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TECHNICAL MEMORANDUM

To: Christella Armijo, Village of Ruidoso Water Resource Director

From: Marty Howell, P.E. Senior Engineer, Souder, Miller and Associates

CC: Dale Lyons, Renewable Energy Client Community Manager, Souder, Miller and Associates

Date: November 14, 2023

Subject: **Village of Ruidoso Regional Wastewater Treatment Plant Solar Feasibility Assessment**

1.0 BACKGROUND

The Village of Ruidoso (Village) contracted with Souder, Miller and Associates (SMA) on July 21st, 2021, to conduct a net metered solar feasibility assessment for the Regional Wastewater Treatment Plant (RWWTP). The RWWTP is located along the Rio Ruidoso on Village property, northeast of the Ruidoso Downs (Figure 1). The objectives of the assessment were to determine the technical, regulatory, and financial feasibility of developing net metered solar photovoltaic (PV) systems at the RWWTP, and to identify any funding sources that the Village can utilize to support project development. SMA submitted the final feasibility assessment to the Village on June 13th, 2022.

As part of the feasibility assessment, SMA conducted a site visit of the RWWTP facility on August 17th, 2021. During the site visit, SMA interviewed RWWTP operators to understand how energy was used at each building and throughout the treatment process, photographed RWWTP components and electrical systems, and performed shade measurements at multiple locations across the RWWTP using the hand-held Solmetric SunEye 210 instrument.

The June 13th, 2022, feasibility assessment concluded that a net metered solar PV project at the RWWTP is technically and financially feasible. Using conservative assumptions, the feasibility assessment determined that a net metered solar PV project would significantly reduce electric utility expenses and have a favorable payback period.

2.0 EXISTING FACILITIES

2.1 Existing System Information and Condition

The RWWTP's design annual average daily flow is 1.90 million gallons per day. The plant utilizes both chemical and biological treatment processes and returns the treated water into the Rio Ruidoso. The RWWTP was designed to be expanded in the future when additional capacity is needed (Molzen Corbin, 2023). The RWWTP's wastewater treatment process has changed over time, most notably newer lift station pumps replaced older Archimedes screws and a new membrane bioreactor (MBR) facility has replaced the use of older settling and aeration basins. Figures 1 and 2 below illustrate the location of the layout of major RWWTP components.

In the May 19, 2023, Draft Utility Master Plan report, Molzen Corbin summarized RWWTP improvement projects planned for the next 20 years, which will be included in the Village's Facilities Capital Improvement Plan. The planned improvement projects are intended to address aging equipment, necessary updates and growth-related needs, and improve overall WWTP efficiency and safety (Molzen Corbin, 2023).

Figure 1. RWWTP Vicinity Map

Figure 2. RWWTP Facility Layout

A	Raw Water Lift Station Pumps	H	Old Settling Basins and Aeration Basins
B	West Electrical Building (lift station and entrance works electrical)	I	Operations & Maintenance Building (O&M)
C	Entrance Works	J	Heavy Equipment Yard
D	Membrane Bioreactor (MBR) Building		
E	Sludge Processing Building		
F	Ultraviolet (UV) Treatment		
G	Old Raw Water Archimedes Screw Lifts		

2.2 Population

As illustrated in Figure 3 below, the total population of Lincoln County and the Village of Ruidoso has remained relatively constant over the period of recorded by the U.S. Census Bureau, from 2000 to 2021.

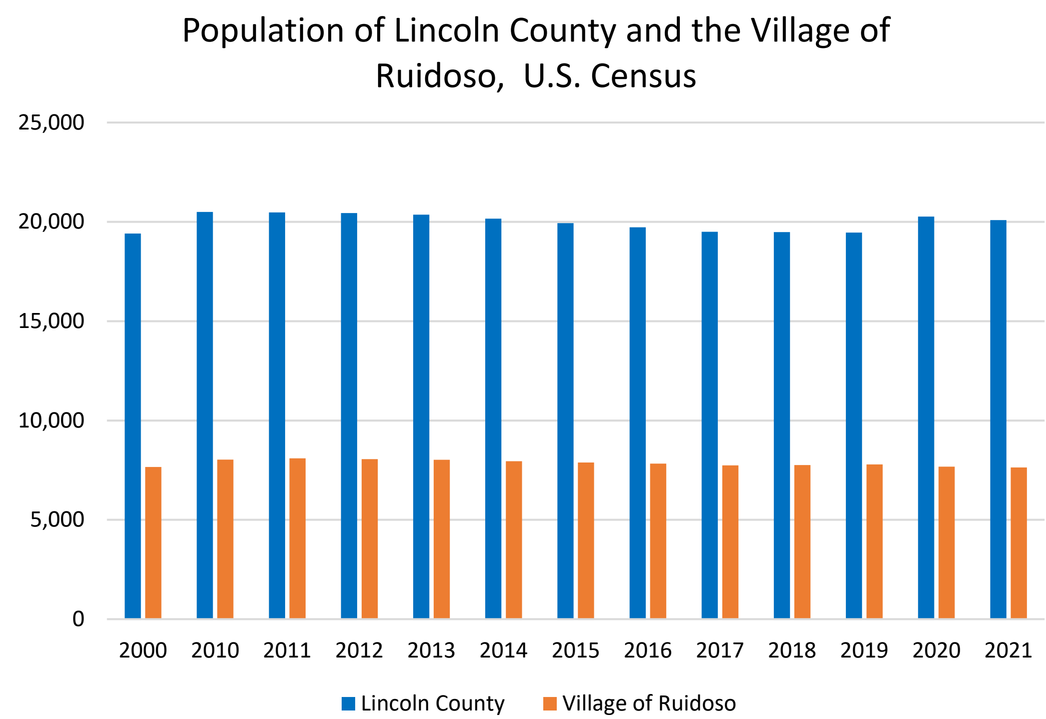

Figure 3. Population of Lincoln County and the Village of Ruidoso

In addition to the Village of Ruidoso and Ruidoso Downs, the Mescalero Apache Reservation and some surrounding areas also contribute to RWWTP demand (Molzen Corbin, 2023). As illustrated in Figure 4 below, residential and commercial connections to the Village's wastewater utility have remained relatively constant over the period recorded by NMED as part of the annual public utility rate survey, from 2014 to 2022 (NMED, 2022). Note that data for the Village was not included in NMED's 2016, 2021, and 2022 surveys.

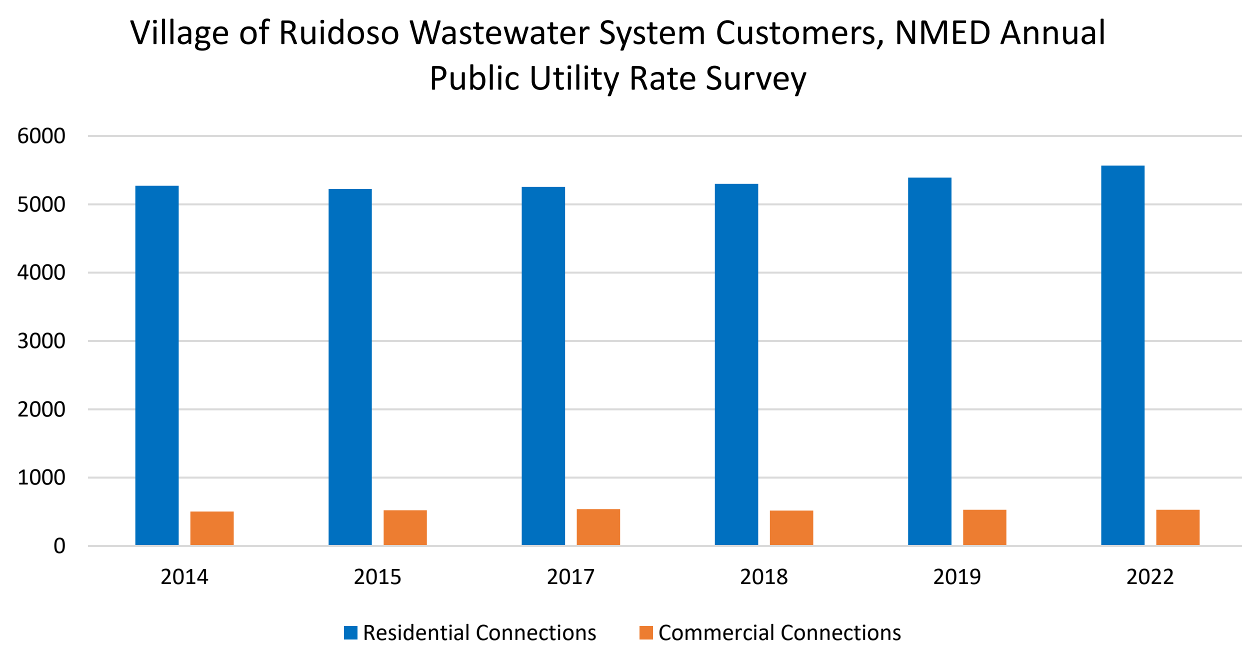

Figure 4. Village of Ruidoso Wastewater System Customers

While RWWTP design flow capacity is sufficient to meet projected demand through 2050, influent loading concentrations (i.e., TSS, BOD, phosphorus, and TKN) are expected to exceed RWWTP influent thresholds by 2050. Thus, an additional treatment train will likely be required to handle higher influent loading concentrations (Molzen Corbin, 2023).

For RWWTP solar project planning purposes, SMA assumes that the population served by the RWWTP will remain relatively unchanged for the life of the project. Further analysis of the current and projected WWTP electric usage is included in Section 2.3, below.

2.3 Electric Usage Records & Future Electric Use Projections

Electric service to the RWWTP is provided by Otero County Electric Cooperative (OCEC). Table 1 below summarizes the four electric meters and associated OCEC accounts at the RWWTP. SMA obtained three years and eight months of monthly electric usage records for each of the above OCEC accounts, from August 2019 through April 2023. Table 1 also summarizes the electric usage and charges for each account over the same three year and eight month period.

Table 1. Summary of RWWTP Electric Meters/Accounts and Usage from August 2019 through April 2023

RWWTP Facility	Electric Meter No.	OCEC Account No.	OCEC Rate No.	Average Monthly Usage (kWh)	Average Monthly Demand Charge*	Average Total Monthly Electric Bill
West Electrical Building (raw water lift station & entrance works)	53188877	2160600	2 Large Power >50KVA	20,295.11	$593.56	$2,889.00
MBR Building, UV Treatment, and Sludge Building (blowers and belt dryers)	53188883	2080000	2 Large Power >50KVA	256,401.78	$5,250.30	$34,273.12
O&M Building (welder, compressor, water well, & some MBR components)	80948851	1561201	2 Large Power >50KVA	47,873.78	$1,316.66	$6,024.38
Heavy Equipment Parking Area	83105747	2087601	1 General Service	5.40	$0.26	$30.67

*Included in total monthly bill

Figures 5-8 below illustrate the monthly variation of total electric usage for each RWWTP facility electric account from May 2017 through April 2023. The graphs include average ambient temperature, shown as a black line.

Monthly electric usage at the RWWTP's West Electrical Building (OCEC Acct. No. 2160600) and MBR Building (OCEC Acct. No. 2080000) increases slightly during the summer months, which coincides with increased visitation to the Ruidoso area from tourists and part-time residents. Over the period of record (2017-2023), annual electric usage magnitude and patterns have stayed relatively consistent. Electric usage at the MBR Building, however, appears to increase over previous years beginning around September 2022. In comparison with previous years, the COVID-19 pandemic that began in the spring of 2020 does not appear to have affected electric usage at either the West Electrical Building or the MBR Building.

Monthly electric usage at the RWWTP's O&M Building (OCEC Acct. No. 1561201) does not appear to fluctuate seasonally. Relative to the periods before and after, electric usage appears to have been elevated from July 2017 through May 2020, then declined from June 2020-April 2023.

Monthly electric usage at the RWWTP's Heavy Equipment Parking Area (OCEC Acct. No. 2087601) is very limited over the period of record. Energy consumption was elevated during the colder months of 2019 and 2023, possibly from the use of electric engine block heaters, but this pattern was not observed in 2020. Given the limited amount of electric use, this account was not included in the solar feasibility assessment.

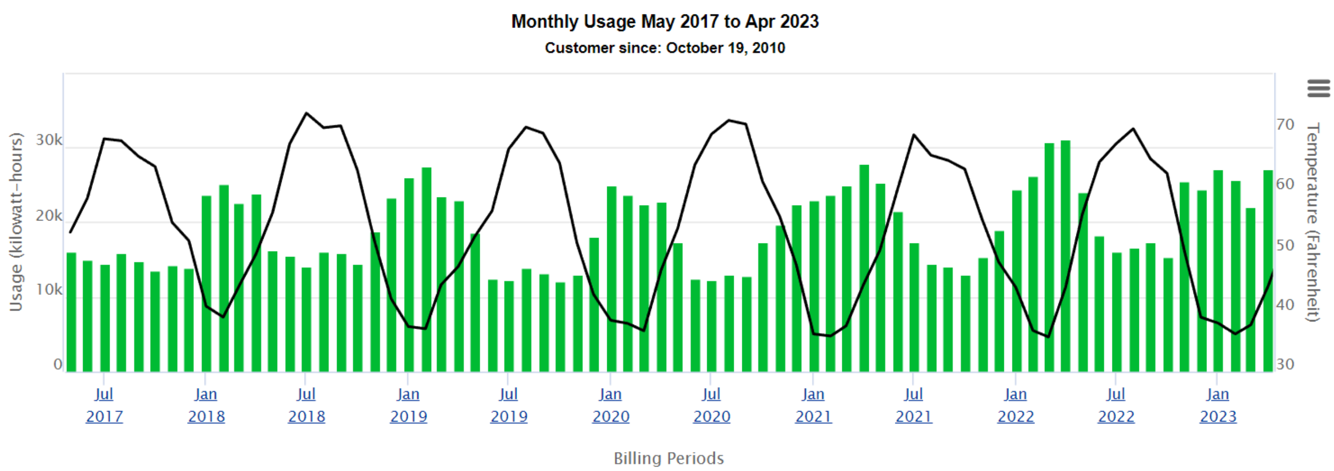

Figure 5. Electric Usage History for RWWTP West Electrical Building (OCEC Acct. No. 2160600), May 2017 through April 2023.

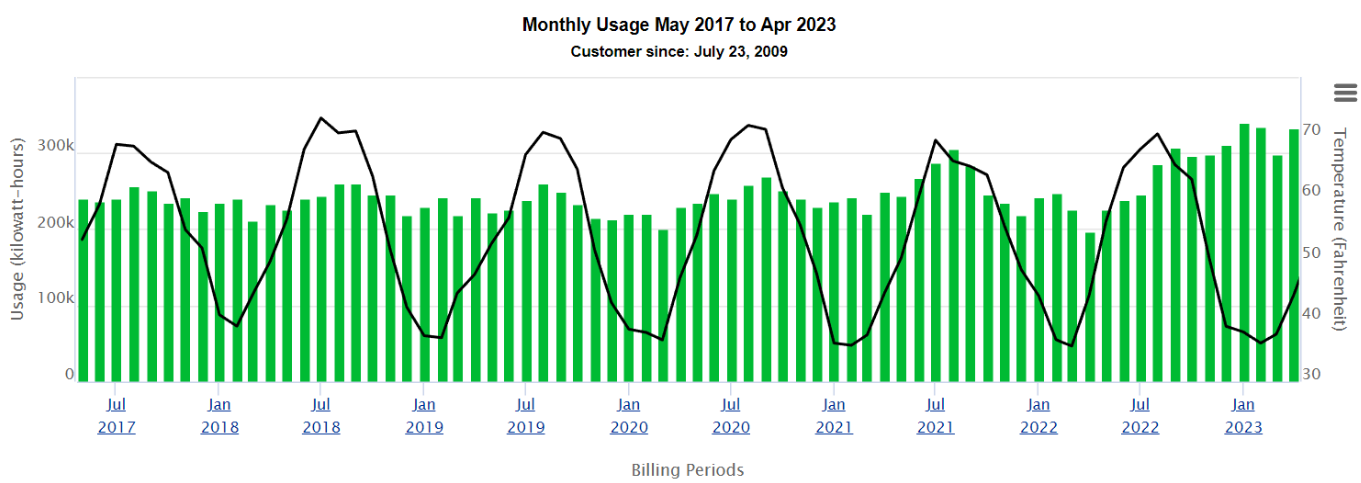

Figure 6. Electric Usage History for RWWTP MBR Building (OCEC Acct. No. 2080000), May 2017 through April 2023.

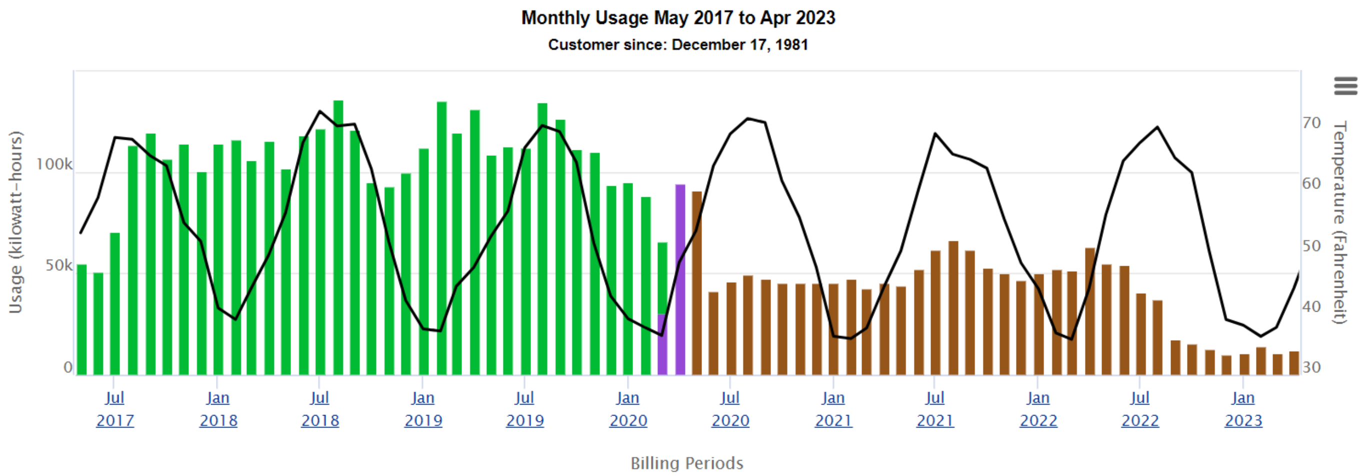

Figure 7. Electric Usage History for RWWTP O&M Building, UV, & Sludge (OCEC Acct. No. 1561201), May 2017 through April 2023. Different Colors indicate changed electric meters.

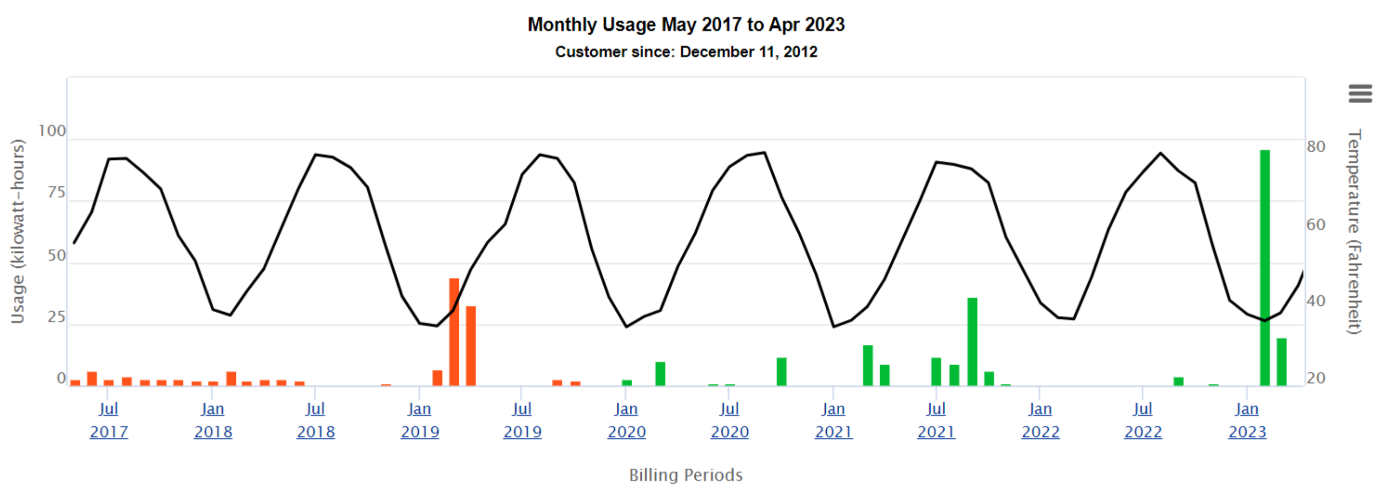

Figure 8. Electric Usage History for RWWTP Heavy Equipment Parking Area (OCEC Acct. No. 2087601), May 2017 through April 2023[1].

As illustrated in Figure 6 above, and summarized in Table 2 below, MBR Building electric usage has increased somewhat over the period of record. For the purpose of developing a case simulation for a net metered solar PV system, SMA will use average monthly electric usage from the period 2021-April 2023, which is approximately 6.5% higher than the electric usage from the period of 2021-April 2023 (Table 2).

[1] OCEC has informed SMA that the temperature profile data in Figure 8 is from the wrong weather station. All other temperature profile data included in Figures 5, 6, and 7 are from the correct weather station located nearby the RWWTP. Regardless, OCEC temperature data was not used as part of SMA's feasibility assessment. Refer to Section 4.2.5 for discussion of solar irradiance and weather data used for the NREL SAM case simulation as part of this feasibility assessment.

Table 2. Summary of MBR Building Monthly Electric Load

	Monthly Average kWh		
	2019-23	2020-23	2021-23
January	257824	261600	275173
February	233024	236680	248507
March	250496	252440	260053
April	246384	252420	258293
May	244820	251227	252800
June	253020	257947	266720
July	277620	283520	296240
August	278000	287173	296160
September	257440	265147	271600
October	247500	258427	266880
November	243400	253253	265040
December	260520	273867	291880
Total	3,050,048	3,133,700	3,249,347
% Load Growth Over 2019-23		2.74%	6.53%

3.0 NEED FOR PROJECT

Electric utility costs constitute a major portion of the overall RWWTP operating costs. The Village needs to develop a net metered solar photovoltaic (PV) project at the RWWTP to reduce facility electric utility costs. Reducing RWWTP operating costs will: 1) forestall the need to raise wastewater system customer rates in a community where median household income is below the state average[2], and 2) allows the Village to spend more money on other wastewater system priorities such as capital improvements.

4.0 PROPOSED PROJECT

4.1 Description of Project

As summarized in Table 1 and in Figures 5 & 6 above, the level of electric usage at the MBR Building is over one order of magnitude higher than at the West Electrical Building. As a practical matter, available space for a net metered solar PV system at the RWWTP is limited, allowing for around 900 kW of solar PV capacity developed as separate arrays within the RWWTP boundary. Providing funding is available, the project will include demolition and removal of the old Archimedes screw pumps to yield some additional area for project development. As discussed in more detail in Section 4 below, a 1 MW solar PV system would generate enough electricity to offset just over half the MBR Building electric usage. Therefore, in the interest of reducing project complexity and cost, it is assumed that a solar PV system developed at the RWWTP would only be net metered with the MBR Building electric meter.

The Village of Ruidoso intends to build one net metered solar PV system at the RWWTP for the purpose of reducing electric utility costs to operate the facility. The net metered solar PV system will be net metered with the MBR Building electric meter. The solar PV system will be developed on Village owned land within the existing RWWTP boundary (Figure 9). The net metered solar PV system will be comprised of separate arrays using three different types of solar PV racking systems: A) ground mounted fixed-tilt, B) ballasted, roof mounted fixed-tilt, and C) carport fixed tilt (Figure 10). The output from the separate arrays will be routed to the MBR Building's electric meter at the northwest corner of the building via buried electrical conduit, combined, then connected on the customer side of the MBR Building electric meter (i.e., net metered).

[2] In 2021, the U.S. Census Bureau estimated that the Village of Ruidoso and Ruidoso Downs median household income are approximately 16% and 51% lower than the New Mexico average, respectively.

Figure 9. Project Development Areas

Figure 10. Layout of Solar PV System Arrays and Types of Racking Systems

4.2 Basis for Design/Design Criteria

4.2.1 RWWTP Electrical System Constraint

Based on SMA's evaluation of the MBR Building's electrical panel amperage/voltage and transformer capacity, the maximum net metered solar PV system capacity at this location is 1,500 kW.

4.2.2 Available Land/Area & Solar PV System Capacity Analysis

Based on available land owned by the Village, SMA estimated the maximum net metered solar PV system capacity using Unirac's U-Builder[3] online tool for roof- and ground-mount systems. The maximum solar PV system capacity at RWWTP is estimated to be approximately 900 kW (Figure 10, above). The SAM case simulation assumed a solar PV system size of 900 kW.

4.2.3 MBR Building Roof Structural Analysis

SMA conducted a structural analysis of the MBR Building's roof to confirm it can support the planned roof-mounted solar PV system. The Unirac U-Builder output estimated a maximum loading of 3.9 pounds per square feet (psf) limited to the extent of the installation's perimeter. MBR Building structural drawings dated February 2009 state that roof design loads are 25 psf and 35 psf for dead load and live load, respectively.

The deadload of the roof itself was calculated to be no more than 6 psf. A collateral dead load of 10 psf was assumed for attachment of miscellaneous items like MEP hardware, fans, and signs. The 3.9 psf of solar will be considered dead load as we do not expect this load to change over the lifetime of the structure. The sum of these dead loads is 20 psf which is below the design dead load of 25 psf. Therefore, the additional weight of the proposed roof-mounted solar PV system will not exceed the MBR Building roof design loads (SMA, 2023).

4.2.4 Electric Utility Rates and Net Metering Rules

The three primary electric utility accounts at the RWWTP (Nos. 2080000, 2160600, and 1561201, for the MBR Building, West Electrical Building, and O&M Building, respectively) are billed under OCEC rate tariff No. 2 Large Power >50 kVA, while account No. 2087601 for the Heavy Equipment Parking Area is billed under OCEC's rate tariff No. 1 General Service.

OCEC's rate tariff No. 2 Large Power >50 kVA, which became effective January 1st, 2020, is not a time-of-use rate. Time-of-use rates have differential costs per kilowatt hour ($/kWh) during on- and off-peak periods each day. Rather, OCEC's rate tariff No. 2 Large Power >50 kVA applies a constant cost per kilowatt hour of $0.1114/kWh for the first 500,000 kWh and $0.0893 for all kWh over 500,000 kWh. In addition to the kWh charge, this rate also includes a demand charge of $11.25 for the first 500 kW and $14.50 for all kW over 500 kW.

Interconnection of net metered solar PV systems in OCEC's service area is governed by the New Mexico Public Regulatory Commission (PRC) Rules 568, 570, and the New Mexico Interconnection Manual. PRC 570 establishes

[3] Unirac U-Builder 2.0

that net metered customers are compensated at the utility's avoid cost rate ($0.0283/kWh in 2022 for OCEC customers) for any excess generation beyond the customer's monthly energy consumption. To incentivize customer investment in distributed generation renewable energy systems, OCEC currently pays net metered customers for the environmental attributes of their generated renewable energy, known as a Renewable Energy Credits (REC), which the utility uses to meet the state's Renewable Portfolio Standard requirements. OCEC's current REC incentive rate paid to net metered customers is $1 for each 1,000 kWh of renewable energy produced.

4.2.5 Net Metered Solar PV System Case Simulation Inputs

SMA used the U.S. Department of Energy, National Renewable Energy Laboratory's System Advisor Model (SAM)[4] to develop a case simulation to evaluate the feasibility of a net metered solar system for the MBR Building at the RWWTP. Model inputs for the case simulation include weather and solar irradiance data for the Ruidoso area, current solar industry project material and construction costs, financial parameters, electric utility rate parameters, and the MBR Building electric load. Electric load at the MBR Building and the associated electric utility rate are discussed above in Sections 3 and 4, respectively. The following includes descriptions of the solar irradiance/weather, solar shading, and project financing term inputs, as well as a summary table of all inputs and assumptions used for the SAM case simulation. SAM case simulation input parameters are summarized in Table 3 below.

<u>Solar Irradiance and Weather</u>

For estimating solar system performance, NREL has developed the National Solar Radiation Data Base (NSRDB). The current version of the NSRDB (v2.0.0) was developed using the Physical Solar Model (PSM) and offers users the latest available data (1998–2014). The NSRDB is a serially-complete collection of hourly and half-hourly values of the three most common measurements of solar radiation (global horizontal, direct normal, and diffuse horizontal irradiance) and meteorological data. These datasets have been collected at a sufficient number of locations and temporal and spatial scales to accurately represent regional solar radiation climates.

Using these datasets, it is possible to determine the amount of solar energy that was available at a given time and location anywhere in the United States and a growing list of international locations. SMA used the NSRDB data (Station ID: 77294, Ruidoso, NM) in SAM to predict the potential future availability of solar energy in Ruidoso based on past conditions.

<u>Solar Shading</u>

Generally, there is very limited shading at the RWWTP throughout the year. For the case simulation, the hourly shade data obtained at multiple RWWTP locations during the August 17th, 2021 site visit was applied in SAM.

[4] SAM Version 2022.11.21

Project Financing Terms

For the purpose of developing the net-metered solar PV system NREL SAM case simulation for the MBR Building, conservative assumptions were used regarding how individual projects would be financed and the financing terms available to the Village. It was assumed that each project would be 100% financed by the Village, without the use of grant money that may be available.

On May 3, 2022, the New Mexico Environment Department, Construction Programs Bureau offered the Village a 0.01% interest, up to 30-year loan for development of the net metered solar PV at the RWWTP. For the NREL SAM case simulation, it was assumed that the 0.01% loan would be repaid over period of 20 years.

Incentives

The NREL SAM case simulation included three incentives:

- OCEC Renewable Energy Credit $0.001/kWh
- NMGRT exemption
- Federal Investment Tax Credit 25.5%[5]

[5] 2022 Inflation Reduction Act Table 4, Subtitle D–Energy Security, Part 1-Clean Electricity and Reducing Carbon Emissions, Extension and Modification of the Credit for Electricity Produced from Certain Renewable Resources, Section 13101.

Solar PV System Capacity

As explained in Section 4.2.2 above, SMA assumed a 900 kW solar PV system in the SAM case simulations.

Table 3. Summary of NREL SAM Case Simulation Inputs

Input Categories	User Modified Input Parameters
Location & Resource	NREL NSRDB Station ID: 77294, Ruidoso, NM
System Size (kW)	900 kW
Module	Standard
Inverter Efficiency	96%
System Design	Roof or Ground Mount: fixed-tilt open rack (30° tilt, 180° azimuth) Ground Mount: single-axis tracking (30° tilt, 180° azimuth)
Hourly Shading	Shade data obtained on-site using Solmetric SunEye 210
DC to AC Ratio	1.2
Total System Losses	14.08%
Lifetime	System Performance Degradation Rate: 0.5%/yr
System Costs	Solar PV System Cost Categories: Direct Capital Costs (module, inverter, balance of system equipment, installation labor, installer margin and overhead) Indirect Capital Costs (engineering and developer overhead, grid interconnection, land prep & transmission). Operations and Maintenance Costs (includes inverter replacement) $18/kW/yr. Average Project Development Cost: $3.00/W installed.
Financial Parameters	Analysis period 25 years; Inflation rate 2.5%/yr; Real discount rate 6.4%/yr; Insurance rate (annual) 0.5% of installed cost; Property tax 0%; Debt 100% of total capital costs, 20-year loan term, 0.01% fixed-interest rate. Salvage Value of 5% of installed costs at 25 years.
Incentives	OCEC Renewable Energy Credit $0.001/kWh NMGRT exemption Federal Investment Tax Credit 25.5%
Electricity Rate Escalation	2%/yr
Taxes	None Applied
Depreciation	None Applied

4.2.6 Case Simulation Performance and Financial Metrics (Model Results)

Among the SAM case simulation financial metrics, Levelized Cost of Energy, Net Present Value, and Payback Period are used to help assess the feasibility of the solar PV systems. Table 4 below summarizes the SAM case simulation results for the net metered solar PV system at the MBR Building. The full SAM case simulation results (solar PV system performance and financial projections) are included in Appendix B.

<u>Levelized Cost of Energy</u>

Levelized Cost of Energy (LCOE) is a measure of lifetime costs divided by energy production. Nominal LCOE reflects current costs, whereas Real LCOE considers future inflation. As a way to evaluate a potential project, LCOE values should be compared to current electricity costs. NREL SAM uses a simple method to calculate a project's LCOE using the following formula:

$$\text{LCOE} = \frac{\text{FCR} \times \text{TCC} + \text{FOC}}{\text{AEP}} + \text{VOC}$$

Where:

- Levelized Cost of Energy (LCOE)
- Fixed charge rate (FCR)
- Capital cost, $ (TCC)
- Fixed annual operating cost, $ (FOC)
- Annual electricity production, kWh (AEP)
- Variable operating cost, $/kWh (VOC)

<u>Net Present Value</u>

A project's Net Present Value (NPV) is a measure of a project's economic feasibility that includes both revenue (or savings for net-metered projects) and cost over the analysis period of 25 years. In general, given the discount rate assumed, a positive NPV value indicates an economically feasible project, while a negative net present value indicates an economically infeasible project. NPV should be evaluated along with other metrics including LCOE, payback period, size of debt, etc.

Payback Period

The payback period is the time in years that it takes for project savings in years two and later of the cash flow to equal the net capital cost in year zero. SAM considers the value of electricity generated by the solar PV system, tax benefits, and incentives to be project savings. The net capital cost is the total installation cost less any investment-based incentives (IBI) or capacity-based incentives (CBI). The payback period for commercial-scale solar PV systems varies nationally between 5 years to 20 years, depending primarily on electric utility rates. Compared to other states, average commercial electric utility rates in New Mexico are slightly below the national average ($0.1123/kWh and $0.1134/kWh, respectively), which means that payback periods for solar PV projects in New Mexico tend to be comparable to that of most other states (USEIA, 2021).

Among the SAM case simulation financial metrics, Levelized Cost of Energy, Net Present Value, and Payback Period are used to help assess the feasibility of the solar PV systems. Table 4 below summarizes the SAM case simulation results for a solar PV system net metered with the MBR Building. The full SAM case simulation results (solar PV system performance and financial projections) are included in Appendix B.

Table 4. Summary of NREL SAM Performance and Financial Projections for Net Metered Solar PV Systems at RWWTP

RWWTP Facility Name & Scenario Description	OCEC Account Number	OCEC Rate Tariff	Solar PV kW AC	Roof/Ground Mount	Fixed Tilt/1-Axis Tracking	Generation Year-1 (kWh)	Capacity Factor Year-1	Energy Yield Year-1 (kWh/kW)	LCOE Nominal (¢/kWh)	LCOE Real (¢/kWh)	Elec bill w/out PV Year-1	Elec bill w/ PV Year-1	Net Savings Year-1	Net Present Value	Simple Payback Period (years)	Debt (100% of Net Capital Cost)
MBR Building	2160600	2	900	Roof & Ground-Mount	Fixed-Tilt	1,555,443	19.7%	1,728	6.35	5.07	$505,209	$316,100	$189,109	$1,672,352	10.2	$2,701,440

4.2.7 Analysis of NREL SAM Results

Using conservative assumptions, SAM case simulation financial projection metrics indicate that optimally sized net metered solar projects for the MBR Building electric account/meter would be economically feasible and substantially reduce current electric utility costs to operate this facility. For this project, the LCOE value is well below current electricity cost, NPV is positive over the analysis period, and payback period is reasonable for public projects (Table 4).

4.3 Land Requirement

The discussion of available land and resulting size of the planned net metered solar PV project is found above in Section 4.2.2.

4.4 Potential Construction Problems

Ground-mount fixed-axis (1-axis) solar PV systems are relatively easy to design and construct using off-the-shelf, pre-engineered components. There are several design-build solar contractors in New Mexico who routinely install similar solar PV systems. The solar contractor will perform a geotechnical analysis to identify any subsoil conditions that would prevent driving the racking system piles into the ground. In the event that subsoil conditions are not conducive to driving the racking system piles, then the piles can be set in concrete foundations. The Village will need to coordinate closely with the selected solar contractor and the electric utility to facilitate interconnection of the solar PV system.

4.5 Permits Required

The selected design-build solar contractor will be required to submit an interconnection application to Otero County Electric Cooperative (OCEC) and obtain interconnection approval from the utility prior to beginning construction, and then again prior to energizing the solar PV system. In addition, the selected design-build solar contractor will be required to obtain building and electrical permits and facilitate inspections from the Construction Industries Division of the Regulations and Licensing Department.

4.6 Total Project Cost Estimate

Based on current solar industry development costs, SMA estimates that a 900 kW ground-mount net metered solar photovoltaic PV system built as multiple arrays would cost approximately $2,206,440 to construct, including a contingency amount for the solar PV system. This amount does not include project management, geotechnical analysis, Archimedes screw pump demolition/removal, or a contingency amount for these additional items. It is estimated that the total project cost, including these additional items and their contingency amount, will be approximately $2,971,440, as summarized in Table 5 below.

Table 5. Summary of Estimated Project Construction Costs

Estimated Project Costs	
Solar PV System	$2,206,440
Indirect Costs	$495,000
Project Management	$ 50,000
Geotechnical Analysis	$ 20,000
Archimedes Screw Pump Demo/Removal	$ 200,000
Contingency	$ 29,500
Total	$ 2,971,440

4.7 Annual O&M Costs

Based on current solar industry costs compiled by NREL, SMA estimated Operations and Maintenance Costs for the planned solar PV system to be $18/kW-yr, or about $16,200/yr. This O&M cost was included in the NREL SAM case simulation. The components of O&M costs applicable to the Village's planned solar PV project include:

- Fixed Costs
  - Administrative fees
  - Administrative labor (e.g., warranty claims, record keeping)
  - Insurance
  - Operating labor (e.g., performance monitoring via SCADA)
  - Site security
- Component Replacement
  - Inverters at 15 years[6]
  - PV modules at 0.05% annual failure rate[7] (1 PV module every 2 years)
- Maintenance
  - Scheduled maintenance over technical life (e.g., visual inspections for plant grown and any objects obstructing and causing shading; visual and physical inspections for corrosion on all terminals, cables, and enclosures; measuring operating current in each string; thermal imaging to identify failed PV cells)
  - Unscheduled maintenance over technical life
  - Vegetation removal
  - Rodent mitigation

The Village's planned 900 kW solar PV system will likely have: a) nine inverters, which cost about $8,000 each to replace, and b) 1,285 x 700 Watt PV modules, which cost about $500 each to replace. As mentioned above, for

[6] NREL: PV Inverter Performance Projections: https://www.nrel.gov/docs/fy06osti/38771.pdf

[7] NREL PV Panel Failure Rates: https://www.nrel.gov/news/program/2017/failures-pv-panels-degradation.html

budgetary purposes, the Village should anticipate replacing all nine inverters in year 15 ($72,000 in year 15) and replacing approximately one PV module every two years ($500 every two years).

4.8 Reserve Account

To budget for O&M expenses, it is recommended that the Village establish a major equipment replacement reserve account. If the Village were to deposit $16,200/yr into the reserve account, this would cover O&M costs (fixed costs, component replacement, maintenance) over the life of the project. Table 6 below summarizes the estimated project O&M expenditures over 25 years.

Table 6. Estimated O&M Expenses over 25 Years

Year	Reserve Account Deposit	Fixed Costs	Inverter Replacement	PV Module Replacement	Maintenance	Reserve Account Year-End Balance
1	$16,200	$6,000			$6,000	$4,200
2	$16,200	$6,000		$500	$6,000	$7,900
3	$16,200	$6,000			$6,000	$12,100
4	$16,200	$6,000		$500	$6,000	$15,800
5	$16,200	$6,000			$6,000	$20,000
6	$16,200	$6,000		$500	$6,000	$23,700
7	$16,200	$6,000			$6,000	$27,900
8	$16,200	$6,000		$500	$6,000	$31,600
9	$16,200	$6,000			$6,000	$35,800
10	$16,200	$6,000		$500	$6,000	$39,500
11	$16,200	$6,000			$6,000	$43,700
12	$16,200	$6,000		$500	$6,000	$47,400
13	$16,200	$6,000			$6,000	$51,600
14	$16,200	$6,000		$500	$6,000	$55,300
15	$16,200	$6,000	$72,000		$6,000	-$12,500
16	$16,200	$6,000		$500	$6,000	-$8,800
17	$16,200	$6,000			$6,000	-$4,600
18	$16,200	$6,000		$500	$6,000	-$900
19	$16,200	$6,000			$6,000	$3,300
20	$16,200	$6,000		$500	$6,000	$7,000
21	$16,200	$6,000			$6,000	$11,200
22	$16,200	$6,000		$500	$6,000	$14,900
23	$16,200	$6,000			$6,000	$19,100
24	$16,200	$6,000		$500	$6,000	$22,800
25	$16,200	$6,000			$6,000	$27,000

4.9 Life Cycle Cost Analysis

As described in Section 4.2.6, NREL SAM calculates both nominal and real Levelized Cost of Energy (LCOE) values. Nominal LCOE is a current dollar value, while real LCOE is a constant dollar, inflation-adjusted value. Real LCOE can also be defined as the ratio between the Life Cycle Cost (LCC) of the solar PV system to the Whole Life Produced Energy (WLPE) as shown in the following equation:

$$LCOE = \frac{\text{Life Cycle Cost (LCC)}}{\text{WLPE}}$$

LCOE is the total project life cycle cost expressed in cents per kilowatt-hour of electricity delivered by the system over its life. The LCOE value can be directly compared to the electricity rate charged by the electric utility. Investing in a solar PV system is essentially creating a hedge against rising utility costs by fixing the per kWh rate at a known cost. Because LCOE is a useful and representative cost-benefit evaluation metric for solar PV systems, it is widely used and accepted by agencies.

LCOE is a more appropriate cost-benefit evaluation metric than LCC for solar PV systems because it considers energy produced by the system and can be compared directly to electric utility rates. In contrast, a Life Cycle Cost Analysis using the methodology found in a typical Preliminary Engineering Report (PER) does not consider the value of energy produced and therefore less appropriate for evaluating solar PV systems. Specifically, because the calculation of Net Present Value (NPV) according to a PER methodology does not consider the value energy produced for a solar PV system, a “no construction” alternative will be deemed better than an alternative involving construction of a solar PV system.

NREL SAM calculates the LCOE based on the costs and benefits of a solar PV system. NREL SAM’s LCOE calculator includes the following costs, some of which having to do with tax liability are not applicable to the Village’s project:

- The project equity investment: Equipment and labor costs, construction period financing costs, project development and financing fees, and sales tax less the size of debt (amount borrowed).
- Operating expenses, including for operation and maintenance, insurance payments, and property taxes.
- Cost of electricity purchased to meet night-time photovoltaic inverter consumption and parasitic loads that occur when the system is not generating power.
- Project term debt costs: Principal and interest payments, and funding of debt service reserve account.
- Funding of and disbursement reserves: Working capital, equipment replacement, and debt service.
- State and federal tax liability.

NREL SAM’s LCOE calculator includes the following benefits:

- State and federal tax benefits: Depreciation, tax credits, deductible expenses, deductible debt interest payments.
- Interest earned on reserve accounts.
- Cash incentives: Investment-based, capacity-based, and production-based incentives.

- Salvage value (SMA assumed 5% of installed cost at 25 years)

As summarized in Table 4, the NREL SAM case simulation for this project indicates that the nominal LCOE is \$0.0635/kWh and the real LCOE is \$0.0507/kWh. These values are well below the electric utility's energy rate of \$0.1114/kWh for the first 500,000 kWh and \$0.0893/kWh for energy usage beyond 500,000 kWh. As explained in Section 4.2.6, the NREL SAM's financial metrics should be considered together (i.e., LCOE should be evaluated along with other metrics including NPV, payback period, size of debt, etc.). In addition, please refer to Appendix B for the cashflow spreadsheet accompanying this Technical Memorandum, wherein are summarized the 25 year project costs, expenses, incentives, and savings.

Regarding the long-term future of the solar PV system beyond the 25-year mark, it is anticipated that the Village will continue to operate the solar PV system for the purpose of reducing electric utility costs. While the PV modules and inverters will likely be replaced with new, more efficient models after 25 years, the galvanized steel fixed-tilt racking systems will likely still be serviceable for another 25 years.

NREL projects that recycling older PV modules in the future will be an essential process that will support a circular economy for production of new PV modules (NREL, 2023). While landfills typically charge \$1 to \$2 to accept a PV module, many landfills do not accept them. Recognizing the business opportunity to recycled PV modules and then sell the extracted materials (silver, copper, aluminum, glass, silicon) to PV manufacturers and other industries, new business have emerged and are currently charging a recycle fee of about \$18 per PV module (Hurdle, 2023).

If we consider that a 900 kW solar PV system is comprised of approximately 1,285 700 Watt PV modules, the cost to recycle those modules would be approximately \$23,142 today. Adjusting for 3% inflation, the cost to recycle those PV modules in 25 years will be \$48,454. Accounting for this future expense at the end of 25 years would not result in a significant reduction in the NREL SAM calculated NPV of \$1,672.352 for the project over 25 year analysis period.

4.10 Project Schedule

The anticipated project schedule is summarized in Table 7 below.

Table 7 Project Schedule

Task	Start Date	End Date	Task Duration	Cumulative Duration
NMED Approval of Tech Memo		11/20/23		
CatEx Publication		12/31/23	1 month	
Procurement of Solar Contractor	01/1/23	3/31/24	3 months	
Contracting	4/1/24	4/30/24	1 month	
Geotechnical Analysis and Report by Contractor	5/1/24	5/31/24	1 month	
Design	6/1/24	6/30/24	1 month	
NMED CPB Design Review	7/1/24	7/31/24	1 month	
Permits (including interconnection application)	7/1/24	7/31/24	2 weeks	
Construction	8/1/24	12/7/24	17 weeks	
Testing and Commissioning	12/1/24	12/7/24	1 week	
Electric Utility Interconnection		12/8/24	1 day	
Village Staff Training	12/9/24	12/15/24	1 week	392 days

5.0 Conclusion and Recommendation

The proposed net metered solar PV system at the RWWTP has the potential to save the Village approximately $189,109/yr in electric utility costs (Table 4). Because the proposed net metered solar PV system has very favorable financial metrics, SMA recommends that the Village pursue development of the project using available CWSRF funding.

If you have any questions regarding this technical memorandum or require additional information, please feel free to contact us.

Sincerely,

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Senior Engineer
Miller Engineers, Inc. d/b/a
Souder, Miller and Associates
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PROFESSIONAL ENGINEER CERTIFICATION

This Technical Memo for the Village of Ruidoso was prepared by:

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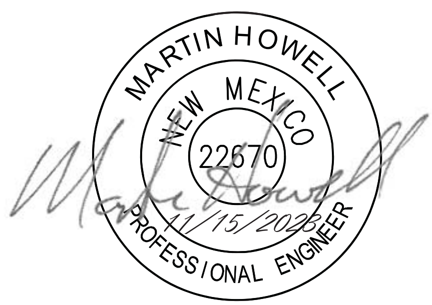
(575) 647-0799

The technical material and data contained in the Technical Memorandum was prepared under the supervision and direction of Martin Howell, P.E., whose seal as a Professional Engineer licensed to practice in the state of New Mexico, is affixed below.



Martin Howell, P.E. Date
New Mexico P.E. License #22670

All questions about the meaning of intent of these documents shall be submitted only to the Engineer of Record stated above, IN WRITING for interpretations.

6.0 References

National Renewable Energy Laboratory (NREL). 2023. Photovoltaics in the Circular Economy. https://www.nrel.gov/pv/pv-circular-economy.html

New Mexico Environment Department (NMED), 2022, "NMED Drinking Water Bureau 2022 Public Water and Wastewater User Charge Survey for December 2021 Rates".

Molzen Corbin and Associates (Molzen Corbin), 2023, "2023 Combined Enterprise Utility Master Plan and Rate Study Summary Report for the Village of Ruidoso". May 19, 2023.

Souder, Miller and Associates (SMA), 2023, "Structural Analysis of Ruidoso RWWTP MBR Building Roof". May 12, 2023.

Jon Hurdle. 2023. "As Millions of Solar Panels Age Out, Recyclers Hope to Cash In". Yale Environment 360, February 28, 2023.
https://e360.yale.edu/features/solar-energy-panels-recycling#:~:text=By%202050%2C%20the%20value%20of,mining%20and%20processing%20new%20silicon

Appendix A – NREL SAM Case Simulation Output

System Advisor Model Report

PVWatts	900 DC kW Nameplate	33.33, -105.7
Commercial	$3.00/W Installed Cost	UTC -7

Performance Model

PV System Specifications	
System nameplate size	900 kW
Module type	1
DC to AC ratio	1.2
Rated inverter size	750 kW
Inverter efficiency	96 %
Array type	fixed open rack
Array tilt	30 degrees
Array azimuth	180 degrees
Ground coverage ratio	N/A
Total system losses	14.08 %
Shading	no

Performance Adjustments	
Availability/Curtailment	none
Degradation	0.5 %/yr
Hourly or custom losses	none

Results	Solar Radiation	AC Energy
	(kWh/m2/day)	(kWh)
Jan	5.43	124,993
Feb	6.23	127,250
Mar	6.74	147,892
Apr	7.19	150,455
May	7.1	150,282
Jun	6.51	129,167
Jul	5.34	109,007
Aug	5.47	111,992
Sep	6.11	124,245
Oct	6.42	140,039
Nov	5.48	119,808
Dec	5.17	120,307
Year	6.1	1,555,443

Financial Model

Project Costs	
Total installed cost	$2,701,440
Salvage value	$135,072

Analysis Parameters	
Project life	25 years
Inflation rate	2.5%
Real discount rate	6.4%

Project Debt Parameters	
Debt fraction	100%
Amount	$2,701,440
Term	20 years
Rate	0.01%

Tax and Insurance Rates	
Federal income tax	0 %/year
State income tax	0 %/year
Sales tax (% of indirect cost basis)	0%
Insurance (% of installed cost)	0.5 %/year
Property tax (% of assessed val.)	0 %/year

Incentives	
Federal ITC	25.5%
Utility PBI	0.001 $/kWh10 yrs

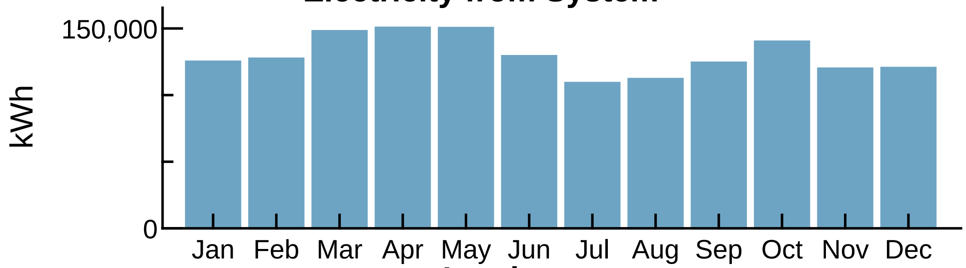
Electricity Usage and Rate Summary

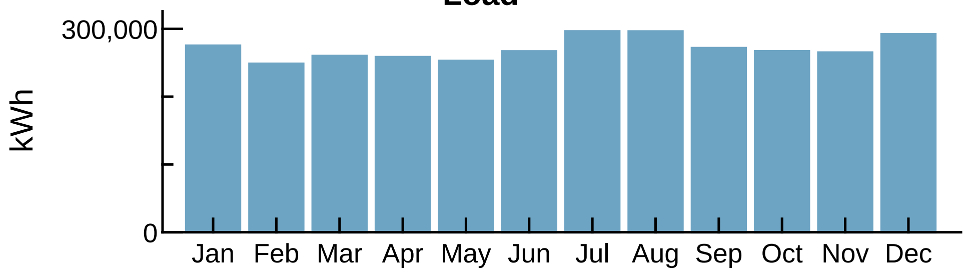
Annual peak demand 1,126.2 kW
Annual total usage 3,249,346 kWh
Large Power - Regular Rate (50 kVA or more)
Fixed charge: $80/month
Monthly excess with kWh rollover
Annual rate escalation: 2%/year
Tiered TOU energy rates: 1 period, 2 tiers
Monthly TOU demand rates with tiers

Results	
Nominal LCOE	6.4 cents/kWh
Net present value	$1,672,300
Payback period	10.2 years

PVWatts	900 DC kW Nameplate	33.33, -105.7
Commercial	$3.00/W Installed Cost	UTC -7

Year 1 Monthly Generation and Load Summary





Year 1 Monthly Electric Bill and Savings ($)

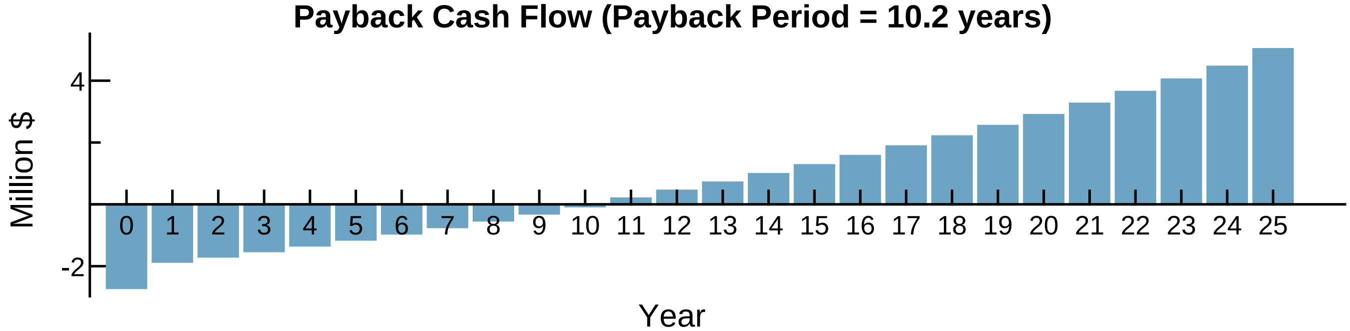
Month	Without System	With System	Savings
Jan	45,439	31,515	13,924
Feb	39,008	24,832	14,175
Mar	39,058	19,300	19,758
Apr	40,752	19,973	20,779
May	38,639	19,113	19,525
Jun	41,203	26,341	14,862
Jul	46,614	33,498	13,116
Aug	45,862	32,441	13,420
Sep	43,162	28,384	14,778
Oct	40,602	23,511	17,090
Nov	39,558	25,283	14,275
Dec	45,305	31,903	13,402
Annual	505,208	316,099	189,108

NPV Approximation using Annuities

Annuities, Capital Recovery Factor (CRF) = 0.1023		
Investment	$0	Sum:
Expenses	$-160,600	$171,000
Savings	$65,600	NPV = Sum / CRF:
Energy value	$266,100	$1,672,000

Investment = Installed Cost - Debt Principal - IBI - CBI
Expenses = Operating Costs + Debt Payments
Savings = Tax Deductions + PBI
Energy value = Tax Adjusted Net Savings
Nominal discount rate = 9.06%

Payback Cash Flow (Payback Period = 10.2 years)



PVwatts	900 DC kW Nameplate	33.33, -105.7
Commercial	$3.00/W Installed Cost	UTC -7

This performance model does not specify any loss diagram items.
Current case name is untitled

Appendix B – NREL SAM Case Simulation 25-YR Cashflow

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