

1 MW Community-Scale Solar Farm

UTE MOUNTAIN UTE TRIBE

2014



Parametrix Inc. conducted a feasibility study for the Ute Mountain Ute Tribe to determine whether or not a community-scale solar farm would be feasible for the community. The important part of the study was to find where the best fit for the solar farm could be. In the end, a 3MW community-scale solar farm was found best fit with the location of two hayfield sites.

**Ute Mountain Ute Tribe
125 Mike Wash Road
970.565.3751
970.564.5333**

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EXECUTIVE SUMMARY

The Ute Mountain Ute Tribe is exploring a variety of options for renewable energy development to strengthen tribal sovereignty, become more energy self-sufficient, and provide improved services and economic opportunities to tribal members and reservation residents. Hydropower from the major irrigation canal feeding the reservation is also highly feasible. Geothermal, wind and biofuels hold some promise. Oil and natural gas development has long been an important source of income to the Tribe and employment to tribal members.

The near-term development of community-scale solar renewable energy and the eventual development of commercial-scale generation are long-defined goals of the Tribe. This look to the future has the following outcomes in view:

- Reducing non-renewable electrical energy consumption and costs.
- Creating sustainable and profitable economic development ventures.
- Providing employment for tribal members.
- Providing education and building knowledge and capacity among tribal members.
- Providing stable income for tribal government.
- Building institutions to properly balance resource development with culturally appropriate regulation.
- Implementing programs to reduce waste and promote efficient use of resources.
- Making the best long-term use of tribal natural resources and lands.

The Tribe has investigated solar energy projects ranging from modest, facility-scale energy projects serving single institutional buildings to commercial-scale projects with energy export potential. This Department of Energy grant, which was given to the Tribe in 2012, gave the Tribe an opportunity to assess the feasibility of building and operating a community-scale solar energy facility or facilities that can generate 1 MW or more of electrical power. The Tribe wishes to use the data and analysis in-hand to make well-informed and technically sound decisions on community-scale solar development sites and projects serving the town of Towaoc and surrounding areas.

PROJECT OVERVIEW

The study primarily focuses on one level of solar power generation feasibility—community-scale. Community-scale power generation facilities are sized and designed to offset direct electricity usage within a given area or community—in this case the Ute Mountain Ute Reservation within Colorado. Minimum power generation of 1 megawatt (MW) direct current (DC) is the baseline requirement of the US DOE grant that funded this study. This feasibility study:

- Quantifies peak and annualized power demand on the reservation.
- Assesses sites with varying degrees of suitability for community-scale development.
- Identifies power transmission and distribution systems and requirements.
- Identifies and analyzes possible forms of interconnection agreements.
- Models system configurations and power outputs.
- Predicts system costs and revenues to determine relative economic benefit-cost.

- Describes potential facility-scale solar sites.

The community-scale solar feasibility study identifies and analyzes potential solar power generation sites and systems on the reservation. The study assesses issues impacting feasibility such as power transmission and distribution systems, interconnection requirements with the local electrical power provider, transportation access, preliminary power generation potential, land use constraints and opportunities, and environmental and other site features. With this information, the Tribe will be able to consider funding and development opportunities with objective and independent information and policies.

OBJECTIVES

The Tribe's objectives for this study and future community-scale solar power facilities are stated in its DOE grant application as:

- Determine the best location, connectivity, and deal structure with the local electric cooperative and the cooperative's larger energy provider for a 1 MW or larger solar renewable energy project.
- Identify the most practical and cost-effective ways to offset the energy demands of the Tribe—with focus on economic benefits for the Tribe.
- Determine how much benefit individual Tribal members will receive from the project and how to maximize this benefit amongst Tribal members with greatest need.
- Assist the Ute Mountain Ute Tribe in embracing clean energy as a part of its energy portfolio, both at the local scale and the commercial scale.
- Assist Tribal members in their understanding of the benefits of solar power development at the local scale and foster greater interest and support for future solar development.

This study developed the following key information providing a solid technical basis for future decision making on community-scale solar development:

- Site-specific renewable resource assessments.
- Transmission and distribution interconnection considerations.
- Appropriate and effective technologies and design.
- Preliminary system costing and phasing plans.
- Comparative costs of purchased and produced electrical energy.

DESCRIPTION OF ACTIVITIES PERFORMED

The Tribe was responsible for assessing cultural and social benefits, most economic impacts (such as employment and job skill development) and for developing business planning elements. Although related to this study, these factors were not included in the study.

Site analysis and resource assessments were applied to 18 sites within the study area. Prior informal assessments by the Tribe resulted in 14 potential community-scale sites being identified

in advance. Analysis of 2 large parcels included in this original 14 was limited to 3 smaller sites within these 2 parcels. An additional 3 sites within the study area were also identified.

The original scope for this study included a three-part review process for arriving at preferred community-scale sites. The Tribe's Renewable Energy Committee reviewed the 18 sites in July 2013. The committee determined that only four of the sites should be given additional analysis. Conditions on these four sites were previously well documented or were augmented by the initial site and resource analysis, are in locations well recognized and central to the community, are generally highly disturbed or in active farming use, and/or have previously been considered for solar development.

The original study scope considered 1MW to 2MW of solar electrical power generation as the target community-scale solar generation capacity. Based on overall and peak electrical power demand information received from the Empire Electric Association (EEA), electrical power cooperative that serves the reservation, this target was revised upward to 3MW. Gradual phasing of a community-scale project is also possible.

Site evaluations and resource assessments were conducted using GIS information, existing studies and reports provided by the Tribe, and three sites of site visits. The study area was screened at the level of a 10-acre minimum site size to identify sites with suitable slope and aspect. Existing power infrastructure—transmission and distribution lines and the single power substation on the reservation—is mapped and capacity is identified, as were land uses and other limiting factors. Tribal staff indicated that the Tribal Council and leadership had stated a clear preference for using previously disturbed sites for community-scale solar development, rather than developing sites that were in productive use or in a relatively unaltered natural state.

Site Size and Capacity

A wide variety of studies and reports suggest as a rule of thumb that 1MW of electrical power can be generated with flat-panel fixed solar PV systems for every 5 acres of land. Some published information suggests up to 9 acres per MW based on climatic conditions, system type and size, shade and obstructions, and other factors. In the Southwestern US, acreage per megawatt can potentially be reduced (i.e improved) based on the year-round consistency and the higher number of sunny days or by using solar power systems that track the sun across the seasons. A value of 4 acres per MW was used in this study. A benchmark of 6 acres per MW was used for single axis tracking systems. These acreage factors were also used to assess if a given site is of sufficient to expand up to including commercial-scale generation.

- Is the site of sufficient size to generate a minimum of 1MW of solar generated electrical power?
- What is the capacity of the site given net developable acreage?

Slope and Aspect

Solar PV flat-panel ground-mounted arrays require flat or gently sloping south-facing areas, usually of less than 4 to 5 percent. Southwest and southeast facing slopes are including in the definition of south-facing. North-facing slopes of less than 1 percent are also deemed suitable if

intermittently occurring within areas that were predominantly south-facing. Some areas with intermittent slopes exceeding these percentages may be interspersed on some potential solar sites. Such sites may, in some cases, be developable with grading and other site alterations. Slope issues can also be partly mitigated by solar PV systems that rotate manually or automatically with the season. These grading and equipment solutions can increase both construction and maintenance costs.

- Is the site primarily south-facing and less than 4 percent slope?
- If not, are site grading and equipment solutions for the site cost competitive with other available sites?

Shade and Obstruction

Without battery storage, solar facilities cannot deliver power once the sun sets. Shading or obstruction of solar panels can also reduce effective power generation capacity. As the sun rises or sets, nearby physical features (hills, mountains, mesas), built features (buildings, large signage), and tall vegetation can keep sunlight from striking the surface of PV panels, even with the addition of manual or automated sun-tracking systems.

- What are the physical features that create significant site shading, and how would impacts on the site vary by season?
- Is the site impacted by shade or obstructions that are “impermanent”—buildings and vegetation—and can the impact be mitigated?

Electrical Power Service and Distribution

The entire study area is served through an EEA substation that is connected into the regional power grid via an 115kV transmission line. A 12kV power distribution network feeds out of this substation to serve much of the study area. In the event of a failure in the 115kV line, EEA states that electrical power for essential services requiring could be sustained for short periods through a separate 12kV line from Cortez that interconnects to the reservation power distribution system in the center of Towaoc.

- What power transmission or distribution lines are available in the given area?
- What is the capacity of the distribution line(s)?
- What is given area’s proximity to the power substation?
- If not present, or of insufficient capacity, what would be the distance/ costs of extending distribution or transmission line(s) to interconnect the solar facility to the local power grid?

Transportation Infrastructure

Adequate and fully maintained all-weather roads are needed to access solar power facilities during both construction and operational phases. Construction phases are a particular concern where trucks and heavy equipment may have to make regular trips to the development site over an extended period causing deterioration in the road surface. This can also create conflicts with other types of traffic and adjacent land uses. Key questions are:

- Are there existing regularly maintained roads to the site?

- Is the road(s) adequately constructed and sufficiently wide to safely support both construction and operational phase traffic?
- Would the traffic created by construction or operations conflict with other types of traffic and adjacent land uses?

Existing and Planned Land Uses

The study describes and maps existing and planned uses and activities—residential, institutional, commercial, agricultural, and recreational—that may impact solar development feasibility. Key questions:

- Are services to the site adequate to support a solar facility—water/sewer, telecommunication, (for any automated site monitoring telemetry or security systems), etc?
- Is the site “disturbed” or is it in a relatively natural state?
- Is there an alternative land use on or planned for a given site that has priority over solar development?
- Would a solar development create significant ongoing conflicts with adjacent land uses or activities, including visual impacts?

Environmental and Natural Resources

A wide range of environmental and natural resources issues or limitations may apply to a given site: wind and temperature, air quality, shade and obstruction, solar irradiance levels, climate impacts, water rights, water quality and supply, soils, predominant vegetation types, flood areas, water courses and washes, topographical variations, surface water drainage and conditions, and presence of threatened or endangered native plants.

- Is there any form of natural resource designation (e.g a location within the Ute Tribal Park) that would prohibit solar development outright?
- Does a given environmental condition constitute a “fatal flaw” to solar facility location?
- Would development of solar facility create adverse environmental impacts or conflicts either on-site or in other areas of the reservation?
- Are there acceptable and practical means to mitigate for any adverse environmental impacts?

Cultural and Agricultural

The identification of cultural, archaeological, and sacred sites, and culturally significant plants and animals, is an issue of particular concern in the study. “Sensitive site” field investigations were, however, outside of the study scope. The Tribal Historic Preservation Office (THPO) should be consulted early in the process of selecting solar development sites, and detailed site investigations should be conducted before any solar developments are undertaken.

Safety and Security

The study describes factors that could impact the safety and security of community-scale solar sites. Questions are:

- Is the site proximate to and visible from well-traveled roadways, and from high use areas such as the casino/hotel, particularly in the evening and nighttime hours?
- Is there evidence of prior vandalism and dumping on the site?
- Are there any public safety records that might indicate that an improved site would attract nuisance behavior or vandalism?
- Do site characteristics lend themselves to economic and effective security solutions, such as fencing or electronic security systems?

CONCLUSIONS AND RECOMMENDATIONS

Project Size

- ✓ A 3MW community-scale solar PV facility is recommended.

The study was originally scoped to consider a community-scale facility of between 1MW and 2MW. Electrical power consumption and power loading records provided by Empire Electric Association (EEA) indicated higher loads than previously understood by the Tribe. In 2012 the average peak demand was 1.658 MW. The single highest peak was 2.483 MW. Numerous peaks were greater than 2MW, particularly in the summer months and later afternoon/early evening.

Electrical energy production from a 3MW solar photovoltaic (PV) array is predicted to be 2.49 MW after “loss” factors—those conditions that make solar arrays operate at less than rated DC capacity. This predicted generation is sufficient to meet current maximum daytime peaks on the reservation and also provides some capacity for future growth.

System Specifications

- ✓ A single-axis solar PV tracking system is recommended.

Fixed-panel and single-axis tracking solar PV systems were evaluated. The benefit of a single-axis tracking system is greater power generation for the same MW capacity. System modeling based on conditions in Montezuma County indicate that for an increased cost of 12 percent over a fixed-panel system, a single-axis tracking system should produce upwards of 30 percent more electrical power.

Estimated development costs, exclusive of substation modifications and power line extensions, for a 3 MW fixed system are:

- Fixed panel: \$9 million
- Single-axis tracking: \$10.05 million

Power substation modifications and power line extension costs do not vary based on the two-system types. The substation modification estimate is a flat \$100,000 for all sites. Relative maintenance costs are not prohibitive. Based on the system modeling program used, maintenance of a 3MW fixed-panel system would cost an average \$60,000 per year and a single-axis tracking system would cost \$90,000 per year.

Project Sites

- ✓ The combined 95-acre Hayfield site (F & G) is recommended as the location for the Tribe's community-scale solar PV facility.

Eighteen sites were initially assessed as potential community-scale solar locations. Four were selected by the Tribe's Renewable Energy Committee for full evaluation. All four sites are near Towaoc, the casino/resort/ and the substation. All four sites have the following common attributes:

- Essentially flat and south-facing thereby minimizing development costs and maximizing power generation potential.
- Close enough to a proposed small hydropower project to allow efficient integration of power production and system maintenance.

The site nearest to the substation (along with a combined site) has significant cumulative attributes recommending it as the best site for community-scale development. These attributes are, in addition to those above:

- Crossed by power transmission lines and near the substation, minimizing cost of extending new interconnecting lines.
- Not constrained by prior development, cultural resources, or stream corridors and other environmental features.
- Good access and close to activity centers—increases security and visibility.
- Site size and dimensions allow flexible solar facility location and possible expansion to commercial-scale generation.
- Site area can easily accommodate tracking solar arrays which require greater land area than fixed-panel systems.
- Siting can accommodate partial continuation of current agricultural operations.

Interconnection Agreements

- ✓ Negotiation of a retail net metering interconnection agreement with EEA is recommended. A whole sales agreement appears to be only marginally economically viable.

The improved ratio of system cost to system power production that comes with a single-axis tracking system results in the community-scale solar facility performing a break-even or better. While more expensive to build and maintain than a fixed-panel system, a tracking system produced approximately 30 percent more power.

This cost-effectiveness of a single-axis solution is considerable but is still dependent on the form of interconnection agreement that can be reached with EEA.

- Under a retail agreement (net metering) the return from a single-axis system could range from 90 percent to 110 percent of cost before the application of subsidies such as grant and tax incentives.
- System modeling indicates that under a wholesale power sales agreement, the Tribe would only recover around half of its development and maintenance costs without applying considerable subsidies to the cost of construction.

Phasing

- ✓ In recognition of interconnection agreement complexities and possible funding challenges for a \$9 million to \$10 million 3MW facility, the community-scale solar project can be completed in phases.

Phasing will reduce initial development costs and may make the negotiation of retail net metering agreements, and certain forms of development such as master metering or solar gardens, more feasible. Phasing on the hayfield site could also provide power offsets for the casino with little additional cost over facility-scale solar PV installations on the actual casino site.

Ute Mountain Casino/Resort Complex

- ✓ Given that the casino/resort complex accounts for over 40 percent of the annual electrical power demand, facility-scale solar PV is recommended if community-scale solar does NOT move forward.

Facility-scale solar power installations are designed and sized to meet power demand from single buildings or building complexes and sites. Facility-scale solar arrays have the advantages of being relatively lower in cost as compared to community-scale and being clearly eligible for retail level (net metering) purchased power offsets. The study was not originally scoped to evaluate potential facility-scale solar PV installations. A high-level assessment was added mid study at the request of the renewable energy committee.

As a practical outcome of lower cost, facility-scale solar may be a more immediately feasible method to being to offset purchased power costs with renewable energy.

Hydropower

- ✓ The tribe's small hydropower initiative at an energy dissipation station on the Towaoc highline canal should integrate power transmission systems and power management with the community-scale solar project.

Energy Conservation

- ✓ The tribe should establish an ongoing energy conservation and efficiency improvement program for its buildings and sites.

Energy conservation and efficiency remain the most cost-effective approaches to reducing purchased energy consumption and costs. Conservation and efficiency actions include weatherizing buildings, using passive heating, implementing cooling and lighting measures, and upgrading heating, ventilation, and air conditioning systems. Reductions in power demand can also translate to smaller and potentially more affordable solar and other renewable power generation facilities.

LESSONS LEARNED

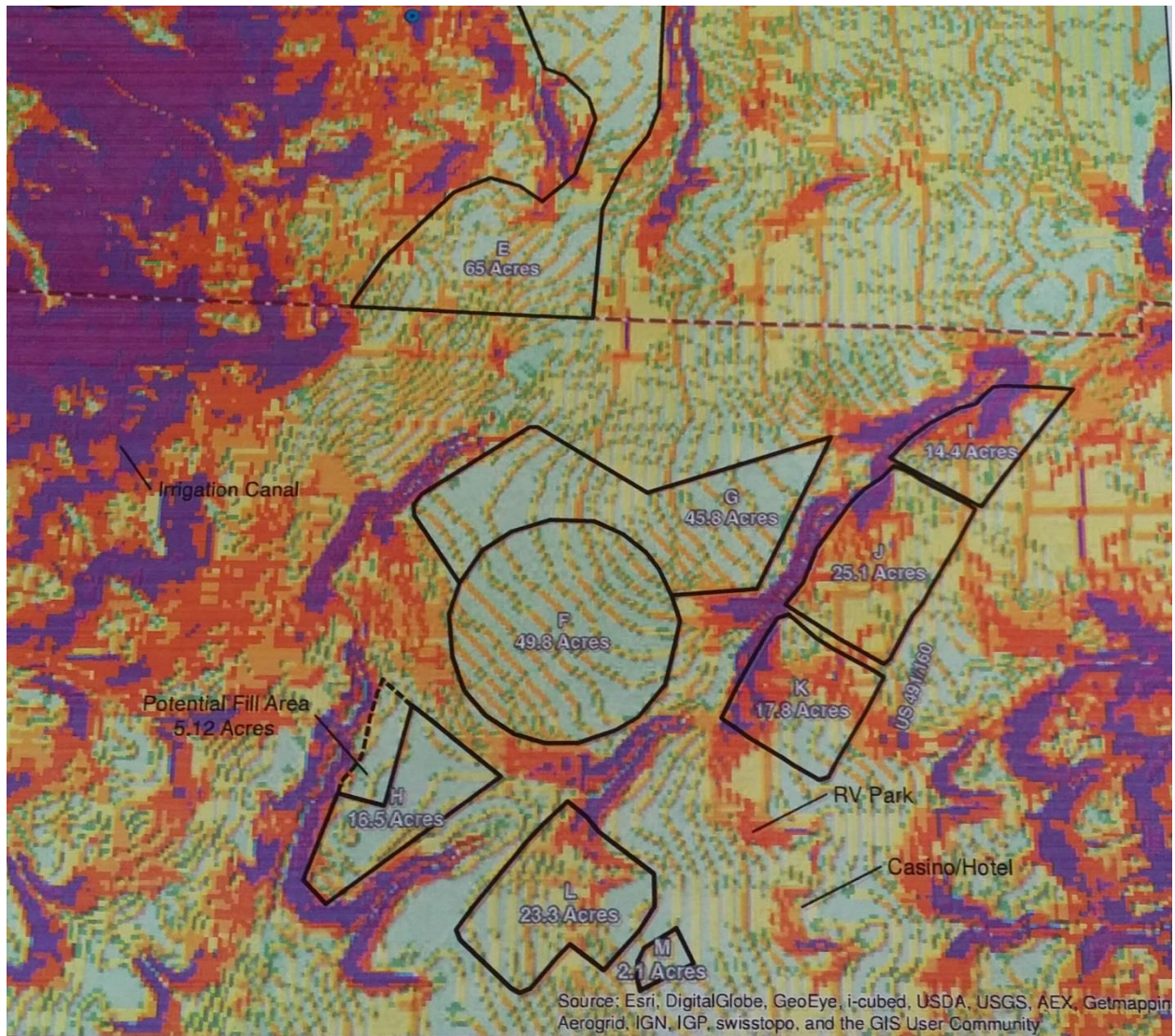
Lessons learned were as follows:

1. Site selection- the Renewable Energy Committee had chosen 4 sites to evaluate in full. But from the beginning, these should have been the 4 sites to look at besides the 18 sites.
2. Site assumptions- (rotating vs single axis), in the beginning, the best choice everyone should have seen and assumed should have been the single axis.
3. Different ideas on power load on reservation- The committee and Parametrix Inc. thought the power load on the reservation wasn't too high which led them to believe a 1MW would be fine. But overall, a 2MW- 3MW is the best choice for the power consumers.
4. Hayfield boundaries- everyone assumed that since the hayfield is perfectly round, it would be a perfect spot for the community-scale solar farm. They are correct but next time a shape won't define how well a fit for solar development will be.

APPENDIX



*Picture above shows the preferred slop and aspect. Hayfield sites F & G have the best slope and aspect data.



*Picture above shows the slope and if the locations are facing south, north, west, or east. F & G are the best choices.

Fixed Ground-Mounted Solar PV		
	<i>RETAIL</i>	<i>WHOLESALE</i>
System Cost (total \$)	\$9,000,000	\$9,000,000
System Cost (wDC)	\$3.00	\$3.00
Solar Value	5.95 kWh/m2/day	5.95 kWh/m2/day
Power Generation (AC)	5,006 MWh	5,006 MWh
Average Purchased Energy Rate	\$0.11 kWh	\$0.06 kWh
Offset Purchased Energy Value	\$551,000	\$300,000
Produced Solar Energy Rate	\$0.15 kWh	\$0.15 kWh
Annual Production Cost	\$751,000	\$751,000
Gross Value	<\$200,000>	<\$451,000>
SREC Sales Value	\$128,000	\$128,000
Net Value (w/SREC)	<\$72,000>	<\$323,000>

Single-Axis Tracking Solar PV		
	<i>RETAIL</i>	<i>WHOLESALE</i>
System Cost (total \$)	\$10,050,000	\$10,050,000
System Cost (wDC)	\$3.35	\$3.35
Solar Value	7.78 kWh/m2/day	7.78 kWh/m2/day
Power Generation (AC)	6,584 MWh	6,584 MWh
Average Purchased Energy Rate	\$0.11 kWh	\$0.06 kWh
Offset Purchase Energy Value	\$724,000	\$395,000
Produced Solar Energy Rate	\$0.12 kWh	\$0.12 kWh
Annual Production Cost	\$810,000	\$810,000
Gross Value	<\$86,000>	<\$415,000>
SREC Sales Value	\$168,000	\$168,000
Net Value (w/SREC)	\$82,000	<\$247,000>