Business & Technology Report
March 2020

Voltage Var Optimization for Use in Poultry Applications

NRECA
America's Electric Cooperatives

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Introduction

With agriculture being a mainstay for many rural electric cooperatives, the financial health of these members is of significant interest to the cooperative. Agricultural operations range in size from family farms to corporate-run entities spanning multiple states. Regardless of size, these operations face many of the same issues, such as:

- Weather – heat, cold, rainfall amounts
- Disease
- Market demands
- Market conditions
- Operating cost increases
- Thin margins

Poultry farms require a lot of electricity to maintain an optimum production environment, whether the output is meat or eggs. Several uses contribute to high consumption levels, including lighting and ventilation.

Poultry stocks are susceptible to temperature. Heatwaves, in particular, present a serious threat to poultry operations. Chickens, for example, can tolerate colder temperatures better than they can heat. Since air conditioning a poultry house can be costly, farmers rely on fans to keep air moving. The ventilation systems not only help regulate temperatures, but also supply a steady flow of fresh air, another requirement for a healthy production environment. New technology applications and processes are available to address these issues while mitigating historic concerns of producers.

Background

Poultry houses are, or can be, notorious energy consumers. A few of the energy hogs (no pun intended) include:

- **Lighting** – poultry houses may be illuminated 24 hours a day during winter months to maintain egg-laying rates.
- **Ventilation** – fresh air and temperature regulation rely on large banks of fans that may also run 24 hours a day, 365 days a year.
- **Leakage** – Poultry houses are rarely adequately sealed to prevent exfiltration and infiltration of conditioned and unconditioned air.
- **Motors** power many areas, including fans, water supply, and so forth.

The Commercial Poultry Market – United States

The commercial poultry market[1] is enormous in the United States, with nearly 240,000 farms involved in production (according to 2012 National Agricultural Statistical Service data[2] – see Figure 1). In fact, the U.S. is one of the largest producers of poultry products in the world, with as much as 19 percent of output exported to other countries. When it comes to broiler production, the U.S. is the largest producer worldwide, with 18 percent of the almost 9 billion broilers produced annually going to exports.

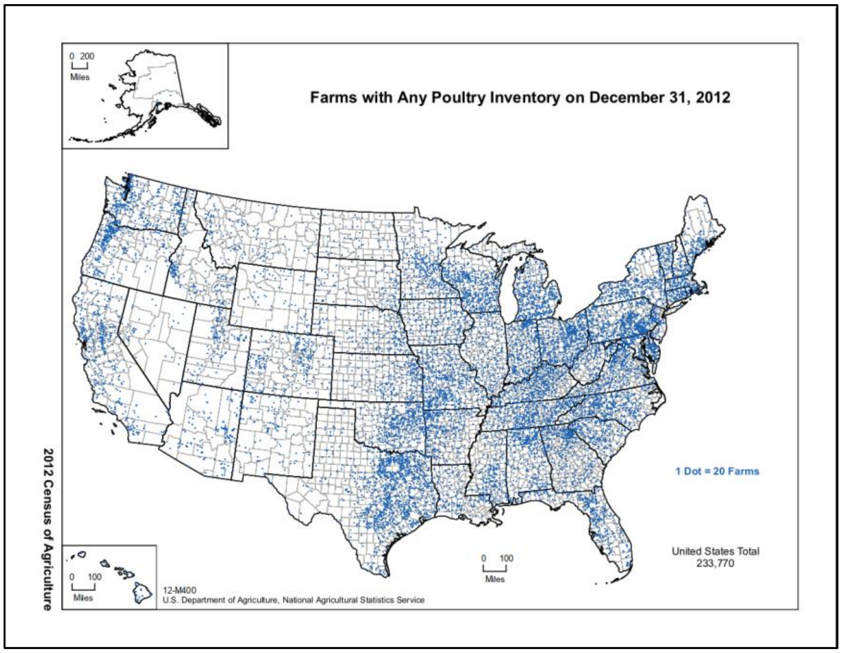


Figure 1: Poultry Farms in the U.S.

[1] https://www.profitableventure.com/starting-a-poultry-farm-business/
[2] https://www.usda.gov/sites/default/files/documents/nass-poultry-stats-factsheet.pdf

More recent data (2018, published 05/2019) illustrates the dollar value of this market.

Table 1: Dollar Value of the Poultry Market

Poultry Value of Production – United States: 2017 and 2018

Year	Broilers [1]	Turkeys	Chickens [2]	Eggs	Total
	(1,000 dollars)	(1,000 dollars)	(1,000 dollars)	(1,000 dollars)	(1,000 dollars)
2017	30,232,203	4,873,677	46,996	7,597,091	42,749,967
2018	31,746,230	3,875,131	49,364	10,586,262	46,256,987

[1] Excludes States which produced less than 500,000 broilers.
[2] Value of sales.

The Commercial Poultry Market – South Carolina

For the electric cooperatives of South Carolina, poultry farms represent a significant portion of their load, and consequently, revenue. This type of farming represents 40 pecent of the total South Carolina agricultural market and generates $1.5 Billion in total revenue. According to the same report referenced above, just over $1 billion of this revenue comes from broiler production (see Table 2).

Table 2: Boiler Production and Value in the U.S.

Broiler Production and Value – States and United States Total: 2018

[Annual estimates cover the period December 1 previous year through November 30. Broiler production including other domestic meat-type strains. Excludes States producing less than 500,000 broilers]

State	Number produced	Pounds produced	Value of production
	(1,000 head)	(1,000 pounds)	(1,000 dollars)
Alabama	1,123,700	6,180,400	3,454,844
Arkansas	1,092,000	7,316,400	4,089,868
Delaware	263,600	1,924,300	1,075,684
Florida	65,400	385,900	215,718
Georgia	1,361,400	8,168,400	4,566,136
Kentucky	303,300	1,971,500	1,102,069
Maryland	289,400	1,736,400	970,648
Minnesota	59,100	360,500	201,520
Mississippi	747,800	4,711,100	2,633,505
Missouri	293,100	1,465,500	819,215
North Carolina	873,600	6,901,400	3,857,883
Ohio	107,900	561,100	313,655
Oklahoma	196,800	1,318,600	737,097
Pennsylvania	200,100	1,140,600	637,595
South Carolina	237,800	1,807,300	1,010,281
Tennessee	177,300	939,700	525,292
Texas	653,500	4,247,800	2,374,520
Virginia	278,900	1,673,400	935,431
West Virginia	83,300	316,500	176,924
Wisconsin	55,800	228,800	127,899
Other States [1]	573,300	3,435,500	1,920,446
United States	9,037,100	56,791,100	31,746,230

[1] California, Illinois, Indiana, Iowa, Louisiana, Michigan, Nebraska, New York, Oregon, and Washington combined to avoid disclosing individual operations.

It is easy to see why the South Carolina cooperatives are interested in ways to help their poultry members remain profitable. With poultry enjoying steady growth as people consume more chicken as a healthier meat alternative, cooperatives will need to make choices in expanding traditional infrastructure and buying more energy to satisfy growing loads, or turning to innovative technologies and applications like voltage var optimization instead.

The South Carolina generation and transmission company (G&T), Central Electric Power Cooperative, Inc., along with four member cooperatives, conducted a pilot to determine the effectiveness and value of voltage var optimization (VVO) for several poultry operations. The equipment used was the Grid Energy Router[3] (GER) manufactured by GridBridge, an Ermco company. The pilot project team is shown in the following graphic:

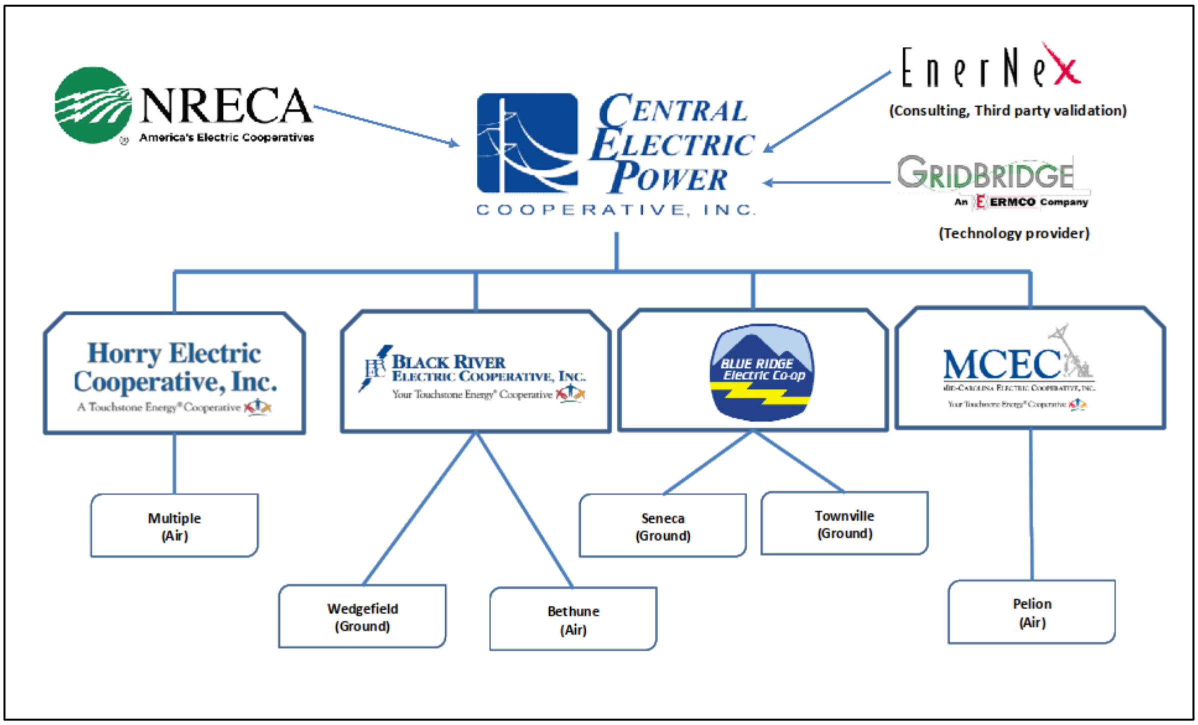


Figure 2: Project Team for Volt Var Pilot Program

Description of Voltage Var Optimization (VVO) Technology

Depending upon who you ask, VVO and conservation voltage reduction (CVR) are either the same thing or distinctly different. A significant difference between VVO and CVR is the way the two technologies are utilized. CVR is frequently used system-wide in

[3] http://www.grid-bridge.com/products-2/

response to a demand reduction event. Some cooperatives use CVR on an always-on basis to reduce costs for every member and to aid in the identification of system issues masked by normal voltage level operation.

VVO, on the other hand, is used in a targeted, always-on approach. Think of VVO as a dedicated energy cost reduction technology that also happens to deliver power quality benefits for the member and greater intelligence about, and control over, the feeder to the cooperative. VVO can also be operated on an event-driven basis to meet demand reduction requirements. However, the consensus among the pilot team participations was to turn the VVO equipment on and leave it on.

Discussions about the similarities or differences between CVR and VVO aside, the focus in this application is voltage optimization, and using voltage optimization to improve efficiency, reduce demand, postpone or eliminate infrastructure upgrades, and extend the operating life of both co-op and member equipment by reducing stresses placed on them by load and voltage variances.

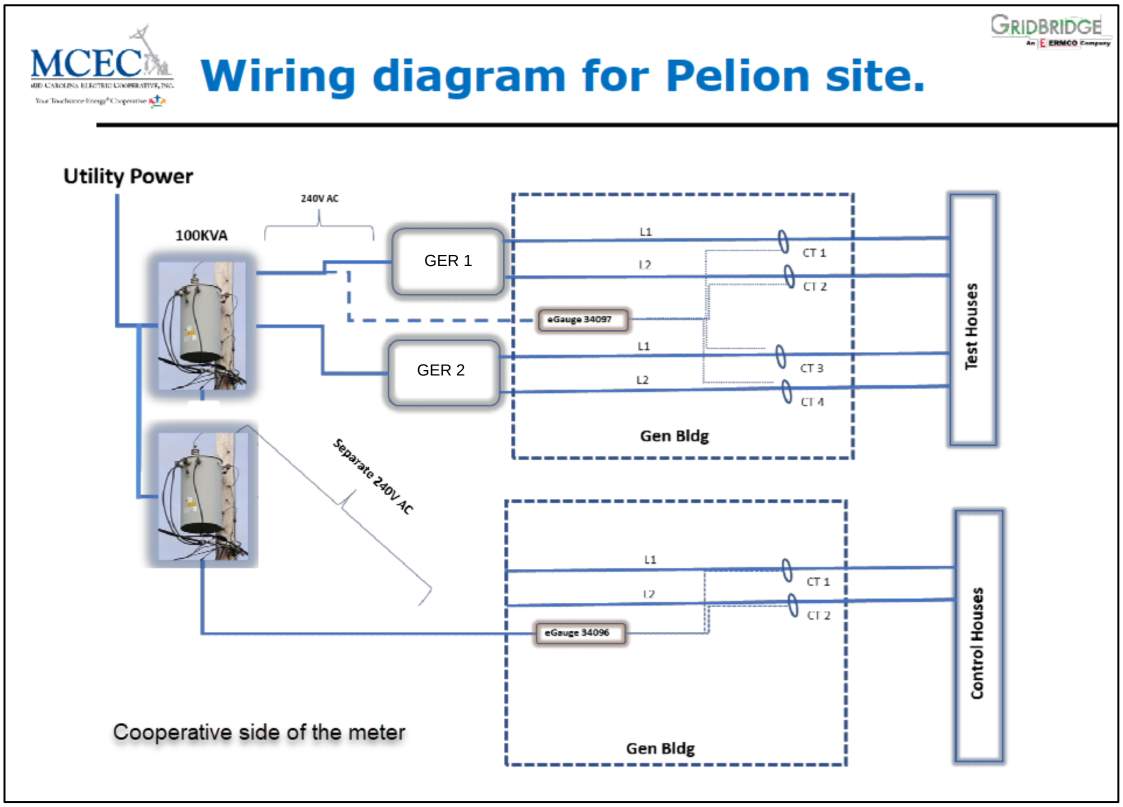
How Does GER Technology Work?

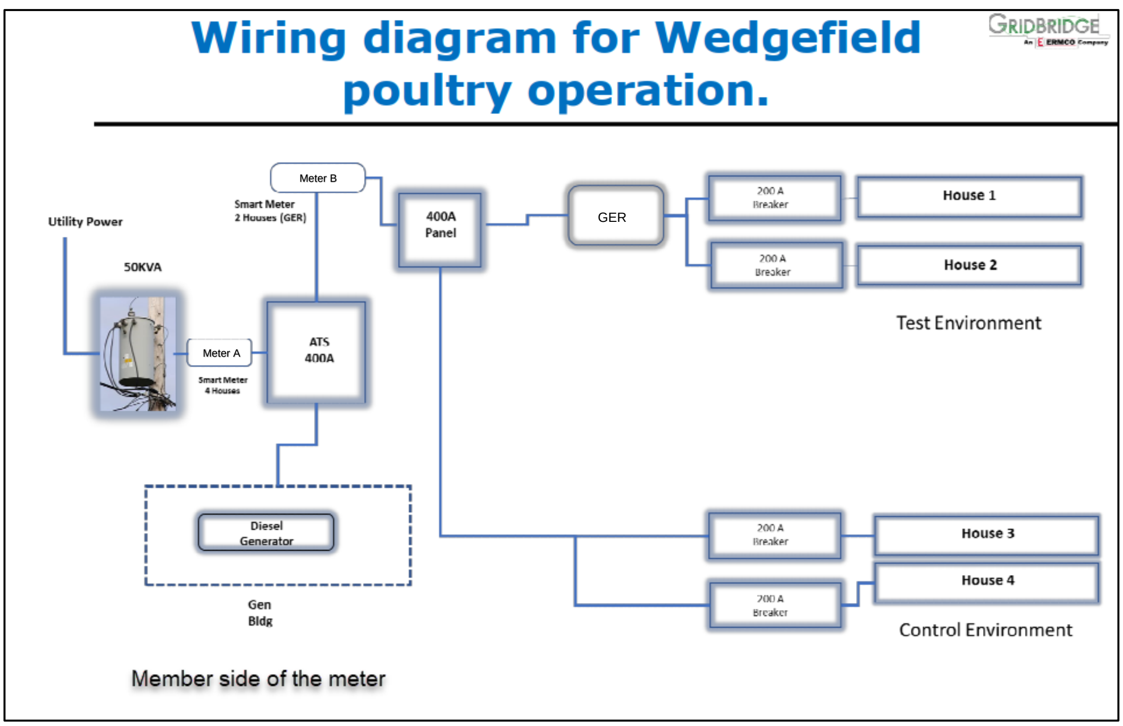
According to GridBridge resources, the GER uses "*a combination of power electronics, software, and communications capabilities to condition the power being delivered from the distribution transformer serving the member load.*" The results of the GER operation include the following:

- Provides precise regulation of both voltage and power factor of power delivered to the member;
- Supports and improves conservative voltage (CVR) efforts;
- Reduces wear on motors by supplying constant voltage, extending equipment life;
- Provides the cooperative with insight into distribution system conditions at the edge of the grid;
- Enables the cooperative to manage the distribution grid at the point of delivery to the member;
- Facilitates the integration and optimization of distributed energy resources; and
- Relieves stresses on substation equipment.

If this sounds like a giant power filter, you are on the right track, although that is a bit understated. The GER is positioned, so that power from the distribution transformer runs through it before entering the member's facilities. Should there ever be a GER event, the system reverts to a bypass mode where all the power flows through the GER unconditioned on a large copper bus. The following two wiring diagrams illustrate installations on both sides of the meter (see Figures 3 and 4).

Figures 3 & 4: Installations on Both Sides of the Meter





What are the Effects of GER Operation?

So, what does the equipment on the other side of the GER equipment "see"? The pilot results were extremely encouraging. They found:

- No adverse effects of farm operations
- Worked equally well in diverse climate and geographical settings
- Power factor improved to near unity
- Flat-line voltage benefitted motors, reducing heat and more closely matching the name-plate voltage
- GER operated well on both sides of the meter
- Produced consistent energy and demand savings

The following chart illustrates the effect of the GER on power output (see Figure 5). This data was collected at one of the participating poultry farms in the pilot. Notice the tight voltage range around 116 volts versus the relatively wide range on unregulated power. The result is that equipment receives flat-line, consistent voltage. When it comes to motors, this is an important contributor to equipment longevity.

Figure 5: The Effect of the GER on Power Output

Designed with Line Crews in Mind

The GER is designed to match existing cooperative distribution equipment form factors. The GER may be installed in either pole top or padmount configuration between the existing distribution transformer and the members load, or be integrated with a newly manufactured padmount transformer. The equipment is available for both single and three-phase service. These familiar form factors make it easier to engineer and install the equipment, using existing work standards and practices.

The following graphic shows the different form factors of the GridBridge GER equipment (see Figure 6).

Figure 6: Different Form Factors of the GridBridge GER Equipment

Where is the Best Place to Install the GER?

VVO technology can be installed on either side of the member's meter, unlike CVR which is installed on the co-op's side, generally in substations. The decision on where to install the equipment will be impacted by both financial and operational considerations. For example, if the VVO equipment is installed by the member on their side of the meter, the co-op avoids the capital expense associated with buying and installing the equipment. While that is beneficial in the short run, the member enjoys the cost savings going forward.

The co-op also does not receive the grid enhancement capabilities that come with installation on their side of the meter. All the control, monitoring, and regulation capabilities are out of reach on the member's side of the meter. As a result, opportunities for using the GER to manage DERs, avoid/postpone infrastructure upgrades, and provide localized system responses are lost.

If the cooperative owns the equipment, the poultry farm member still enjoys the costs savings, but the cooperative generally creates a smart connection that can deliver a variety of benefits that will impact all the members over time.

The following table (Table 3) presents a summary of the benefits to cooperatives and members for both the always-on and the event-driven applications. Source of this information was from pilot participants.

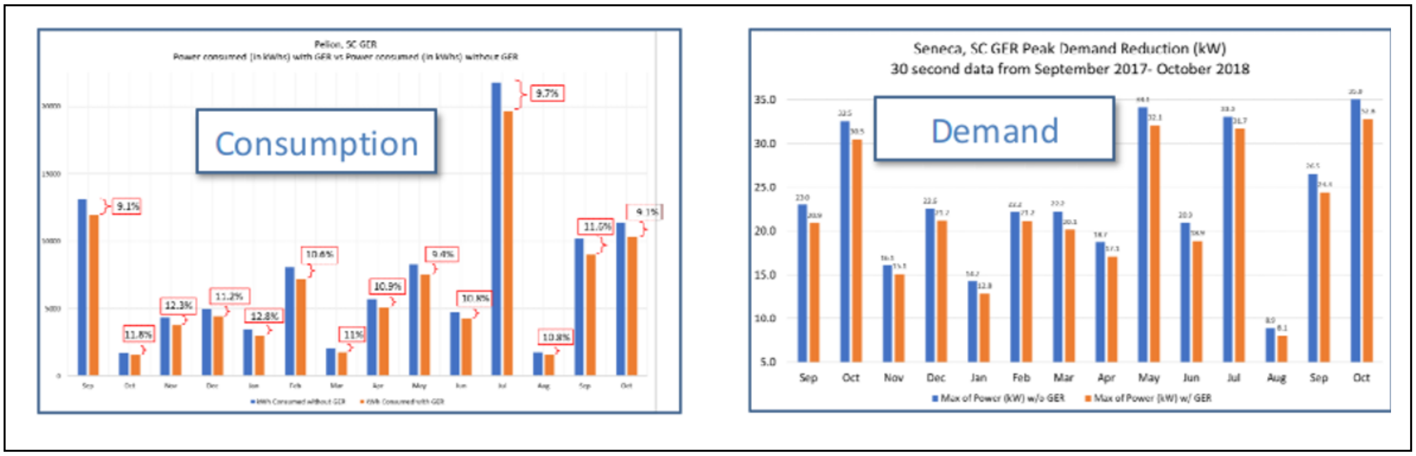
Table 3: Benefits to Cooperatives and Members

Always-on	**Event-driven**
Cooperative benefits	
Investing in member's infrastructure	Supports peak demand reduction during load control events
Lowers capacity requirements	Unity power factor (less equipment heat)
Postpones or eliminates infrastructure upgrades	Revenue retention
Provides distribution control at DER locations	Impactful, transparent to member load control
Member benefits	
Delivers flat-line, consistent voltage to motors	Delivers flat-line, consistent voltage to motors
Voltage more closely aligned to name-plate rating	Reduces pass-through demand charges
Financial savings help increase thin margins	

What Results were Achieved?

The pilot demonstrated excellent results in energy savings, demand reduction, cost savings, and distribution system benefits. The next graphic illustrates the savings in energy consumption and demand (see Figures 7 & 8).

The table below the graphic shows the results for five pilot participants over several months. Results vary by the site, but the reductions are all quite acceptable (Table 4).



Figures 7 & 8: Utility VVO – Reduction in Consumption and Demand.
(Source: GridBridge)

Table 4: Results of Pilot Participants Over Several Months (Source: GridBridge)

Location	Pelion[1]	Bethune	Wedgefield	Seneca	Townville
Utilities	MCEC	Black River	Black River	Blue Ridge	Blue Ridge
Number of months measured	14	10	11	14	3
Meter type	eGauge	Landis & Gyr	Landis & Gyr	Itron	Itron
Data Source	eGauge	GER	GER	GER	GER
Average utiliity provided voltage	247	243	244	244	246
Average regulated set point	232	232	232	232	232
Average voltage reduced by GER	14	10	8	11	13
KWh consumed without GER	101,521	42,924	44,352	79,376	14,776
Average energy reduction %	10%	6%	9%	9%	5%
Avg. Max Power without GER (kW)	73	28	27	24	22
Typical demand reduction %	9%	4%	4%	7%	7%

[1] Deployment at Pelion location included 2 GERs on a 100 kVA transformer.

The farms saw no adverse impacts on their operations, while enjoying cost savings on both the electric bill and equipment wear and tear (motors primarily). The other half of the equation is financial. How does this investment perform from a financial perspective? Quite well, as it turns out. For the Pelion installation, if the farm were to fund the entire equipment cost, the ROI would be approximately 4 years (see Figure 9).

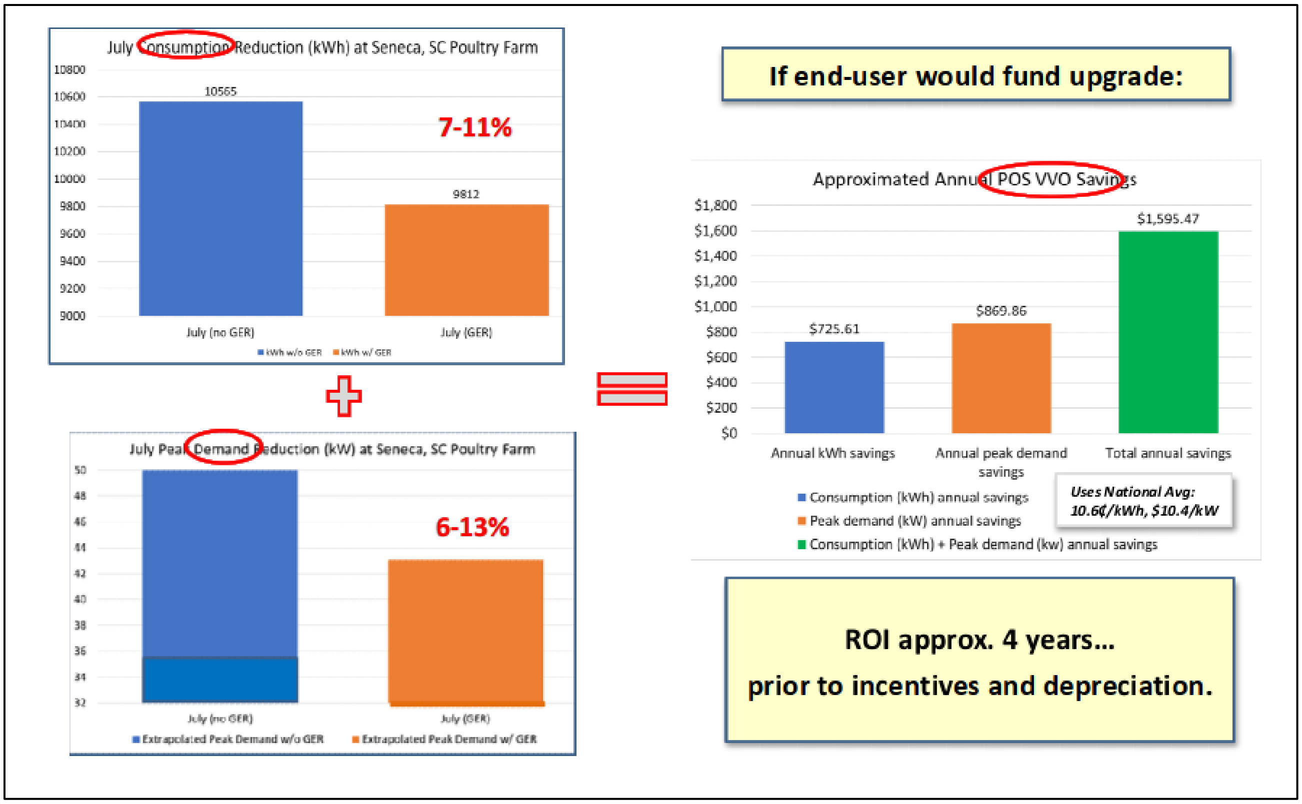


Figure 9: Calculation of the ROI

As is to be expected, the results vary with the installation. Still, the ROI appears to be consistently acceptable across widely varying installations.

Conclusion

The results from the pilot are very encouraging, and performance across the different sides was universally positive, even if the results did vary. The use of VVO using GER to other load management and demand reduction techniques shows VVO appears to be a promising methodology for cooperatives looking to accomplish:

- Energy and demand savings;
- Improved power quality and control beyond distribution transformers at the grid's edge;
- Enhanced management of distributed energy resources; and
- Delays in upgrading capacity of existing infrastructure to accommodate load growth.

About the Author

Tom Tate has been in the electric utility world for 25 years, working in various capacities for both IOU and cooperative operations and is well versed in the municipal business model. With experience in every member service, marketing, and sales management role, Tom discovered a passion and talent for writing about technology in a manner that makes complex concepts easily understandable for members and customers. Today, he runs his own freelance writing company and provides content for several cooperative and industry operations from his adopted home of Minneapolis, MN.