of estimated costs and benefits rather than the methodology for conducting cost-benefit analysis. Therefore, the emphasis of the Collaborative has been the development of a methodology and guidance for conducting an analysis rather than actual evaluation of potential smart grid investments.

Specifically, the Collaborative tried to answer the following questions:

* + How should the Commission analyze and evaluate the cost-benefit of smart grid investments?
	+ What costs and benefits should be included in the analysis – and how should costs and benefits be captured?
	+ How should the analysis be structured?

**Traditional Cost-Benefit Principles and Guidelines**

Cost-benefit analysis is usually concerned with estimating and summing the equivalent value of the benefits and costs of investments to establish whether they are prudent and worthwhile on an economic basis from a single point of view or perspective. The process generally involves determining the cost of the investment (including both the initial investment and ongoing expenses) and comparing this cost to the expected benefits from the investment. Typically, the following steps are used to reach a conclusion:

* + All factors or variables potentially having an impact (positively or negatively) on the investment are identified. An estimate or assumption is made as to the amount of impact each variable is expected to have on the project – sometimes called the “quantification” of variables.
	+ All aspects of the investment must be expressed in common terms – the most usual being monetary. The process of taking the quantitative impact of each factor or variable and converting into equivalent monetary value is sometimes called “monetization.” This conversion into equivalent monetary terms involves accounting for the time value of money – usually by converting the future expected streams of costs and benefits into a present value amount via a discount rate. In financial calculations, the discount rate is sometimes equal to the entity’s weighted average cost of capital (WACC), representative of the market rate of return for the mix of financial assets the entity uses to finance capital investment (capital structure).
	+ Calculations of multiple valuation measures can be performed to emphasize different aspects of the financial profile of the investment. Some of the most common are:
		- Payback Period – the period of time required for the return of and on an investment to "repay" the cost of the original investment.
		- Breakeven Point – the point at which cost or expenses and revenue are equal and there is no net gain or loss. This is often expressed in terms of units sold in a production environment in which there are fixed and variable costs.
		- Net Present Value (NPV) – the difference between the present value of cash inflows and the present value of cash outflows over a defined period, at a given interest rate. In calculations for most corporate decision-making, the cost of capital expected to support the investment is used as the interest (or discount) rate.
		- Internal Rate of Return (IRR) – the discount rate that makes the net present value of all cash flows from a particular investment equal to zero. In contrast with NPV, which is an indicator of the magnitude of the investment return, IRR is an indicator of the efficiency or yield of an investment.
		- Benefit-Cost Ratio – the ratio of the present value benefits of an investment to its present value costs.
	+ Since capital is often constrained (i.e., entities have insufficient resources to invest in every attractive project), investments are often compared in a capital budgeting process before final investment decisions are made. Quantitative as well as qualitative factors (e.g., fit with strategy, public policy issues) typically factor into the capital budgeting decision.

**Cost-Benefit within the Context of Smart Grid**

Certain challenges arise when attempting to apply traditional cost-benefit analysis to a proposed smart grid investment. Some of the key ways in which evaluation of the costs and benefits of smart grid investments can be different from traditional investment analyses include:

* + All costs and benefits related to smart grid may not be borne or realized by the investing entity. This raises questions such as: should these additional costs and benefits be incorporated into the analysis? If so, then how (in practice) this multi-entity perspective be modeled in the analysis?
	+ Uncertainty with respect to the magnitude of benefits is not unique to smart grid. However, there are some potential benefits associated with smart grid (e.g., reliability value, environmental impact) that present particularly difficult issues in calculating the level of benefit.

Over the past few years, there have been various models and constructs put forth related to evaluating smart grid investments. A review of several of the most prominent revealed that there was no single reference that adequately addressed all of the concerns identified within the scope of the ISSGC cost-benefit framework. However, the following references as well as other relevant state regulatory decisions that have addressed these and other similar issues can provide considerable insight into smart grid cost-benefit analysis and are worthy of note.

* + EPRI published a report in January 2010 on an approach for evaluating the DOE’s Smart Grid Demonstration Projects.[[1]](#footnote-1) It leverages many studies that have been performed previously and represents the most comprehensive approach to smart grid cost-benefit analysis put forth to date. The ten-step approach outlined in the report can be applied generically to most smart grid investments, but the discussion within each of the steps focuses on issues specific to smart grid. The ten steps are organized into three groups as follows:
		- * 1. Characterize the Project: review project elements; identify smart grid functions associated with the project; assess the characteristics that are reflected in the project;
				2. Estimate Benefits: map each function onto a standard set of benefits; define the project baseline and how it will be estimated; identify and obtain the data necessary; quantify the estimated benefits; convert the benefit estimates to monetize the values;
				3. Compare Costs to Benefits: estimate the relevant costs; compare costs to benefits and summarize the cost-benefit.
	+ Several other studies and reports address specific aspects of smart grid analysis. Each of the following is particularly useful within its respective scope:
		- McKinsey & Company developed a spreadsheet model for comparing the costs and benefits of AMI and made it available to energy providers, regulatory commissions, customer advocacy groups, and AMI vendors in August 2006 to assist in analyzing AMI deployments.[[2]](#footnote-2) The model captures user inputs regarding the expected capital costs and utility O&M savings and calculates the resulting cash flows, NPV, and IRR. While useful in tracking costs and benefits for operational impacts in the AMI context, it is not directly applicable to many smart grid applications, since it does not incorporate costs or benefits associated with demand response, reliability, or societal benefits.
		- California Energy Commission sponsored study on the value of distribution automation.[[3]](#footnote-3)
		- EPRI published a report on societal benefits of smart metering.[[4]](#footnote-4)
		- Lawrence Berkeley National Laboratory published a report for the DOE’s Office of Electricity Delivery and Energy Reliability on the value of service reliability.[[5]](#footnote-5)
		- Brattle Group published a report for PJM and the Mid-Atlantic Distributed Resources Initiative (MADRI) on quantifying demand response benefits in PJM.[[6]](#footnote-6)
	+ The following four sections describe the Collaborative’s recommended Cost-Benefit Framework for smart grid investments and provide related recommendations on the use of the Cost-Benefit Framework
		- Elements of the Framework and General Requirements
		- Cost-Benefit Analysis Mechanics and Assumptions
		- Quantification and Monetization of Costs and Benefits
		- Monitoring and Verification of Results

**Elements of the Framework and General Requirements**

This section describes the overall structure of the recommended cost-benefit framework for the economic evaluation of smart grid investments, including an identification of the basic “building blocks” of the framework. The section also provides some general recommendations to the Commission on how the framework should be used.

**Use of the Cost-Benefit Framework.**

The cost-benefit framework described in this section is intended to apply to smart grid investments only. The framework is not intended to exclude investment in pilot projects whose purposes include substantiation of cost-benefit estimates. Although smart grid investments may differ in the specific kinds of estimated costs and benefits they include, the Collaborative has attempted to define a construct that is sufficiently robust and flexible to support the evaluation of all smart grid applications. The cost-benefit framework can provide the structure for an economic evaluation of a proposed smart grid investment or of smart grid investments already made. Finally, the Collaborative has not provided recommendations on the controversial issue of cost allocation. Allocations for the purpose of recovering costs may or may not be subject to a different methodology from that used for projecting costs and benefits.

**Building Blocks**

The major elements or “building blocks” of any cost-benefit analysis, including this cost-benefit framework, are the estimated costs and benefits associated with the investment and the discount rate used to calculate the present value of future cost and benefit streams. The following sections provide a generic description of the elements of the cost-benefit framework; however, it should be noted that the specific costs and benefits used to evaluate an investment will vary by investment and by the perspective of the analysis.

***Estimated Costs***

Consistent with standard accounting practices, costs generally can be expected to fall into the following categories:

* + Capital (changes in capital spending)
		- Hardware
		- Software
		- Labor
			* Installation
			* Software integration
	+ O&M (changes in on-going direct/indirect support costs associated with ongoing maintenance and operation of capital investments)
		- Labor
		- Software
		- Hardware
		- Service agreements
		- Consumer education
		- Program administration
	+ Stranded costs that may be created by the investment
	+ Potential negative impacts
		- Customer, including negative impacts on customer privacy, customer safety, customer equipment, or customer costs
		- Technology, including risks and costs resulting from increased reliance and dependence on digital technologies
		- Employee and Public Safety
		- Utility Operations, including potential increases in undetected energy theft, legal costs, or customer care costs.

***Potential Benefits***

Potential sources of benefit may be categorized according to the entity that would initially and directly realize the benefit. These categories include:

* + Customer Value – potential benefits realized by individual electricity consumers in Illinois, including reductions in customer costs for electric delivery service and energy supply service, and decreases in outages and improved power quality
	+ Utility Value – potential benefits realized by state jurisdictional distribution or transmission providers, including reductions in operating costs, reductions and/or deferrals in capital spending, increases in system reliability, and improved employee safety.
	+ Regional Electricity Market Value – potential benefits observable in regional wholesale electricity markets. This could include reductions in price volatility, reductions in the prices of energy supply and capacity resulting from changes in the magnitude or timing of electricity demand and deferrals or reductions in transmission and generation investment.
	+ RTO/ISO Value – potential benefits to the regional transmission operator or independent system operator. This could include increased regional system reliability grid stability, improved situational awareness, improved forecasting, and improvements to the settlement process
	+ Competitive Supplier/Third Party Value – potential benefits to alternative retail electric suppliers, non-state jurisdictional entities, and other third parties
	+ Societal Value – potential benefits realized by society as a whole, not necessarily Illinois electricity consumers (e.g., environmental benefits, improvements to public health/safety, economic development, and improvements to or the expansion of broadband communications networks).

***Discount Rate***

Smart grid applications, like other investments, can be expected to require upfront capital investments and additional on-going support for future capital and operations and maintenance (O&M) spending.  The realization of benefits may occur gradually and over extended time periods.  (Specific considerations for the appropriate time horizon for the analysis are described elsewhere in this chapter.)  Therefore, all cost-benefit analyses in support of a smart grid investment should reflect and adjust for the expected timing of estimated costs and benefits.  Future expected streams of costs and benefits should be converted into a present value amount via an appropriate discount rate. Guidance on appropriate discount rates for smart grid cost-benefit analysis is provided in the Multiple Views/Perspectives section of this chapter. However, the discount rates used in the analyses are not intended to affect the rate of return that the Commission may set for future cost recovery on the investment

**General Requirements**

The cost-benefit analysis of smart grid investments is intended to be comprehensive. However, in order for all of the elements to be incorporated into an economic analysis, all quantified costs and benefits must be expressed monetarily. The analysis should include any factor (i.e., cost or benefit) that meets the following criteria:

* + Significant -- can be expected to have a meaningful economic impact on the utility’s investment decision or are relevant to the Commission’s approval decisions
	+ Quantifiable and transparent -- can be reasonably and transparently quantified and monetized
	+ Relevant -- is relevant to the analysis, specifically including the costs of achieving claimed benefits.

Costs and benefits should only be counted once; there can be no double-counting of benefits.

All costs and benefits used in the analysis should be incremental to the investment when compared with a baseline or “business as usual” scenario. The baseline scenario should reflect the related costs or benefits that would be anticipated if the investment were not made.

***Uncertainties***

Some factors in a cost-benefit analysis may have a high degree of variability and/or uncertainty. Key assumptions underlying the analysis, including those that drive estimates of major cost components, should be clearly documented and the variability or uncertainty of estimates should be incorporated into those estimates. The cost-benefit analysis should discuss the uncertainties associated with estimates of costs and benefits over the term of the payback period.

***Treatment of Stranded Costs***

This refers to the treatment of existing assets retired before they have reached the end of their useful life and have been fully depreciated (the stranded costs). The Collaborative discussed whether stranded costs should be included or excluded from the cost-benefit analysis**.** In a strictly economic sense, these stranded assets represent sunk costs since the investment is in the past and the investment in a new technology should be evaluated on its own merits. However, from a cost recovery standpoint these investments are being recovered in rate base and are not fully “paid for” – although they have been “paid for” in a procurement/economic sense. The magnitude of resulting stranded investments may bear on the prudence of the investment decision for regulatory purposes. The cost-benefit analysis should recognize as a separate line item any stranded costs that would result from the smart grid investment.

***Implementation Timing***

Smart grid technologies and implementation methods can reasonably be expected to improve in efficacy and scope over time, while costs of the equipment and technologies may reasonably be expected to change over time. Thus, the relative costs and benefits of smart grid investments and approaches will depend on the timing of implementation. To the extent that they are known or can reasonably be anticipated, a cost-benefit assessment of smart grid investments and approaches should include discussion of the potential change in benefits and costs that may occur over time assuming various implementation schedules.

***Potential Overlap with Statutorily-Required Energy Efficiency and Demand Response Programs***

Costs and benefits resulting from statutorily-required energy efficiency and demand response measures and programs should be identified and accounted for separately from costs and benefits associated with smart grid investments. Any amounts charged (or benefits flowing) to customers for statutorily-required measures and programs should be separated from any amounts charged (or benefits flowing) to customers for smart grid investments when calculated and itemized.

***Alternative Approaches***

A cost-benefit assessment of smart grid investments and approaches should include identification and discussion of other investments or approaches (if any) that reasonably might achieve similar results. To the extent those expected benefits can be achieved through other investments or approaches, assessment of the incremental costs and incremental benefits of smart grid investments or approaches should be done relative to the cost and benefit of such investments or approaches, so as to identify and isolate the “extra” costs and benefits attributable to smart grid, if any.

**Cost-Benefit Analysis Mechanics & Assumptions**

This section contains identification and discussion of issues related to the analysis itself and the specific assumptions and inputs required in performing the analysis. The following issues were discussed in the Collaborative and are included in this section:

* + Multiple Views/Perspectives
	+ Sensitivity Analysis
	+ Benefits Dependent on Penetration Levels and/or Changes in Customer Behavior
	+ Appropriate Timeframe for Cost-Benefit Analyses
	+ Treatment of Smart Grid Applications with Shared Infrastructure Investments

**Introduction**

One of the challenges associated with performing cost-benefit analysis of smart grid investments is that the investment required may involve parties in addition to the utility. For example, some programs requiring an “in-premises device” contemplate having the customer or third party make this initial investment. Similarly, the benefits realized by a smart grid investment may extend well beyond the boundaries of the investing utility and its customers to third parties or society as a whole. Finally, the benefits realized by a “participant” in a smart grid application/program may be different from those of a “non-participant.” From a cost-benefit perspective, this is different from most traditional analyses in which the potential investor incurs the full cost and the investment decision is based on the cash flows that are expected to revert directly back to the investor. This lack of congruity between the investor and the beneficiary adds a level of complexity to smart grid cost-benefit analysis.

The cost-benefit evaluation of demand-side management programs shares many of the same challenges as the evaluation of smart grid programs – a complexity that has been addressed in that arena by analyzing the investment from a series of vantage points or perspectives. The Collaborative turned to the legacy of demand-side management (DSM) program evaluation as a starting place in the development of a smart grid cost-benefit framework.

**Multiple Views/Perspectives**

There is a considerable body of work that exists for evaluating DSM and energy efficiency programs according to different perspectives. Perhaps the definitive source in this area is the *California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects* most recently produced by the California Energy Commission in October 2001 (with predecessor documents going back to 1983). While portions of this work may not be directly applicable to some smart grid investments, many of these concepts are being applied to smart grid by forerunners and experts in the field. In fact, EPRI’s *Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects* (January, 2010) recommends directly applying the tests and calculations from the California Standard Practice Manual to evaluation of the projects receiving funds from DOE’s Smart Grid Investment Grant program. At least some of its rationale for this is that “in general, these tests are applicable to smart grid evaluations, because a major driver of smart grid benefits will be avoided supply side costs realized through demand reductions, and assessing these impacts was the original driver behind the development of these models.”[[7]](#footnote-7)

Within the context of DSM and energy efficiency, many state jurisdictions require multiple perspectives to be presented (i.e., multiple tests performed), regardless of the test (or tests) that are ultimately relied upon for decision-making. The different combinations of costs and benefits could conceivably result in certain smart grid applications “passing” according to some views/perspectives, but not others – which leads to questions surrounding which views/perspectives to weigh more heavily. There was a specific concern addressed by some Collaborative participants that smart grid investments that were deemed uneconomic according to other views/perspectives would be implemented based solely on a view/perspective that included societal benefits.

The following “tests” represent those utilized historically for DSM programs that are now beginning to be applied to smart grid investments:

* + Participant Cost Test (PCT). This test measures the quantifiable costs and benefits of the program to the participating consumer, attempting to determine if the participant is better off. Within the context of smart grid, it might be appropriate for this test to be performed when evaluating customer-oriented applications (those offering products and/or services on the customer (load) side of the meter).
	+ Ratepayer Impact Measure (RIM) – This test measures the net impact of the program on customer rates/bills to determine if overall rates will be lowered. The RIM test incorporates the utility’s lost revenues as a key cost component (i.e., reduced consumption impacting the utility’s recovery of its fixed costs).
	+ Program Administrator Cost (Utility Cost Test). This test measures net program costs, like a TRC test, but excludes participant costs. Its concern is determining if revenue requirements are reduced. This test does not include the utility’s lost revenues as a cost (which is the primary difference between this test and the RIM test).
	+ Total Resource Cost (TRC). This test measures the net cost of the program as a resource option, including both the utility’s and participants’ net costs, in an attempt to determine if resource efficiency is improved.
	+ Societal Cost Test. This test expands the TRC to incorporate external benefits (e.g., environmental, third parties, societal). Competitive Supplier/Third Party Value benefits (benefits to alternative retail electric suppliers, non-state jurisdictional entities, and other third parties) may be appropriate for inclusion in the Societal Cost Test. Societal Value benefits should only be included as an element in the Societal Cost Test.

The following matrix identifies the various potential costs and benefits associated with the respective tests in which they would be included.

| **Test** | **Included in Test Calculation** |
| --- | --- |
| **Potential Costs** | **Potential Benefits** |
| Participant Cost | * Costs incurred by those customers participating (initial capital cost including sales tax, ongoing O&M costs, removal costs less salvage value)
* Potential negative impacts on those customers participating
 | * Reduction in utility bills for those customers participating
* Tax credits paid to those customers participating
* Utility incentives paid to those customers participating
 |
| Ratepayer Impact Measure(RIM) | * Initial and ongoing costs incurred by the utility (e.g., hardware, software, customer education, administration, customer incentives costs) including stranded assets
* Utility’s lost revenue from reduction in sales
* Potential negative impacts on the utility
 | * Utility avoided costs (capital or O&M)
* Utility’s revenue gains from increase in sales
 |
| Program Administrator Cost | *Same as RIM, but excluding the utility’s lost revenues** Initial and ongoing costs incurred by the utility (e.g., hardware, software, customer education, administration, customer incentives costs) including stranded assets
* Potential negative impacts on the utility
 | *Same as RIM, but excluding the utility’s revenue gains** Utility avoided costs (capital or O&M)
 |
| Total Resource Cost(TRC) | *All of those included in the Participant and RIM, but excluding the utility’s lost revenues and customer incentives paid by the utility** Costs incurred by those customers participating (initial capital cost including sales tax, ongoing O&M costs, removal costs less salvage value)
* Initial and ongoing costs incurred by the utility (e.g., hardware, software, customer education, administration costs) including stranded assets
* Potential negative impacts on those customers participating
* Potential negative impacts on the utility
 | *All of those included in the Participant and RIM, but excluding the revenue impacts from sales (to/from participant and customer) and customer incentives paid by the utility** Utility avoided costs (capital or O&M)
* Tax credits paid to those customers participating
 |
| Societal Cost | *All of those included in the TRC, plus the following externalities:** Costs incurred by third parties associated with external benefits included
* Potential negative impacts on third parties associated with external benefits included
 | *All of those included in the TRC, plus the following externalities:** Benefits accruing to society as a whole (e.g., environmental, public safety, economic productivity)
* Benefits accruing to third parties, but not to customers or the utility
 |

***Recommendations***

Utilities should be required to present multiple views, or perspectives, as part of their cost-benefit analysis to be filed with the regulatory commission. The ICC and others should have the benefit of these different perspectives when weighing the merits of smart grid investments.

All known and measurable costs required for the implementation of a particular application (whether borne by the customer, utility, or third party) should be incorporated into the cost-benefit analysis in the appropriate view(s).

* + A Total Resource Cost perspective for investments should be presented by the utilities – both with societal costs and benefits and without societal costs and benefits
	+ Other perspectives that should be presented include a Ratepayer Impact view (depicting how rates would be impacted) and a Customer/Participant view (depicting the impacts of customer-specific costs and benefits)

The Customer/Participant Test is relevant for smart grid applications that meet both of the following criteria:

* + Customers may to choose to participate in the application (or not)
	+ Participants would be expected to realize quantifiable benefits not realized by non-participants.

The Societal Cost Test is the only test that would include societal costs and benefits.

As appropriate to each test, the cost-benefit analysis should separately identify:

1. those costs and benefits that will be directly incurred or realized by ratepayers through the traditional ratemaking structure
2. those costs that can be expected to be incurred by non-utility parties
3. those benefits that will flow, if at all, through the wholesale price of energy or other markets
4. those benefits associated with broader societal objectives or results that are not necessarily reflected in regulated customer rates.

For certain tests, the rate of return on utility investments could be a reasonable choice for a discount rate. However, the use of a different discount rate may be appropriate for other tests because customers may have a different assumed cost of capital. (The discount rates used in the analyses are not intended to affect the rate of return that the Commission may set for future cost recovery on the investment.) Discount rates used in the analyses, and the rationale for their use, should be clearly documented.

The Commission’s decision to approve (or not approve) any particular smart grid investment may be based on a number of considerations, some of which could be outside the context of the cost-benefit analysis (e.g., policy considerations).  However, the Collaborative believes that application of the cost-benefit framework defined herein will provide the Commission with valuable perspectives on the economic value of the smart grid investment -- perspectives that should be given considerable weight by the Commission in its overall evaluation.

The Collaborative does not believe that cost-benefit analysis or any particular cost-benefit test or tests should be considered dispositive. However, as indicators of the economic value of the investment to the utility, ratepayers, participants, and society, the Collaborative believes that the results of the cost-benefit analyses should be of central importance in informing the Commission’s ultimate decision.   For this reason, the Collaborative believes that the Commission should not approve an investment that does not pass at least one of the tests.

Furthermore, some stakeholders believe that the Commission should reject any smart grid investment which passes only the Societal Cost Test. Other stakeholders believe that the Commission should approve the investment if the evaluation of one or more of the tests is sufficiently strong to ensure that, on balance, the investment would likely serve the best interest of Illinois ratepayers.

**Sensitivity Analysis**

Most cost-benefit evaluations include some form of sensitivity analysis in which key variables, especially those that are less certain, are modified to determine how much results would change from the “base case” (i.e., that with the greatest level of expectation). There is consensus among the Collaborative that sensitivity analysis should be performed for smart grid investments.

***Recommendations***

Utilities should be required to include a sensitivity analysis as part of the cost-benefit information filing to support their smart grid investments. While reasonable discretion should be provided in terms of the variables and assumptions to be included, the sensitivity analysis should:

* + Identify the key variables from the cost-benefit analysis that merit sensitivity analysis. Good candidates for inclusion are variables (such as emission costs and reliability) that have a wide range of potential values and/or are more subjective in nature.
	+ Produce cost-benefit results using alternate values for the variables in order to demonstrate the sensitivity/impact various scenarios might have on the economic profile of the smart grid investments.

**Benefits Dependent on Penetration Levels and/or Changes in Customer Behavior**

For some smart grid applications (e.g., those associated with demand response), the level of benefits expected is dependent on an assumed level of customer participation and/or changes in customer behavior. Therefore, there is a degree of uncertainty with respect to benefits that should be expected from these smart grid applications.

***Recommendations***

The utilities should make best efforts to incorporate into the cost-benefit analysis reasonable estimates for customer participation, the impacts on customer bills, usage, and peak load reduction, as well as estimates of the persistence of customer behavior and estimated benefits over a lengthy period of time. Costs needed to realize the projected behavioral impacts should be included in the cost-benefit analysis.

The degree of participation, assumed behavioral impacts, and persistence of customer behavior changes should be among the variables included in sensitivity analyses.

**Appropriate Timeframe for Cost-Benefit Analysis**

Evaluation issues arise if the useful life assumed for economic evaluation purposes is significantly different from the actual life of the asset (i.e., an overly optimistic or pessimistic projection of benefits could result). Also, it may be appropriate to bundle a set of applications together for evaluation purposes if the applications are dependent upon each other to deliver the intended functionality. For example, an investment in Core AMI functionality may also include outage management and remote connect/disconnect functionality. In cases such as this, questions may arise as to how to evaluate the package appropriately from a useful life perspective.

***Recommendations***

An entire “package” of related smart grid investments/applications should be included in a consolidated cost-benefit evaluation and considered over a single timeframe. However, smart grid investments/applications should be grouped into a package only if they are needed to function together or provide otherwise unachievable synergies. To the extent that it is feasible to separate underlying platforms from individual applications, smart grid applications contained within a package should still be subject to an individual cost-benefit analysis based on their stand-alone incremental costs and benefits.

The length of time over which a cost benefit analysis is calculated should reflect the projected useful life of the smart grid investment or system.  “Useful life” means the continuous period of time when the components and system of the investment operate correctly and reliably to perform their designed functions.  Absent any persuasive contrary evidence, the depreciable life of the investment for regulatory (non-tax) purposes should match the useful life of the investment.  The utility should document the basis for its determination of the useful life of the investment.  The utility should also document the length of time over which reasonable customer benefits can be reliably estimated.

Since payback period is an important consideration in technology investments with potentially short useful lives, a payback period should be calculated based on the present value of the annual cash flows of the smart grid investment or package.

**Treatment of Smart Grid Applications with Shared Infrastructure Investments**

Some issues in this area were dealt with in the context of the appropriate timeframe issues discussed earlier in this document. One of the remaining questions was: should applications that are included in a package as part of a shared infrastructure investment (an investment in infrastructure that would support multiple applications) be considered individually? Of concern are the multiple permutations that could occur with a shared infrastructure investment that enables/facilitates multiple smart grid applications by the utility or others. It could become unduly burdensome were a separate analysis required for each individual application and each potential combination.

Another key issue is how to deal with an infrastructure investment that could potentially provide revenues from unregulated activities by the utility or others (for example, communications infrastructure). Of importance in a cost-benefit evaluation is ensuring that expectations for non-regulated revenue are accounted for appropriately, and that regulated utility investment (expected to be funded by “above-the-line” utility revenues) is justified by the regulated utility benefits.

***Recommendations***

Wherever and to the extent possible, a utility’s shared infrastructure investments (those that support multiple applications) should also incorporate the known and measurable costs and benefits of all of the associated applications in the cost-benefit analysis. When that is not possible, the infrastructure investment should be supported in the cost-benefit analysis by only those applications being used to justify the utility investment. (Potential future applications and benefits not included as part of the implementation package could be treated separately as an option value.) The rationale behind the packaging of investments should be clearly identified in the utility’s proposal.

The cost-benefit analysis should not attempt to assign or allocate the relative amount of the total investment and benefits to the individual applications that are supported in the implementation of the shared infrastructure. However, in order to demonstrate the net benefit of each application supporting the infrastructure investment, each application should be subjected to an individual cost-benefit analysis based on the incremental costs and benefits of the application (excluding cost of the shared infrastructure).

Allocations for the purpose of recovering costs in a rate proceeding may be subject to a different methodology from that used for projections in a cost-benefit analysis.

Potential non-regulated, third party, or incidental revenue from smart grid infrastructure investments should be reflected in the cost-benefit analysis.

**Quantification and Monetization of Costs and Benefits**

This section identifies and contains Collaborative discussion and recommendations surrounding smart grid-related costs and benefits that are difficult to quantify and/or monetize. The following issues are included in this section:

* + Monetization of Environmental Benefits
	+ Monetization of Reliability Benefits
	+ Treatment of Smart Grid Applications with Shared Infrastructure Investments
	+ Monetization of Benefits Associated with Retail Generation Supply Prices

**Monetization of Environmental Benefits**

If it is determined that environmental benefits should be included in a cost-benefit analysis, the projected benefits must be quantified. In many cases, environmental benefits can be estimated based on the average cost of installing emission reduction technology. For example, the estimated cost of building a flue gas desulfurization scrubber and the corresponding reduction in SO2 expected can be estimated with a high degree of certainty. In other cases, there are market instruments from which the benefits can be readily calculated (e.g., spot and future values of allowances that trade hands in market exchanges). Often, if entities have a choice of environmental compliance alternatives (e.g., in the case of SO2 there are allowances that can be purchased or a generator can switch fuels or install a scrubber), they will choose the long run least-cost alternative. Since spending capital to install technology is an alternative, this cost often represents a ceiling for price projections of associated market instruments or allowances.

Currently, valuing CO2 is problematic with respect to the methodologies above. The market for instruments cannot fully develop unless and until carbon constraint legislation is passed (acceptable emission levels and rules for compliance are not in place yet), nor are there commercially available technological solutions from which carbon reduction costs can be determined.

In Collaborative discussions, some distinction was drawn between “harder” environmental benefits associated with some smart grid applications (e.g., reducing the number of combustion vehicles on the road as a result of PHEVs) and those that are “softer” (e.g., reduced emissions from power plants as a result of a shift in the load curve, and different generation dispatch, as a result of demand-response applications).

***Recommendations***

To the extent that they can be reasonably quantified (and that they can be attributed to the smart grid investment), environmental benefits should be quantified and monetized in the cost-benefit framework in the appropriate societal views/perspectives.

Any assumptions regarding environmental benefits incorporated in the analysis (e.g., emissions reduced, values of emissions/allowances) should be clearly stated and supported.

**Monetization of Reliability Benefits**

The overriding issue in the monetization of reliability benefits is in determining the appropriate value of reducing the frequency, duration, or scope of outages. Currently, the state of the art in reliability monetization (essentially, the cost of an outage) is based on customer surveys and their perception of the cost of outages of various duration. For example, in EPRI’s *Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects*, the values from 28 customer studies from ten different utilities were consolidated.

* + Typically, outage costs are not linear. There is a “fixed” component of any outage (which may be low or high, depending on the customer) and a “variable” component that also impacts the overall cost to the customer. The cost of an outage – and the relative cost of a short or long outage – will vary considerably based on the nature of the customer’s activity or business.
	+ As with any survey, variability in results will occur based on the quality of the underlying survey instrument(s) and the understanding/sophistication of the survey-taker. This adds uncertainty with respect to the benefits that might actually result.

Another issue in monetizing reliability benefits is ensuring that the improvement in reliability associated with the smart grid investment is an improvement that would not have occurred otherwise. In other words, business as usual should not assume that there would be a degradation in reliability and may actually mean improvement, as older system assets are replaced with newer (but not smart) equipment.

***Recommendations***

Reliability benefits should be quantified and monetized in the cost-benefit framework in all of the appropriate tests, although the values could potentially be different for different tests.

A reasonable effort should be made to estimate reliability benefits separately for various groups of customers, since the cost of an outage could vary significantly based on the type of customer (and even for different customers within the same group). Note that the Collaborative is referring to perhaps three or four customer groups, and is not referring to the multiple rate classifications represented by the utilities’ rate tariffs.

* + Cost should be estimated for a minimal outage for the respective customer groups. The incremental cost of an extended outage should also be estimated in order to provide an indication of the impact of short and long outages on the respective customer groups.
	+ Reasonable effort should be made to estimate the permanent economic cost of an outage to various customer groups, including the following:
		- In cost terms for residential customers, who may sustain little or no economic impact from brief outages, but substantial damage from lengthy outages.
		- In profitability terms for business customers (i.e., the impact on a customer’s profit as opposed to in general revenue terms).
	+ Because most reliability investments affect a combination of different types of customers associated with particular circuits, substations, or geographic areas, the use of a composite system average monetized reliability value would be appropriate in some cases.

To further guide potential reliability related investments (both smart and non-smart), the Collaborative recommends that the ICC sponsor an independent review of the available studies and data on the monetization of reliability benefits, and, if needed, conduct a subsequent Illinois-specific study (or studies) to determine the cost of outages on various customer groups in Illinois.

**Monetization of Benefits Associated with Retail Generation Supply Prices**

It is expected that a Smart Grid cost-benefit analysis will include, where applicable, an analysis of how the described benefits associated with demand response and efficiency programs could result in benefits to retail customers as a result of lower generation supply prices. These benefits typically result when the smart grid demand response or efficiency program results in lower peak energy prices and/or lower demand for generation supply. Changing the dispatch of generating units, thereby affecting wholesale market prices, could benefit customers within the region, not just participating customers of the utility. The evaluation should project the extent of the demand response that is likely to occur as a result of one or more smart grid applications relied upon to justify benefits associated with lower generation supply prices. The magnitude of any effect on wholesale markets would depend on the extent of demand response by retail customers at any given time. Changes in the load curve could produce:

* + Energy price mitigation. Reduced usage may result in lower real-time and short-term energy market clearing prices, particularly if the specific generation mix utilized to meet the adjusted load shape has a lower variable cost of production (largely fuel). The effect of reduced usage on market energy prices could be magnified during times when the transmission system is constrained, because congestion is a component of Locational Marginal Prices (LMPs). Reduced line losses due to smart grid functionalities (such as dynamic line rating) could add to the mitigation of energy prices, especially during times when the delivery system is constrained (and higher than average loss factors occur).
	+ Capacity price mitigation. In the long run, lower electricity demand may defer construction of generation and transmission and may lead to lower wholesale capacity market prices.
	+ Depending on the market and/or administrative mechanisms and policies employed by an RTO to set and recover energy and capacity costs, how power and energy are acquired in the market, and how these costs are allocated and recovered from retail customers by utilities and other providers, reduced demand could engender customer savings in the RTO region. The extent to which such effects can be monetized in the short run for customers will be dependent on the certainty and timing of projected reductions in load.

Estimating the value associated with the respective categories of benefits listed above can require complex models with numerous inputs and calculations. Depending on the types of benefits being modeled, simplifying assumptions and models can be utilized – making the number of inputs and calculations more manageable, while maintaining an acceptable level of precision. The type of model required is driven by the nature of the benefits that are being estimated:

* + A system dispatch model could be utilized to evaluate the potential value associated with reduced production costs.
	+ Load flow studies could be performed under different scenarios to evaluate the potential value associated with lower congestion costs and line losses.
	+ A system planning model could be utilized to evaluate the potential value of deferring future generation and/or transmission investments.

The potential impact across a large system footprint raises issues surrounding which, if any, such benefits should be included in the analysis. Alternatives range from not including any such benefits, to accounting for only those benefits accruing to participating customers (when applicable), to all utility customers, to all affected customers in the state of Illinois, or to customers within the regional dispatch footprint (i.e., the ISO).

The extent of direct customer benefits from wholesale market effects depends in part on the procurement process for energy and capacity and how those costs are recovered from retail customers. The existence of long term wholesale energy procurement contracts on behalf of retail customers (such as contracts supporting the IPA procurement process) and other factors (e.g., load profile changes insufficient to change procurement products or strategies) could serve to limit or defer the realization of expected benefits associated with changes to the load curve that would otherwise accrue to retail customers. This is especially true in cases where the pricing of wholesale contracts during the contract term is unaffected by changes in the wholesale price of energy.

***Recommendations***

The estimation of potential benefits associated with changes in load shape should be accompanied by a discussion of the methodology and assumptions used in deriving the estimates. This discussion should describe the model(s) used, model inputs and outputs, model logic (at a high level), scenarios performed, and how model results are to be interpreted.

Benefits from changes in the load shape should be limited to those that are expected to accrue to electricity consumers in Illinois. Benefits expected outside the state can be noted, but should not be included in the cost-benefit analysis except in support of a Societal Test.

**Monitoring and Verification of Results**

This section contains Collaborative discussions and recommendations on issues related to monitoring and verification of expected costs and benefits

Given the magnitude and uncertainty surrounding some potential smart grid investments, as well as the likelihood that such investments may take place over an extended period, it may be appropriate to provide for an ongoing evaluation of smart grid investments following Commission approval and implementation. Ongoing evaluation could confirm that actual costs and benefits are in fact reasonably consistent with those estimated in the cost-benefit analysis, and could develop more accurate estimates for future analyses. Monitoring and verification can potentially identify flawed initial assumptions and provide for modification of smart grid deployment, planning, and implementation . It may be possible to structure implementation of some large smart grid investments in phases so that results can be confirmed on a smaller scale prior to full-scale implementation. However, it should be recognized that, with some smart grid investments, the realization of benefits may take an extended period of time to develop. The timing of estimated benefits (and costs) should be reflected in the cost-benefit analysis. How and when to assess the prudence of smart grid investments for regulatory purposes is a separate and distinct issue for the Commission to evaluate.

This document does not reflect any consensus or recommendations with respect to linking utility cost recovery to actual predictive results

***Recommendations***

The Commission should periodically evaluate if the projected costs and benefits associated with an approved smart grid investment are being realized for customers, the utility, society, and/or other stakeholders prior to approving similar future investments.

The cost for monitoring and verification of benefits should be included as part of the investment/operations costs when evaluating the smart grid investment.

Large smart grid investments should be structured for implementation in time-phased stages, for evaluation purposes, if doing so does not have a significant deleterious impact on the economic viability of the investment. Structuring investments in this manner may facilitate the verification of benefits and provide opportunities for cessation of investments in the event that initial assumptions and estimates of cost/benefit prove to be inaccurate; thereby minimizing the potential for future stranded investments.

Post-implementation evaluations of smart grid investments should be based on the initial cost-benefit analysis approved by the Commission.

1. *Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration*

*Projects*. EPRI, Palo Alto, CA: 2010. 1020342. [↑](#footnote-ref-1)
2. *Advanced Metering Infrastructure Example Project Valuation Model – Version 1.00*; McKinsey & Company; August 7, 2006 [↑](#footnote-ref-2)
3. Blazewicz, Stan, Gene Shlatz, Forrest Small, Steven Tobias, and Jacquelyn Bean (Navigant Consulting, Inc.). 2008. *The Value of Distribution Automation*. California Energy Commission, PIER Energy Systems Integration Program. CEC‐500‐2007‐103. [↑](#footnote-ref-3)
4. *Characterizing and Quantifying the Societal Benefits Attributable to Smart Metering Investments.* EPRI, Palo Alto, CA: 2008. 1017006. [↑](#footnote-ref-4)
5. Sullivan, Michael; Mercurio, Matthew; Schellenberg, Josh; Freeman, Sullivan & Co. “*Estimated Value of Service Reliability for Electric Utility Customers in the United States*,” prepared for the U.S. Department of Energy Officeof Electricity Delivery and Energy Reliability, LBNL-2132E June 2009. [↑](#footnote-ref-5)
6. Brattle Group. *Quantifying Demand Response Benefits in PJM,* prepared for PJM Interconnection, LLC and the Mid-Atlantic Distributed Resources Initiative (MADRI), January 29, 2007. [↑](#footnote-ref-6)
7. *Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects*; EPRI, Palo Alto, CA: 2010. 1020342; p.4-24 [↑](#footnote-ref-7)