CRN
Cooperative Research Network

TechSurveillance

Geo Validation Program Overview:

Background and Goals for Western Farmers Electric Cooperative's New Program to Validate Savings from Ground Source Heat Pumps

BY **LAURA MOOREFIELD**, MOOREFIELD RESEARCH & CONSULTING
NOVEMBER 2013

Can high efficiency ground source heat pumps (GSHPs) help a generation and transmission (G&T) cooperative reduce the size of their next power plant by 30 to 50 MW? Western Farmers Electric Cooperative (WFEC) thinks so. To find out, they're embarking on a 16-month validation study to measure demand reduction, energy savings, project economics, and member satisfaction with this often-overlooked technology. This article explains GSHP technology, its benefits and drawbacks, and the experiences of WFEC with implementation. It is the first in a series of articles following WFEC's study.

INTRODUCTION

WFEC, headquartered in Anadarko, OK, serves 22 distribution co-ops in Oklahoma, eastern New Mexico, and small areas of Texas and Kansas. The co-op owns and operates the Hugo Plant, a 450 MW coal-fired power plant, as well as several natural gas power plants. They also purchase wind, hydro, and additional natural gas resources. Over the past several years, WFEC has seen significant load growth, largely due to the expanding oil and gas industry in their territory. In addition, because much of the region experiences summertime temperatures in excess of 100°F, handling summer peaks can be problematic.

NRECA
A Touchstone Energy® Cooperative

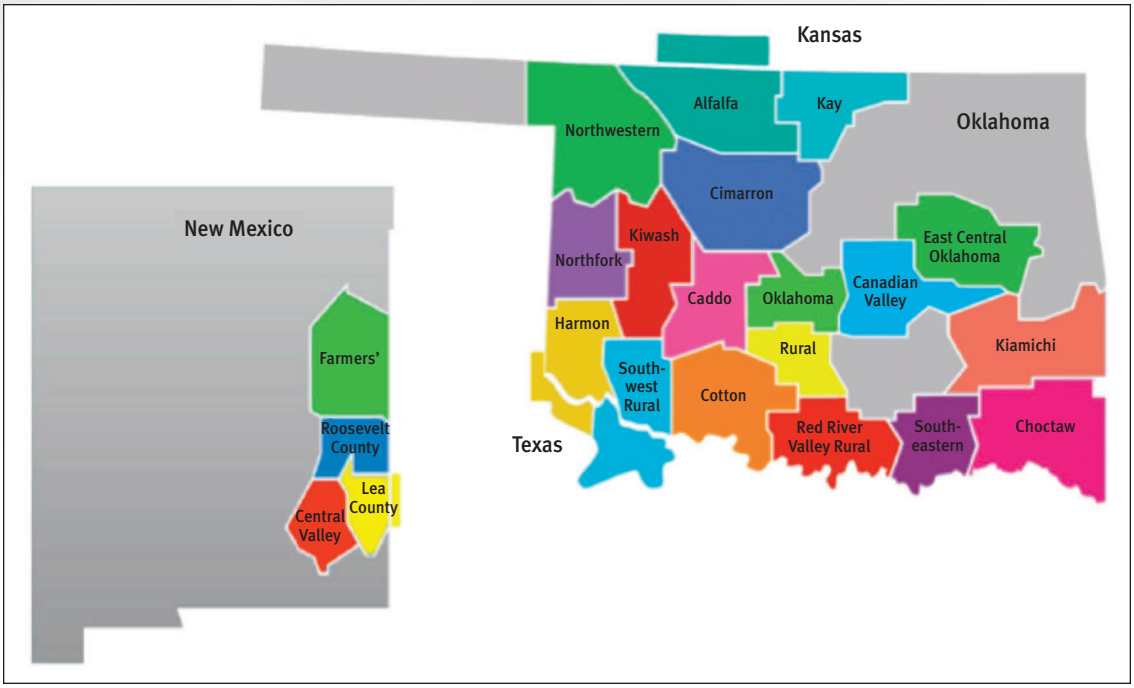

FIGURE 1. Map of WFEC's service areas

A GSHP system is comprised of one or more underground loops connected to a heat pump unit that is then connected to a home's heating and air conditioning system.

To meet this growing demand and reduce their summer peak, WFEC is planning to build a new, 450 MW, combined cycle, natural gas power plant in the next few years. But, they also wondered if they could offset some of this need through cost-effective energy efficiency and demand reduction measures. At $1,850 per kW, a 30 MW size reduction would shrink the initial cost of the new power plant by more than $55 million. A 50 MW reduction would save more than $92 million. Enter the Geo Validation Program, an innovative program to measure the performance of ground source heat pumps that is just getting underway.

TECHNOLOGY OVERVIEW

Ground source heat pumps (GSHP), also called geothermal heat pumps or geoexchange systems, are electrically powered devices that use the consistent year-round temperature underground (approximately 45° to 75°F depending on U.S. region[1]) to regulate indoor air temperature. A GSHP system is comprised of one or more underground loops connected to a heat pump unit that is then connected to a home's heating and air conditioning system (Figure 2). The underground loops, fluid-filled pipes buried at least ten feet below ground, act as heat exchangers. In the summer, the loops transfer heat from the home into the ground, or in some cases, well water. In the winter, the process is reversed. Because GSHPs take advantage of the moderate temperature below ground for heating and cooling, in most climates they are much more efficient than air source heat pumps and other standard HVAC equipment.

[1] See: http://geoheat.oit.edu/pdf/tp32.pdf.

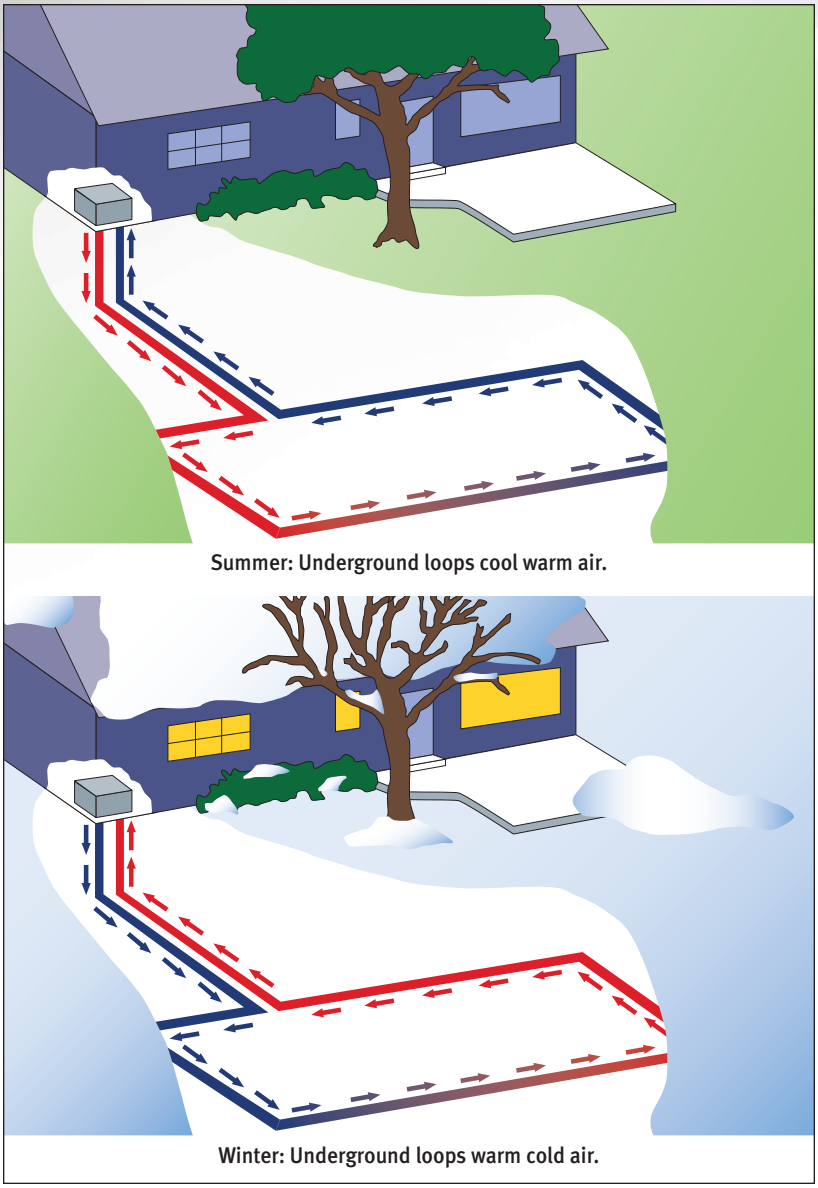

FIGURE 2. Ground source heat pump underground loops.
Source: U.S. Geological Survey 2003

With the addition of a *desuperheater*, or hot water generator, GSHPs can also produce hot water relatively easily, eliminating the need to heat water with gas or electric resistance.

Ground source heat pumps offer several benefits to co-ops and members. They can:

- Reduce summer air conditioning peaks due to high efficiencies in hot weather.
- Provide a high-efficiency heating system that can compete with gas or propane heating.
- Allow utilities to serve all-electric households without resorting to expensive electric resistance heating.
- Offer secondary benefits, such as free domestic hot water or pool heating.
- Get rid of noisy outdoor condensing units.
- Improve overall load factor.

While savings vary depending on climate, the U.S. Department of Energy estimates that most homeowners will recover the extra expense of a GSHP system in two to ten years through lower energy bills. If the investment is financed on a mortgage, cost savings begin immediately.[2]

PROGRAM BACKGROUND

Mark Faulkenberry, Manager of Marketing and Communications at WFEC, believes that ground source heat pumps present a "huge opportunity" that is relatively untapped—fewer than two percent of Oklahoma homes currently use them despite the fact that the technology has been available since the 1940s. Today's GSHPs use more than 40 percent less energy than the much more common air source heat pumps, and up to 70 percent less energy than electric resistance heating with standard air conditioning equipment.[3] But, according to Kalun Kelly, WFEC's Marketing Commercial and Industrial Manager, while GSHPs save energy and money in the long-term, several key barriers to adoption must be overcome—"Ground source heat pumps require an underground loop to allow

[2] Source: http://energy.gov/energysaver/articles/choosing-and-installing-geothermal-heat-pumps
[3] Source: http://energy.gov/energysaver/articles/choosing-and-installing-geothermal-heat-pumps

With WFEC's program, members are able to realize a net savings due to higher efficiency of GSHPs.

The before and after measurements unique to the Geo Validation Program allow WFEC and distribution cooperatives to better tailor the program to member needs.

for heat transfer, which adds cost to the system, and the loop itself may take up to two or three weeks to install. Also, there is a general lack of knowledge about the technology, but co-ops are continuing to make great progress in providing education and programs."

Many co-ops already help mitigate the upfront costs through several strategies, including rebates, on-bill financing, and education about state and federal tax credits. WFEC has offered rebates through their distribution member co-ops for both air source and ground source heat pumps since 2006. Their rebates must be matched by the distribution cooperatives. For GSHPs, the result is minimum rebate amounts of $525 to $675 per ton of cooling, depending on the unit's efficiency. These rebates were designed around a peak demand reduction estimate of 0.65 kW/ton[4] for a high efficiency[5] GSHP with a desuperheater. (This savings estimate is consistent with studies for similar climates.) If WFEC and the distribution co-ops achieve the expected demand reduction with these rebate amounts, the cost comes out to $800 to $1,000 per kW saved[6]—about half the cost of building a kW of new power generation. WFEC wants to validate these savings and cost assumptions by recording actual data from homes in their territory retrofit with GSHPs.

In addition, the G&T is currently working with three of its distribution cooperatives to test the economics of a "thermal service" program option. In this scenario, the distribution co-op builds, owns and maintains the underground loop, which is a significant portion of the overall cost of installing a GSHP system, and provides it to their member as a utility service at a fixed monthly tariff rate. The member would need only to purchase and maintain the in-home unit, for which they would receive a rebate from the co-op, a low-interest loan for the GSHP equipment, and any applicable federal and state tax credits for their new GSHP unit. Even with a monthly thermal energy service tariff and the loan repayment, the member can still realize a net savings because of the higher efficiency of GSHPs. Lyndal Moore, Bosch's National Sales Manager, expects participants will save an average of $100 per month, netting a $70 savings after the $30 lease payment. However, savings will vary from home to home based on the type and age of equipment being replaced. WFEC's goal is that all participants are cash-positive throughout the term of the loan. When the loan is paid off, their monthly savings should increase dramatically.

The co-op is partnering with GSHP manufacturers Climate Master and Bosch for this program. Both manufacturers contributed to the funding for the savings validation portion of the study.

PROGRAM GOALS

As the name implies, the core of the Geo Validation Program is to measure and verify the energy savings, demand reduction, costs and cost-effectiveness of high efficiency GSHPs in WFEC's territory.

---

[4] A typical home's HVAC system is 3-4 tons. One ton is equal to 12,000 British Thermal Units (BTUs).

[5] For WFEC's standard rebate, a GSHP must have a 2nd stage EER greater than 15.9. A GSHP with a 2nd stage EER greater than 18.5 earns a higher rebate. Because the 1st stage is not typically running when the outside air temperature is above 100°F, they consider only 2nd stage ratings, since the unit will more than likely be running in the 2nd stage at these high temperatures.

[6] Note that these costs are rebates only and do not include any program administration expenses.

WFEC aims to leverage GSHPs for future plant planning and ultimately have GSHPs qualify as a resource under renewable portfolio standards.

To do so, WFEC will document:

- Demand reduction on critical peak days in the summer before and after retrofits,
- Energy usage reductions, especially during peak time-of-use rate intervals (3:00 PM – 7:00 PM), before and after retrofits,
- Underground ("entering") loop temperatures to assure that software properly sized the loops,
- Loop energy (BTU) transfer rates,
- Variance between actual savings and those projected by manufacturer's software,
- Desuperheater's contribution to a home's hot water needs,
- Average cost for loop installation for both Oklahoma and New Mexico homes,
- Average cost for GSHP units (equipment and labor) for both Oklahoma and New Mexico homes, and
- Member satisfaction with contractors, drillers, equipment, comfort and program.

These detailed before and after measurements are what makes the Geo Validation Program unique. Said Paul Bony, Director of Residential Market Development for Climate Master, "We've gathered data before on geothermal heat performance in the field before, but this is first time that I know of that we'll get load profiles from both the old air conditioning units and the new geothermal heat pumps from the same customers, in the same houses, in the same week."

With this information, WFEC can work with their distribution co-op members to craft appropriate rebates, tailor the broader program design to meet members' needs, and identify what kind of financing and business models would most effectively remove barriers to adoption.

Furthermore, the G&T will leverage the results to continue its outreach and education efforts. Faulkenberry noted, "There is a general lack of awareness of the benefits ground source heat pumps offer; we want to get the word out about actual savings not just to co-op members, but to everyone in the region." As part of this effort, WFEC, along with Touchstone Energy, Climate Master, Bosch and Water Furnace, sponsored the "Go Go Geo" Video Challenge where Oklahoma high school students produced videos to promote geothermal technology while competing for more than $60,000 in college scholarships.[7]

Ultimately, WFEC wants to determine if GSHPs can be leveraged throughout their region to reduce the size and price tag of their next power plant. By doing so, they help their distribution co-ops save their members money and energy. If individual members reduce demand at their homes, distribution co-ops are able to avoid purchasing expensive on-peak electricity from WFEC, which helps to keep rates down for everyone.

Reducing the need for new capacity also mitigates risk for the G&T, since state and federal governments are actively adopting renewable energy requirements and moving toward carbon dioxide (CO_2) regulations. WFEC and its member co-ops want to pro-actively plan for these changes through demand reduction and energy efficiency, instead of building more CO_2-producing power plants. Their longer term goal is to have GSHPs qualify for as a resource under renewable portfolio standards (RPS).

TIMELINE

WFEC began recruiting participants from across their entire region in early 2013. Participating homes had to meet several criteria, including having existing HVAC equipment at least ten years old and having internet, so that data can be uploaded over the course of the study. Home owners also had to agree to upgrade

[7] See: www.gogogeochallenge.com

TABLE 1. Distribution Co-ops Participating in the Geo Validation Program

Caddo Electric Cooperative	Harmon Electric Cooperative	Oklahoma Electric Cooperative
Cotton Electric Cooperative	Kay Electric Cooperative	Roosevelt Electric Cooperative
East Central Electric Cooperative	Kiamichi Electric Cooperative	Rural Electric Cooperative
Farmers Electric Cooperative	Northfork Electric Cooperative	Southeastern Electric Cooperative

insulation to ENERGY STAR® levels if necessary, since it is more cost-effective to size a GSHP system for a properly sealed insulated home than for a poorly insulated, leaky home.[8] Ultimately, WFEC selected 22 homes from 12 distribution co-ops to participate (Table 1). Five homes are in New Mexico; the rest are in Oklahoma.

FIGURE 3. Sub-metering equipment installation in participating home. *Source: www.wfec.com/media-center/photo-galleries/geo-validation-underway*

Distribution co-ops then coordinated next steps at participants' homes. A co-op representative conducted a review of the home's insulation and weatherization and the GSHP equipment installers and drillers provided bids. Co-ops assisted in getting bids for additional insulation or sealing if required. Once the homeowner had selected bids, their distribution co-op ensured all vendor contracts and agreements between the co-op and the members were in place.

The next step was to gather baseline data on how much electricity the homes consumed in total, with separate measurements for air conditioning, air handling, and hot water (if electric) prior to any upgrades. The program also collected data on indoor and outdoor temperature and humidity levels to better understand member behavior. To collect this data, WFEC worked with distribution co-ops to install current transformer (CT) clamps on relevant circuits in the homes' electrical panels, and set up wireless gateways in each home to transmit electricity and temperature data at five-minute intervals back to the co-op. Baseline data collection began early in June of 2013.

Only one home required a building shell upgrade prior to the GSHP conversion. All other homes met ENERGY STAR's minimum specifications. However, a few homes will receive additional weather sealing and insulation in the fall

[8] For a complete list of program requirements, see: www.wfec.com/sites/default/files/022113%20Geo%20Validation%20Program%20Criteria.pdf

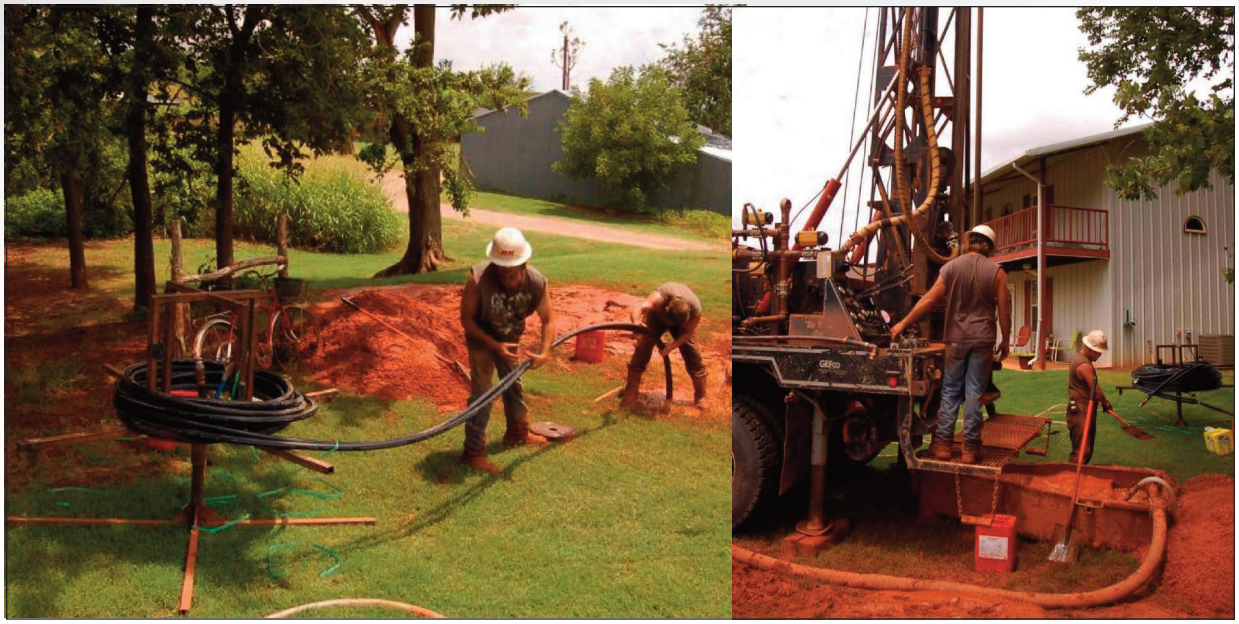

FIGURE 4. Underground loop installation at participating home. *Source: www.wfec.com/portal/marketing/communications/photo-galleries/geo-drilling*

of 2013 after the summer's savings from the switch to a GSHP have been documented.

Finally, drillers began digging vertical wells and installing the underground loops (Figure 4). All loops were installed by July 26, 2013. Contractors then installed the above-ground GSHP units during the week of July 29th. All 22 systems were operational by August 2, 2013. The program selected early August for the retrofits to take effect, so that their sub-metering data would include readings from hot summer days with old equipment as well as new GSHPs. Data collection for these homes will continue until through October 2014.

WFEC will analyze the data as it is collected at quarterly intervals. Their first report on findings is scheduled for completion in late 2013 with subsequent reports in 2014. For these reports (when available) and other program information and updates, see WFEC's website (**www.wfec.com**).

Once the results are final, WFEC will determine next steps for scaling-up this innovative program, and, they hope, scaling-down plans for a new power plant. ■

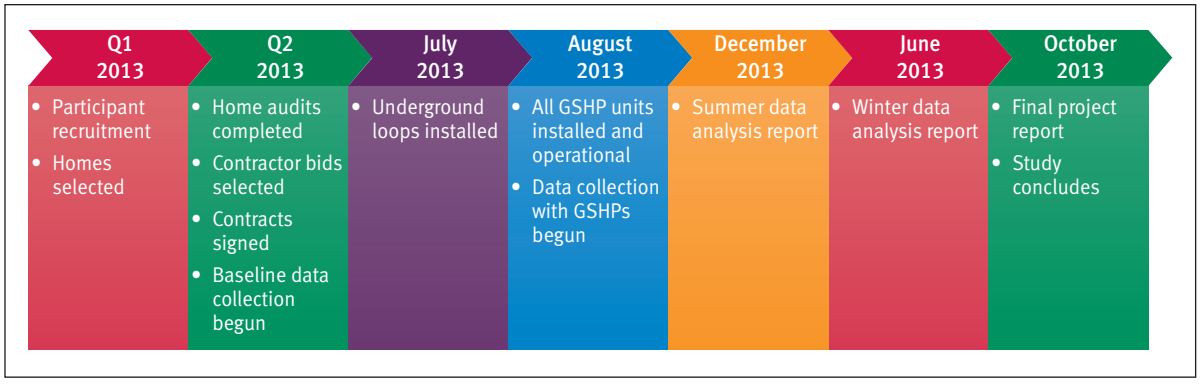

FIGURE 5: Timeline graphic

RESOURCES

Database of State Incentives for Renewable Energy (DSIRE) website. (2013). **www.dsireusa.org**

Lund, John W. (n.d.). *Geothermal Heat Pump Utilization in the United States*. Klamath Falls, Oregon: Oregon Institute of Technology, Geo-Heat Center. Available from: **http://geoheat.oit.edu/pdf/tp32.pdf**

U.S. Department of Energy. (2012). Geothermal Heat Pumps website. **http://energy.gov/energysaver/articles/geothermal-heat-pumps**

U.S. Environmental Protection Agency. (2013). ENERGY STAR Most Efficient Geothermal Heat Pumps website. **www.energystar.gov/index.cfm?c=most_efficient.me_geothermal_heat_pumps**

U.S. Environmental Protection Agency. (2013). ENERGY STAR Program: Heat Pumps, Geothermal website. **www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=HP**

U.S. Geological Survey. (2003). Geothermal Energy—Clean Power from the Earth's Heat (Circular 1249).

Western Farmers Electric Cooperative. (2013). Geo Validation Program website. **www.wfec.com/portal/marketing/programs/geovalidation**

About the Author

Laura Moorefield, Principal, Moorefield Research & Consulting LLC

Laura has consulted to utilities, state and federal governments, and non-profits on energy efficiency, renewables, and new technologies for more than seven years. She has conducted industry-leading research on plug loads and lighting, and has been influential in the development of innovative programs and policies to spur energy savings. Laura has authored numerous reports for audiences from lay people to utility regulators on a wide range of topics including landfill gas-to-energy, smart meters, residential and commercial plug loads, on-bill financing, LEDs and consumer guidance on the recent federal light bulb standards. She is frequently a featured speaker at industry conferences and webinars. Formerly with Ecos Consulting and Ecova, Laura founded Moorefield Research & Consulting in 2013. She currently resides in Durango, CO and is a member of La Plata Electric Association.

Questions or Comments

Brian Sloboda, Senior Program Manager, Cooperative Research Network, NRECA

Legal Notice