

Low-Cost CVR May Pay for Your AMI System

New Study Turns Traditional Smart Grid Business Case Analysis on its Head

Jerry Jackson, Ph.D., Leader and Research Director
Smart Grid Research Consortium 37 N. Orange Ave, Suite 500 Orlando, FL 32804
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Summary

A recently-completed Smart Grid Research Consortium (SGRC) study identifies a new smart grid investment strategy that can transform a poor AMI business case into an attractive investment. Many electric cooperatives and public utilities have rejected AMI systems because expected meter-related benefits are not compelling enough to outweigh costs. Adding demand response savings boosts benefit-cost ratios; however, the uncertainty and long lead times surrounding these customer engagement programs add more risk. Adding distribution automation (DA) benefits and costs including customer valuations of improved reliability provide added costs and benefits but leaves utility decision-makers skeptical.

This new SGRC study shows that the combination of AMI and low-cost conservation voltage reduction enabled with smart meters can provide a compelling business case for many of these utilities with little risk.

This study turns the traditional smart grid business case analysis approach on its head: instead of viewing AMI as the foundation, then adding demand response and then distribution automation benefits and costs, the analysis started with a joint AMI/low-cost conservation voltage reduction (CVR) strategy as the foundation for the business case. The low-cost CVR provides significant benefits and, because it is enabled with smart meter data, more than makes up shortcomings in the stand-alone AMI business case for many utilities without going on to more speculative smart grid benefits.

A significant advantage of this new strategic approach is that costs and benefits of individual AMI and CVR elements can be determined with considerable certainty prior to initiating the project. In addition, the low-cost CVR component can be developed simultaneously with the AMI implementation avoiding the long delays that many utilities are experiencing with customer engagement infrastructure development. The CVR strategy requires utility distribution information including some voltage-demand experiments; however, this information is inexpensive to collect and analyze with our Smart Grid Investment Model.

The CVR strategy considered here is low cost, averaging about \$15,000 per feeder for controls, communications and installation with no new investments in voltage regulators or capacitor banks. This CVR strategy uses smart meters for voltage metering, retrofitted controls and communications to existing feeder equipment, where appropriate, and lowers and “tightens” grid voltage control during peak periods.

This study and its implications for utilities are noteworthy for six reasons:

- The AMI/low-cost CVR strategy reflects a new paradigm for smart grid business case analysis
- The analysis quantifies an often omitted contribution of smart meter data,
- Results illustrate the incremental financial value of limited, low-costs CVR grid improvements enabled by smart meter data,
- The financial value of this strategy is easy to verify beforehand,
- The CVR portion can be implemented simultaneously with the AMI implementation, and
- Contributions of smart meter-enabled CVR can turn a negative AMI business case positive

Study analysis is based on results from a recently completed SGRC CVR study conducted for an electric cooperative utility and data on electric coops and municipal utilities drawn from existing CVR, and other smart grid pilot studies and implementations.

This paper includes summary results of the new study for a generic electric cooperative utilizing the Consortium's Smart Grid Investment Model along with a description of the Consortium's AMI/low-cost CVR applications assessment and implementation services.

Why Some AMI Business Cases Fail

AMI/smart meter business cases do not meet investment requirements at some electric cooperatives and municipal utilities for two primary reasons:

1. Utilities who previously installed AMR systems are already achieving much of the AMI meter-reading benefit. While these systems have reduced meter-related costs, many do not provide the bandwidth required to support many modern AMI systems' valued-added benefits associated with outage management and other distribution management functions.
2. Distribution system characteristics, operating structure, wage levels, and customer characteristics at some utilities are such that AMI meter-related savings estimates are not sufficient to provide an attractive business case.

Conservation Voltage Reduction

Conservation voltage reduction (CVR) reduces voltage during peak period times reducing peak kW demand. CVR reduces the monthly demand charge for utility wholesale power purchases or, for utilities that self-generate, provides excess power to sell at peak prices on the wholesale market. CVR has received new attention in recent years as metering, communications and control technologies have advanced.

CVR strategies attempt (among other objectives) to provide voltage at the meter as close to 114 volts as practicably possible. ANSI standards require voltage between 114 and 126 volts. Voltage declines from the head end of a feeder at the substation depending on the length of the feeder, loads along the feeder and other variables like conductor size, temperature and placement of voltage regulators and capacitor banks. Voltage along the feeder varies from day to day and hour to hour. Determining the appropriate substation voltage to maintain minimum voltage at the meter is not an easy matter.

A variety of voltage drop calculation approaches are used to determine desired substation feeder voltage and to estimate meter-level voltage. Most utilities set head end voltage at considerably higher levels than necessary to reduce the possibility of low-voltage situations at the meter. This is a prudent approach since meter –level voltage is an estimated value with a large confidence interval.

The Consortium’s work with utilities in 20 Smart Grid Investment Model projects and a review of case study reports indicate that typical head end voltage is typically 122 – 125 volts with meter-level voltage in the 118 – 120 range.

Low-Cost CVR

The low-cost CVR strategy considered here includes developing and processing feeder-level information from smart meter data to reduce end-of-line voltage closer to the 114 minimum. Costs are estimated to be \$15,000 per feeder which includes controls, communications and labor costs. Voltage information is provided by smart meters. Substation costs for a substation with a single substation transformer and three feeders would be \$45,000 in this example.

This cost is “low” at 6-10 percent of the cost of comprehensive volt/VAR control and optimization that add voltage regulators, capacitor banks, metering, communication and control, and other technologies/strategies. The low-cost CVR strategy achieves load flattening where possible with existing voltage regulators and capacitor banks using meter-level data to adjust settings of voltage regulators and capacitor banks and adding control/communications capabilities as appropriate to equipment that already exists along feeders.

A relatively small number of utilities already apply no-cost CVR by lowering substation voltage by small amounts during peak period times. These strategies tend to be quite conservative because of the uncertainty of meter-level voltage that occurs with this voltage drop during peak period times. These utilities can also benefit from the low-cost CVR strategy described in this paper.

The AMI Business Case

The objective of this paper is to examine the potential impact of including low-cost CVR benefits in a joint AMI/low-cost CVR business case when the AMI business case alone fails. These low-cost CVR benefits are enabled with the data available from the new AMI installation.

As indicated in a previous section, the CVR program considered here results only in a “tightening-up” of voltage control with no addition of voltage regulators, capacitor banks and other investments that would be applied in more comprehensive voltage/VAR and CVR initiatives.

Every utility presents a unique AMI/ low-cost CVR business case depending on current meter-related costs, distribution infrastructure, system peak period hourly load profiles and avoided cost structures. The representative utility used for this analysis has about 60,000 customers with system load shapes consistent with a moderately hot and humid climate reflecting about 85 percent residential, 10 percent commercial and 5 percent industrial loads. The utility purchases its power and faces a peak

demand charge of \$12.00/kW with a one year ratchet that applies the previous year’s average 4-month summer peak to each month of the current year.

The utility has an AMR system that was installed a decade ago providing automated meter reading but does not have the ability to connect and disconnect remotely and does not have bandwidth and latency to provide many AMI functions.

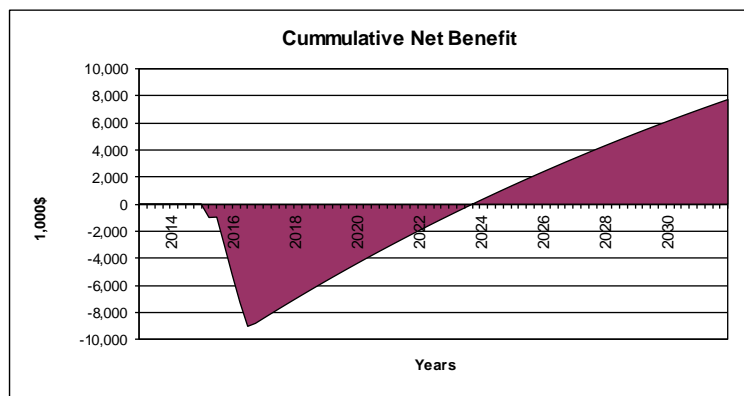
If instead of its dated AMR system, this utility reflected a typical electro-mechanical metering-based utility, its AMI business case would look something like that shown in the following figure. The internal rate of return (IRR) reflects the return on the investment. An IRR greater than the cost of capital (i.e., the interest rate on utility bonds) is considered an attractive investment. The undiscounted breakeven period is the payback period and the discounted breakeven period is the discounted payback period, that is, the payback period when financial values are discounted to reflect current financial values. The net present value is the discounted benefits minus discounted costs. The benefit cost ratio is calculated as discounted benefits divided by discounted costs (see the note at the end of this paper for more information on present value and discounting).

The cumulative net benefit chart shows discounted benefits minus discounted costs in each quarter of the analysis period. The point where the line crosses the X-axis is the discounted breakeven period. The distance from the X-axis to the line is the net present value at that time period.

Figure 1. Representative AMI Business Case for a Utility with Electromechanical Meters

Representative AMI Business Case
(Existing electromechanical meters)

Internal Rate of Return (%)	10.0%
Undiscounted Breakeven Period	7.25 Years
Discounted Breakeven Period	8.75 Years
Net Present Value (NPV, \$mill)	7.650
Benefit/Cost Ratio	1.68



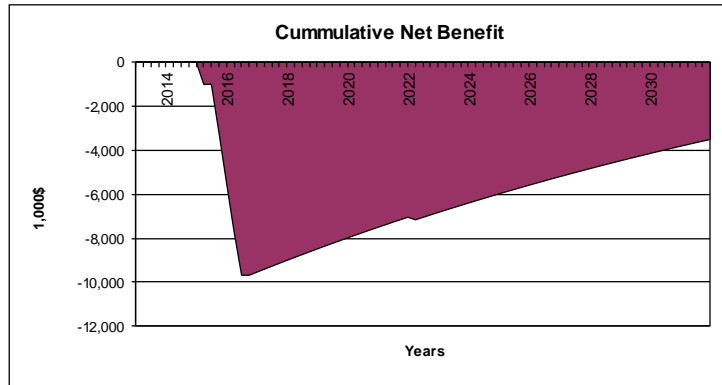
This business case would probably be sufficient for the utility to move forward with an AMI upgrade.

However, our example utility’s AMR system already captures about 2/3 of the benefits of an electromechanical- to-AMI system upgrade reducing per-meter benefits to about \$12/meter. Consequently, the AMI business case of the example utility looks like the following – clearly not an attractive investment with a benefit cost ratio of 0.7.

Figure 2. Representative AMI Business Case for a Utility With an Existing AMR System

Representative AMI Business Case
(Existing AMR meters)

Internal Rate of Return (%)	*
Undiscounted Breakeven Period	*
Discounted Breakeven Period	*
Net Present Value (NPV, \$mill)	*
Benefit/Cost Ratio	0.70



Evaluating the Joint AMI/Low-Cost CVR Business Case

As indicated above, uncertainty over meter-level voltages results in voltages that typically are anywhere from 4 to 6 volts above the minimum of 114. However information from a strategically selected sample of smart meters can provide near-real time information on meter-level voltages along each feeder. Analysis of this data, including voltage experiments to estimate feeder conservation voltage reduction factors (CVRf) can provide a low-cost CVR strategy that at most requires a limited investment in communications and control technologies. This analysis assumes an investment cost of \$15,000 per feeder or \$45,000 for the single-transformer, 3-feeder substation mentioned above. Our analysis indicates that the added information provided by smart meters permits the typical utility to reduce its voltage by 2 to 3 percent during peak periods. A typical conservation voltage reduction factor (CVRf) of 0.75 reduces peak demand by about 1.5 to 2.25 percent for feeders for which low-cost CVR is attractive (typically about ½ the total number of feeders).

The impacts of voltage reductions of 2 and 3 percent are presented below for a joint AMI/low-cost CVR strategy applied to the example utility with avoided power costs of \$12/kW. These Figures should be compared to Figure 2 that shows the AMI case without low-cost CVR benefits.

Figure 3. AMI-Low Cost CVR Business Case, Existing AMR System, 2 % Voltage Reduction, \$12/KW

AMI With Low-Cost CVR Savings
(Existing AMR meters, 2% voltage reduction)

Internal Rate of Return (%)	11.8%
Undiscounted Breakeven Period	7 Years
Discounted Breakeven Period	8.25 Years
Net Present Value (NPV, \$mill)	8.849
Benefit/Cost Ratio	1.76

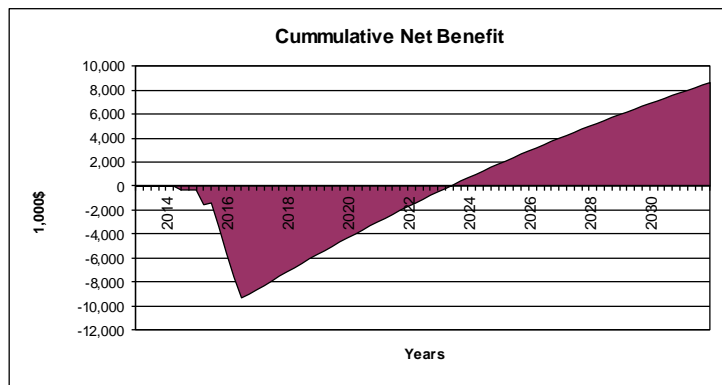
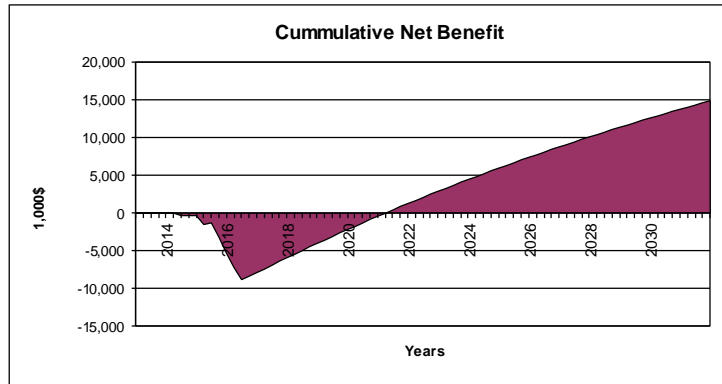


Figure 4. AMI-Low Cost CVR Business Case, Existing AMR System, 3 % Voltage Reduction, \$12/KW

AMI With Low-Cost CVR Savings
(Existing AMR meters, 3% voltage reduction)

Internal Rate of Return (%)	20.8%
Undiscounted Breakeven Period	5.5 Years
Discounted Breakeven Period	6.25 Years
Net Present Value (NPV, \$mill)	15.049
Benefit/Cost Ratio	2.30



Both of the business case outcomes above provide a positive with paybacks in 5.5 and 7 years for 2 and 3 percent voltage reductions, respectively. The benefit cost ratio has increased from 0.7 for the AMI case alone to 1.76 and 2.30 for the two joint AMI/low-cost CVR.

It is important to reemphasize that the low-cost CVR benefits are a result of additional information derived from the smart meters and not from a traditional CVR initiative which would include, among other things, addition of voltage regulators and capacitor banks. That is, the low-cost CVR benefits are a side benefit of the smart meters in this analysis.

Low-cost CVR benefits are substantial enough to provide a positive business case even where peak demand charges are as low as \$6/kW as shown in figure 5. Figure 6 shows results with avoided power costs of \$9/kW

Figure 5. AMI-Low Cost CVR Business Case, Existing AMR System, 3 % Voltage Reduction, \$6/kW

AMI With Low-Cost CVR Savings
(Existing AMR meters, 2% voltage reduction)

Internal Rate of Return (%)	7.6%
Undiscounted Breakeven Period	8.25 Years
Discounted Breakeven Period	10 Years
Net Present Value (NPV, \$mill)	5.934
Benefit/Cost Ratio	1.51

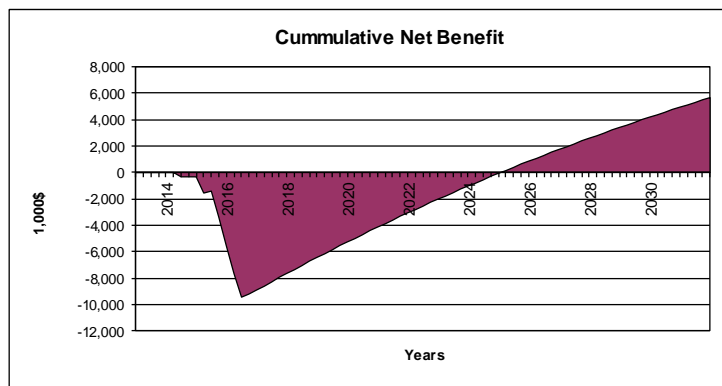
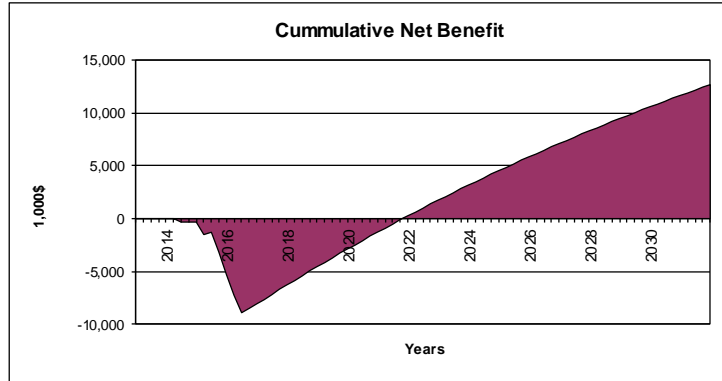


Figure 6. AMI-Low Cost CVR Business Case, Existing AMR System, 3 % Voltage Reduction, \$9/kW

AMI With Low-Cost CVR Savings
(Existing AMR meters, 3% voltage reduction)

Internal Rate of Return (%)	17.8%
Undiscounted Breakeven Period	6 Years
Discounted Breakeven Period	6.75 Years
Net Present Value (NPV, \$mill)	12.863
Benefit/Cost Ratio	2.11



Consortium AMI/Low-Cost Analysis for Coops and Public Utilities

The Consortium works with client utilities to evaluate AMI, customer engagement, DA, CVR, Volt/VAR optimization and the topic of this paper: AMI/low-cost CVR with smart meter data. The Consortium’s analysis process when working with utilities to assess AMI/low-cost CVR applications includes:

- Evaluating the AMI business case utilizing utility data and the Smart Grid Investment Model (SGIM)
- Analyzing feeder-level data to estimate current end-of-line voltages
- Estimating conservation voltage reduction factors for each feeder using historical transformer or feeder demand data and voltage experiments,
- Incorporating feeder level CVR-related data and avoided peak period power costs in the SGIM,
- Analyzing various CVR strategies and assessing joint AMI/low-cost CVR strategies
- Developing a strategy and milestones for implementing the AMI/CVR system
- Working with utility staff and vendors to develop vendor cost bids in the analysis
- Working with utility staff to assess post investment CVR peak-period benefits

Conclusions

A new study by the Smart Grid Research Consortium finds that many utilities can achieve large returns with an integrated AMI/low-cost conservation voltage reduction (CVR)- strategy that utilizes smart meter voltage data to achieve peak period voltage reductions - even if the AMI portion doesn’t meet financial targets on its own. For utilities that already have an AMI system, this low-cost CVR strategy can boost returns and significantly shorten payback periods.

The low-cost CVR strategy differs from comprehensive Volt/VAR and CVR initiatives in that no new voltage regulators or capacitor banks are installed on feeders while voltage information from smart meters and low-cost communication/control technologies are used to “tighten” up voltage delivery, eliminating the extra margin traditionally used to ensure sufficient voltage delivery at the meter.

The added benefit of smart meter data in a voltage control application is quantitatively isolated in this study with the Smart Grid Investment Model – that is, the voltage reduction achieved is a result only of more accurate information and more precise control provided by data from smart meters.

This strategy is especially important for utilities with existing AMR systems and other utilities that do not see a positive AMI business case.

This study and its implications for utilities are noteworthy for six reasons:

- The AMI/low-cost CVR strategy reflects a new paradigm for smart grid business case analysis
- The analysis quantifies an often omitted contribution of smart meter data,
- Results illustrate the incremental financial value of limited, low-costs CVR grid improvements enabled by smart meter data,
- The financial value of this strategy is easy to verify beforehand,
- CVR portion can be implemented simultaneously with the AMI implementation, and
- Contributions of smart meter-enabled CVR can turn a negative AMI business case positive.

The take-away from this analysis is that utilities who have considered AMI investments and found the business case lacking should reconsider a combination AMI/low-cost CVR business case.

The Smart Grid Research Consortium provides business case analysis, investment strategy development and implementation planning and support for AMI/low-cost CVR and other smart grid projects designed to maximize utility benefits and investment returns.

About the Consortium and Author

The Smart Grid Research Consortium (SGRC) (www.smartgridresearchconsortium.org) is an independent, objective research and consulting firm with headquarters in Orlando, Florida. The SGRC was established in 2010 and is currently completing its twentieth smart grid investment analysis project.

The SGRC is managed and its research is led by Dr. Jackson, an energy economist with more than thirty years' experience in new energy technology market analysis, financial model development, utility program development and project management. He was previously a professor at Texas A&M University, chief of the Applied Research Division at Georgia Tech Research Institute, and president of a consulting firm where he has worked with utilities, state regulatory agencies, equipment manufactures and others in addressing energy industry issues. Dr. Jackson can be reached at Smart Grid Research Consortium, 37 N Orange Ave, Suite 500, Orlando, FL 32801, 979-204-7821 or by email at jjackson@smartgridresearchconsortium.org.

Aside on Time Value of Money and Discounting

\$100 today has a different value from \$100 a year from now. If \$100 today can be invested with a 5 percent interest rate, its value in a year will be \$105. If interest is compounded annually we also know that \$100 today is equivalent to \$110.25 (\$105 at the end of the first year times 1.05 interest equals 110.25—with 25 cents the bonus from compounding) in two years. Working backwards, any future amount, A, can be evaluated as a present value (or discounted to the present) with the following formula:

$$PV = A/(1.0 + i)^t \quad (4.1)$$

Where i is the interest rate and t is the time period. The critical variable in this calculation is, of course, the interest rate, considered to be a cost of capital, or more specifically the cost of borrowing funds to pay for a capital investment.

The ability to discount future values and cash flows back to the present permits us to put any future amount or series of future amounts in present terms and compare their values to make financial decisions. Future values that have been discounted to the present are referred to as discounted values. The process of converting future values to present values is called discounting.

Discounting is an important element of financial analysis. Income streams with different time periods, mixed income streams, and income streams that begin one or two years in the future can all be discounted to their present value to provide a common basis for comparison.