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Office of Electricity Delivery & Energy Reliability

Conservation Voltage Reduction

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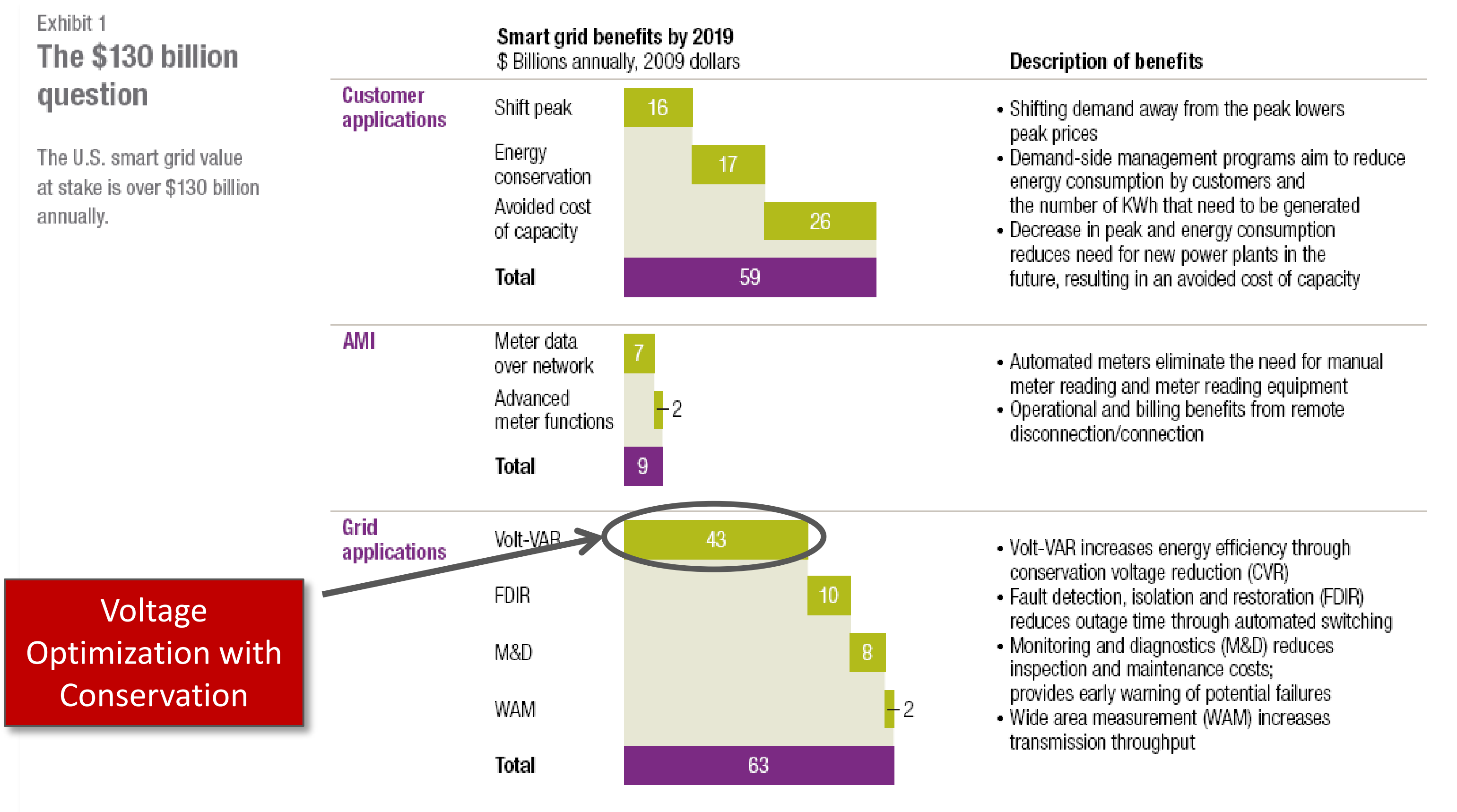
National Summit on Smart Grid and Climate Change
Washington, DC

SMARTGRID.GOV
RECOVERY ACT SMART GRID PROGRAMS

Energy Efficiency Potential thru Volt / VAR Optimization



** 2019 value including societal and GHG benefits*

Source: McKinsey on Smart Grid, Summer 2010

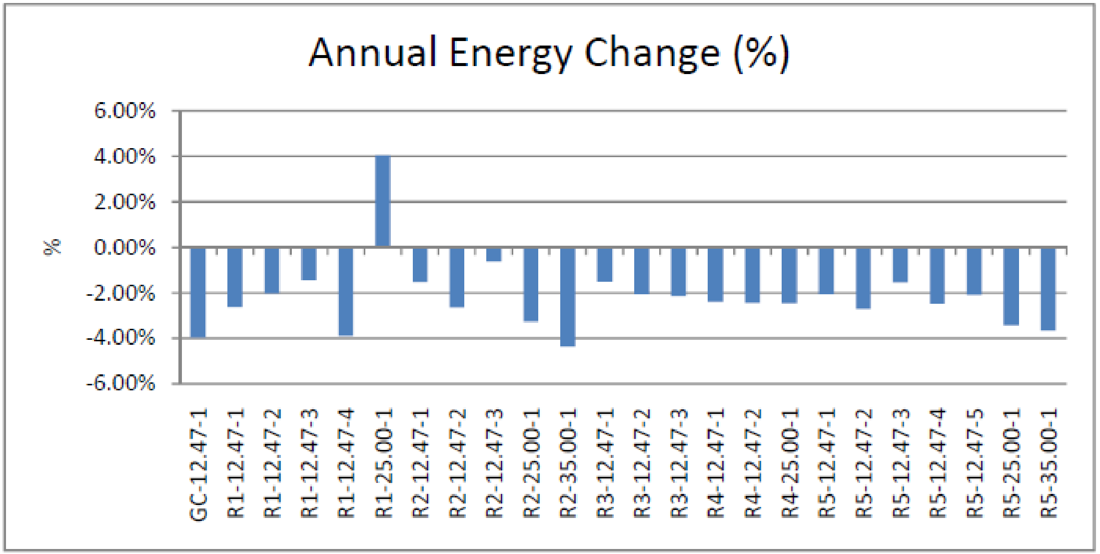
2010 GRID-LAB-D Analysis: National deployment of CVR provides a 3.0% reduction in annual energy consumption for the electricity sector. 80% of this benefit can be achieved from 40% of feeders.

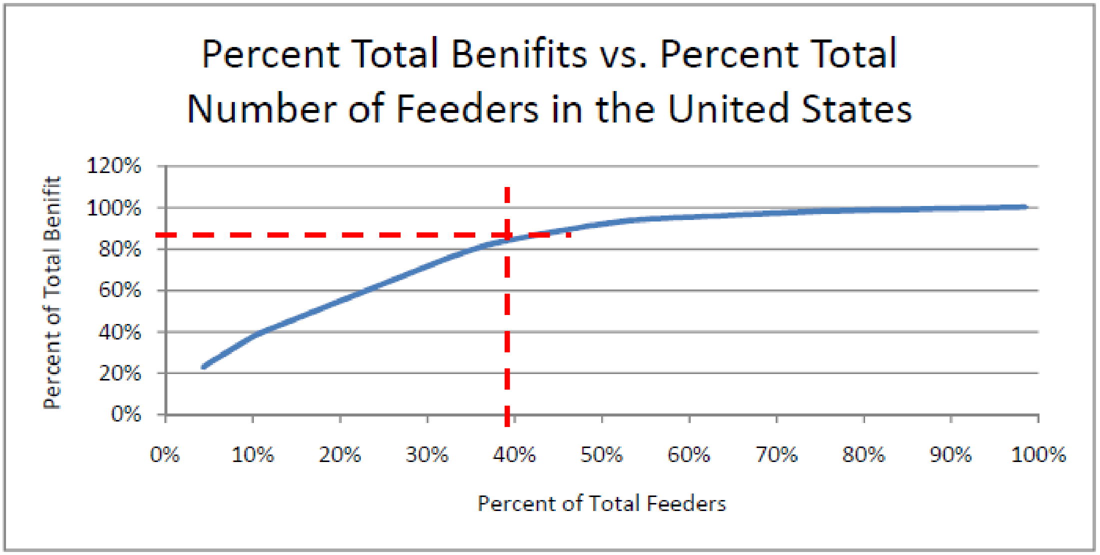
PNNL National Assessment of CVR

GridLAB-D simulation on 24 prototypical feeders:

- Annual energy reduction per feeder ranges from 0.5 - 4%, however, the result depends..
- National deployment results in 3% annual energy reduction (6,500 MWyr = 5 million homes)
- If deployed on high-value feeders (40%), the annual energy consumption can be reduced nationally by 2.4%

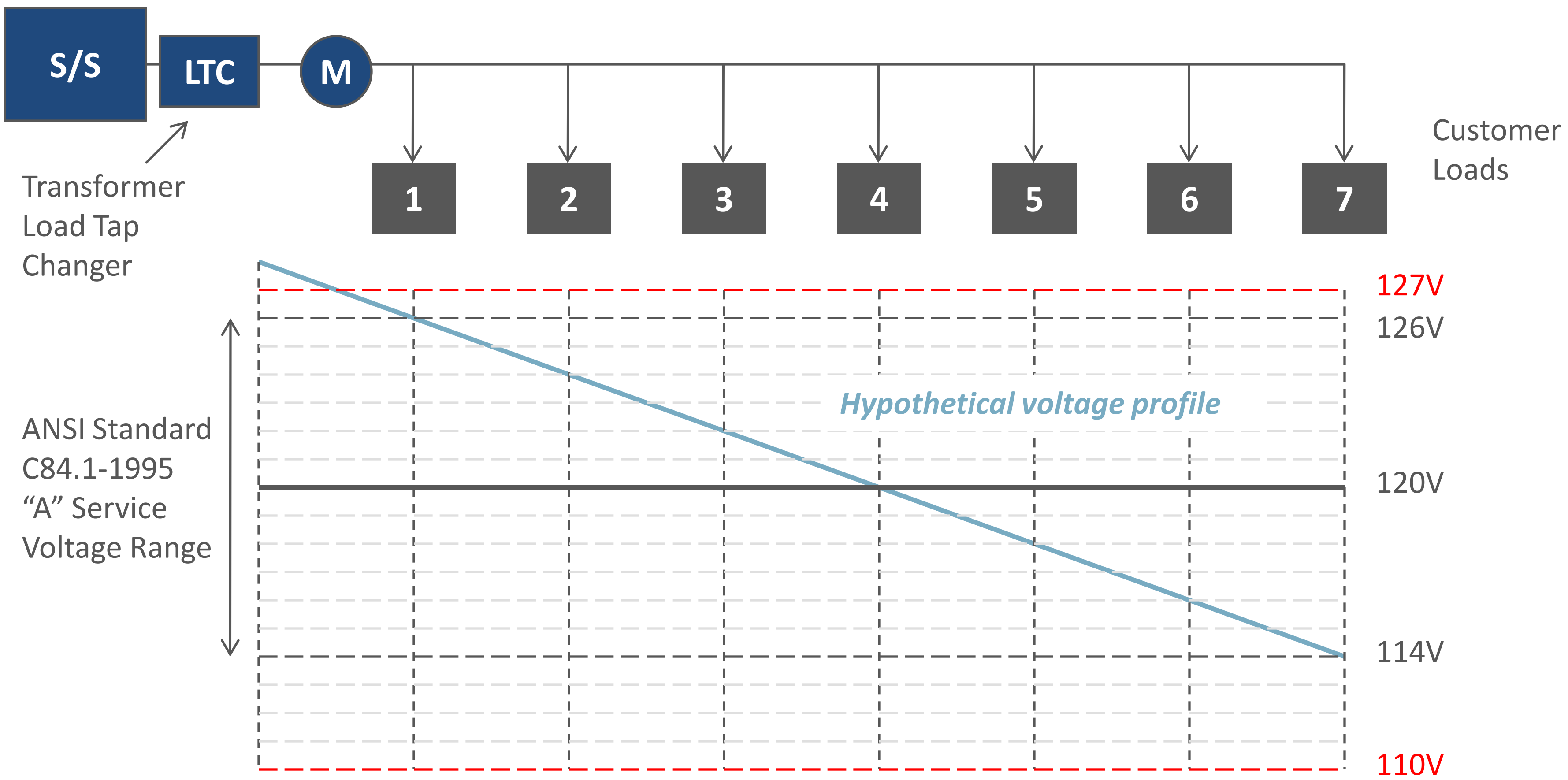
From "Evaluation of Conservation Voltage Reduction (CVR) on a National Level", by KP Schneider et al., July 2010, PNNL - 19596





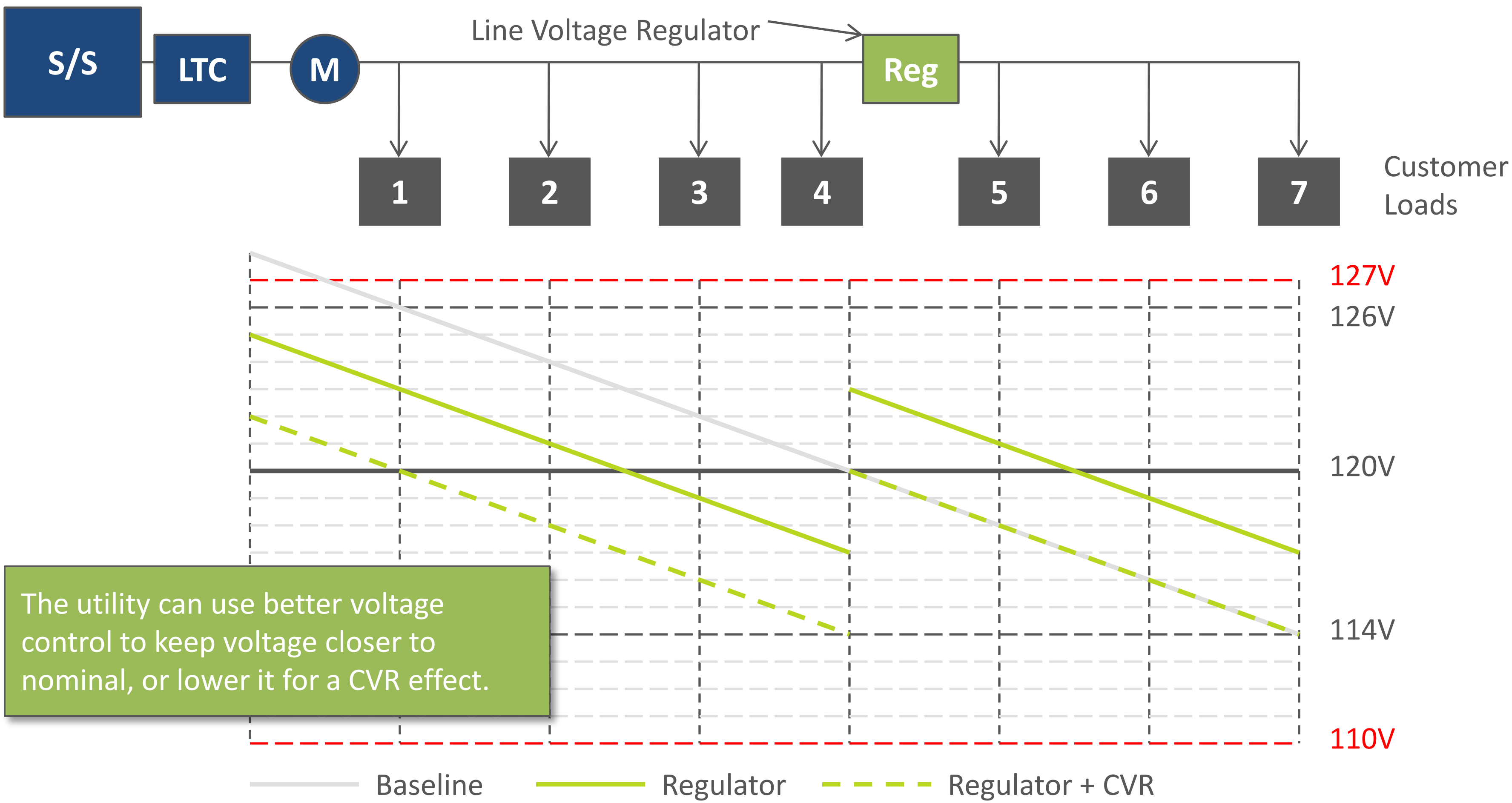
Voltage Profile

Line voltage drops from the LTC at the head of the distribution line to customers farther out on the line.



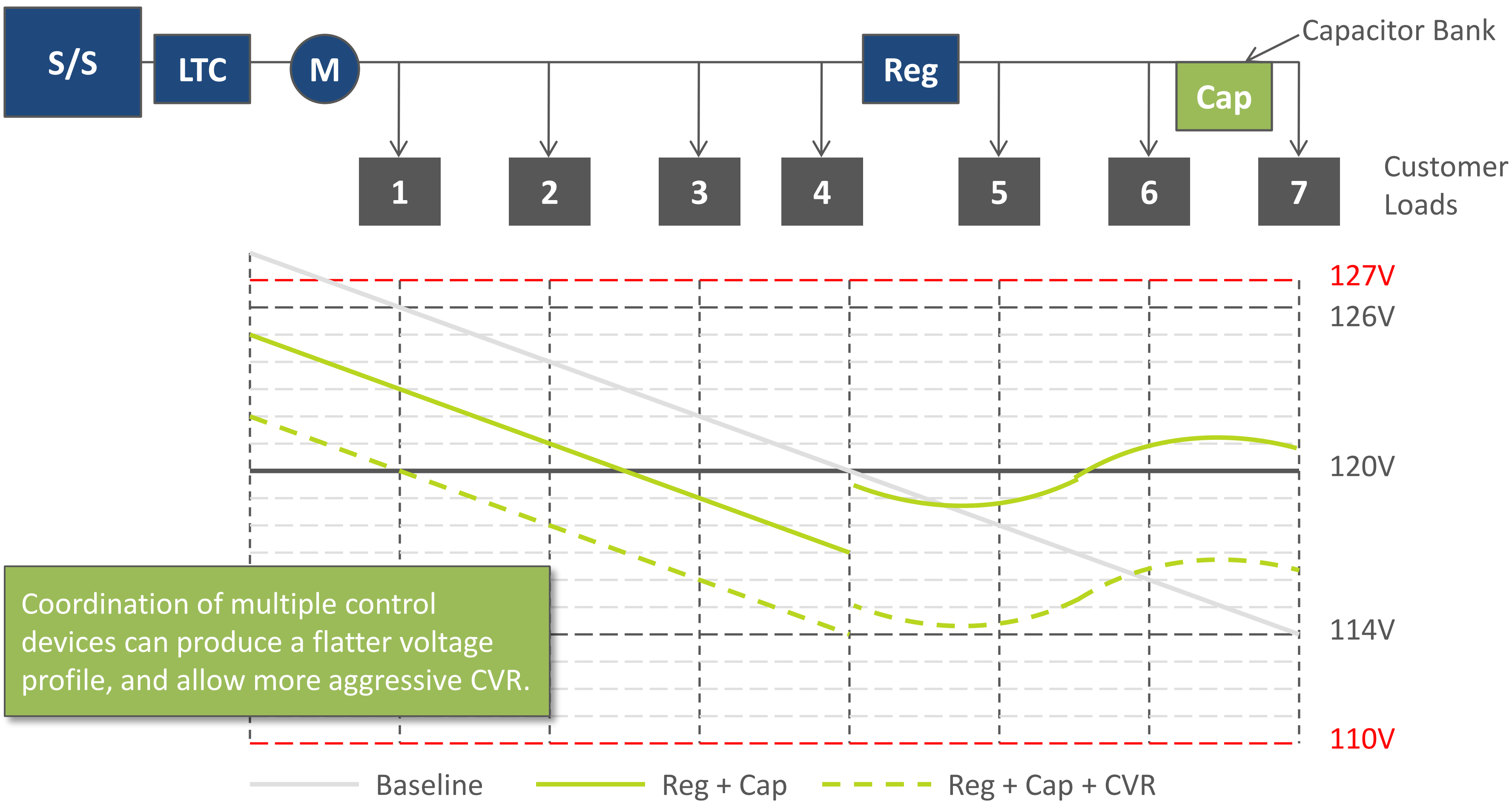
Voltage Optimization

A voltage regulator can boost (raise) or buck (lower) voltage at a point on the distribution line and regulate down-line voltage.



Coordinated LTC, Regulator and Capacitor Bank

A capacitor bank can help regulation by compensating for the lagging power factor of load and the line itself.



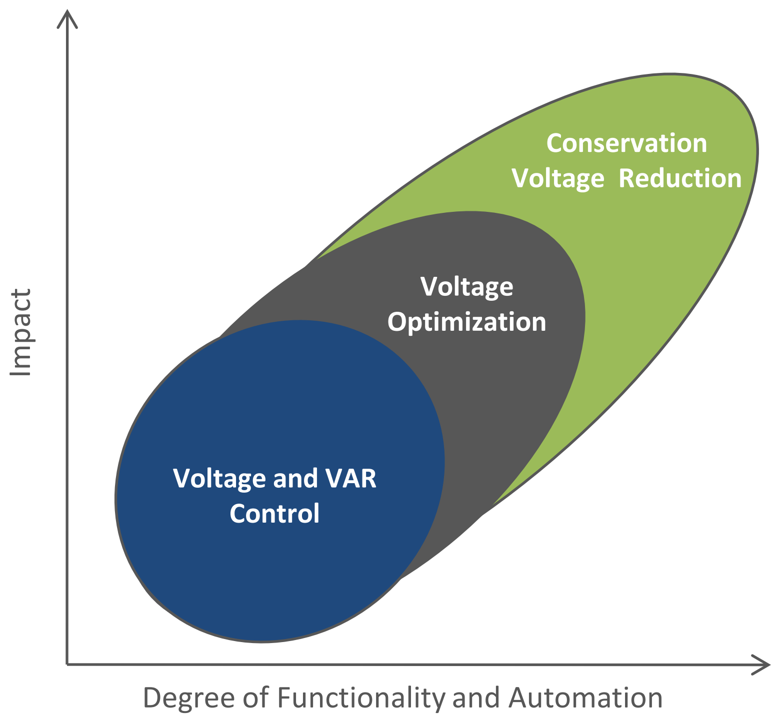
Coordination of multiple control devices can produce a flatter voltage profile, and allow more aggressive CVR.

Approaches Vary Significantly

Projects vary with utility objectives, operational experience, and current system configurations and equipment.

Functionality	SGIG Projects
Voltage and VAR Control	17
Voltage Optimization	11
Voltage Optimization and CVR	13
Total	41

Source: SGIG Proposals, MBRPs Build metrics and Navigant analysis

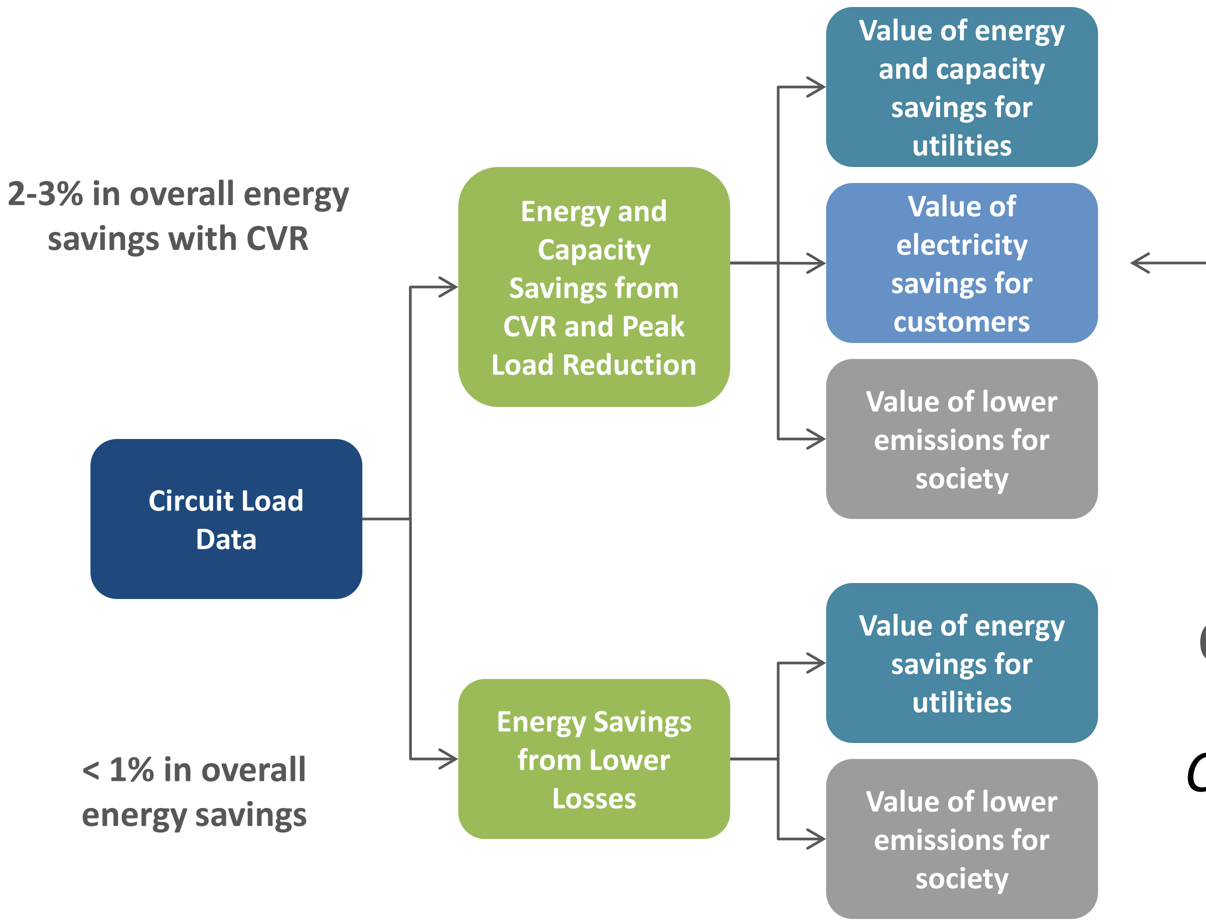


CVR – reduce voltage at lowest extent possible during peak and/or non-peak

VO –flatten the load curve and/or optimize voltage to meet utility's objectives, e.g., peak demand reduction, reactive power compensation, line loss minimization

VVC – sensing and remote operation of voltage and VAR control devices

Benefit Streams from Improved Voltage Management



Energy efficiency translates directly into customer savings (from reduced fuel requirements)

CVR Factor (*CVRf*):

$$CVRf = \frac{\Delta P}{\Delta V} \; watts/volt$$

<u>Additional Benefits</u>: system stress relief (emergency load reduction) and voltage management needed for integration of distributed energy resources

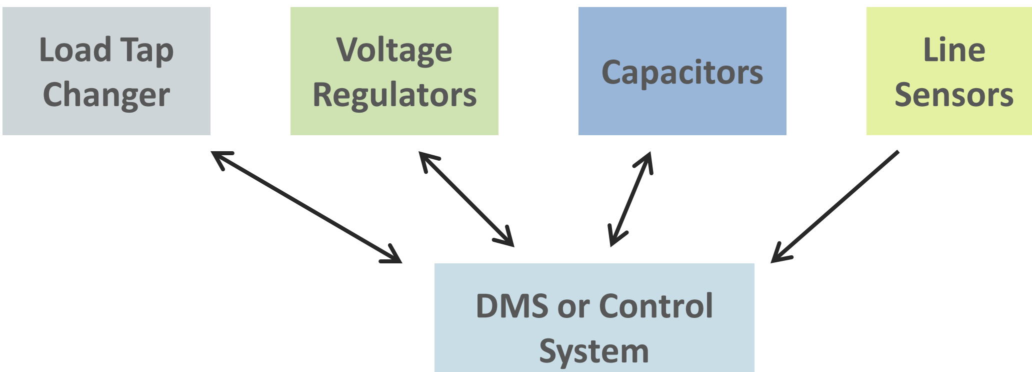
Energy and Demand Reductions

Type	(%) Average Voltage Reduction	Average CVR Factor Expected ENERGY	Average CVR Factor Actual ENERGY	% Reduction ENERGY	Average CVR Factor Expected PEAK	Average CVR Factor Actual PEAK	% Reduction PEAK
IOU	0.76 - 4.10	0.40 - 1.30	0.06 - 1.24	0.78 - 3.00	0.33 - 1.48	0.33 - 1.24	0.84 - 2.84
Coop	1.98 - 5.00	0.80	1.00 - 1.09	1.60 - 2.62	0.75 - 1.06	0.85 - 1.61	2.98 - 3.84
Muni	1.00 - 4.00	0.36 - 1.05	0.34 - 1.10	0.82 - 2.15	0.50 - 1.00	0.50 - 2.70	1.00 - 7.00
Federal	1.00 - 4.00	0.50 - 1.50	? ? ?	0.75 - 2.50	0.50 - 1.50	? ? ?	? ? ?
NEEA	2.50	0.60	0.69	2.07	0.6	0.78	1.80

Based on an investigation of 41 CVR studies by DOE's National Technology Energy Laboratory and Applied Energy Group for the DOE Office of Electricity Delivery and Energy Reliability

Conservation Voltage Reduction at AEP

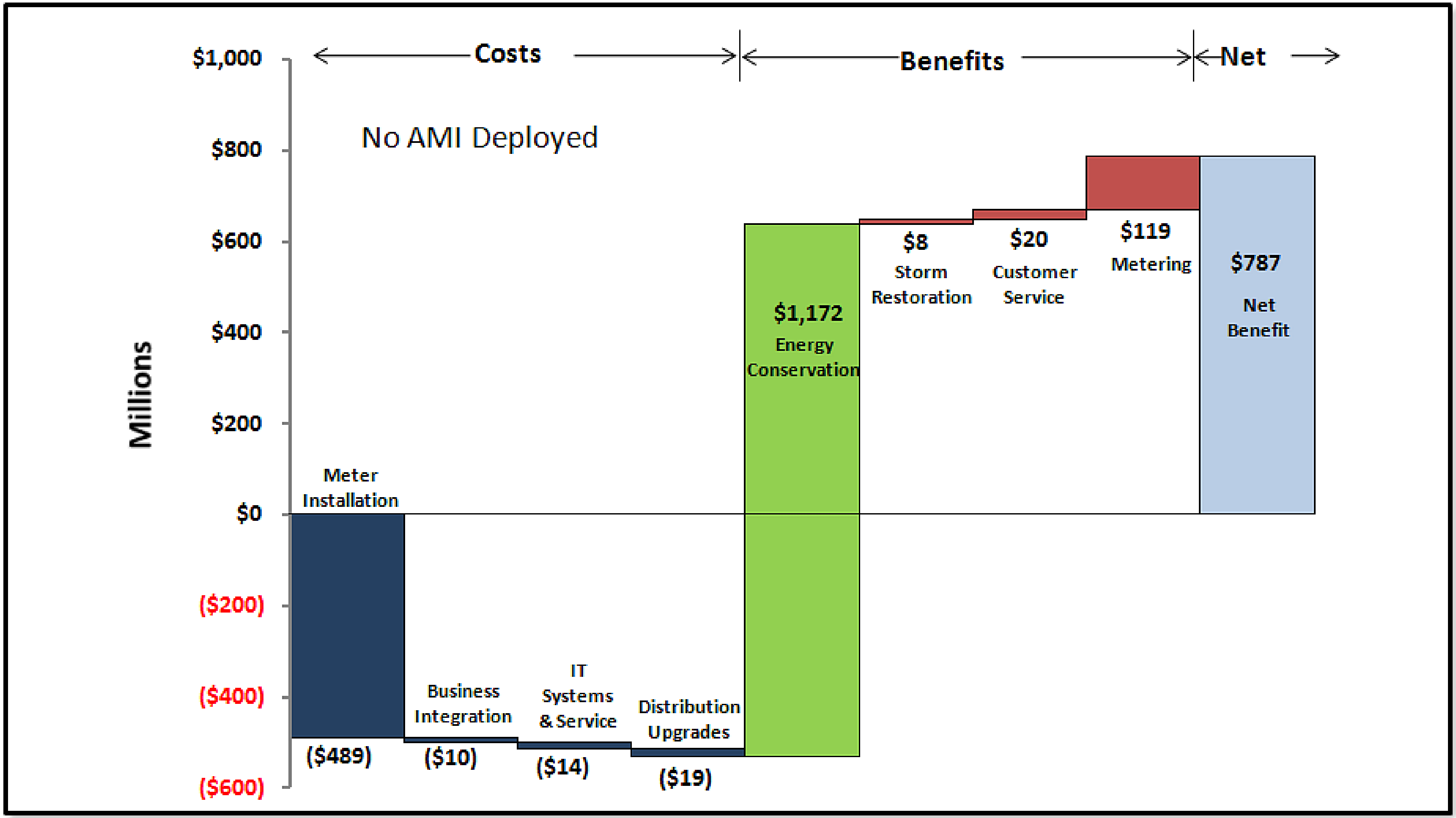
Objectives: Apply data from end-of-line sensors to automatically control line voltage regulators and load tap changers at substation feeder head. Also, coordinate capacitors to keep power factor of the substation transformer near unity.



Near-real-time feedback loop enables optimized operation of these components.

Results Averaged across 11 Circuits	Initial Results	Potential Customer Savings (estimated for a 7 MW peak circuit with 53% load factor)	
Customer Energy Reduction	2.9%	943 MWh/year	$75,440 (at $.08/kWh)
Peak Demand Reduction	3%	210 kW	Defer construction of peaking plants

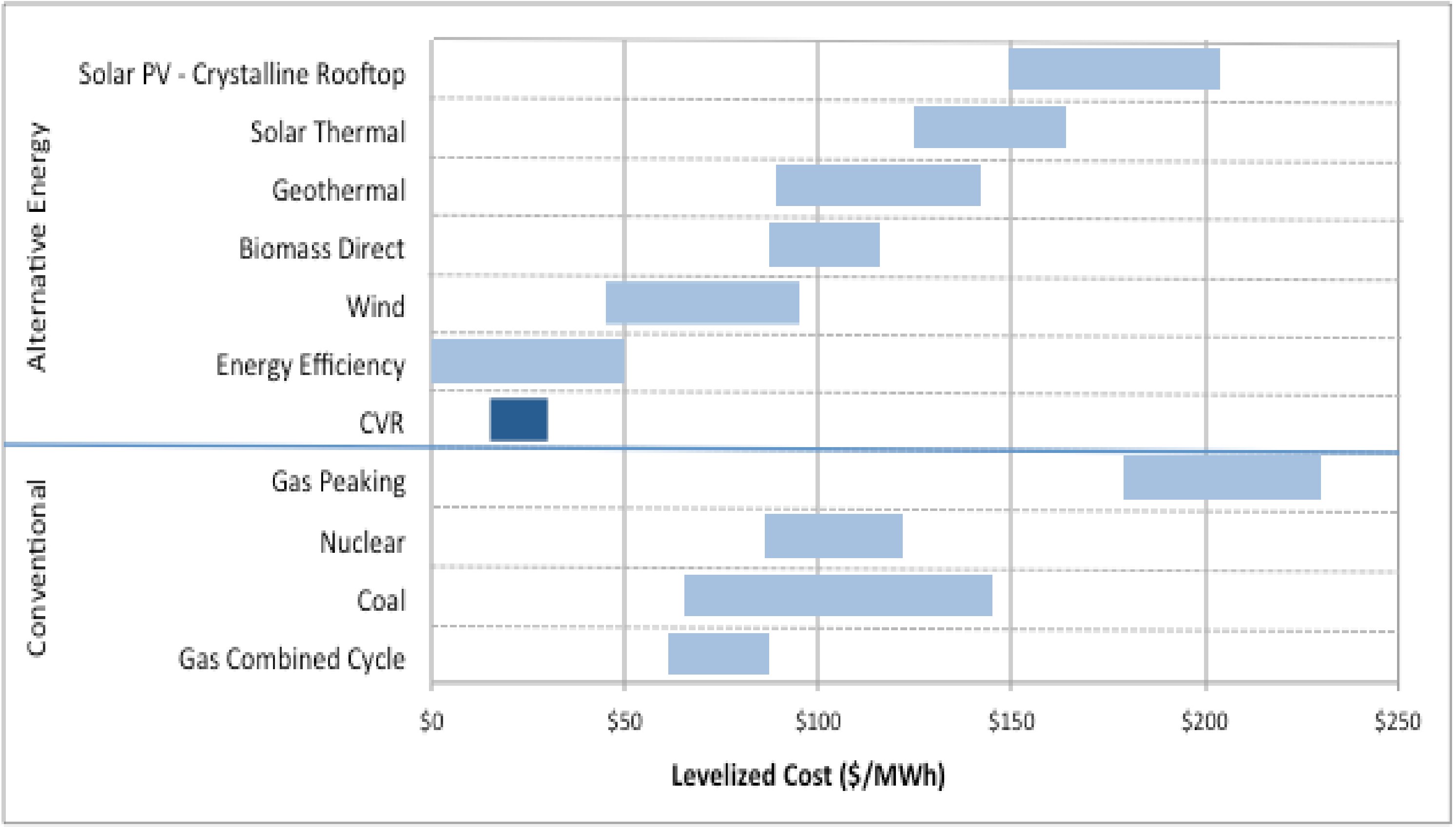
Dominion Virginia Power's CVR Business Case



In August 2008, Dominion Virginia Power had developed a business case for its AMI solution for its 2.4 million Virginia jurisdictional customers.
(Projections based on data filed in Dominion Virginia Power rate case PUE – 2009-00019)

Levelized Cost of Energy

<u>Levelized Cost of Energy (LCOE)</u> – A metric for comparing the relative economics of an energy resource. LCOE is expressed in $/kWh (generating OR cost of energy saved) and incorporates the lifetime costs of a resource (capital expenses, operating expenses and fuel).

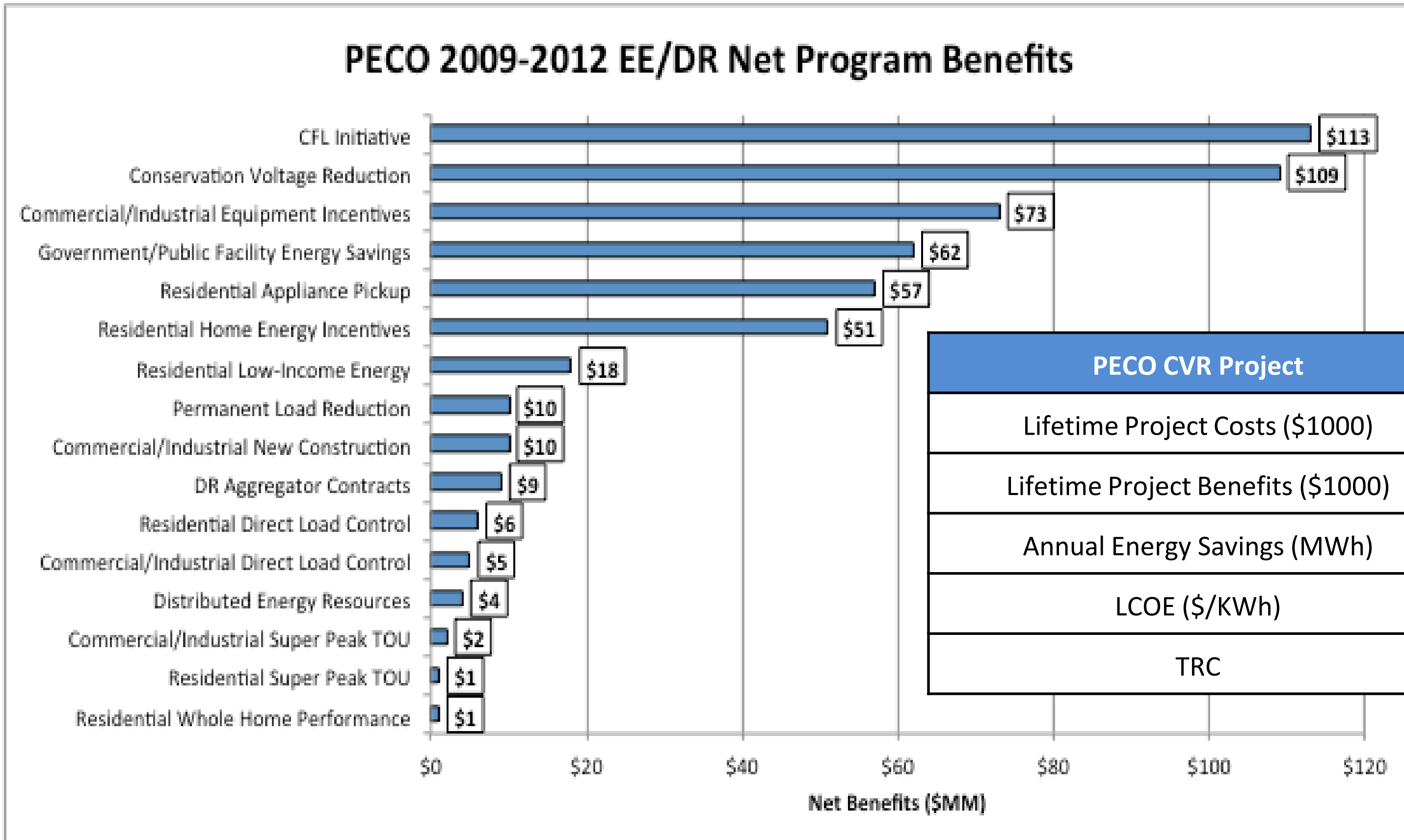


From Lazard's LCOE analysis (Sept 2014) combined with Applied Energy Group's analysis (for CVR)

[1] PECO - PECO Energy Efficiency and Conservation Plan (Program Years 2009 – 2012). 2009
[2] Project costs are annualized using 15 year measure life and a 6% discount factor

Philadelphia Electric Company

PA Act 129 (2008) – PA utilities required to reduce energy consumption and peak demand (2009 – 2012). PECO's CVR program budget was 1.2% of the total program budget ($328.6 million) with highest net benefits accounting for 20% of the total



PECO CVR Project	
Lifetime Project Costs ($1000)	$4,500
Lifetime Project Benefits ($1000)	$110,000
Annual Energy Savings (MWh)	110,000
LCOE ($/KWh)	$0.003
TRC	23.5

Observations

1. Major advancements in CVR technologies without compromising reliability
2. Value proposition is strong, but
   a. Reliable full-scale deployment cost data remains elusive (many pilot projects)
   b. Value proposition for utilities impacted by disincentive of lost revenues
3. Momentum building as some utilities and regulators beginning to treat CVR in the EE resource portfolio, and leverage the regulatory mechanisms (e.g., cost recovery and lost revenue adjustments) and performance incentives already in place for EE programs.
   a. For example, OH, MD, WA, OR and PA include CVR in EE portfolios, CO, CA and IL under consideration
   b. However, there is lack of standardization in planning and evaluation tools (cost-benefit model specifications for comparative resource planning)
4. Business hurdles exist:
   a. New technology and vendor risk (including DER integration)
   b. Competing investment priorities
5. Leadership and increased awareness needed:
   a. Sharing of CVR cost/performance data and regulatory treatments
   b. Industry organizations can develop and promote reliable planning and evaluation tools/protocols