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DISTRIBUTED WIND CASE STUDY: SAN ISABEL ELECTRIC COOPERATIVE

How a southern Colorado distribution cooperative fulfills its state requirements and its mission with distributed wind.

RADWIND Project

This is the seventh in a series of case studies on distributed wind projects at electric cooperatives and other rural utilities for NRECA Research's *Rural Area Distributed Wind Integration Network Development* (RADWIND) project. RADWIND's goal is to understand, address, and reduce the technical risks and market barriers to the adoption of distributed wind technologies by rural utilities. Distributed wind projects can use any scale of turbine from small kilowatt-scale units up to large multi-megawatt units, as long as they are connected on the distribution side of the electric grid. Turbines may be connected on the customer side of the meter to serve a local load, directly to the distribution grid as a utility generating asset, or directly powering an off-grid load. For more information on the project and additional resources, please visit the project landing page at www.cooperative.com/radwind.

The distributed wind project profiled in this case study is part of a front-of-meter wind farm connected to the co-op's distribution grid.

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Project Snapshot

Cooperative	Project Ownership	Project Size	Turbine Size	Connection	Energy End Use
San Isabel Electric Association (SIEA)	SANY (owner and wind turbine manufacturer)	8 MW	2 MW	Front-of-meter, distribution grid	Reduces wholesale power purchase costs

Cooperative Profile

San Isabel Electric Association (San Isabel) is an electric distribution cooperative headquartered in Pueblo West, Colorado, 110 miles south of Denver. The co-op's territory extends another 110 miles south to the New Mexico border and covers an area larger than Connecticut, Rhode Island, and Vermont combined.

To serve its 24,000 members — 21,000 of whom are residential — the co-op owns and maintains 4,600 miles of power line. Commercial and industrial activities in this region are largely related to extractive industries, including cement manufacturing, quarries, mines, and numerous natural gas and carbon dioxide production facilities.

This sparsely-populated area experiences dynamic weather due to its location between the Rocky Mountains and the eastern plains. On one notable day, co-op line workers responded first to an outage caused by heavy snowfall and later to one resulting from a tornado.

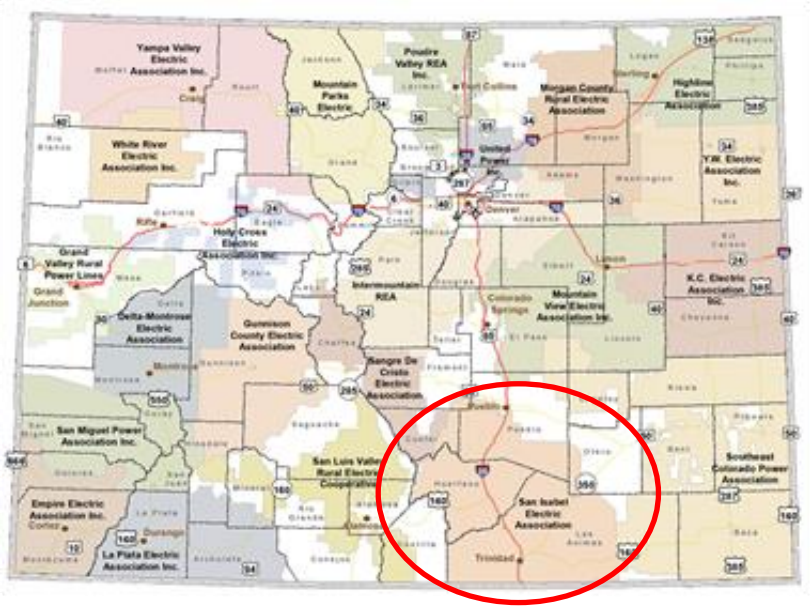

Figure 1. San Isabel Electric Association's Southern Colorado Territory

Tri-State Generation and Transmission Association (Tri-State),[1] headquartered in Westminster, Colorado, is San Isabel's power supplier. Currently, San Isabel has an all-requirements contract with Tri-State, which includes an allowance to generate up to 5% of its energy locally. In 2020, San Isabel purchased nearly 440,000 MWh from Tri-State to sell to its members. In a typical year, the co-op has a summer peak of 83 MW and a winter peak of 79 MW.

San Isabel offers several innovative programs and services to its rural southern Colorado membership through its Empower program.[2] Empower helps members bundle upgrades to reduce their overall energy expenses through beneficial electrification. Program measures include home energy assessments, all-electric home certification and design support, rebates for energy-efficient appliances, education on electric vehicles and home charging, and on-bill financing. Further, the co-op identified a need to support members' interests in residential solar PV and now offers solar options, including on-bill financing, through a partnership with a local solar developer.

empower BY SAN ISABEL ELECTRIC

San Isabel is also a leader in distributed wind. Its 8 MW Huerfano River Wind Farm came online in 2013, becoming the largest distributed generation wind facility in Colorado, which still holds true. In recognition of this project, San Isabel was named "Wind Cooperative of the Year" for 2014 by the U.S. Department of Energy.

[1] https://tristate.coop/

[2] http://siea.com/empower/

Project Background

San Isabel began internal discussions about developing its own renewable generation around 2010. The co-op had a multi-faceted goal of helping members control their energy costs, improving local quality of life, and meeting the state's renewable portfolio standard (RPS), which was established by voters through a ballot initiative in 2004.[3]

San Isabel's territory has an abundance of wind and sun. Colorado is the sixth sunniest state in the country.[4] The region also has impressive winds caused by air rushing down the eastern slope of the Rocky Mountains towards the plains. Around the time that San Isabel began investigating its renewable energy options, large renewable energy companies took notice of the region's resources. Vestas, a global wind turbine manufacturer, opened a tower manufacturing factory just north of the co-op's territory in Pueblo, Colorado. The area surrounding San Isabel's territory is now home to several large utility-scale wind and solar farms that are online or under construction.

Co-op staff evaluated the wind and solar options available to them and found that wind energy was the more attractive option. They also considered including battery storage, but at the time of project development, battery technology was not financially viable. Subsequently, a local developer approached San Isabel with a proposal to build an 8 MW wind farm within the co-op's territory, and the co-op decided to proceed.

The wind farm was sized to meet San Isabel's requirements under Colorado's RPS. Although the RPS has been updated since the time of San Isabel's project development, the initial goal was that 20% of investor-owned utilities' and 10% of rural electric distribution cooperatives' retail electricity sales in the state be made up of renewable sources, including wind and solar, by 2020.

Figure 2. Huerfano River Wind Farm. Source: Wikimedia[5]

[3] https://programs.dsireusa.org/system/program/detail/133

[4] https://worldpopulationreview.com/state-rankings/sunniest-states

[5] Creative Commons license: https://commons.wikimedia.org/wiki/File:Huerfano_River_Wind_Farm.JPG

Technical Details

The four wind turbines that make up Huerfano River Wind Farm (see Figure 2) are 2 MW models made by SANY,[6] a Shanghai-based manufacturer of industrial vehicles and energy sector equipment.

- Wind turbine model number: SE10020 DF
- Hub height: 80 meters/262 feet
- Rotor diameter:102 meters/335 feet
- Blade length: 43 meters/141 feet
- Overall tip height (from the base of the turbine to the tip of a blade pointed straight up): 116 meters/380 feet[7]
- Cut-in speed (the lowest wind speed at which the wind turbines generate electricity): 2.5 meters per second (m/s) or 5.6 miles per hour (mph)
- Cut-out speed (the wind speed at which the wind turbines stop generating electricity to avoid overheating and other damage): 25 m/s or 60 mph[8]
- Average capacity factor: 23.85%

The developer selected wind turbines with double-fed (or doubly-fed) induction generators (DFIG),[9] which increase overall wind turbine efficiency and reduce inverter and power factor control costs compared to direct-in-line models.[10] According to Clinton Smith, system engineer at San Isabel, the DFIG configuration also improves outage response.

Siting and Interconnection

Huerfano River Wind Farm is centrally located in San Isabel's territory on land that had been divided into residential parcels, but was not developed. The co-op and the project developer, New Centennial Power, selected the site with help from the National Renewable Energy Laboratory (NREL) in Golden, CO, and Colorado State University in Fort Collins, because of its good to excellent wind speeds. In fact, the wind farm is located in a wide band on the eastern slope of the Rocky Mountains that is considered a "special wind region"[11] by the American Society of Civil Engineers,[12] meaning that it may have unusual wind characteristics caused by nearby mountain ranges, gorges, and other prominent topographic features.[13] While the area does have a good wind resource, it can also have extreme winds on occasion, such as in 2017 when wind speeds reached 135 mph at the site.

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[6] https://www.SANYgroup.com/

[7] https://en.wind-turbine-models.com/turbines/2087-SANY-se10020 and https://worldjournalnewspaper.com/huerfano-river-wind-project-is-a-go/

[8] SANY SE10020 - 2,00 MW - Wind turbine (wind-turbine-models.com)

[9] For overviews, see: https://www.elprocus.com/using-double-fed-induction-generator/ and https://www.esig.energy/wiki-main-page/wind-turbine-technologies/

[10] http://web.mit.edu/kirtley/binlustuff/literature/wind%20turbine%20sys/DFIGinWindTurbine.pdf

[11] https://www.cppwind.com/special-wind-regions/

[12] *Minimum Design Loads for Buildings and Other Structures,* https://ascelibrary.org/doi/book/10.1061/9780784412916

[13] https://www.cppwind.com/special-wind-regions/

The project is connected to San Isabel's Huerfano Substation, an existing 69 kV, 15 MVA distribution substation that had been rebuilt in the early 2000s with a standardized, pre-packaged substation transformer kit that was available in one size only. This size was larger than needed at the location at the time, but SIEA installed it favoring construction and commissioning time over correct sizing. Therefore, prior to the wind farm, the substation was lightly loaded (5% - 7%) and had plenty of capacity for the interconnection. Even with the wind farm, Huerfano Substation stays below 50% of its full load capacity.

The co-op repurposed a 7.2/12.47 kV feeder line for the collection system that spans the approximately 1,000 feet from the closest wind turbine to the substation. From there, the wind energy is distributed to the primarily rural, residential members served by that substation. Any excess is further distributed to several other substations on the same 69 kV line, reaching about one-third of San Isabel's members. This distribution plan ensures that all of the wind energy is used on the distribution side and does not backfeed onto the transmission system. The wind farm does not have the required communications infrastructure that the balancing authority requires for bulk transmission backfeed.

Metering

Three separate meters onsite record production. Tri-State owns the primary, definitive meter located at the substation delivery point. Both San Isabel and SANY also have meters on site for informational purposes.

Production

According to Smith, the project supplies around 4% of San Isabel's annual energy needs and about 10% of its demand based on nameplate capacity. In 2018 and 2019, monthly production ranged from a low of 649,000 kWh in August 2018 to a high of 2,552,000 kWh in February 2019, as shown in Figure 3. In 2019, the best production year to date, the wind farm produced more than 19 million kWh resulting in an average capacity factor of 27% for that year.

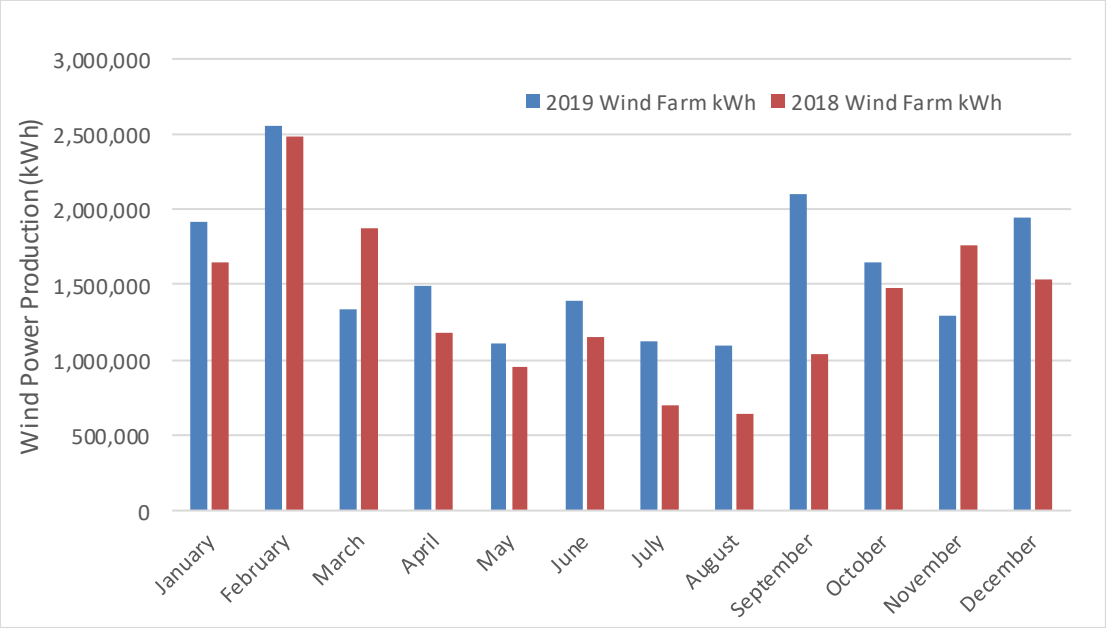

Figure 3. Huerfano River Wind Farm Monthly Production (kWh), 2018 and 2019.
Courtesy of San Isabel Electric Cooperative, 2020.

Often, the wind farm's daily production aligns with the co-op's demand. See Figure 4, where hourly data from a sample day of the wind farm's production (blue line) and the co-op's demand (red line) are both normalized to 100% (represented as 1 in the y-axis) for visual comparison. Note that on this day, the wind farm was producing at its maximum output at nearly the same time that San Isabel's demand peaked. While the wind farm's daily peak production in MW is much lower than San Isabel's daily peak demand in MW, Figure 4 illustrates how both curves align on some days.

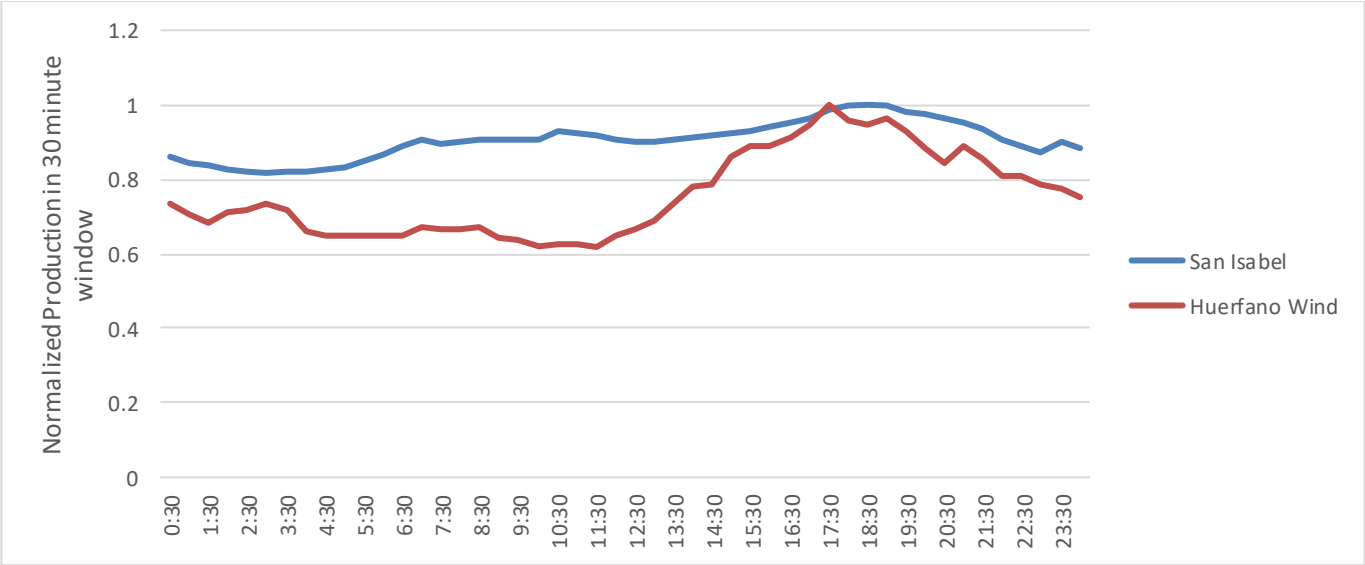

Figure 4. Huerfano Wind Production Curve Compared to San Isabel's Daily Demand.
Courtesy of San Isabel Electric Cooperative, 2020.

Planning & Engineering

San Isabel worked with the project developer and Tri-State on the planning and engineering phase of the project. Because the Huerfano Substation was so lightly loaded prior to the wind farm, upgrades were not required on the transmission side of the system, other than the addition of SCADA to the substation where the project would be interconnected.

Operations & Maintenance

SANY, the wind turbine manufacturer and current wind farm owner, is responsible for all operations and maintenance (O&M). According to Smith, "Wear on the turbines is higher than we expected it to be." For example, all turbines have needed gearbox replacements. Smith has observed that often one of the four turbines is offline for maintenance. SANY's technicians, who are based in Texas, typically resolve O&M issues in a timely manner.

Economic Details

San Isabel chose to enter into a power purchase agreement (PPA) for the project instead of outright ownership. The project's total cost was approximately $17 million,[14] and the owner secured financing for the project.

San Isabel has a 25-year PPA with SANY America for the purchase of wind energy from the project. San Isabel's wholesale electric service contract with Tri-State allows for the purchase of up to 5% of San Isabel's total energy requirements from sources other than Tri-State. Additionally, through their Board Policy 115, Tri-State provides a bill credit to San Isabel for the electricity that San Isabel purchases from the project. Renewable energy credits (RECs) are assigned to San Isabel per the terms of the PPA. San Isabel in turn sells the RECs to Tri-State under the terms of Tri-State's Board Policy 117, which provides a Tri-State member the ability to sell RECs from local projects to Tri-State.

The negotiated PPA pricing along with the sale of RECs to Tri-State made the project financially viable by helping San Isabel meet its financial goal of reducing the co-op's wholesale power purchase costs and providing rate stability for San Isabel's members while also meeting its RPS requirements.

Figure 5. Huerfano River Wind Farm. Courtesy of San Isabel Electric Association, 2020.

Members and Community

Meeting the Colorado RPS was an important impetus for the project, but according to Smith, there was a "more significant" requirement for the wind farm – improving members' quality of life. "Our board takes very seriously the impact that we have on the community." Reflecting that, the co-op's mission statement includes upholding social and ethical values in addition to providing electricity:

[14] https://www.chieftain.com/article/20120106/BUSINESS/301069891

To provide our Membership with electric power and other needed products and services which will improve their quality of life. We will provide excellent service and maintain the highest social and ethical standards as we evaluate and utilize new technologies and resources to meet the needs of our Membership.[15]

San Isabel serves large portions of three counties—Huerfano, Las Animas, and Pueblo—where 16% to 20% of the population lives below the poverty level. This is twice as high as the statewide poverty level of 9% and well above the national rate of 12%.[16] More than anything, San Isabel wanted to save their members money on their power bills and improve the quality of life through reduced emissions.

Smith noted how the clean energy aspect of the project is becoming increasingly important to members. The wind farm is located adjacent to I-25, Colorado's major north-south interstate. Members frequently drive past it and can clearly see the turbines from the highway. San Isabel's members are proud of the co-op's investment in this project, so much so that they often comment when the turbine blades are not spinning.

Project Experience, Opportunities, and Challenges

Huerfano River Wind Farm has contributed to the financial success and steady retail rates that San Isabel provides to their member-owners. At this point, San Isabel does not have plans to repower the turbines or upgrade them beyond routine O&M. However, the co-op has begun exploratory discussions with the Electric Power Research Institute (EPRI) about ways to store wind energy and dispatch it during peak load times to further reduce the co-op's expenses by lowering its peak power purchases and demand charges. In addition to a battery, another idea in discussion is to use grid-interactive residential water heaters to heat water when there is excess wind energy, thereby reducing water heater demand during peak times.[17]

Key Lessons and Insights

Smith encourages other co-ops to consider distributed wind projects, and offers the following practical suggestions based on San Isabel's project experience and lessons learned:

- Consider a PPA, since it can protect the co-op from liability and unanticipated maintenance costs;
- Get competitive bids and carefully evaluate performance history from potential developers and manufacturers;
- Keep in mind that the least expensive option upfront may not be the best long-term choice;
- Use local manufacturers, contractors, and maintenance technicians whenever possible;

[15] https://siea.com/mission-vision/

[16] Poverty level estimates based on 2019 American Community Survey data as reported by the U.S. Census: https://data.census.gov/cedsci/

[17] https://www.coloradocountrylife.coop/two-colorado-co-ops-win-with-wind/ For a similar pilot project at another cooperative, see: https://www.cooperative.com/programs-services/bts/radwind/Documents/RADWIND-Case-Study-Lake-Region-May-2021.pdf

- Even with a PPA, stay involved in all phases of the project, keeping a tight handle on specifications, because all of the equipment will ultimately connect to the co-op's grid;
- Ensure all contracts and agreements are compatible, and hire a third-party to conduct a thorough contract review on behalf of the co-op; and,
- Outline project performance and turbine availability minimums in the PPA.

San Isabel and Smith are proud of the wind farm and what it accomplishes for their state, the co-op, and its members. Going forward, staff and board members will look for more ways to leverage this asset to further the co-op's economic and social value-driven mission.

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Additional Information on NRECA Research's RADWIND Project

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Want to stay informed of our progress with the RADWIND project, and provide your input and feedback? We welcome all NRECA voting members to join the project as advisors. Contact our team at: RadwindProject@nreca.coop.