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Innovation in Transportation

FREE ENERGY SOLAR HIGHWAY PROGRAM

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FREE ENERGY SOLAR HIGHWAY PROGRAM

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16. Abstract

Highway rights-of-way (ROW) can host alternative energy generation system resources for many state departments of transportation (DOTs). In an era of limited state DOT budgets, ROW areas can be a source of income and cost reduction to DOTs through alternative energy development, especially in the area of solar energy. In addition, generating power via solar systems is a way for state DOTs to reduce their overall carbon footprints by reduced greenhouse gas emissions and promote positive public relations through adoption of innovative approaches to transportation sustainability

The New Mexico Department of Transportation's Research Bureau has established a research project to identify best practices nationally and to determine the financial feasibility of generating solar power on NMDOT property at the lowest possible cost. The best practices section describes experiences at eleven solar highway projects in the United States. This portion of the study identifies and provides samples of types of legal agreements used by state DOTs, including power purchase agreements, airspace/land lease agreements and energy savings performance contracts. The study also examines best practices for maintenance, security, liability, and long-term ownership of photovoltaic systems. It examines projected and actual financial outcomes of the installation where data is available.

The feasibility section examines district-specific opportunities for NMDOT to develop solar power generation in state ROWs. The study identifies agreements that can be employed and performs financial analyses to determine which opportunities promise the greatest revenues or savings.

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PREFACE

Several state departments of transportation (DOTs) have found the utilization of right of way (ROW) for solar energy development to be viable and cost-effective. This research project identifies best practices for state DOT and tollway use of ROW for solar generation. The research also evaluates the cost feasibility for implementation of solar energy systems in ROW of individual New Mexico DOT Districts. The study provides a detailed guide, outlining the steps needed to implement solar highway projects.

NOTICE

DISCLAIMER

ABSTRACT

The Free Energy Solar Highway Program research project identified best practices nationally and determined the financial feasibility of generating solar power on NMDOT property at the lowest possible cost. The State of New Mexico has one of the highest potential solar incidence in the United States while having one of the lowest solar utilization. The best practices section describes experiences at eleven (11) solar highway projects in the United States. This portion of the study identifies and provides samples of types of legal agreements used by state DOTs and tollways including power purchase agreements, airspace/land lease agreements and energy savings performance contracts. The study also examines best practices for maintenance, security, liability, and long-term ownership of photovoltaic systems. It examines projected and actual financial outcomes of the installation where data is available. The feasibility section examines district-specific opportunities for NMDOT to develop solar power generation in state ROWs. The study identifies agreements that can be employed and performs financial analyses to determine which opportunities promise the greatest revenues or savings.

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- Jan Niclas – District 6 Assistant District Engineer
- Jerry Gonzales – District 3 Administrative Operations Manager
- Richard Chavez – General Services Bureau Chief – Buildings and Grounds

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ACRONYMS

AC – alternating current
BLM – Bureau of Land Management
DC – direct current
DOT – Department of Transportation
ECMD – Energy Conservation and Management Division
EMNRD – Energy, Minerals, and Natural Resources Department
ESPC – Energy Savings Performance Contracting
ESCO – Energy Service Company
FAA – Federal Aviation Administration
FDOT – Florida Department of Transportation
FHWA – Federal Highway Administration
GHG – greenhouse gas
G&T – Generation and Transmission
GO – General Office
GPS - Global Positioning System
HDOT – Hawaii Department of Transportation
HSAT – Horizontal Single-Axis Tracking
HVAC – Heating, Ventilation, and Air Conditioning
IOU – investor-owned utility
ITC – investment tax credit
kW – kilowatt
kWh – kilowatt hour
MACRS – Modified Accelerated Cost-Recovery System
MassDOT – Massachusetts Department of Transportation
MW – megawatt
MWh – megawatt hour
NEG – net excess generation
NMDOT – New Mexico Department of Transportation
NREL – National Renewable Energy Laboratory
NYSDOT – New York State Department of Transportation
O&M – Operations and Maintenance
NPV – net present value
ODOT – Oregon Department of Transportation
PPA – Power Purchase Agreement
PV – photovoltaic
REC – Renewable Energy Certificate
REIA-NM – Renewable Energy Industries Association of New Mexico
RFP – Request for Proposal
ROW – right-of-way
RPS – Renewable Portfolio Standard
SEIA – Solar Energy Industry Association
SLO – State Land Office
SRECs – Solar Renewable Energy Credit
UDOT- Utah Department of Transportation
USDOE – U.S. Department of Energy
VTrans – Vermont Agency of Transportation

EXECUTIVE SUMMARY

These are the basic research elements addressed by the Free Energy Solar Highway Program project. The project identified best practices nationally and determined the financial feasibility of generating solar power on NMDOT property at the lowest possible cost. The best practices section describes experiences at eleven (11) solar highway projects in the United States. This portion of the study identifies and provides samples of types of legal agreements used by state DOTs and tollways including power purchase agreements, airspace/land lease agreements and energy savings performance contracts. The study also examines best practices for maintenance, security, liability, and long-term ownership of photovoltaic systems. It examines projected and actual financial outcomes of solar installations where data is available.

The feasibility section examines district-specific opportunities for NMDOT to develop solar power generation in state ROWs. The no-cost approach does not require NMDOT to provide any financial resources for solar development and long-term maintenance. The initial capital needed is covered by the solar developer and/or other entities that secure the development funding. Solar photovoltaic (PV) systems can reduce energy consumption from grid electricity, offset energy costs, provide needed revenue, and reduce operating costs to NMDOT. This report provides a guidebook for developing a statewide solar program to reduce energy costs while reducing carbon emissions from electricity generation and promoting positive public relations through adoption of innovative and sustainable approaches.

A financial feasibility analysis was performed on several appropriately-sized hypothetical PV solar systems using the three aforementioned business models. The financial feasibility study was performed at the NMDOT district level and not at site-specific locations. The research team found that solar energy generation within NMDOT surplus and ROW property is cost effective to the agency at select districts and utility territories using each of the three partnership types. The project feasibility is based on current project parameters. Solar feasibility in particular, is contingent on a series of variables and assumptions that are often in flux. As an example, there are federal incentives for solar power generation that will decrease in the coming years which will influence project viability. Paradoxically, at the same time, solar component prices continue to decrease due to larger scale deployment. The research team recommends using this document as a foundation reference for near-term project feasibility but suggest partnering with a solar developer to perform real-time assessments of future projects.

STATE DOT LESSONS LEARNED

The research team identified and contacted a total of 11 DOTs and tollway project managers that have developed and implemented solar projects within highway or roadway ROWs. These interviews identified best practices and lessons learned for the assessment, installation and maintenance of solar systems that will be a useful reference to NMDOT as it develops solar projects. Based upon the initial interviews and outreach, the following *projects* were identified for more detailed interviews and data collection efforts:

- Northwest Parkway-Colorado (Tollway)
- E-470 Tollway Solar Program (Tollway)
- NYSDOT Region 5 Solar Project
- New York Thruway Authority Solar Program
- Utah DOT- Rampton Motorpool Project
- Oregon Baldock Safety Rest Area
- Oregon I-5/I-225 Solar Project
- Vermont DOT- Fairhaven Welcome Center
- Massachusetts DOT-Bundled ROW
- Florida DOT Turkey Lake Service Plaza
- Hawaii DOT-Hawaii Airport Solar Project

Appendix B contains summary sheets of lessons learned from solar projects for the above-mentioned projects.

The information gained from this research will allow NMDOT to anticipate challenges and develop approaches toward solar system installation within the ROW. In addition, this solar project information was important in developing the solar feasibility study. The principal driver for most DOTs and tollways to implement solar energy generation was based on climate change mitigation and alignment with state and agency sustainability programs and efforts. For most state DOTs, project revenue was a secondary or indirect benefit. Select DOTs recognized significant financial benefits from reduced energy costs based on the local factors related to higher electricity prices, specific solar incentives, local utility rate schedules, and land values. The following are some of the lessons learned from state DOT and tollway authorities that will aid NMDOT representatives:

- Project Partnership Agreements were the most common approach used by no-cost projects in which all capital and long-term maintenance costs are the responsibility of the developer.
- The large majority of projects researched used ground mounted systems that generate less than 1MW of power and requires less than 4 acres of area.
- Solar projects were developed by most states to be in compliance to climate change regulations and directives by state legislatures and governors by increasing renewable energy and reducing greenhouse gas (GHG) emissions.
- Financial revenues and energy cost reductions were realized by many interviewed DOTs and tollways although cost savings was not a major driver.
- Solar projects provided a great educational and outreach tool to the public showing innovation and sustainability.
- Many DOTs and tollways relied upon solar system developers to perform initial pre-construction cost analysis to develop no-cost solar projects; a close working relationship with developers and utilities is important in a successful project.
- A project champion is critical in acquiring and directing a project team from solar energy system conception through construction.
- To achieve a successful project, a significant level of effort will be needed by the project manager and staff to coordinate project conceptualization, procurement, developer

selection, legal assessment, site selection, NEPA impacts and overall contractor management.
- It is important for the NMDOT project manager to leverage internal agency resources who are familiar with ROW management and utility coordination.

THREE OPTIONS FOR SAVINGS/REVENUES FROM SOLAR PROJECTS

Many state DOTs and private tollways have developed and contracted solar power generation projects via a) power purchase agreements (PPAs) for fixed-rate, below-market-rate power, b) long-term airspace/land lease agreements which offer financial resources to the DOT in exchange for land to host solar facilities and c) energy savings performance contracts (ESPCs) to reduce overall energy costs through solar generation and energy conservation measures across multiple facilities.

PPAs Viable for Specific Project Scale and Context

PPAs have been shown to be viable for NMDOT for large ground mounted solar systems greater than 1 Megawatt (MW) (about 4 acres) and are the most popular no-cost agreements by interviewed state DOTs and tollways.

Using a PPA, the cost savings to NMDOT include the following based on bundling projects up to 1MW or more:

- District 1 Office in Deming (200kW capacity, 351,812 annual kWh): ~$258,000 savings over 20-year period.
- District 2 Mesa Rest Area (50kW capacity, 86,279 annual kWh): ~$60,000 savings over 20-year period.
- District 4 Maintenance Patrol (15kW capacity, 8,627 annual kWh): ~$15,000 savings over 20-year period.

Districts 3, 5 and 6 were not viable candidates for PPA agreements due to the combination of utility pricing and lack of sufficient energy usage at NMDOT facilities. Further description of solar locations in each district are described in Section 2.

Air/Land Lease Feasible Based on Developer Interest

Air/land leasing has potential in generating NMDOT revenue but is dependent upon site location, available ROW area, and the transaction cost associated with internal coordination having a lower cost than the future lease income. The land leasing option is most suitable for large, stand-alone, ground mounted projects that have the benefit of being the most visible (and considered most innovative) to the traveling public. The research team modeled 1MW and 5MW systems and would provide NMDOT lease income between $21,500 and $325,000 over a 20-year period, depending on lease per acre value of $250 or $750 and the size of system (1MW or 5MW). 1MW and 5MW projects require approximately 4 and 22 acres of land, respectively. The development of solar projects is dependent upon specific site conditions, the ability for interconnection into the electrical grid, and most importantly, the interest of solar developers or utilities to deploy a project:

- District 2 has 95 surplus parcels for a total of 405 acres available for development.
- District 3 has 59 surplus parcels for a total of 47 acres available for development.
- District 1 has 9 surplus parcels for a total of 28 acres available for development.
- District 5 has 81 surplus parcels for a total of 144 acres available for development.

Districts 4 and 6 were not viable candidates for airspace/land lease agreements due to lack for available ROW for development.

ESPC OPPORTUNITIES FOR SOLAR DEPLOYMENT AT DOT FACILITIES

ESPCs offer the best short-term solar project opportunities of the three partnership pathways assessed. To maximize savings, ESPCs would be used to retrofit and upgrade existing NMDOT buildings electrical, heating, and water facilities while *installing solar*. ESPCs are the best agreements for smaller roof type solar systems of 10-500 kilowatt (kW) capacity in which several maintenance facilities can be bundled together to achieve overall improved energy savings. Project investment by an Energy Service Company (ESCO) would need to be $1 million or more to merit developing a project, which could encompass one project or multiple projects at either the District or NMDOT agency level throughout the state. This approach can be beneficial by all NMDOT Districts, regardless of geographic location and utility provider. The ESPC approach has a downside of being tied to buildings, and thus not applicable for stand-alone ground mount arrays that are visible by the traveling public.

NMDOT CHALLENGES TO FINANCIAL FEASIBILITY OF SOLAR PV PROJECTS

Based upon the research performed in this study, the following are the main challenges facing NMDOT associated with the development and installation of solar systems within the NMDOT's ROW, surplus property and facilities:

- Utilities in New Mexico are shifting rate schedules to ensure that transmission costs for the utility are covered as more renewable projects are added to the energy resource mix. Utilities have recently increased demand charges, effectively reducing the amount of savings a solar project can garner.
- There is relatively low electricity demand (load) near highway ROW given that NMDOT is generally not responsible for roadway lighting costs in urban areas.
- Projects are restricted to the level of PPA pricing solar developers can offer based on their need to make the project financially feasible from their perspective.
- Available ROW outside of the clear zone is limited.
- Potential adverse site conditions can encumber an otherwise profitable location.
- Tribal and Pueblo land directly off the ROW edge precludes solar development without partnerships. NMDOT ROW consist in many locations as easements on tribal, State Land Office, Bureau of Land Management (BLM), and Forest Service lands; thus, understanding ownership of the ROW is critical prior to planning projects.
- There is an uncertain national policy regarding tariffs and trade agreements on imported solar panels/equipment that can affect solar energy cost effectiveness.

NARRATIVE GUIDE

The purpose of the Narrative Guide is to provide an easy-to-follow guide that explains the steps and process for NMDOT to implement solar projects that meet the conditions and business models described in this Free Energy Solar Highway research project final report (see Appendix C). This guide provides a consistent and basic step-by-step approach to implement a solar project for all NMDOT districts. This guide also identifies the administrative resources, staff, legal expertise, and other resources required to carry out these steps. The guide is tailored to NMDOT

representatives, reflecting process information gathered in interviews with key senior district and general office staff. Prior to starting a project, the project team should understand the nature and timing of project elements so they are collectively prepared for the process complexity. The type of partnership and scale of solar projects (individual, district, agency-wide) will dictate the level of effort and the complexity of tasks that each of these steps illustrate.

This Narrative Guide provides a step-by-step overview of the process of developing a solar PV project at NMDOT and includes the following steps:

- Step 1 – Project purpose and management
- Step 2 – Project team assembly
- Step 3 – Preliminary site assessment and evaluation
- Step 4 – Determine appropriate model and partnership
- Step 5 – Due diligence of priority sites
- Step 6 – Project development and maintenance

RECOMMENDATIONS AND NEXT STEPS

The results of this study have shown that it is financially feasible for NMDOT to initiate solar energy projects within the identified NMDOT Districts, locations, and scales. It is recommended that NMDOT:

- Implement an ESPC type solar project via a local ESCO, that either bundles projects at the District or state-wide level to improve District facilities electrical, heating and water infrastructure, reduce overall utility operating costs and deploy solar energy that offsets energy use. There is already a program in place with Energy, Minerals, and Natural Resources Department (EMNRD) in the State of New Mexico with pre-qualified ESCOs to support potential projects.
- Initiate a conversation with local solar developers (Affordable Solar, Positive Energy, RES and others) and share the results of this report's financial analysis as well as the identification of priority PPA locations for project development. Determine if the solar developer is interested in evaluating the potential to bundle multiple projects and whether they will conduct some of the due diligence to establish project feasibility at additional sites not studied in this research plan.
- Contact solar developers and utilities to initiate interest in leasing available ROW for solar generation. Site assessments and electrical interconnections are critical elements for making airspace/land lease projects feasible within NMDOT ROW and surplus properties.
- Use the Narrative Guide as a reference on how to implement solar projects. The guide provides a step-by-step approach to implement solar projects from internal organization to developer selection to solar system installation decommissioning. The guidance discusses the implementation process and resources needed to develop a successful solar project.
- If the electrification of the NMDOT transportation grid moves forward, there will be a need for infrastructure to provide charging every 40 or 50 miles. It is possible that private parties will provide this amenity. If the NMDOT has parcels available or can work with the State Land Office (SLO) to obtain parcels, the concept of solar-powered charging stations, may be feasible.

- The use of electrical vehicles by the NMDOT may reduce operating costs. As the Energy Conservation and Management Division (ECMD) has explored, the ESPC contract process may provide vehicle replacements for internal combustion vehicles. In such an event, it is possible to provide electric service vehicles and support vehicles (sedans, SUVs and pickups) along with solar PV chargers.
- Solar PV arrays along the highway ROW could provide offsetting power to the NM Rail Runner Express. The Rail Runner Express is a day-time load, so using solar energy could be a matching energy source. Electrification of the Rail Runner Express could reduce the present operating costs by 60% according to EMNRD (as per written communication with EMNRD).

INTRODUCTION

In an era of limited state DOT budgets, solar power generation in the ROW is being realized by many states and tollways as a source of income, operational cost reduction and a means to reduce greenhouse gas emissions. Solar facilities can include large solar arrays within rights of way and surplus properties that can generate megawatts of electrical energy and revenue, or smaller infrastructure mounted systems that can reduce utility costs within facilities. ROW areas can also be leased to energy developers and other investment firms for energy generation or a DOT and tollway can enter into a PPA for a reduced price of electrical power.

NMDOT ROW may provide an excellent location for solar energy generation since the state of New Mexico currently ranks in the top ten (10) states for both installed solar capacity and solar irradiance (sun exposure). In recognition of this solar energy potential, NMDOT's Research Bureau has established a research-based program (called the Free Energy Solar Highway Program) to determine the financial feasibility of generating solar power on NMDOT property without using NMDOT funds to develop or maintain the solar facilities.

This document provides a summary of best practices conducted by state DOTs and tollways to assess and develop solar installations within ROWs. Many state DOTs and tollways have successfully installed solar systems that have reduced energy costs and greenhouse gas emissions as part of a climate change mitigation strategy. FHWA has recognized 14 solar projects throughout the United States (1). Several DOTs and tollways were interviewed and a summary of best practices is provided including topics such as: cost effectiveness, innovative partnerships, contract mechanisms, lessons learned, and potential solar developers (see Appendix B).

A financial feasibility analysis was performed for all six NMDOT Districts to determine if the development of solar energy projects is economically viable. The feasibility study estimates potential savings and revenues for each NMDOT District that could be generated from developer and utility partnerships. The study also ranks the most optimum no-cost approaches for each NMDOT District.

It is envisioned that the results of this study will provide information that will help identify site selections within NMDOT Districts for future solar system implementation within the State of New Mexico.

PROJECT PURPOSE AND STRUCTURE

The Free Energy Solar Highway Program research project identified best practices nationally and determined the financial feasibility of generating solar power on NMDOT property at the lowest possible cost. The State of New Mexico has one of the highest potential solar incidence in the United States while having one of the lowest solar utilization. The best practices section of this report describes experiences at eleven (11) solar highway projects in the United States. This portion of the study identifies and provides samples of types of legal agreements used by state DOTs and tollways, including power purchase agreements, airspace/land lease agreements and energy savings performance contracts. The study also examines best practices for maintenance, security, liability, and long-term ownership of photovoltaic systems. It examines projected and

actual financial outcomes of the installation, where data is available. The feasibility section examines district-specific opportunities for NMDOT to develop solar power generation in state ROWs. The study identifies agreements that can be employed and performs financial analyses to determine which opportunities promise the greatest revenues or savings.

The overall project approach used a combination of data collection methods including: DOT/tollway contact discussions, interviews and data collection from solar developers and operators, interviews and data collection from utilities and performing financial feasibility analysis. Best practices information was collected and evaluated from state DOT interviews that were used as a reference for the financial feasibility analysis. The financial feasibility analysis deployed three separate financial tools to ensure a high level of confidence in the modeled facilities and expected benefits including the National Renewable Energy Laboratory's (NREL) PVWATTS and System Advisor Model (SAM) (2, 3). Additionally, Energy Toolbase (ETB) provided a platform to conduct utility specific PPA modeling (4). The study found three business models that could function for NMDOT such as PPAs, ROW area or surplus project land leasing, and ESPCs.

The approach used for this research study involved the execution of two main tasks:

- State DOT Best Practices – determination of lessons learned and approaches used by other DOTs and tollways who have been successful in planning solar projects within ROWs at no cost. A review of best practices was conducted via emails, interviews and limited web-based searches.

- District Specific Feasibility Studies – determination of projected benefits/costs and energy development strategies for each NMDOT District using cost feasibility models that are based on the utility and/or third-party offerings in a NMDOT district geographic area.

SOLAR ENERGY BACKGROUND

Historically, state DOTs have utilized solar PV technologies for small-scale highway applications (e.g., traffic signals, bridge lighting and remote message signs); however, in the last decade, state DOTs and tollways have turned their attention toward medium-scale solar PV deployments that can either generate electricity for transportation operations (highway ROW, facilities, offices, rest areas) or connect into the electric grid to provide electricity to utility customers at a reduced energy cost. State DOT sustainability and solar program leaders are beginning to look at other innovative solar applications, such as noise barriers and as a pavement substitute. Solar noise barriers are a solar application for the roadway that have been deployed in Europe for years (see Figure 1) and is under review by state DOTs in Connecticut, Georgia, Arizona and Massachusetts. Massachusetts Department of Transportation (MassDOT) is developing a pilot project to develop the first solar noise barrier in the country. If constructed, the system would be installed on a 2,500-foot section of the Route 128 in Lexington, MA (5).

FIGURE 1 Solar Noise Barrier in Europe

SOLAR PHOTOVOLATIC TECHNOLOGY BASICS

Solar PV systems collect and convert direct and indirect sunlight into direct current (DC) electricity using solid-state semiconductors. An inverter then converts DC to alternating current (AC), at a voltage compatible with onsite or electrical grid systems. Crystalline silicon (c-Si) PV panels are the predominant type of solar panel. Solar energy is often described as distributed generation, meaning that it is a smaller, decentralized energy generation source as opposed to a centralized, large-scale electricity generation (e.g., coal, natural gas, hydropower). Solar PV systems allow for electrical generation to be sited closer to where electricity is being used given its modularity.

A typical solar PV system includes the following components (see Figure 2):

- PV panels
- Mounting structures that affix to panels to a rooftop or ground

- Inverters
- Electrical equipment to connect the system to the electric grid (e.g., wiring and switches)
- Ancillary equipment (e.g., battery bank, solar tracker, security camera, fences, roads)

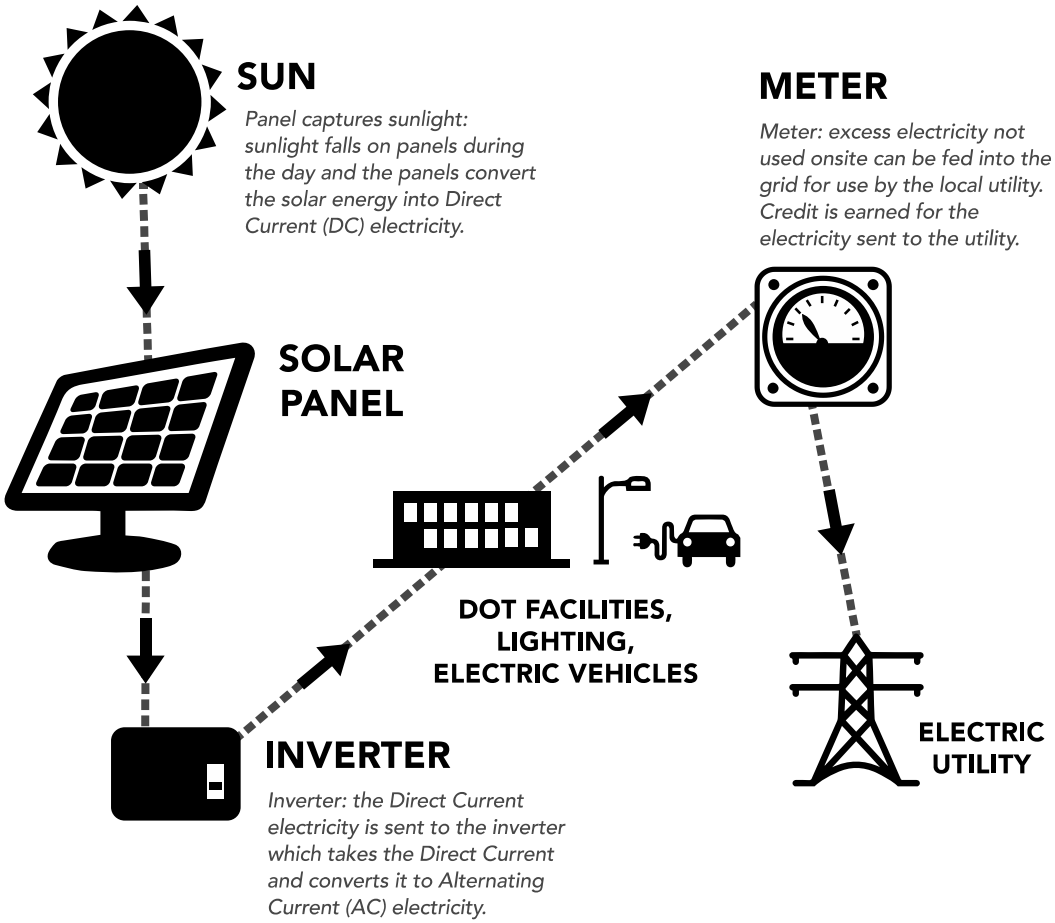

FIGURE 2 Solar PV Process

MEASURES OF ENERGY CAPACITY AND USE

A kW is a measure of power or measure of the potential to generate power. A kW unit is 1,000 watts and a MW is a 1,000 kW of capacity. The two most common methods of talking about the solar potential of a PV solar system are in kW and MW units.

Additionally, there is the measure of the amount of energy being produced or consumed that is referred to in kilowatt hours (kWh) or Megawatt hour (MWh). For the purposes of this plan the research team only uses kWh based on the scale of projects discussed.

DESIGN AND INSTALLATION TYPES

Rooftop and ground mount are the two most common land-based methods of installing solar PV panels. Table 1 below outlines the major points of differentiation between rooftop and ground mount systems.

TABLE 1 Basic PV Installation Types.

Mounting Type	Description	Benefits	Challenges
Rooftop	Attached to a building rooftop or roof structure (e.g., parking lot canopies) via bolted racking system, ballasted racking or affixing to roof membrane.	Uses under-utilized space, rather than using land that might have alternative use.	- PV system limited to size of roof. - HVAC shading, and newness of roof. -Weight of PV array can be a challenge.
Ground mounted	Installed on the ground either adjacent to buildings or on open sites and mounted via driven piers, footing mounted or ballasted racking.	Potential for larger scale projects (1MW or greater).	- Available properties may not be close to electricity use or transmission (phase 3 power, substation). - Aesthetics.

Aside from mounting on a rooftop or ground, solar PV systems can differ in the types of tilt and tracking systems they employ:

- Fixed-tilt systems are stationary systems that are installed at the most productive orientation and fixed angle to the south to maximize their ability to generate electricity from the sun's path. Fixed-tilt systems are the predominant type of design for ground mount and rooftop systems.
- Single-axis tracking systems are horizontal single-axis tracking (HSAT) systems that allow the solar PV modules to follow the sun from east to west over the course of the day rather than being fixed to the south. This type of PV tracking system is generally used for large scale projects and generates more power than fixed-tilt systems (6).
- Dual-axis solar tracking systems use a motor combined with Global Positioning System (GPS) or timer to rotate and track the sun over the course of a day. These systems can produce more energy than fixed and single-axis tracking arrays because they maximize the amount of sunlight captured by the modules.

DOT APPLICATIONS AND SITING

State DOTs and tollways develop solar systems in specific locations based on the intent and purpose of their programs. The two primary types of solar projects that utilize property are ROW and adjacent properties and DOT/tollway facilities. The most common applications and locations for solar PV installations are:

- Rights-of-way and adjacent properties
  - Interchanges or cloverleaves
  - Right-of-way outside clear zone parallel to highway or roadway
  - Surplus, larger DOT/tollway properties away or on road systems
  - Roadside rest areas
  - Park and ride areas
  - Available unused tracts of land such as:
    - Material supply yards
    - Former quarry or gravel sites

        - Brownfield sites
- Facility systems
    - Office buildings
    - Maintenance yards and facilities
    - Inactive or abandoned weigh stations
    - Other transportation assets and locations: airports, truck inspection facilities

The main uses of electricity generated by state DOT and tollway solar projects include:

- Offsetting electricity load at DOT facilities (producing some or all of the on-site electricity use)
- Generating electricity for use by a local utility to be sold to the property host or another party
- Generating electricity for a third-party user of electricity, the property host or another party

SITING SOLAR PROJECTS IN NEW MEXICO

NMDOT ROW areas have physical and topographical characteristics that complement the generation of solar energy such as:

- Well maintained or limited ground vegetation
- Ease of access to the solar array facility adjacent to the road
- Proximity to electrical transmission lines that often follow the ROW alignment
- Minimal presence of trees or other objects that can shade or fall on the arrays
- Near year-round solar exposure

Figure 3 illustrates the solar energy resource available to New Mexico. It is interesting to note that the large majority of DOTs who have and are developing viable solar projects are located in higher latitudes than New Mexico such as New York, Massachusetts, Connecticut, and Oregon. These higher latitude locations provide much lower solar generation potential (insolation) (7).

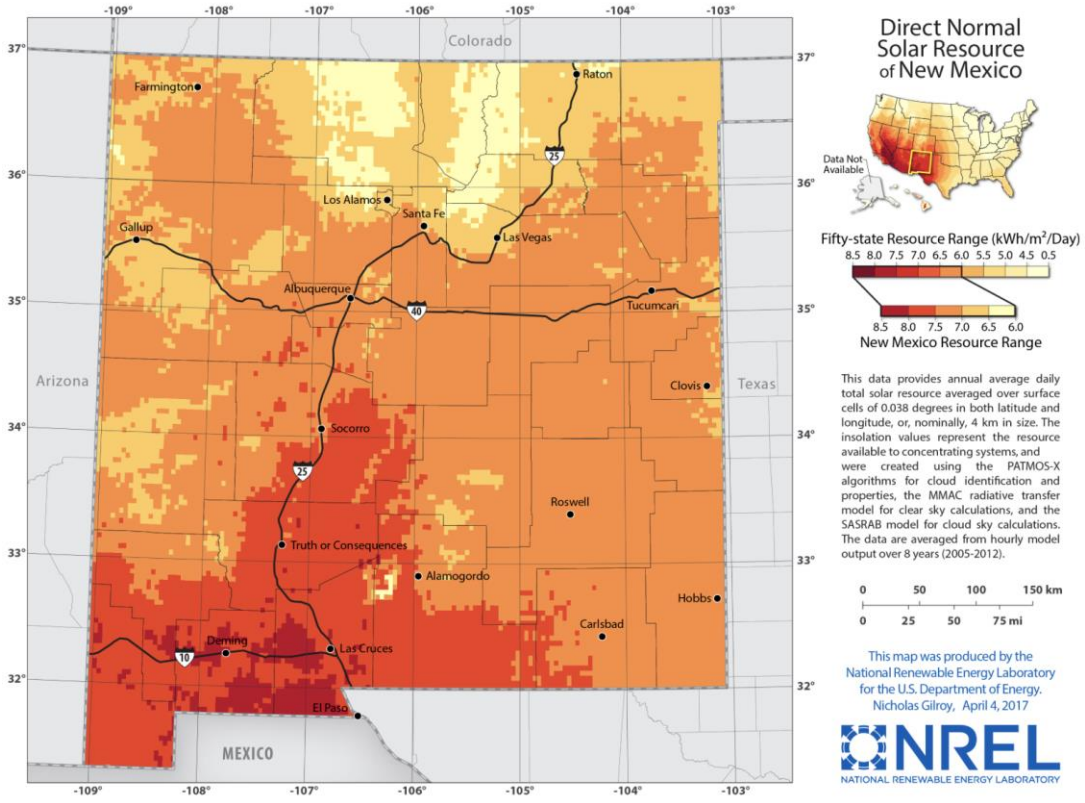

FIGURE 3 Solar Resource in New Mexico

STATE DOT BEST PRACTICES

The focus of Task 1 was to identify best practices for implementation of solar energy generation in ROWs and other surplus properties by studying other state DOTs and tollways who have been successful in developing solar systems with no capital or long-term maintenance costs (free energy approach). The main effort under Task 1 was to conduct personal interviews with state DOT and tollway representatives and to assemble documents and financial data to provide real world insights for best practices in the areas of cost-effectiveness, partnerships, project efficiency, cost estimation and lessons learned. This information will be a helpful reference to NMDOT towards developing partnerships, understanding agreements, economic estimates, measures of success and lessons learned.

POLICY OVERVIEW

FHWA Policy Directives and Resources

The Federal Highway Administration (FHWA) has developed specific directives and information resources associated with solar generation within ROWs. The main FHWA concern is driver safety and avoiding pre-emption of future transportation facility needs. The FHWA has strict access requirements associated with interstate systems. Any DOT must coordinate with FHWA officials in developing solar generating system within federal interstate system and Federal-aid highways ROWs. Federal aid highways mean a public highway eligible for assistance other than a highway functionally classified as a local road or rural minor collector (23 USC 101(a)(6). In addition, the FHWA may assign determination of highway ROW uses in a Stewardship/Oversight Agreement (23 CFR 710.405).

Regional FHWA officials have varying interpretations of the acceptability of and benefits from solar power facilities in the ROW. The following documents are an excellent reference to FHWA policy directives when conceptualizing and developing a solar project (Appendix A).

Requirements for Renewable Energy Projects in Highway Right-of-Way

This short guide provides direction to state DOTs to relevant FHWA requirements for renewable projects in the highway ROW. FHWA provides guidance on two pathways for meeting requirements based on whether a utility accommodation plan (UAP) includes or does not include renewable energy (8).

Guidance on Utilization of Highway Right-of-Way

This guidance describes FHWA's interests in accommodating utility facilities in the highway ROW (9).

STATE DOT BEST SOLAR APPLICATION PRACTICES

The NMDOT consultant team initially identified and attempted to contact 22 state DOTs, universities and tollways to determine if solar power generation systems were actively being used within their ROW areas using a no-cost approach:

- Arizona
- California
- Connecticut
- Florida
- Georgia
- Maryland
- Massachusetts
- Virginia
- Michigan

- Minnesota
- New York
- Oregon
- Vermont
- Utah
- Nevada
- Maine
- Colorado
- Texas
- Colorado - Northwest Parkway Authority
- Colorado - E-470 Tollway Authority
- New York Thruway Authority
- Los Angeles County

The research team tried to contact neighboring state DOTs due to topographical and climate similarities such as Texas, Arizona, Colorado and Utah.

Solar Projects Contact and Interviews Questions

Based upon the initial state DOT outreach and research, the following seven (7) state DOTs and three (3) tollway authorities were short listed for more in-depth interviews. Based upon the initial interviews and outreach, the following eleven solar projects were identified for more detailed interviews and data collection efforts:

- Northwest Parkway Tollway Authority (Colorado)- NWP Solar Project
- E-470 Tollway Authority (Colorado)-E-470 Solar Project
- NYSDOT Region 5 Solar Project
- New York Thruway Authority Solar Project
- Utah DOT- Rampton Motorpool Project
- Oregon DOT- Baldock Safety Rest Area
- Oregon DOT- I-5/I-225 Solar Project
- Vermont DOT- Fairhaven Welcome Center
- Massachusetts DOT-Bundled ROW
- Florida DOT Turkey Lake Service Plaza
- Hawaii DOT-Hawaii Airport Solar Project

The consultant team developed survey questions and sent them to the state DOT and tollways before the interviews to obtain consistent information in a short amount of time. The interviews were scheduled for one hour which was dependent upon the interviewee's time availability and willingness to talk in detail. The following questions below were submitted to the DOT and tollway a week before the scheduled interview. Most project managers were receptive to discussing their projects, but nine (9) out of 11 did not provide requested financial documentation due to developer confidentiality or the data was not readily available or time constraints in acquiring the requested information. The DOTs that provided requested financial documentation were Vermont and Florida. The following list of questions were discussed with to the solar project managers and their staff:

- What is the project name?
- What type of agreement/partnerships was used?
- What is the name of the transportation entity?
- Can you provide a project overview?
- What type of solar system design or installation was used?
- What was the main project driver(s)?
- Were there any utility, state or other cost incentives?
- Who were the partners to the agreement?

- Who was the main utility partner?
- What party was responsible for infrastructure ownership, security, installation and long-term maintenance costs, liability for damage and vandalism?
- Did the party agreement specify responsibility for ownership and buyback?
- What were the anticipated costs and revenues prior to the construction as well as actual (post-implementation) costs and revenues?
- Did the project meet expected outcomes and/or reasons for failing to meet expected outcomes?
- What were the agency, local, state, federal legal/regulatory constraints and how were they addressed and overcome?
- What were the main lessons learned?

Appendix B contains solar projects lessons learned summary sheets for the above-mentioned projects and questions. This appendix is important to NMDOT representatives interested in solar applications, in understanding the approach, challenges and successes of DOT projects and how NMDOT can learn from them. This information is summarized in the following sections.

STATE DOT PROJECT PARTNERSHIP TYPES

Based upon conversations with DOT and tollway authorities, solar projects fall into three partnership agreements types: 1) PPA, 2) land or airspace/land lease agreement or 3) ESPCs by ESCOs. Each of these mechanisms have their own advantages and unique characteristics in order to achieve a no-cost solar project for NMDOT. All of these agreement types require close coordination with third-party solar developers, utilities and internal DOT resources (project management, procurement, ROW management, environmental and legal resources). The financial details of these agreements are provided in the cost feasibility section of this report. Appendix A contains examples of written agreements and Requests for Proposals that would be a good resource to NMDOT representatives.

Power Purchase Agreements (PPA)

A power purchase agreement is a partnership contract that commits a solar developer to finance, build and maintain the solar system for a given time duration. Generally, both parties enter into a long-term agreement (e.g., 15-25 years) with the DOT or tollway agreeing to purchase the electricity produced from the solar facility at a defined price that may or may not include an annual price escalator (e.g., 1-3%). The PPA transfers the obligation of upfront capital costs to the developer as well as the responsibility for operational and maintenance costs over the term of the agreement. More detailed information can be found in the feasibility section of this report.

Lease Agreement

For large scale solar projects where DOTs or tollways do not have onsite or nearby electricity load such as maintenance or administration facilities, an airspace/land lease agreement may be used. In this scenario, a DOT or tollway could coordinate with a third-party developer to host a larger scale project in the highway ROW or a surplus property. A DOT airspace/land lease agreement would require prior approval from FHWA. Federal rules require charging fair market value (FMV) and any resulting revenue must be used for transportation purposes. The only DOT lease agreement in the United States using an airspace/land lease agreement involved a Massachusetts project in the Town of Carver, MA.

Some DOT projects used a hybrid approach with a PPA with an airspace/land lease agreement. MassDOT has the most innovative hybrid program in the country and has developed bundled solar projects with airspace/land leases that are based in a PPA agreement; however, those projects also receive annual lease payments. It is important to note that the market and incentive conditions in Massachusetts have made solar projects more financially feasible for project developers and therefore there are multiple mechanisms to share some of those value streams. MassDOT projects have been able to take advantage of more amenable utility price structures and solar renewable energy credit (SRECs), which are similar to renewable energy certificates (RECs).

Energy Savings Performance Contracts (ESPCs)

ESPCs are made with private companies referred to as ESCOs. This type of agreement is associated with both building energy upgrades and energy efficiency improvements. ESPC projects may include lighting (indoor, outdoor, street lights), heating ventilation and air conditioning (HVAC), energy management systems, building envelope measures, and water conservation measures. This approach does not require capital investment by the DOT and the initial capital investment is financed by an ESCO or a third party. Projected cost savings, which are guaranteed as part of the contract with the ESCO at the forefront of the project, are used to pay for the upgrades that include solar energy generation. An ESCO makes money by bringing a package of projects that serve to reduce overall energy usage. The ESCO is paid through the energy savings which cover the initial capital needed for building upgrades.

One researched project from the Hawaii Department of Transportation (HDOT) used an ESPC agreement for solar development at the Honolulu Airport and other municipal airports. The agreement established by HDOT was the largest ESPC agreement in the United States and was very successful by having two project phases and installing a total of roof mounted 24,000 solar panels in multiple airports.

SOLICITING AND ACQUIRING PARTNERSHIPS

There are two main approaches to developing a partnership with a third-party entity. One is to identify and cultivate a partnership based on mutual benefit through direct negotiation. For instance, NMDOT can informally or formally connect with solar developers and utilities directly to determine the viability of partnering on a project. This approach does not preclude the requirement for developers to competitively bid for projects. Often, project partners will want to have site screening and selection completed in order to understand the potential opportunities for collaboration. The second option is to release a request for response (RFR), request for information (RFI), or request for proposal (RFP) to determine if there are interested third-party developers to bid on a solar project. For some agencies, such as MassDOT and New York State Department of Transportation (NYSDOT), the RFP process has been successful while other organizations such as Arizona Department of Transportation (AzDOT) released an RFI with no solar developer firms expressing interest. Oregon Department of Transportation (ODOT) directly partnered with a utility provider to bring a project to fruition. For projects that are developed with a third-party, the level of financial benefit to the state DOT or tollway is outlined using a PPA or airspace/land lease agreement, either in a fixed electricity price or lease payment. Appendix A provides some examples of RFP and RFI documents.

DOT AND TOLLWAY SOLAR PROJECT SUMMARY

Appendix B provides detailed information on the various type of DOT and tollway solar projects investigated in this study. Overall, there are 11 DOTs/tollway projects that have established solar energy systems within their ROW areas who were contacted by the research team. Nine out of the 11 projects researched were using a no-cost approach meaning that no DOT financial resources were used on the solar project for design, construction and maintenance. The interviewed DOTs and tollways were asked for specific types of financial information regarding pre- and post-cost construction savings or cost; however, limited information was obtained from these projects. Most of the DOT and tollway projects did not produce construction financial information, rather they left it to the developers; therefore, information was not readily available or the solar projects did not have the time to transmit the information. Primarily the DOTs and tollways relied on whether or not the price of power or the lease income was a "better deal" than what they had before. In addition, some DOTs such as NYSDOT, had the primary objective of reducing carbon emissions to mitigate climate change impacts and were unconcerned with financial benefit.

The main focus of the DOT and tollway best practices was upon projects and not solar programs. Some of the projects contained one specific project at one location while some projects bundled several solar areas into one project due to developer cost efficiency. The financial costs and returns from these bundled-multi area projects are difficult for direct project comparisons; however, the information provided shows that 10 of 11 solar projects have been successful in meeting their solar project objectives.

The following is a summary of the information collected from the state DOT and tollway solar project managers during interviews. This information will be helpful to NMDOT representatives when conceptualizing a solar project.

Solar PV System Types

Ground mounted solar installations in ROWs dominated the type of installed solar energy system in this study (9 out of 11 solar projects). NYSDOT, the Northwest Parkway and E-470 used a combination of ground mounted and roof installations to power administration and maintenance operations. Eight ground mounted systems used PPA agreements with close coordination with solar developers. The ground-mounted systems were placed within the ROW of interchanges, along the roadway alignment and placed outside the clear zone for driver safety. Rest areas and service plazas are common solar energy locations and accounted for three out of 11 projects researched in this study. These ground mounted array systems were 4 acres or greater in order to generate more energy than roof top systems.

The Hawaii project was included in this research study to show how solar panels could be mixed within a successful ESPC agreement structure. Hawaii DOT used a combination of ground mounted PV systems along with roof top systems, that in combination generated over 8 MW of power.

Overall, ground mounted systems provide a great opportunity to achieve cost reduction while mitigating climate change for several projects. Ground mounted systems along highway alignments and rest areas provide a visual impression upon the traveling public that promotes

innovation, education and improves overall public relations. Six of the 11 projects mentioned the importance of informing and educating the general public.

Project Drivers

Incentives or drivers to initiate solar programs and projects fell into two categories, greenhouse gas reduction to mitigate climate change and energy cost reduction. Seven of the 11 projects researched in this study were motivated to reduce greenhouse gas emissions to mitigate climate change. Most of the solar projects in the northeast portion of the United States were driven by state legislatures and/or governor directives to reduce carbon emissions. Portions of the country such as Colorado, Oregon and Hawaii developed solar projects as part of existing internal sustainability programs. These sustainability programs were also concerned about carbon emission reductions as part of a climate change mitigation. Eight states have aggressive carbon reduction programs that help drive solar projects, such as Hawaii with a goal of 70% renewable energy statewide by 2030 and 100% by 2045. New York has passed legislation for a 40% reduction in greenhouse gases by 2030. The following is a list of contacted DOT and tollway authorities that were driven by greenhouse gas reductions and climate change mitigation and internal sustainability programs:

- Northwest Parkway Tollway Authority (Colorado) NWP Solar Project
- E-470 Tollway Authority (Colorado) E-470 Solar Project
- NYSDOT Region 5 Solar Project
- New York Thruway Authority Solar Project
- Oregon DOT Baldock Safety Rest Area
- Oregon DOT I-5/I-225 Solar Project
- Massachusetts DOT Bundled ROW Phase 1
- Hawaii DOT Airport Solar Project

Three projects such as Vermont Transportation (VTrans) Fair Haven Welcome Center, E-470 Solar Project and Florida Enterprise Turkey Lake Welcome Center were driven by reducing energy costs. UDOT's Rampton Motorpool Project was uniquely driven by the Utah Governor by using the state's extensive solar and land resources in the most efficient way possible.

Cost Incentives

Eight out of 11 projects took advantage of cost incentives by either state or utility rebates. State tax incentives were provided to ODOT and MassDOT to help fund the solar projects. Utility rebates were provided to the two Colorado Tollway Authorities. Three projects received tax rebates from utilities. For example, Colorado, New York and Hawaii have a specific percentage goal for solar energy generation within their states and rebates were provided to reduce overall project costs. Utility companies took advantage of tax rebates offered by both the federal and state governments. It is important to select solar developers who fully understand cost incentives and have working relationships with utilities and financial institutions. Two utilities such as Duke Energy and Rocky Mountain Energy provide direct grants to promote solar energy projects.

State and federal tax rebates have not been used by solar projects in the past few years due to lack of financial resources and political priorities. It is possible that as there is more of a national

and state interest in addressing climate change mitigation more energy rebates and tax incentive may become available.

Agreement Investors

The most common agreement investors found in this study are solar developers and their design and construction subcontractors (eight out of 11 projects). Oregon DOT solar projects were unique in which they had a financial institution involved as an active partner in the PPA agreements. For the HDOT Honolulu Airport Solar Project, the main partner for this ESPC project was not a solar developer but rather the ESCO (Johnson Controls, Inc.). Florida Enterprise and Utah DOT did not use developers as major partners.

For no-cost projects it is important that developing a close working relationship with developers is critical to the success of a solar project. Developers have well established relationships with utilities, financial institutions, subcontractors that make the no-cost option viable.

Utility Partners

The utility partner is the local provider of electrical energy for the solar project operation. It is common to have numerous potential utility partners within a given DOT district or region. Utility providers may have their own solar incentive programs and usually develop contractual agreements with developers regarding acceptance of solar generated electricity into their grid system. All 11 solar projects interfaced and partnered with local utilities for either funding, energy costs or power interconnection purposes. Most of these utility discussions were initiated and facilitated by solar energy developers.

Coordinating with utilities can be complex and detailed. There are numerous issues that need to be addressed by the project and developer in regard to energy cost agreements, interconnection locations and fees, and escalation rates. It is important that an interested transportation entity leverage on other state agencies or developers to work with and negotiate with utilities.

Party Responsibility for Infrastructure Ownership, Security, Installation and Long-Term Maintenance Costs, Liability for Damage and Vandalism

The ten interviewees in this study who used a no-cost type agreement had contractual language about these important long-term items. The solar developer has the main responsibility for these long-term obligations for the duration of the contract; therefore, the solar project had no capital or maintenance cost obligations. Although developers were responsible for long term maintenance, some tollways provided mowing operations and erosion control within the security chain link fence area containing the solar system. Two projects that did not use a no-cost approach took on the risk and costs for long term maintenance and damage/vandalism issues. The VTrans Fair Haven Welcome Center and Utah Rampton Motorpool Projects were the two projects that used internal resources for PV system purchase and maintenance. The Florida DOT hired a contractor to perform solar system maintenance at the Turkey Lake Service Plaza.

It is advantageous for no-cost solar projects to reduce their liability and risks by leveraging upon the solar developers. Most researched projects found it important that system ownership, security, installation and long-term costs for maintenance and damage be specified contractually. This approach relieved the DOT and tollway project manager and staff from the burden of managing contractors and maintaining solar equipment. Appendix A contains example

agreement language about ownership, maintenance, and risk issues. The following are examples of potential agreement language:

"Providers will be required to safely and properly maintain the solar arrays installed in the right-of-way throughout the duration of the contract. Providers must also perform certain ground maintenance duties at the installation site (e.g., snow removal, waste disposal, tree trimming, mowing, and vegetation control). Therefore, Providers will need to obtain Annual Work Permits issued by NYSDOT/NYSTA. Access to the solar arrays to safely conduct maintenance activities will be dependent on-site conditions and shall be subject to certain terms stipulated in the Annual Work Permit. If a Provider has multiple sites, NYSDOT/NYSTA may elect to consolidate such multiple sites into one Annual Work Permit." (NYSDOT).

"Licensee shall cause the System to be operated and maintained at Licensee's sole cost and expense, including the cost of capital repairs and replacements, throughout the term of this License (collectively, the 'O&M Work'), including, without limitation, monitoring and maintenance of metering equipment, determining the quantity of electricity produced by the System, in a manner reasonably satisfactory to Licensor; (b) Licensee shall, at Licensee's sole cost and expense, maintain and repair the Licensed Area and shall also be responsible for maintenance and repairs to the Adjacent Licensor Property or other property to the extent such maintenance and repairs are necessary as a result of Licensee's Permitted Use; and (c) Licensee shall maintain the Licensed Area and the security fencing surrounding the Licensed Area in a commercially reasonable manner at Licensee's sole cost and expense…licensee shall take all necessary and reasonable safety precautions with respect to performing the Installation Work and the O&M Work, including compliance with all applicable laws and requirements pertaining to highway safety or the safety of persons and real and personal property. Licensee shall promptly report to Licensor upon discovery by Licensee any death, loss time injury, or property damage to Licensor's property that occurs on the Licensed Area or the Adjacent Licensor Property, or as part of the Licensee's operation of the System." (MassDOT).

Agreements Specify Responsibility for Ownership and Buyback

Four PPA and one ESPC agreement projects specified solar system ownership and the ability for the transportation entity to purchase solar equipment within their contractual agreements. The time the system would be able to be purchased ranged from 180-day notice (New York Thruway); after 6 years of operation (Northwest Parkway and E470 Tollway) and 20-25 years for the other four projects. No interviewed project representative has acted upon the buyback option to date.

In agreements it is important that the following items are specified:

- Duration of operation before taking over system ownership and buyback
- Cash purchase price and closing costs
- Prior written notice and closing date to exercise option
- Purchaser assumes all terms and conditions of all agreements made with the utility and other parties

Many types of solar systems are still substantially productive in generating electricity after 20 years and worth operating internally. If the project is not interested in maintaining a 20-year-old

system from the developer, the solar panels and equipment are usually decommissioned by the developer.

Copies of Agreements

The research team was able to find links to agreements for three projects; MassDOT, ODOT and VTrans. Links to these project agreements are located in Appendix A. Many of these agreements include system specifications and requirements, land management, electrical requirements, system design, electrical generation modeling and regulatory requirements. The research team was unable to procure copies of formal agreements from the following projects:

- Northwest Parkway-Colorado (Tollway) - developer confidentiality
- E-470 Tollway Solar Program (Tollway) - lack of response to information request
- Hawaii DOT-Hawaii Airport Solar Project - agreement extensive with an airport emphasis
- Utah DOT- Rampton Motorpool Project- future PPA not yet created
- NYSDOT Region 5- directed to PPA agreement in the RFP
- New York Thruway- directed to PPA agreement in the RFP
- Florida DOT- Turkey Lake Rest Area

Agreements for the above projects were difficult to obtain due to developer confidentiality or unwillingness to distribute the information to the research team after repeated attempts.

Anticipated and Actual Costs and Revenues (Pre- and Post-Implementation)

It was interesting that eight of the interviewed solar projects did not perform their own or independent in-depth financial analysis in preparation to develop the solar project. These financial forecasts were provided in developer responses to RFPs as part of the selection process. What this implies is that the project may have gotten a good deal but may have had the information necessary to negotiate for a better deal.

Two projects from VTrans and FDOT performed cost forecasting on spreadsheets. These projects were not no-cost projects and performance risk and liability were taken on by these DOTs. Two Colorado tollway projects performed rough internal cost spreadsheet estimates but relied heavily upon developer forecasting data.

VTrans owner-operator project including a 20kW project at a DOT garage that is estimated to have saved the agency $3,500 in the first year of operation and will save VTrans over $130,000 over a 30-year lifespan. Additionally, a 60kW project at Rutland Airport is estimated to save VTrans over $11,000 in its first year and almost $400,000 over a 30-year life. The aforementioned projects have a payback of 13 years and 10 years, respectively. The 20-year and 30-year net present value (NPV) for the garage and airport projects are -$6,000 and $4,000 using a 5% discount rate. For the Rutland airport the NPV is $9,000 and $41,000.

MassDOT projected that the electricity rate negotiated in a PPA will generate at least $15 million in savings/revenue (aggregated cash flow) over the contract period of 20 years (10, 11). Projects that used DOT funds for development, principally used simplified models to calculate payback period.

Project Met Expected Outcomes and/or Reasons for Failing to Meet Expected Outcomes
Based upon project representative interviews, all ten of 11 projects felt that they met the expected outcomes by either reducing carbon emissions or saving energy costs. All nine no-cost projects researched were successfully developed without expending money for design, construction and maintenance. Seven projects felt they reduced their carbon emissions according to legislative mandates but did not yet have success metrics in place to quantify emission reductions. These seven projects were driven by legislative mandates and were not driven by financial returns.

Other interviewees saved a significant amount of financial resources depending upon the size and scale of the project from $5,000 annual cost savings for Colorado's Northwest Parkway to $25 million savings per year for Hawaii's bundled Solar Airport Project. Hawaii's project is covered under an ESPC agreement and therefore the $25 million in annual savings is attributed to all project upgrades, of which solar energy savings is 7-10% of that figure ($1.75-$2.5 million).

The Florida Turnpike project was the only interviewed project that did not meet financial expectations based upon a FDOT case study. Appendix B provides more specific details on the Turkey Lake Rest Area financial analysis.

Three solar projects from Oregon and Colorado felt the solar systems provided a great public relations tool illustrating sustainability, renewable energy technology and innovation.

It was observed that many projects did not have performance metrics to identify project success, especially those that were driven by carbon emission reductions.

Agency, Local, State, Federal Legal/Regulatory Constraints
Federal, state and local agencies regulations did not pose significant problems to five out of 11 researched solar projects. To address potential regulatory problems some state DOT and tollways took a proactive approach early in the project by coordinating with local, state and federal agencies. For highway ROW projects, six state DOTs engaged and prioritized communication with the FHWA district office. Particular emphasis was directed to NEPA regulations and utility accommodation. Navigating federal policies in particular are addressed in greater detail in the Narrative Guide in Appendix C.

State and local policies are more straightforward but require early engagement with stakeholders. For the Northwest Parkway Tollway (Colorado), a local municipality was initially concerned about aesthetic impacts from the solar array panels. The project manager worked closely and early with the concerned municipality to alleviate potential concerns and the project was not impacted. Both FHWA's New York and Vermont district offices were initially skeptical of installing solar systems within the right of way and required significant staff time and back and forth to find a common solution towards project implementation.

NYSDOT representatives for the Region 5 and New York Thruway projects worked closely with FHWA officials. Access issues that could impact safety were the main concern by FHWA and led to the elimination of several potential solar system sites. New York FHWA representatives expected to see specific site locations with preliminary environmental clearances in place at the

time of the initial discussion. During negotiations, NYSDOT explained to FHWA how state regulations were developed for energy conservation and generation. NYSDOT communicated that the generation of solar energy helped offset DOT operational costs.

Compliance with the National Environmental Policy Act (NEPA) was a challenge to the ODOT for both solar projects (Baldock Rest Area and I-5/I-225 Interchange). There was initial concern by the local public about aesthetics and glint and glare impacts. These potential impacts were successfully addressed by ODOT, but it did not completely alleviate the "not in my back yard" (NIMBY) mentality. Categorical exclusions were the most commonly used NEPA mechanism by all seven DOTs to address potential environmental impacts. Even though private money could be used for solar development, if the facility would be located on federal ROW, a NEPA assessment is required. If the non-federally funded project is located on a state ROW, the individual state DOT NEPA process would be applicable.

There are several FHWA regulatory requirements associated with the installation of solar systems within the interstate highway system. These are detailed in the Narrative Guide in Appendix C.

SOLAR PROJECTS LESSONS LEARNED

One of the most informative parts of the solar project interviews was discussing the lessons learned on what went right and wrong. There were many common critical issues that need to be avoided or considered in the decision-making process. It is important that NMDOT representatives interested in developing a solar project or program be aware of these lessons that will save monetary resources, project management and development time.

Siting and Interconnection

Two state DOTs, Massachusetts and Oregon, experienced unforeseen challenges of interconnection of a solar PV installation to either a substation or three-phase power requirements. Part of the challenge was ensuring that there is enough transmission line capacity to accommodate the solar project coming online. Site screening and selection proved an important step for state DOTs. Massachusetts mentioned that earlier in their program they spent more time and money on expensive studies for potential sites with no energy load and low population nearby that resulted in the systems not being built. Further description of site selection screening criteria is included in the Narrative Guide (Appendix C).

Mandate, Management Support and Project Champion

State DOTs and tollway project managers mentioned the importance of having a strong project purpose and goal with management support. Four out of 11 projects stressed the importance of having a project champion, preferably at an upper level management position. Projects that had the direction from a program champion were successful and efficient in project development and implementation. Three successful northeastern DOTs solar projects were driven by state mandates via governors or legislatures that are associated with greenhouse gas emission reductions and climate change mitigation. This type of support made it easy to get the buy off and support needed from numerous DOT departments to initiate the project within the ROW.

Level of Effort, State DOT Knowledge, Time and Other Hidden Costs
Seven projects mentioned that the level of time and internal resources needed to conceptualize and implement a solar project was underestimated. The project manager and staff need to consider the project as multi-disciplinary and coordinate with a wide variety of internal departments and staff. At a minimum, internal NMDOT project managers need to consider the time needed for procurement coordination, RFP development, contractor selection and contract development, site selection and NEPA clearances and construction coordination including traffic controls. Three solar projects mentioned the amount of time needed to initiate and implement a project was underestimated. The lack of project time coupled with a lack of resources might not allow a project to get off the ground. Four projects identified the unexpected time needed to address the NEPA requirements.

Three projects indicated that for a successful solar project, internal DOT technical resource coordination is required by multiple internal departments and agencies. NYSDOT recognized early in the project that basic staff knowledge was not enough to work with a complex project with numerous participants. Initial discussions with the Georgia DOT brought out the importance of including contract procurement staff early in the process given the solar energy contracting pathway will not be a familiar to the contracting process.

Shared Property Ownership
Arizona has a number of properties that are shared by a state land easement; therefore, there is a significant challenge to granting third-party access into those areas given "gift clause" laws. Gift clause laws forbid subsidies to private entities on public lands. Projects are possible but require separate agreements for fair market value for that land. An interview with one of the ESCOs indicated that NMDOT needs to be aware of this part of the process but it should not pose an insurmountable challenge in solar development. In the event that the site or sites that NMDOT is developing solar projects are located on another public agency's property, a shared property easement would need to be developed that ensures the use of solar in that location.

Utility Legal Structures and Interest
In Connecticut, Florida, Massachusetts and Vermont site location and different utility legal and policy requirements proved to be a challenge. Project developer partners or the state DOT found significant differences between investor-owned and municipal or cooperatives utilities, particularly in the utility rate structures and their direct effect on project financial viability. Some utilities are more amenable to solar projects and this is reflected in their utility rate structures and the ease with which a solar project can be implemented in a utility territory. This is a relevant concern in New Mexico and the following Feasibility Study section outlines the different rate structures for both investor-owned and cooperatives utilities and their direct influence on project viability.

Smaller Facility Siting and ESCOs
MassDOT has a number of small facilities scattered around the state and found it hard to roll-up or bundle those smaller facilities into one ESCO project. As a result, they have decided to focus on larger solar projects and utilizing ROW or surplus property to develop these types of projects. This lesson learned needs to be considered by NMDOT with a lot small and scattered facilities.

No Guarantee RFP, RFQ or RFI will Generate Third Party Interest or Responses
To gauge solar generation interest, Arizona put out an RFI for solar development with the highway ROW in 2015, but it did not generate interest from developers. One of the challenges to putting out a simple RFI is that it requires developers to do significant site due diligence, which might take a considerable amount of time, effort and overhead expense, with or without a positive outcome. In contrast, MassDOT identified sites in the RFP that met necessary site clearance conditions by developers and resulted in significant project interest (e.g., access to three-phase power, outside the clear zone). Examples of an RFP and an RFI are provided in Appendix A.

Leveraging State Agency Assistance
For some state DOTs, other state agencies provided substantial assistance for solar PV projects. The project should exploit the expertise of other state agencies who are experienced working with complex utilities and solar installations. General service departments or energy offices often provide expertise in developing solar projects. For New Mexico, the Energy, Minerals, and Natural Resources Department (EMNRD), the General Services Department, and the Public Regulation Commission are potential resources. Working with utilities and developers can be complex depending on the scale of the project and level of due diligence to ascertain financial feasibility for both entities. This expertise will help identify potential unknown costs and technical issues that may increase the project timeline or internal resource needs. More information on those roles and process are included in the Narrative Guide in Appendix C.

NEPA and Adjacent Communities and Municipalities
As previously mentioned, Oregon's DOT had to undergo a significant public review and comment process to ensure neighboring residents that it had done its due diligence with respect to solar glare, viewshed aesthetics, tree removals and fears of unfounded health and safety concerns such as toxicity and electromagnetic fields exposure. The lesson for a state DOT engaging a project is to identify potential concerns before they arise.

Safety
Work closely with safety engineers and representatives about the placement of solar systems in the ROW. Maintaining a clear zone and protecting the public safety is FHWA's primary concern. Safety representatives need to be educated not only on the solar system placement but on construction materials and glare/glint issues. In addition, maintenance representatives need to be educated and made aware of solar system placement and potential maintenance and access risks.

FEASIBILITY STUDY

PURPOSE AND APPROACH

The research team conducted six district-specific feasibility studies for NMDOT implementation of the no-cost solar energy projects on NMDOT ROW. This section details the following elements that would be important to a NMDOT District employee interested in initiating a solar project:

- Identify cost mitigating partnerships, incentive programs, airspace/land lease agreements and other means of implementing a no-cost approach for six NMDOT Districts.
- Provide examples of at least two agreement alternatives for each NMDOT District without specific site conditions.
- Each agreement alternative will provide agreement type, party responsibility, liability, damage and vandalism and preferred type of PV technology.
- Identification of applicable legal and regulatory constraints and FHWA policy considerations for the no-cost approach.
- A ranking of no-cost approaches for each District based upon savings, revenues and ease of implementation.

This section contains a summary and reference to a Narrative Guide (Appendix C) that contains the steps needed to implement at least one no-cost alternative presented in this section. NMDOT resources are identified for administration, staff, legal expertise and other resources needed to initiate a no-cost solar project.

This feasibility chapter has five main sections:

1) **Project Partnership Types, Policies, and Incentives:** This section provides an overview of relevant types of partnerships (e.g., third-party PPA, airspace/land lease, ESCO) that fit the New Mexico no-cost context. First, the research team conducted interviews and reviewed utilities' solar policies and programs to determine, electrical utility service districts assistance programs, interest, legal pathways for contracting solar or financing to support the development of solar projects in their territories. Second, the research team conducted interviews with Energy, Minerals and Natural Resources Department (EMNRD) to get more information on ESCOs and solar PV developers and operators to determine what kinds of proprietary financing and delivery models they offer that may be different from in-state competitors. Finally, the research team compiled relevant state and federal policies and incentives that a third-party developer would utilize to develop a solar project.
2) **Potential Partners:** This section identifies which types of partners exist for no-cost solar projects and name specific potential solar development partners in New Mexico and why they could be a good fit for NMDOT. These potential partners include:
   - Solar developers
   - Utilities
   - Rural cooperatives
   - Energy Service Companies
3) **Common Internal NMDOT Challenges and Opportunities:** The list of common challenges and opportunities emerged from interviews the research team conducted with NMDOT staff. The conversations covered the extent and details of potential site or cost

challenges as they relate to each of the NMDOT District's project feasibility analysis. Challenges and opportunities for each District are included financial feasibility section.

4) **Financial Feasibility Analysis:** With the information from the PPA and airspace/land lease business models, the research team evaluated each NM DOT District using both Energy Toolbase and NREL's SAM financial modeling tool. Given that the ESPC pathway is connected to several types of potential building-level upgrades, a comparable baseline is not possible; therefore, the research team shares examples of ESPCs but did not include them in the more detailed financial analysis. The financial tools distinguish and compares different PV array sizes (e.g., 10kW, 75 kW, 200kW, 1 MW, 5 MW) based on PPA pricing differences (single project vs. bundled projects). The research team modeled different scenarios to test and evaluate which projects satisfy the no-cost approach and generate the greatest savings compared to existing electricity prices or other revenue that could be derived from leasing the property.
5) **District Summary, Comparison Table and Priority Districts:** Following the financial model runs, the research team provides the results in a prioritized section by NMDOT District that show where the best value is possible in each district based upon savings, revenues, and ease of implementation.

PROJECT PARTNERSHIPS

NMDOT ownership and third-party ownership are the two main pathways to develop solar PV projects. Given the goal of this research to identify no-cost options, the research team focused this section on third-party partnerships that eliminate the upfront capital and operating expenses for NMDOT. The three main models for third-party partnership are PPAs, airspace/land lease agreements, and Energy Savings Performance Contracts with ESCOs.

The type of agreement or business model will be dictated by the size of the solar PV project and whether it is a facility-level (rooftop) project versus a larger scale project that occupies larger tracts of land (ground mounted systems). For facility-level projects that are offsetting NMDOT electricity use, PPAs and ESPCs are the most common approach. An airspace/land lease agreement with a solar developer or utility will be the most appropriate vehicle for project development for larger projects (greater than one MW in capacity) located in the highway ROW or at large surplus properties, and that do not offset NMDOT electricity use. Solar developers are more interested in larger-scale projects than smaller facility-scale projects due to their profitability potential. Contacted developers expressed interest in meeting NMDOTs needs and the potential of developing a portfolio of projects in order to meet a variety of site and organizational interests for the NMDOT, while maintaining profitability.

Third-party Ownership Business Models

A third-party ownership solar project would be owned by the project solar developer. This approach would provide NMDOT either cost savings or a revenue stream coming from either a reduced electricity price or from an airspace/land lease payment. A third-party developer may serve a number of necessary project roles or be the intermediary to bring those project elements together. Project financing, engineering procurement and construction (EPC), and owner/operator are each specific project roles or a combination of tasks that a developer may contract from NMDOT.

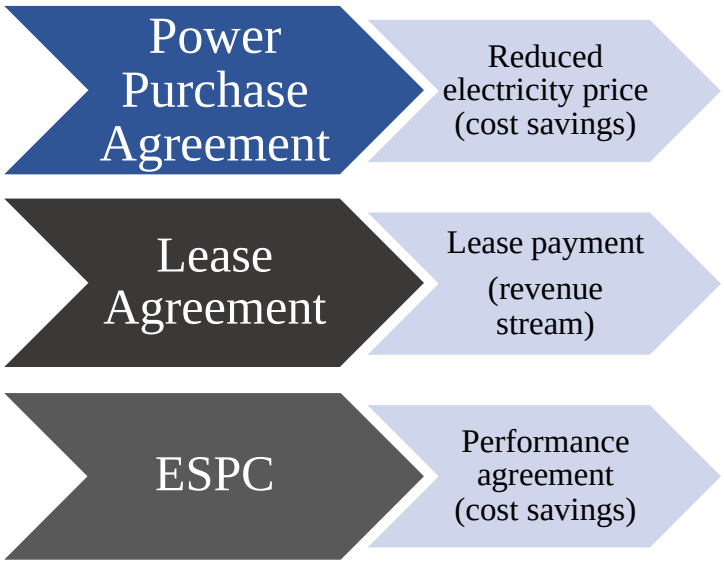

FIGURE 4 Third-Party Solar Partnership Types

An overview of three main approaches for no-cost solar along with the challenges and advantages is provided in Figure 4 and Table 2 compares the three partnership approaches:

- Power Purchase Agreement
- Lease Agreement
- Energy Savings Performance Contract (ESPC)

In Massachusetts, MassDOT entered into an agreement with Ameresco that is a hybrid of a PPA and an airspace/land lease agreement which provides income streams both in electricity savings via PPA and airspace/land lease payments. MassDOT's project has a large onsite electric load (demand) and project scale that made this approach work. However, this model is not as likely in the New Mexico context given that property values are not as high and the incentive structures in Massachusetts offer solar project developers significantly more financial benefit that they are able to share with project partners.

Power Purchase Agreement

A PPA is the most common vehicle for developing a third-party agreement for state DOTs. A PPA would commit a solar developer to finance and build the system on NMDOT property. Both parties enter into a long-term agreement (e.g., 15-25 years) and NMDOT would agree to purchase the electricity produced from the solar facility at a defined price that may or may not include an annual price escalator (e.g., 1-3%). The PPA transfers the obligation of upfront capital costs to the developer as well as the responsibility for operational and maintenance costs over the life of the agreement. The contract allows the developer a steady stream of income as well as financial incentives that are not available to public agencies, such as the federal ITC, which may make the project feasible and mutually beneficial for the developer and NMDOT. The viability of a PPA is highly specific to utility district and rate schedule, proximity to electricity load (i.e., demand for electricity), and the PPA price that the PV developer offers NMDOT.

A PPA contract would allow the solar developer to receive a steady stream of income from NMDOT while at the same time providing a reliable method of cost reduction to NMDOT. In

addition, the developer is able to obtain financial incentives that are not available to public agencies, such as the federal Investment Tax Credit (ITC) which would make the project feasible and mutually beneficial for the developer and NMDOT.

The PPA was identified as the most common agreement type used by DOTs and tollways to develop solar projects using a no-cost approach. Of the 11 contacted transportation projects, eight used a PPA to initiate and implement no-cost solar projects. This mechanism allowed DOTs a reliable cost reduction savings over a 15-20 year time period compared to their previous utility rates. All of the upfront costs and long-term maintenance was performed by the developer. The developer also negotiated with the local utility on connection fees, electrical rates and long-term cost escalation.

TABLE 2 Model Comparison of Three Partnership Approaches.

Model	Opportunities and Advantages	Challenges and Disadvantages
PPA	• Reduces NMDOT financial risk by not requiring NMDOT to provide initial capital for project investment. • NMDOT can predict some level of energy savings over the life of the project and negotiate whether the electricity cost remains flat or escalates on an annual basis. • Designates primary project management responsibilities to developer. • Transfers O&M responsibilities to developer. • Allows public agency to leverage benefit from tax credits via private 3rd party partner.	• NMDOT has limited financial reward given that third party assumes most project risk. • Challenging economics for smaller projects and higher transaction costs. • Reliant upon third party to bring project to completion. • Some level of uncertainty during negotiations that NMDOT is getting the best deal it could. • Relatively small public relations benefit due to lack of visibility and the fact that array is of conventional type tied to building facilities.
Lease Agreement	• Reduces NMDOT financial risk by not requiring NMDOT to provide initial capital for project investment. • Allows for passive income on property that might not be utilized otherwise. • Designates primary project management responsibilities to developer. • Transfers O&M responsbiilities to developer. • Allows public agency to leverage benefit from tax credits via private 3rd party partner. • High public visibility and perception of innovative green technology for larger scale solar projects.	• NMDOT has limited financial reward given that third party assumes most project risk. • Reliant upon third party to bring project to completion. • Some level of uncertainty during negotiations that NMDOT is getting the best deal.
ESPC	• Reduces NMDOT financial risk by not requiring NMDOT to provide initial capital for project investment. • Work is guaranteed by the ESCO, no change orders. • Guaranteed energy and cost savings, and if those conditions are not met the ESCO has the responsibility to pay in the event of a energy savings shortfall. • Guaranteed payback time period and annual savings are verified by the International Performance Measurement & Verification Protocol (IPMVP). • O&M responsibilities can be part of ESPC. • Provides the opportunity for a path to ownership after agreed upon timeframe of the contract.	• Requires internal NMDOT education and coordination internally to understand the opportunities that ESPC can provide as a limited risk financing pathway. • Generally requires $1 million or more in project upgrades requiring larger or multiple facilities to be completed at once. • ESPCs are best suited for buildings that will not be changing substantially in occupancy, operating schedule, or major equipment within ten years. • Relatively small public relations benefit due to lack of visibility and the fact that array is of conventional type tied to building facilities.

- **Applicability to NMDOT:** NMDOT does not use a large amount of electricity at individual facilities but instead is comprised of a large number of facilities statewide, with a low electricity demand at each site. Unlike other state DOTs, which incur significant costs from roadway lighting, NMDOT does not pay these costs but instead lighting costs are paid by local jurisdictions (local governments, counties, tribal organizations, or utilities). NMDOT does not have a significant amount of electricity demand and therefore can only participate in a PPA up to the NMDOT facility energy use onsite or adjacent areas. Larger projects necessitate that the third-party developer identifies and arranges an off-take agreement for a PPA in which another organization/entity that can use that solar produced electricity. This off-take would be covered under a land leasing arrangement with a solar developer that either finds an off-taker for the electricity via the utility or a large energy user. Potential areas for increased load in the future may be the conversion to electric vehicles for NMDOT's fleet or the utilization of energy from the New Mexico Rail Runner Express. Serving these types of loads onsite would allow for siting a larger solar PV system which will make financial feasibility and cost savings more reliable.
- **Roles of Third-Party Developer and NMDOT:**
    - *Third party developer:* the developer is the entity in charge of bringing the solar development project to fruition and will likely perform all of the necessary functions including financing, engineering, procurement, construction, and maintenance. The detailed steps and components of these activities are described in further detail in the Narrative Guide (Appendix C).
    - *NMDOT:* The state agency enters into an agreement to use the electricity produced from solar PV system in direct proximity to the solar array. NMDOT may need to undertake other project responsibilities depending on the scope, scale, and nature of the agreement. These include legal, procurement, planning, environmental permitting, traffic control and utility interconnection.
- **Resources:** Two good resources for evaluating PPAs and other ownership models include:
    - *Solar Power Purchase Agreements: A Toolkit for Local Governments*, Interstate Renewable Energy Council (IREC) (11)
    - *Third-Party Solar Model RFP for Local Governments and Schools, Clean Energy Resource Teams* (13)

Air/Land Lease Agreement

For larger scale projects where NMDOT does not have onsite or nearby electricity load requirements, an air/land lease agreement with a project developer is most appropriate. In this scenario, NMDOT would coordinate with a third-party to develop a larger scale project in the highway ROW or a surplus property to sell the power to another party other than NMDOT.

State DOTs have experience using this pathway for air/land leases, whereby a third party is granted access to use the land or airspace on DOT property, for a fair market value. 23 CFR §710.405 (b) allows state DOTs to grant rights for permanent or temporary occupancy or use of the interstate system airspace for non-highway purposes as long as such airspace is not required presently or in the foreseeable future for the safe and proper operation and maintenance of the ROW. This approach does require prior approval from FHWA if the site utilizes the highway ROW. Federal rules require charging fair market value and any revenue must be used for transportation purposes which would be very different depending on where the location was sited

in an urban vs a remote part of New Mexico. When utilizing an airspace/land lease to site a solar energy facility, it is advised that the state transportation agency consult with the state-level FHWA division office at the earliest opportunity as the specific terms and conditions of the lease will influence project agreements and strategies.

- **Applicability to NMDOT**: A airspace/land lease agreement is the most reasonable business model for larger scale solar PV projects (>500kW) that do not cover NMDOT's onsite or nearby electricity load. New Mexico has a considerable amount of land resource in comparison to other states which does reduce the market rate for leases. Solar developers provided a range of potential airspace/land lease prices between $250-$750 per acre per year based on a variety of factors including proximity to urban areas, load, and interconnection to the grid or three-phase power. One interviewed solar developer mentioned that projects that have lease values of $250 per acre per year are not as likely to go forward given the limited financial benefit to the land owner. Per conversations with FHWA, airspace/land leases in other states have been valued from between $100 to $400 per acre per year. It is important in the site selection process to identify project sites based on their location in certain utility districts that may generate better financial feasibility and merit future project development. Note that FHWA may ask NMDOT to demonstrate that there is not a higher market rate for another use. This can prove challenging in that other sites may carry a higher airspace/land lease value because of their specific location, whereas the potential solar site may not have the same opportunity for a higher value lease. While receiving fair market value for an airspace/land lease is a good way to capture value, an airspace/land lease is not required per FHWA's guidance: "The regulations do provide an exception to charging airspace market rent if the state DOT shows, and the FHWA approves, that such an exception is in the overall public interest for social, environmental, or economic purposes. This exception may be appropriate for activities that positively address climate change, contribute to improvements in air quality, and similar environmental initiatives." (14)
- **Roles of Third-party Developer and NMDOT:**
    - Third party: A third-party developer would fulfill similar actions as a third party would for a PPA. This entity may play all of the roles depending on the scope and scale of the solar project including financing, engineering, procurement, construction, and maintenance. The third-party developer could also be responsible for all elements of ownership, design, installation, long term maintenance costs, liability for damage and vandalism and placement of optimum solar technology if stipulated in the agreement. The detailed steps and components of these activities are described in further detail in the Narrative Guide (Appendix C).
    - NMDOT: Communicate and coordinate with FHWA regional staff to ensure that the site meets the conditions for an airspace/land lease. Airspace/land lease agreements must reflect planning, environmental, design, construction, maintenance, financial, legal, insurance, safety and security requirements as well as ensuring that the site will not be required for future needs (e.g., lane expansion, permanent structure expansion). NMDOT may need to assist the developer in defining and completing these project elements.
- **Resources:**
    - Federal Highway Administration: 23 CFR §710.405(b) (15)

Energy Savings Performance Contracts (ESPCs)
For facility-level projects, NMDOT can coordinate with an ESCO to develop solar energy in addition to building upgrades and energy use improvements. It is worth noting that select ESCOs also have experience completing larger scale projects under a PPA or airspace/land lease agreement as was the case for the majority of the MassDOT solar projects being completed by Ameresco.

ESPCs are a no-upfront-cost approach to implementing building improvements which increase operational function and efficiency and reduce energy and water costs. ESPC projects may include non-photovoltaic energy conservation measures such as lighting (indoor, outdoor, street lights), HVAC, energy management systems, building envelope measures, and water conservation measures. This approach does not require capital investment by the public agency. Instead the initial investment is financed by an ESCO or a third party that the ESCO identifies. Projected cost savings are guaranteed as part of the contract with the ESCO at the front of the project, so it limits the amount of risk that NMDOT would incur. The ESCO is paid back via the NMDOT utility bill savings. Figure 5 below from the U.S. Department of Energy (USDOE) overviews how building operating costs are allocated before, during and after an ESPC (16). It is important to note that a public agency does not pay any more than it currently does for its operating costs while repaying the improvements. Depending on the combination of project upgrades and anticipated savings, the ESCO will identify different scenarios that the agency can select. For instance, solar does not offer the project payback or return that LED lighting upgrades can provide; therefore, solar or other projects that have longer paybacks could be added to the portfolio, but cost savings may not be as great in the short term. Solar projects will provide "free energy" after the ESPC's term is over.

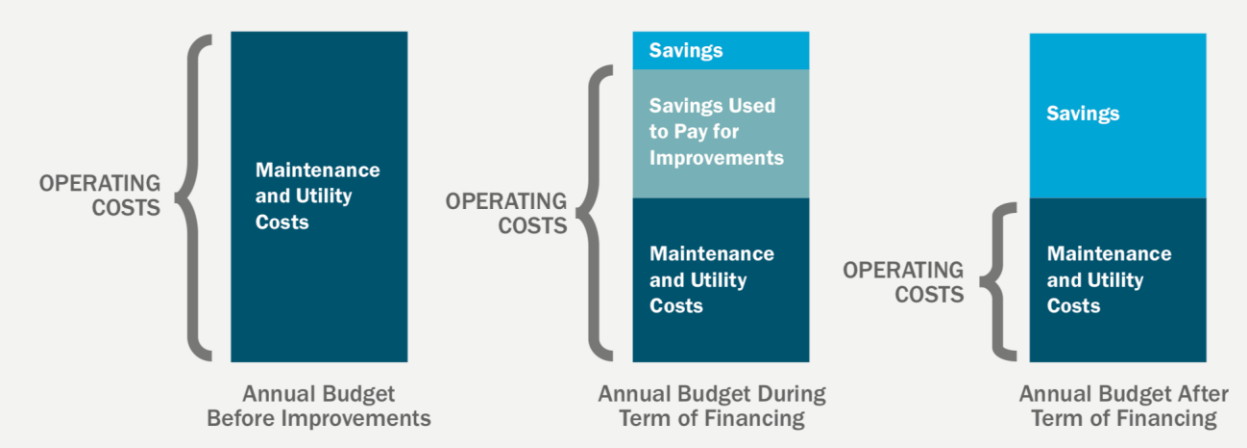

FIGURE 5 Overview of Operating Costs and Savings Before and After ESPC

Figure 6 from the USDOE shows the structure of project costs and savings for ESPC projects over a 15-year period (17).

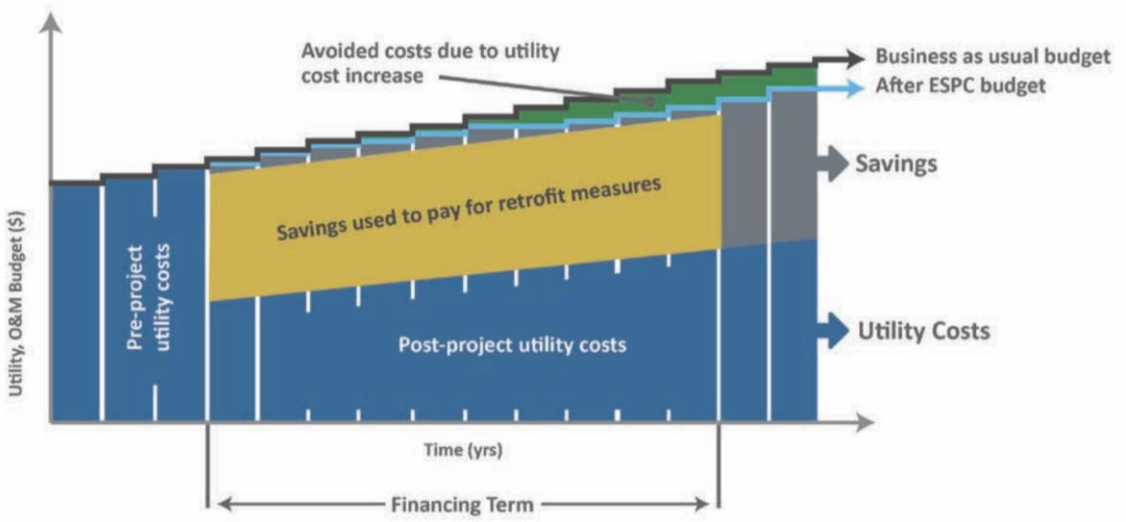

FIGURE 6 ESPC Project Savings Over a 15-Year Period

The State of New Mexico, via EMNRD, has established a program for state agencies to more easily approach and develop ESPCs with ESCOs. The Energy Conservation and Management Division (ECMD) is a division of EMNRD and has processed $49.5 million in ESPCs covering over 200 buildings across 13 institutions and 8.6 million square feet (18) in New Mexico. EMCD has developed a suite of materials that can assist NMDOT and other public agencies engage ESCOs to develop ESPCs. The resources section below shares the location of those materials.

ESPCs represent a different approach to financing and project development, that are a safe, effective, and established approach. ESCOs are required by law and via contracts to provide a fixed-cost project and they carry the risk and cost of change orders. EMNRD and New Mexico Finance Authority have put together legal and policy safeguards within the state to ensure that public agencies are protected. Figure 7 provides a summary of the ESPC process in New Mexico.

- **Applicability to NMDOT:** NMDOT Districts are concerned about the extensive deferred maintenance at their building facilities. One NMDOT District Engineer mentioned a significant backlog of funding is needed statewide to restore existing maintenance building infrastructure. While most district engineers were interested in the no-cost solar approach, facility building needs are a more urgent priority. ESPCs could be a good means to accomplish building level energy and water upgrades while also adding solar at the same time.
- **Roles of ESCO and NMDOT:**
    - *ESCO:* performs most or all of the following tasks to bring a project to fruition including the elements mentioned in the scope of work that relate to ownership, design, installation, and long-term maintenance:
        - Auditing and assessing project site locations for project opportunities
        - Project proposals with guaranteed project savings that cover all costs
        - Educating NMDOT on project financing
        - Engineering, procurement and construction
        - Training for NMDOT staff to use facility upgrades

        - Ongoing maintenance services
        - Measure and verify savings
    - *NMDOT:* The agency would be responsible for carrying out the project management and interface between the ESCO and the individual NMDOT Districts. A NMDOT team should include staff members, such as the General Services Bureau Chief, with expertise in financing as well as the building and maintenance needs of district-level facilities. Legal and procurement departments are needed for contract approval although this process can be streamlined given that EMNRD has already approved and pre-qualified ESCOs.
- **Resources:**
    - EMNRD (19)
        - Presentation materials (20)
        - Sample RFP to ESCOs (21)
        - Statewide Price Agreements (22)
        - ESCO process via EMNRD website (see Figure 7 below) (23)
    - U.S. Department of Energy (24)

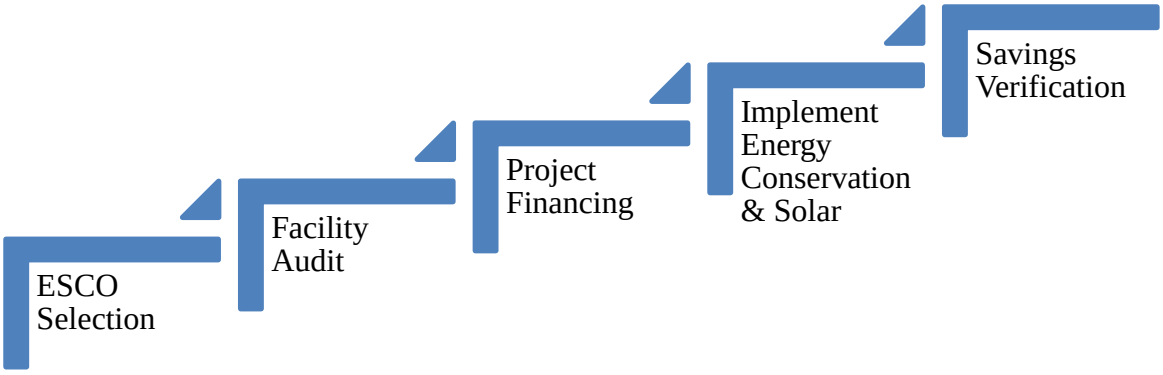

FIGURE 7 ESCO Process in New Mexico

POLICIES

This section provides an overview of the solar development and financing policies in New Mexico. Many of these policies will apply to NMDOT solar projects; however, many of them will more directly relate to the solar developer or partner that conducts the project development and financing roles.

State of New Mexico Policies

New Mexico's solar policy ranks in the top 20 states for policies that make solar projects more feasible according to Solar Power Rocks which analyzes policies and incentive structures by state. The main policies that New Mexico currently has in place relate to net metering, the renewable portfolio standard, and the interconnection standards. Figure 8 below summarizes the letter grade of New Mexico policies and incentives (25).

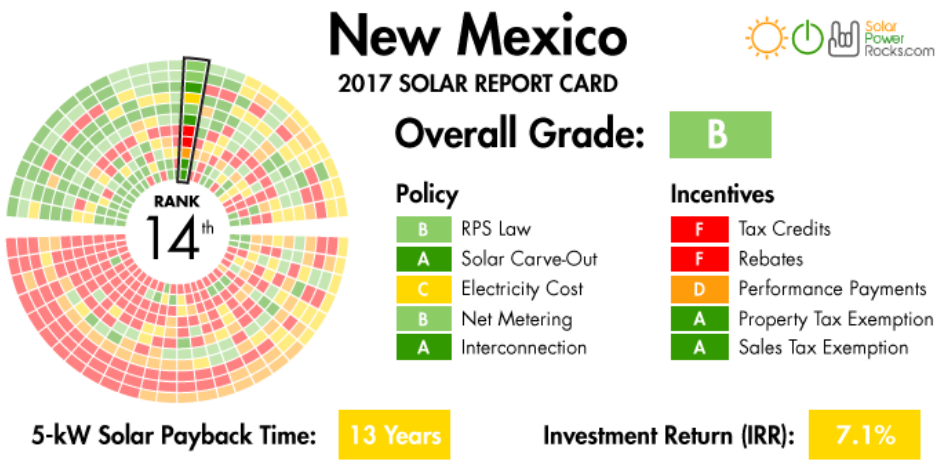

FIGURE 8 Solar Report Card for New Mexico

Net Metering

Net metering is a policy that allows a customer-generator of solar energy with a capacity of under 80 MW to tie to the electricity grid and be compensated for the excess amount of electricity that is not used at the facility, termed Net Excess Generation (NEG). This means that the solar power generation occurs on the customer side of the meter and will reduce the demand or exceed the demand – causing an export of the surplus power to the grid. In effect, NMDOT would become a small electricity generator. New Mexico has an advantage in that this net metering policy does not exist in every state or is not capped at lower generation levels. Currently, in New Mexico there are no safe-harbor rules for customer-generators, which means that utility companies can impose fees and charges that could make it less profitable to NMDOT. This provides some uncertainty to the financial modeling. For solar PV systems between 10kW and 80 MW (all NMDOT solar facilities will fit this range), the NEG delivered from a qualified facility to the utility is "purchased by the utility at the utility's applicable time-of-use or single period energy rate (retail rate)" but municipal utilities are exempt from participating in net metering requirements (26).

Renewable Portfolio Standard and Solar Carve-Out

A Renewables Portfolio Standard (RPS) requires utilities to increase the percentage of renewables as part of the energy mix delivered to customers inside a state. The State of New Mexico has a strong RPS, mandating that 20% of all energy for investor-owned utilities (IOUs) must come from renewable sources by 2020, and 10% of energy for rural electric co-ops. IOUs have a solar carve-out requiring 4% of the 20% coming from solar projects. While further RPS targets have not yet been established, a higher percentage of renewable mix is anticipated in coming years as most states raise their standards over time. Figure 9 below outlines the different thresholds of RPS for IOUs and rural electric cooperatives (27).

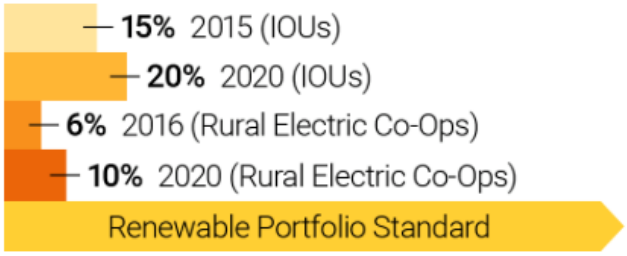

FIGURE 9 RPS Thresholds for New Mexico Utilities

Interconnection Standards

Interconnection is a fundamental component of any solar project ensuring that a net metered project is connected to the electric grid. The State of New Mexico has scaled required studies for interconnection based on project size. For smaller projects, simplified or fast track processes are available while larger projects will require full interconnection studies. The interconnection studies will be managed and developed by the third-party partner. Table 3 provides a summary of interconnection by system type.

TABLE 3 Interconnection by System.

Eligible Systems	Type of Interconnection
≤10 kW	Simplified process
>10kW and <2 MW	Fast track process
>2MW and ≤10 MW	Eligible for full interconnection study
>10 MW	Follow case specific study process

Resources

New Mexico Right-of-Way Resources

- NMDOT Right of Way Handbook Volume I Preliminary Right of Way Studies January 2016 (26)
- NM ROW Acquisition (27)

FHWA Policies

Rest Areas and Concessionaire Agreements

Rest areas have hosted solar projects around the country and are likely to support solar if the purpose is cost reduction or avoidance of purchasing power for the highway purpose or if it contributes to funding the highway purpose. 23 USC 1.23 (b) states:

Use for highway purposes. Except as provided under paragraph (c) of this section, all real property, including air space, within the right-of-way boundaries of a project shall be devoted exclusively to public highway purposes. No project shall be accepted as complete until this requirement has been satisfied.

The State highway department shall be responsible for preserving such right-of-way free of all public and private installations, facilities or encroachments, except (1) those approved under

paragraph (c) of this section; (2) those which the Administrator approves as constituting a part of a highway or as necessary for its operation, use or maintenance for public highway purposes and (3) informational sites established and maintained in accordance with §1.35 of the regulations in this part.

(c) Other use or occupancy. Subject to 23 U.S.C. 111, the temporary or permanent occupancy or use of right-of-way, including air space, for nonhighway purposes and the reservation of subsurface mineral rights within the boundaries of the rights-of-way of Federal-aid highways, may be approved by the Administrator, if they determine that such occupancy, use or reservation is in the public interest and will not impair the highway or interfere with the free and safe flow of traffic thereon."

If the solar panels were dedicated to electric vehicle charging systems that require payment, there would be a clear conflict. 23 USC 111 states: *"Agreements relating to use of and access to rights-of-way Interstate System. (a) In general. All agreements between the Secretary and the State highway department for the construction of projects on the Interstate System shall contain a clause providing that the State will not add any points of access to, or exit from, the project in addition to those approved by the Secretary in the plans for such project, without the prior approval of the Secretary. Such agreements shall also contain a clause providing that the State will not permit automotive service stations or other commercial establishments for serving motor vehicle users to be constructed or located on the rights-of-way of the Interstate System. Such agreements may, however, authorize a State or political subdivision thereof to use or permit the use of the airspace above and below the established grade line of the highway pavement for such purposes as will not impair the full use and safety of the highway...."*

In 23 USC 710.701-710.709, FHWA provides the terms of concession agreements. Principally, a solar project on the roof of or in the leased concession ground area could be possible if it does not interfere with the function of the highway purpose and if it meets the fair market value test as it states in section 710.709 – "Determination of fair market value":

a) Fair market value may be determined either on a best value basis, highest net present value of the payments to be received over the life of the agreement, or highest bid received, as may be specified by the highway agency in the request for proposals or other relevant solicitation. If best value is used, the highway agency should identify, in the relevant solicitation, the criteria to be used as well as the weight afforded to the criteria.

(b) In order to be considered fair market value, the terms of the concession agreement must be both legally binding and enforceable.

(c) Any concession agreement awarded pursuant to a competitive process with more than one bidder shall be deemed to be fair market value. Any concession agreement awarded pursuant to a competitive process with only one bidder shall be presumed to be fair market value. Such presumption may be overcome only if the highway agency determines the proposal to not be fair market value based on the highway agency's estimates. Nothing in this subpart shall be construed to require a highway agency to accept any proposal, even if the proposal is deemed fair market value. For purposes of this subsection, a competitive process shall afford all interested proposers an equal opportunity to submit a proposal for the concession agreement and shall comply with applicable State and local law.

(d) If a concession agreement is not awarded pursuant to a competitive process, the highway agency must receive fair market value, as determined by the highway agency in accordance with State law, so long as an independent third-party assessment is conducted and made publicly available.

(e) Nothing in this subpart is intended to waive the requirements of part 172, part 635, and part 636 whenever any Federal-aid (including TIFIA assistance) is to be used for a project under the concession agreement. It should be noted that these sections include the terms of competitive contracting for Federally funded engineering, construction or equipment purchase.

Utility Accommodation Plan for Highway ROW

The Federal Highways Law 23 USC 101(a)(6) states that property on highway that receive federal aid must be used for highway purposes; however, there are exceptions for use of airspace, vending machines operated by the blind (rest areas) utilities, railroads and temporary use for non-highway purposes.

FHWA provides guidance on a two-part test via 23 USC 645 Subpart B to determine if the renewable energy facility can be sited using utility accommodation and meets the regulatory definition of a "utility". Since renewable energy facilities and therefore solar PV facilities produce electricity, they satisfy the first part of the test. The second part of the test asks if the facility meets the public service criteria specified in the definition. According to the guidance, a facility satisfies this test when it provides service to the general public or when it is dedicated to a transportation agency for its own use.

Most grid-connected renewable energy facilities are likely to satisfy the two-part test. The solar facility must still conform to the specific policies and standards detailed in NMDOT's Utility Accommodation Plan which is a programmatic agreement between NMDOT and FHWA addressing if, to what extent, and under what conditions the state allows the siting of utilities in the ROW.

NMDOT is currently undergoing changes to its policies with regard to utility accommodation. Under the current version of the plan, renewable energy projects are not included. Conversations during this project with the NMDOT Utilities Section Manager shared some of the examples that other state DOTs have employed to include renewable energy in the highway ROW and identify the language that would meet this requirement for the updated utility accommodation plan. The research team recommends including this renewable energy language into the utility accommodation plan to avoid potential issues with solar ROW properties and FHWA.

- **Resources:**
  - Massachusetts DOT: Chapter 5 – Telecommunication and Renewable Energy (28)
  - Vermont DOT: Utility Accommodation Plan: Renewable Energy (29) Generation/Transmission on Non-Limited and Limited- Access Highways
  - Oregon Solar Highway Program Guidebook (30)
  - FHWA Guidance on Utilization of Highway Right-of-Way (31)
  - FHWA Requirements for Renewable Energy Projects in Highway Right-of-Way (32)

INCENTIVES

Solar project incentives are targeted to taxable entities and therefore only developers and project partners can capture those direct financial benefits. However, the benefit to private developers will allow for lower PPA pricing to NMDOT or higher airspace/land lease values. The two incentives modeled in the research team's analysis were the federal ITC and accelerated depreciation. Certain incentives, such as the Renewable Energy Production Tax Credit, has sunsetted and is no longer available as of January 1, 2018.

Federal Investment Tax Credit (ITC)

Incentive structures, such as the federal ITC, are directed at developers and financing partners. The federal ITC is a business energy investment tax credit of 30% of the initial cost of the solar equipment. This type of incentive is not available to public agencies because they do not have tax liability; therefore, a solar developer or third-party investor is required that has a tax liability equivalent or higher than 30% of the cost of the solar equipment, in order to fully benefit from this solar incentive. Congress recently changed the value of the ITC on coming years. The tax credit sunset will reduce the value of the credit starting in 2020, stepping down to 26%, 22%, and then 10% in subsequent years, as shown in Figure 10.

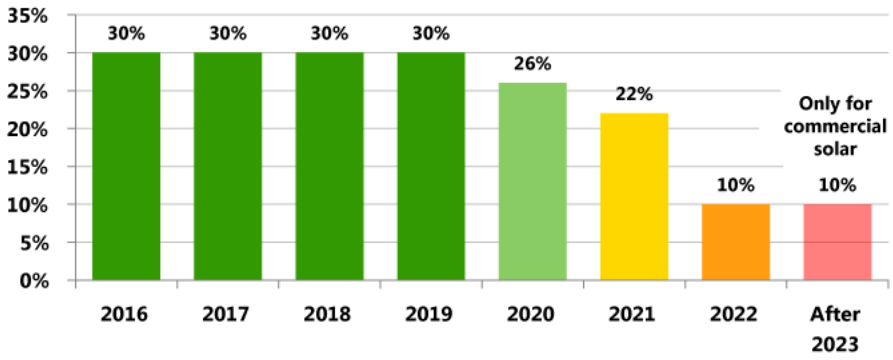

FIGURE 10 Reduction of the Federal Investment Tax Credit

Modified Accelerated Cost Recovery System (MACRS)

MACRS is a private sector incentive allowing for the accelerated depreciation of solar PV systems. Currently, the federal government treats solar PV systems as an asset that can be depreciated over a five-year timeframe. This shorter period for depreciation allows for the project cost to be recouped faster than it would otherwise be treated from a financial perspective.

Gross Receipts Tax Exemption for Wind and Solar Systems to Government Entities

North Carolina Clean Energy Technology Center's Database of State Incentives for Renewables & Efficiency (DSIRE) shares details on an incentive for solar PV projects that are going to be implemented for government entities in New Mexico. Solar developers or businesses can avoid the sales tax associated with the PV system costs. This incentive was signed under Senate Bill 201, signed in March 2010, included the exemption for solar PV and thermal systems; prior to 2010 it had initially targeted wind projects.

POTENTIAL PARTNERS

NMDOT can choose from three main types of partners for solar projects including solar developers, ESCOs, and utilities. In some cases, partners may serve as the owner-operator of a

solar project and in other situations the third-party may be a facilitator or stakeholder in the project development process.

Solar Developers

In New Mexico, there are close to 100 companies that produce solar PV panels, develop, finance, and construct solar projects. Many of these companies focus on smaller scale residential and commercial projects. A select group of the 100 companies in New Mexico are capable of implementing a bundle of solar projects or a utility-scale sized project (33).

For the purposes of this plan, the research team interviewed three of the solar developers that have a local and regional presence. They also have historically and currently financed, built and maintained larger scale commercial and utility scale solar projects that meet the size thresholds of the projects outlined in this study.

- Affordable Solar
- Positive Energy Solar (SunPower)
- RES

In addition to Affordable Solar, Positive Energy and RES, the following solar companies or developers are also part of New Mexico's statewide pricing agreement for solar above 50kW:

- Osceola Inc.
- Paradise Power
- Sol Luna Solar

The research team interviews with solar developers were key in determining anticipated agreement components and approximate thresholds and values for agreement participation by solar developers. Solar developers are interested in larger scale projects (greater than 1MW in individual or bundled projects) to meet financial requirements for financial feasibility. Solar developers do prefer longer term multi-year projects as often certain projects and locations can require time to develop or project variables (e.g., utility pricing) to align. Solar developers prefer projects that are either near load demand or urban locations but will consider project locations that are near interconnection. Larger project sites would require a range of property between 4-20 acres.

One solar developer mentioned that many solar project developers acquire project financing from similar financing sources such as Next Era which have comparable expectations in terms of financing costs and timeframes. This implies that pricing is going to be similar for most solar projects. For smaller projects or a bundle of projects of less than 1 MW in capacity, Wiseman Capital and American Renewable Capital could provide financing but most solar developers are not going to participate directly in accessing this capital because the transaction cost is too high.

EMNRD's presentation materials include solar installation details for three public agencies solar PPA projects. Table 4 provides the information about the amount of investment, projected annual savings, and energy generation (35). It is important to note that these projects are of a certain size threshold, close to ~1MW, a scale preferred by developers based on project returns and the costs of project development and delivery.

TABLE 4 Solar PPA Projects with New Mexico Public Agencies (35).

Agency/Entity	Total Investment	Annual Estimated Savings	Contract Duration	Array Size (kW/MW DC)	Guaranteed Electricity Generated (kWh/year)
Silver City	$5.9 million	~$170k	20 years	1.1 MW*	1,697,788
Truth or Consequences	$5.6 million	$325k	25 years	1.8 MW*	3,256,278
City of Alamogordo	$4.8 million	$156k	25 years	937 kW	1,564,327

*Installed by Affordable Solar

Additional Resources:

- The New Mexico Solar Energy Association (NMSEA) hosts a directory of solar companies in New Mexico (35).
- SEIA manages a national solar database that identifies the location of PV manufacturers and installers by location by each state (36).

Energy Services Companies

While ESCOs are most commonly associated with ESPC agreements, there are a number of circumstances where an ESCO will carry out the same roles as a solar developer. EMNRD has pre-qualified seven ESCOs and has negotiated pricing agreements with the following companies and these pricing agreements are renewed annually:

- Ameresco
- Energy Control/Opterra Energy
- Johnson Controls
- McKinstry Essention
- Noresco
- Siemens Buildings Technology
- Yearout Energy Services

EMNRD has information materials outlining ESPC projects for three New Mexico entities. Table 5 provides information by entity on the project cost, building and square footage impact, as well as the projected annual savings. The research team's interviews with ESCOs indicated that project investment would need to be $1 million or more to merit developing a project. That threshold could include multiple buildings and given the building inventory and number of NMDOT facilities, should be easy to access.

TABLE 5 Successful New Mexico ESPC Projects (37).

Agency/Entity	Project Cost	Impact	Project Annual Savings
New Mexico State University, Las Cruces Campus	$15.7 million	60 buildings ~4 million ft^2	$1.3 million
McKinley County	$2.2 million	44 buildings ~350k ft^2	$330k
City of Bloomfield	$450k	10 buildings ~120k ft^2	$30k

Utilities

Investor-owned utilities are electricity-providing companies that are managed as private enterprises rather than a government or cooperative utility. NMDOT may directly participate in utility requests for renewable generation through utility Requests for Proposals (RFPs). As a general rule the third-party solar developer will interface with the utility on the behalf of NMDOT and develop a proposal on behalf of the DOT and themselves in a joint effort.

In New Mexico there are three primary IOU utilities:

- Public Service Company of New Mexico (PNM)
- El Paso Electric Company
- Southwest Public Service Company (SPS) (owned by Xcel Energy)

PNM's service territory is shown in Figure 11 and Table 6 references the NMDOT District and communities that are located in PNM service territory. The orange color in the map outlines PNM's service territory in different regions of New Mexico.

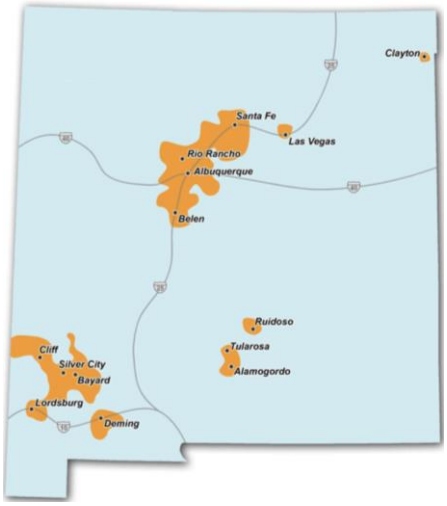

FIGURE 11 PNM Service Territory (38)

TABLE 6 NMDOT Districts in PNM Territory.

PNM	
Community	**NMDOT District**
Bayard	District 1
Belen	District 1
Cliff	District 1
Deming	District 1
Lordsburg	District 1
Silver City	District 1
Alamogordo	District 2
Ruidoso	District 2
Tularosa	District 2
Albuquerque	District 3
Los Lunas	District 3
Rio Rancho	District 3
Clayton	District 4
Las Vegas	District 4
Santa Fe	District 5

Xcel Energy's service territory is shown in Figure 12 and Table 7 references the NMDOT District and communities that are located in Xcel Energy service territory.

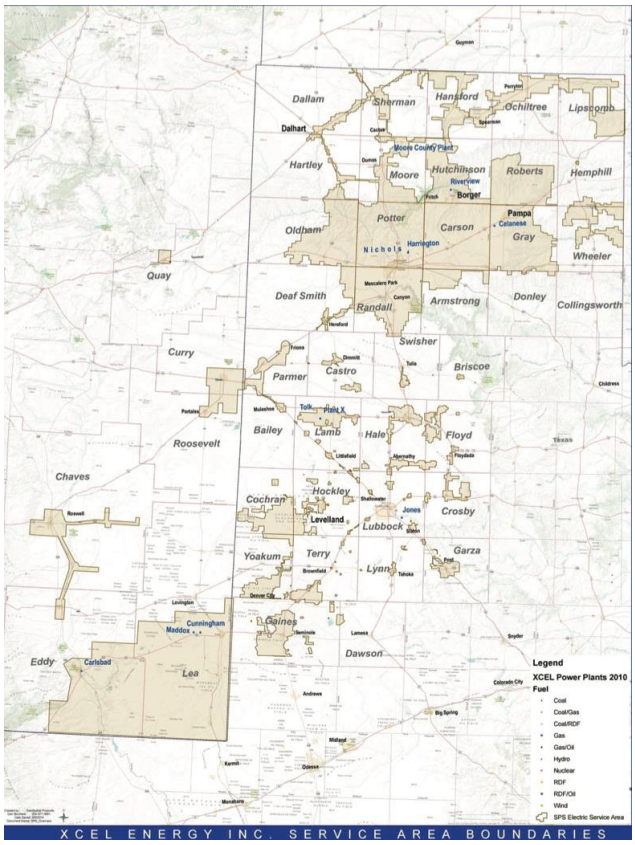

FIGURE 12 FIGURE 12 Xcel Energy Service Territory (39)

TABLE 7 NMDOT Districts in Xcel Energy Territory.

Xcel Energy	
Community	**NMDOT District**
Roswell	District 2
Clovis	District 2
Portales	District 2
Tucumcari	District 4
Santa Rosa	District 4

El Paso Electric's service territory is shown in Figure 13 and Table 8 references the NMDOT District and communities that are located in El Paso Electric service territory.

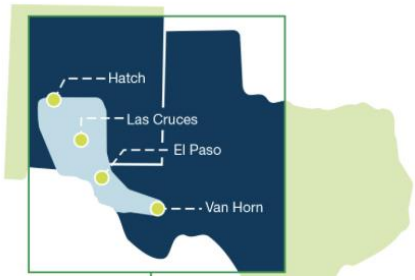

FIGURE 13 El Paso Electric Territory (40)

TABLE 8 NMDOT Districts in El Paso Electric Territory.

El Paso Electric (EP)	
Community	**NMDOT District**
Las Cruces	District 1
Anthony	District 1
Hatch	District 1

Rural Cooperative Utilities – New Mexico is served by a large number of rural electric cooperatives. Figure 14 shows the service territories for the rural co-ops with each color designating a different rural cooperative utility (41). Note that Jemez Mountains is not noted in color in the map but is located just south of Northern Río Arriba.
Table **9** lists the rural cooperatives by NMDOT District, and first lists those rural cooperatives that solar developers mentioned as being interested in solar projects.

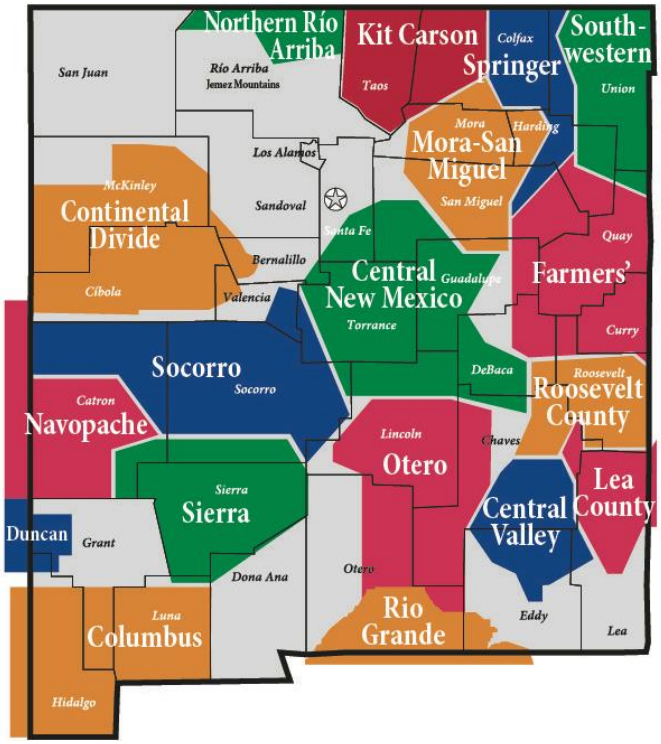

FIGURE 14 Rural Cooperative Utilities in New Mexico

TABLE 9 NMDOT Districts in Rural Cooperative Territory

Co-ops	
Solar Interest	**NMDOT District**
Central New Mexico Electric	District 4 & 5
Continental Divide Electric	District 6
Jemez Mountains Electric Cooperative	District 5
Farmers' Electric	District 4
Kit Carson Electric	District 5
Northern Río Arriba Electric	District 5
Otero County Electric	District 1 & 2
Other Rural Co-ops	**NMDOT District**
Central Valley Electric	District 2
Columbus Electric	District 1
Lea County Electric	District 2
Mora-San Miguel Electric	District 4
Navopache Electric	District 6
Roosevelt County Electric	District 2
Sierra Electric	District 1
Socorro Electric	District 1 & 6
Southwestern Electric	District 4
Springer Electric	District 4

Rural cooperative utilities in New Mexico in many cases are distribution cooperatives and are served by generation and transmission (G&T) cooperatives that provide energy and transmission to their districts. In New Mexico, Tri-State Generation and Transmission and Western Farmers Electric Cooperative are the two G&T cooperatives that serve 15 of New Mexico's distribution cooperatives. Under agreement, New Mexico rural cooperatives that receive energy from Tri-State and Western Farmers' G&T cooperatives are required to purchase at least 95% of their energy from the G&Ts. This means that NMDOT can work either directly with the rural cooperatives to implement solar projects or NMDOT can partner with a third-party developer to bid on an RFP when those are released by the G&Ts, but they are limited to only 5% of that generation coming from their own or partner projects. Tri-State Generation has two large-scale solar projects in New Mexico. A 30 MW facility in Cimarron and 25 MW facility in the Deming area are both 200 acres plus in size.

Tri-State provides power to 11 rural cooperatives in New Mexico including:

- Central New Mexico Electric Cooperative
- Columbus Electric Cooperative
- Continental Divide Electric Cooperative
- Jemez Mountains Electric Cooperative
- Mora-San Miguel Electric Cooperative
- Northern Rio Arriba Electric Cooperative
- Otero County Electric Cooperative
- Sierra Electric Cooperative
- Socorro Electric Cooperative
- Southwestern Electric Cooperative
- Springer Electric Cooperative

Western Farmers provides power to four rural cooperatives in New Mexico including:

- Central Valley Electric Cooperative
- Farmers Electric Cooperative
- Lea County Electric Cooperative
- Roosevelt County Electric

New Mexico's Public Regulatory Commission (PRC) outlines solar projects that have been completed by the IOUs, G&Ts and rural cooperatives through 2015 in Table 10 (42). Information on likely utilities to engage with and project size comparisons are referenced in the District-level feasibility section.

TABLE 10 New Mexico Renewable Energy Projects by Entity

Entities	Project Name	Location	Year	Capacity
El Paso Electric	Macho Springs Solar facility	Luna County	2014	50 MW
El Paso Electric	NRG Energy Roadrunner Solar Generating Facility	Doña Ana County	2011	20 MW
El Paso Electric	Hatch Solar Energy Center	Doña Ana County	2011	5 MW
El Paso Electric	Centennial Solar Farm – Sun Edison	Doña Ana County	2012	12 MW
El Paso Electric	El Chaparral Solar Farm	Doña Ana County	2012	10 MW
El Paso Electric	Rio Grande carport	Doña Ana County	2009	64 kW
PNM	New Mexico Wind Energy Center*	DeBaca & Quay Counties	2003	204 MW
PNM	Red Mesa Wind Energy Center* Nextera Energy	Cibola County	2010	102 MW
PNM	Manzano Solar Energy Center: 5 plants (Los Lunas, Deming, Alamogordo, Las Vegas, Albuquerque)	Valencia, Bernalillo, San Miguel, Otero, and Luna Counties	2011 & 2013	36.5 MW
PNM	La Luz Solar Energy Center	Otero County	2013	7.5 MW
PNM	Meadowlake Solar Energy Center	Valencia County	2014	9.1 MW
PNM	Sandoval County Solar Energy Center	Sandoval County	2014	6.1 MW
PNM	Cibola Solar Energy Center	Cibola County	2014	7.6 MW
Xcel Energy / SPS	Sun Edison solar project	Lea and Eddy Counties	2011	50 MW
Xcel Energy / SPS	NM Community Solar Project	Curry, Lea, and Chaves Counties		0.1 MW
Xcel / SPS	Caprock phase I & II*, Cielo Wind Power	Quay County	2004 & 2005	80 MW
Xcel / SPS	San Juan Mesa*	Roosevelt County	2005	120 MW
Xcel / SPS	High Lonesome Mesa*	Torrance County	2009	100 MW
Arizona Public Service	Aragonne Mesa*	Guadalupe County	2007	90 MW
Tucson Electric Power	Macho Springs Power	Luna County	2014	50 MW
Exelon / LCEC Generation	Wildcat Wind Ranch	Lea County near Lovington	2012	27 MW
Exelon / LCEC Generation	Anderson Wind Project	Chaves County	2015	15 MW
Exelon / LCEC Generation	Guadalupe Mountains	Chaves County	2015	134 MW
Exelon / LCEC Generation	Roosevelt Wind Farm	Roosevelt County	2015	250 MW
Exelon / LCEC Generation	El Cabo Wind Farm	Torrance County near Willard	2015	278 MW
G&Ts	**Project Name**	**Location**	**Year**	**Capacity**
Tri-State G&T	Cimarron Solar Facility – First Solar	Colfax County	2010	30 MW
Tri-State G&T	Escalante Station - case study with EPF	McKinley County near Prewitt		
Western Farmers Electric Coop (OK)	Brahms Wind Project	Curry County near Grady	2014	20 MW
Rural Cooperatives	**Project Name**	**Location**	**Year**	**Capacity (MW)**
Mora-San Miguel Electric Coop	Standard Solar	San Miguel County	2005	1.5 MW
Otero County Electric Coop	OCEC-owned	Alamogordo substation	2014	76 kW
Kit Carson Electric Coop	KCEC-owned	Taos County	2010	3 MW
Kit Carson Electric Coop	Owned by Washington Gas Energy	Taos County	2012	1.5 MW
Springer Electric Coop	currently building one	Colfax County	2015	1 MW

COMMON INTERNAL CHALLENGES AND OPPORTUNITIES FOR NMDOT DISTRICTS

The research team interviewed individual NMDOT Districts, in addition to representatives at the general office for procurement, utility section, and property management. Additionally, the research team conducted calls with EMNRD and the FHWA Division office. Prior interviews with state DOTs provided additional context and detail for each of these considerations. The purpose of these conversations was to learn about what types of challenges and opportunities PV solar projects may encounter at both the state and NMDOT District level. This section provides an overview of the common challenges and opportunities that each District will experience. Specific considerations by district are included later in this section under the district chapters.

Pricing, Utility/G&T Interest and Resource Load

Across the United States, utilities are contending with concurrent dramatic industry shifts. These include new energy sources coming online, old sources going offline, energy customers pursuing energy efficiency and distributed energy generation (such as solar) to meet their own load requirements. This dynamism in the energy resource base may foment utility reluctance to a DOT suggested project. Other state DOTs are subject to the unique context and conditions of their state and the current energy mix and the thresholds for renewable portfolio standards that dictate the amount of new electricity generation. State DOTs that pursue a no-cost approach are in the position of enticing a solar developer to participate rather than being in control of developing a project. This pull versus push relationship means that no matter the interest of NMDOT to develop a project, if the project parameters and financial conditions conducive for third-parties is not present then NMDOT solar projects will not be developed.

In New Mexico there are constraints on the level of interest that utilities have for more solar generated electricity. As mentioned above, energy efficiency coupled with both small and large-scale renewable energy projects can reduce the general appetite for solar projects by the utility. New Mexico's electricity costs are low, just under the national average, and therefore the financial feasibility of solar or any energy generation project are subject to more challenges. The three New Mexico IOUs and the G&Ts that serve the rural cooperatives are most interested in identifying and selecting solar projects that best meet their energy resource needs. G&Ts are not going to be interested in partnering with NMDOT so those efforts should be better directed to rural cooperatives or IOUs. However, IOUs are interested in developing solar in a manner that it best fits into their resource mix and conforms to balancing out their system.

In New Mexico, NMDOT can partner with a third-party developer to bid on utility RFPs developing solar PV projects that develop new generation that is paid by the utility. However, the timing and scale of those projects may not fit the scale of property or location that best suits NMDOT. For instance, Xcel Energy released an RFP in early 2018 for a solar project that specified proximity to specific Xcel substations. PNM plans to let out similar requests for solar in the coming years but the defined nature of those projects will be specific to location and the scale and type of generation that is most ideal to PNM. As part of this plan, the research team contacted and interviewed the utilities to gauge their level of interest. Of the utilities that responded, most presented general interest in NMDOT solar facilities and not larger ground mounted systems. Net metering rules allow for facility-level projects and larger-scale projects

that could be entertained via the RFP process or direct negotiation. A special project working directly with a utility could be an option. Another option is that the solar developer identifies an off-taker for the electricity. For instance, Facebook is currently building solar projects in partnership with PNM and Affordable Solar is building those projects. Another developer mentioned that it might be able to find interested private companies that want to enter into a virtual PPA agreement with NMDOT.

Local Control and Management Capacity
Most NMDOT District offices communicated the need for the General Office (GO) in Santa Fe to be the initiator of a solar program. Particularly for larger scale, multi-district solar approaches, the GO could serve to direct efforts and priority and assist with project management at the District level. Additionally, legal and procurement components would need to be assisted by the GO.

Value of Power and RECs in a Commodity Market
Energy markets and prices at the wholesale level are very dynamic and can go up or down with market conditions in a way that makes them unpredictable. While rates are fairly static to the consumer, the utility may be more or less interested in solar projects based on their current market position. For example, when a utility is short on generated power or on its allocation of renewable power it is more likely to pay more through its contractual agreements with energy suppliers and producers. Over time, wholesale power prices may actually decrease as happened nationally with the 2008 recession. The U.S. EIA anticipates that power prices should decrease in the next 10-15 years as renewables come online and take on a larger percentage of the energy mix. For this reason, selecting a contract with a fixed rate or an indexed rate for a unit of power is safer than purchasing power with a PPA that has an annual escalation rate of 1-3% annually. The PPA price will determine how much NMDOT pays for electricity. A fixed rate will ensure that this rate does not change over the duration of the agreement. An escalation rate may start with a lower price of electricity but will increase by a certain agreed upon rate and this rate of increase may reduce the financial viability of the project over its lifetime. This should be one of the variables assessed in the financial analysis.

Proximity to Load and Interconnection
Any entity interested in developing a solar project, whether they are a utility, solar developer, owner/operator, will have to contend with interconnection to the grid. Ideally solar projects are sited in the most direct proximity to a substation or three-phase power, otherwise they may bear significant costs to study and install the physical infrastructure. These studies and implementation costs are large enough that they may make a project infeasible.

A considerable amount of the land in New Mexico is located in rural landscapes that are often distant from population centers and electricity use. New Mexico is the fifth-largest state by area but the sixth-least densely populated with one in four residents living in Albuquerque. Conversations with individual NMDOT Districts indicated that most of NMDOT electricity use and cost is associated with NMDOT facilities. Unlike other state DOTs, NMDOT does not pay the electricity costs for highway lighting, but instead this is incurred by the local jurisdiction. To ensure that proximity to load and interconnection are addressed, the site selection process and

identifying sites in proximity to both load and interconnection are included in more detail in the Narrative Guide (Appendix C).

Limited Capacity and Budget
Similar to most state DOTs, NMDOT is increasingly challenged by inadequate funding given that the Highway Trust fund has not increased with inflation since the implementation of the gas tax in the late 1980s. In addition to the financial limitations of the current transportation system, increased use of the system increases the need for the funding, while the fuel economy of new vehicles is also decreasing the total fuel consumed per vehicle. The net result is an ever-accelerating need for repairs and replacements while the costs go up. These no-cost solar projects, in lieu of additional system costs, represent opportunities and incentives to either reduce costs or develop new forms of revenue for NMDOT.

Condition of Buildings and Infrastructure
As previously mentioned, NMDOT District interviews indicated a widespread need and priority for NMDOT Districts to address dilapidated facilities in need of maintenance. Rooftop solar projects may not be a reasonable option for facilities in need of new roofs or that are subject to structural issues. Ground mount systems adjacent to facilities (or integrated into new covered parking structures or electric vehicle charging stations rolled into the cost of solar installation) may be more appropriate. Additionally, working with ESCOs to implement building upgrades, in addition to solar, may present a solution that meets multiple benefits.

Property Ownership and Overlap with Clear Zone
In conversations with NMDOT's utility section manager and individual districts, NMDOT staff mentioned that in some stretches of highway, NMDOT only owns 20-50 feet from the edge of the road parallel to the roadway. And of that roadway, depending on the posted speed and average daily traffic, up to two-thirds may be in the clear zone limiting the potential space for a solar PV array. NMDOT's utility section manager stated that this width is wider along state interstates. It is imperative that site property analysis identifies not just available highway ROW and surplus property but considers the clear zone or the ability to put up protective rail. Some sites will not possess the adequate space necessary to install a solar PV array. The financial feasibility section provides an overview of PV solar array sizes and the required area needed as well as estimated annual production in kWh.

NMDOT's Property Management department provided specific information on NMDOT parcels by district and this information is shared in the NMDOT District specific feasibility section of this report. The scope of this plan did not include individual site selection or assessment; however, this is an essential next step in the process for NMDOT if the agency plans to move forward with a solar project and overall program. The scope and scale of state DOT properties vary state by state, but the task of site identification and selection is a common process. Many of the steps are close to a standardized process for solar site selection based upon prior experience and guidance documents available from Massachusetts, New York, Oregon, and Vermont. This information and guidance are included in the Narrative Guide in Appendix C.

Buyback versus Decommissioning

Some DOTs have been concerned with decommissioning the facility at the end of the contracted or warranted life. Oregon DOT negotiated for the panels to be taken back by the manufacturer for an upfront fee for proper recovery and/or disposal. Oregon found that the salvage value of the system is similar to the cost of decommissioning, but this will vary by site. Solar facilities continue to perform well beyond the warranty, but their productivity of the panels slowly degrades (~0.5% per year). NMDOT should consider assuming the costs and responsibility of owning the older system as the return on investment and benefit to the DOT may increase substantially. A financial study of the productivity of the panels and the maintenance (cleaning, mowing, wire checking) and replacement costs (inverters) should be done to contrast with the earning potential of the existing array despite a decrease in total production.

The research team recommends that NMDOT plan to operate and maintain the solar PV system once the agreement ends. At the end of the agreement term (e.g., 20 years), NMDOT could enter into a maintenance agreement with a solar company or determine to conduct that work via internal staff. Financial modeling is needed to determine the scale of benefit relative to costs.

Damage to PV Panels by Extreme Weather Events

One consideration for New Mexico is the damage that could be done to solar panels during extreme weather events. Most weather events such as tornados or hurricanes that could damage solar panels do not occur in New Mexico. Hail and lighting strike are the most likely to create problems for solar projects and have caused damage to buildings and vehicles. Florida DOT's assessment for the Turkey Lakes Service Plaza project identified challenges with high winds and lightning strikes. In both cases, improper installation and lack of necessary equipment created panel damages and system downtime. For the lightning strike, the system should have been equipped by multiple Transient Voltage Surge Suppressors (TVSS). Conversations with project and PV installers should cover mitigating potential risks to panels and NMDOT should ensure that the warranty that specifically covers those types of events. Panel security risk and preventing vandalism is discussed in the Narrative Guide in Appendix C.

FINANCIAL FEASIBILITY ANALYSIS

OVERVIEW OF FINANCIAL ANALYSIS

The consulting team evaluated each individual NMDOT District for the PPA and land leasing pathways using two solar PV modeling tools: the Energy Toolbase and NREL's SAM financial modeling tool. The team interviewed all NMDOT Districts, except for District 5, and gathered facility electricity usage from each of the six NMDOT Districts. The research team developed an Excel spreadsheet to support the feasibility modeling and evaluations. *Note: while the research team canceled its account to Energy Toolbase at the conclusion of this project, Energy Toolbase maintains the data used for this analysis if NMDOT decides to subscribe to this tool for subsequent analysis.*

Financial feasibility of an individual solar project is conducted by a few calculation steps to produce a set of metrics that can be used to compare projects side-by-side.

- First, the size of the proposed PV solar project is determined. The research team modeled the size of the proposed array based off of the historic electricity demand for NMDOT District level locations. The size of the PV system and corresponding infrastructure (e.g., inverter) provided an initial first cost associated with the design and build of the solar array. Energy Toolbase is connected to NREL's PVWatts calculator which provides the estimated cost for different systems based on their robust database of PV panel producers and equipment providers.
- Second, the research team modeled the annual production of the proposed solar array based upon on the solar insolation or the availability of sunlight and its direct relation to the amount of solar energy that could be produced at that specific location or region. The amount of electricity produced and the timing of that electricity production, which fluctuates over the course of a year based on weather and cloud cover, provides the basis for meeting the demand curve for electricity at that stage of the year as well as attributing a price for that electricity.
- Third, with the cost and production parameters in place, the next step develops the specific calculations and results of cash flow, net present value, developer payback period, and breakeven PPA price. The cash flow represents the annualized inflow or outflow of cash for NMDOT which is the addition of the PPA payments NMDOT makes to its PPA partner and the electricity bill savings. For a positive cash flow project, the electricity bill savings should be higher than the PPA payments, both annually and cumulatively over the agreement lifetime. Net present value measures the present-day value of a project considering the anticipated inflows of revenue in comparison to investing that same amount of money at compound interest. For the purposes of this study, the research team used a discount rate of 5%, which indicates that the proposed solar project is compared against investing the same amount of capital with an interest rate of 5%. The research team calculated the NPV for both NMDOT and the project developer. Projects that showed a positive NPV for both NMDOT and the developer are the most likely to be pursued further. Given that many of the projects did not meet these criteria, the research team ran an additional analysis to determine the breakeven PPA price, or the blended value of electricity the developer would charge NMDOT which would result in the developer covering their initial investment. Payback period measures

the number of years that it takes for the project developer's initial investment to be returned. The research team measured the number of years that it would take to recoup the third party's initial investment. The timeframes for these projects ranged from 12 to 30 years based on a breakeven PPA price. Following the initial set of calculations to see if the project was viable for NMDOT, the research team determined the level of benefit and payback for the developer.

In summary, the first step develops the cost structure and the second step of production defines the financial value of the project both on annual basis and over the agreement lifetime (shown in 20 and 30-year increments). The third step uses the cost and revenue production values based on a proposed site and array size to provide metrics that can help compare and contrast different projects, locations, and utilities. Additional details are provided in Appendix D, which includes some of the graphical and tabular results from the financial analysis.

The performed financial analysis distinguishes and compares six different PV array sizes:

- 10 kW Facility-level
- 75 kW Facility-level
- 200 kW ROW or Facility-level
- 500 kW ROW or Facility-level
- 1 MW ROW/Surplus Property Ground Mount
- 5 MW ROW/Surplus Property Ground Mount

Table 11 shows the array sizes and the module sizes, land area and estimated annual anticipated production (kWh).

TABLE 11 SOLAR PV SYSTEM SIZES AND ANNUAL PRODUCTION

Array Size *kW/MW*	**Module area** *square feet*	**Total Land Area** *acres*	**Annual Production** *kWh*
2 kW	211	0	3,451
10 kW	421	0	17,256
20 kW	1,053	0.1	34,511
50 kW	2,737	0.2	86,279
75 kW	4,211	0.3	126,583
100 kW	5,476	0.4	167,563
200 kW	11,161	0.9	351,812
500 kW	28,219	2.2	902,526
1 MW	56,439	4.3	1,764,785
2 MW	113,090	8.7	3,534,244
5 MW	282,829	21.7	8,837,939
10 MW	565,658	43.3	18,022,926

The research team modeled the feasibility of projects for comparable sized systems for each of the NMDOT Districts to produce comparable outcomes. Note that specific site conditions were not considered in this analysis. Additionally, the research team conducted feasibility analysis for the 22 facilities within the six districts, but these did not include site specific challenges.

FEASIBILITY METHODS AND ASSUMPTIONS

This section provides an overview of the assumptions made in the course of the feasibility assessment.

- **Solar potential and generation:** Each district was assessed for its particular solar potential and quality which generates an output of the annual production. For example, a 10kW system generates 15,790 kWh annually in New Mexico as an average. Both Energy Toolbase and the SAM model use NREL's PVWATTS Version 5 to determine solar exposure potential by district location. Both platforms have variables included for inverter efficiency (96%) and system losses (14%) that reduce the energy generation potential on a daily to annual basis.
- **Electricity usage and average costs:** Electricity usage and costs for facility PPA agreements was acquired from each district. In addition to specific facility modeling, general sized solar projects were also modeled using annual generating output of a solar facility as the amount of energy used. Our rationale for this modeling approach was to identify differences between districts and specific utility schedules to determine which sized systems were more feasible and which utilities have rate schedules that are conducive for solar projects. Additionally, the research team assessed the costs for the most recent year or years. In the results section, the average cost per kWh is provided in one of the columns. The analysis used more sophisticated modeling to ascertain cost differences in the utility rate structure.
- **System scaling:** The research team sized systems between 80-100% of the facility's annual electricity usage. One solar developer mentioned that depending on the utility and rate schedule they may decrease the size of the system to 40-60% of annual electricity usage. The research team ran scenarios for each facility at 50% of annual electricity usage to determine whether it would change the feasibility for specific locations. The results indicated that only the Milan Project Office #1 in District 6 would become profitable, albeit only $169 over a 20-year timeframe.
- **Utility rate schedules:** Each IOU and rural electric co-op manages different rate schedules based on the amount of current energy usage. These rates are included in the Excel table for each District facility (e.g., PNM 3C, Xcel Energy SGS, Central NM Co-op GS) and are part of the database for both Energy Toolbase and the SAM model. Utility rate schedules are one of the most important variables in the feasibility analysis due to wide variability. These rates vary based upon facility size and output, distinct rate schedules that outline the energy charges, demand charges, and time of use. In recent years, utilities have modified rate schedules to move customer costs to demand charges, particularly to ensure that solar produced by customers pays a "fair share" of the distribution and transmission costs, given that most of these facilities are grid connected. A direct consequence of this approach is that utilities are disincentivizing the feasibility of solar projects.
- **Solar PV system costs:** Energy Toolbase and the SAM model use NREL PV Watts default values based on system size. According to Solar Energy Industries Association and solar system prices have declined 52% over the last 5 years in New Mexico, even with solar tariffs. To date, there is 700 MW of solar projects in the state and 998 MW of solar is anticipated to be constructed in New Mexico in the next five years.

- **Installation location:** For the purposes of uniformity in the analysis the research team chose to select cost structures for rooftop solar when projects were less than 200kW and ground mount for projects larger than 200kW.
- **Racking system:** Single, fixed racking system without tracking features
- **Tilt angle of panels:** 10 degrees
- **Azimuth angle of panels:** 180 degrees
- **PPA Model:**
    - Initial PPA rate to NMDOT as customer: Solar developers provided PPA values for each size of system 10kW, 75kW, 200kW, 500kW (range between $0.09, $0.10, $0.13 per kWh). *Solar developers provided different rates as to whether a project was an individual single project or if the project was part of a broader bundle of projects adding up to 1MW of solar capacity or more.*
    - PPA escalation rate: 1% increase in rate annually (common term of solar agreement)
    - Term of PPA agreement: 20 years (common term of solar agreement)
    - Electricity cost increase: 1.4% annually (based on US EIA electricity price increases and modeled in the feasibility Excel tool) (43)
- **Airspace/Land Leasing Model:**
    - Lease rate per acre to NMDOT as provider: $250 and $750 per acre
    - Lease escalation rate: assumed no increase in lease rate
    - Area needed for PV solar system: 4 acres for a 1MW facility and 22 acres for 5MW facility based on SAM model
    - Term of lease agreement: 20 years
- **Trade tariff:** Within the NREL's SAM model, which offers a multitude of options for solar panels brands and models, the research team used the default for American made panels. The research team decided to go this route in part not to subject the feasibility study to the recent increases in solar panel tariffs for imported panels. Aside from the modeling, market shifts are occurring as Chinese-based companies are identifying opportunities to bypass tariffs. In spring 2018, Jingko Solar announced its plan to invest in a U.S. based factory to produce tariff-free panels which will supply NextEra Energy with up to 2.75 gigawatts of solar modules over a four-year period (44).
- **Competition with other renewable energy:** Our analysis did not account for the competition with new sources of energy, renewable or otherwise. New Mexico contains a wealth of fossil fuel, mineral, and renewable energy resources and is the seventh-largest net supplier of energy to the nation (much of that energy mix is based in petroleum, natural gas, natural gas liquids, and coal) (45).
- **Incentives:**
    - Incentives were not included because they do not directly affect the feasibility for NMDOT.

HIGH LEVEL RESULTS

Overall Feasibility by Project Size

The analysis shows that bundled PPA projects, projects that bundle solar projects at 1MW or larger would potentially offer positive savings to NMDOT via energy cost reduction over the course of a 20-year solar agreement. The bundled PPA analysis compares the project returns by project size and averages them over IOU and rural cooperative rate schedules.

Similarly, Table 12 shows that leasing projects also demonstrate a positive income potential both at low and higher airspace/land lease values. These leasing projects provide between $21,500 and $325,000 over a 20-year period depending on whether the system is 1MW or 5MW and if the value of the lease is $250 or $750 per acre per year.

TABLE 12 Summary Results by Project Size.

	PPA		Lease			
	Average Bundled PPA Price ($0.10 kWh)		Annual Lease - Low Value ($250/acre/year)		Annual Lease - High Value ($750/acre/year)	
	1st Year Savings/Cost	20 Year Savings/Cost	1st Year Revenue	20 Year Revenue	1st Year Revenue	20 Year Revenue
System Size						
10 kW Facility-level	-$240	$1,311				
75 kW Facility-level	-$1,542	$16,379				
200 kW Facility-level	-$4,871	$26,865				
500 kW Facility-level	-$12,753	$52,975				
1 MW Ground mount			$1,075	$21,500	$3,225	$64,500
5 MW Large Ground mount			$5,425	$108,500	$16,275	$325,500

Note: The color coding in the results sections are meant to identify the level of savings or costs, and to distinguish viable projects versus those that are less likely to be viable. Green denotes a positive value and the darker green indicates a savings or NPV above $100,000.

ESPCs Project Viability

ESPCs were not modeled to the level of detail as PPA or airspace/land lease agreements because solar projects are included with other efficiency upgrade projects making it difficult to select solar project attributes. Solar projects have longer payback periods. Interviews with ESCOs indicated that often a project payback for solar will decrease from 20 years to 15 by combining a solar project with facility-level upgrades that have better cost efficiencies and returns.

Yearout Energy Services developed an ESPC with Bernalillo County. Table 13 shows some of the basic parameters of the agreement including the utility and O&M savings.

TABLE 13 Bernalillo County ESPC Overview.

Project Price	$13,86,921
Year 1 Utility Savings (electricity and natural gas)	$496,212
Year 1 Operations & Maintenance Savings	$78,903
Estimated Incentives from Utility Provider	$139,887
Capital Contribution by Bernalillo County	$2,000,000
Project Financing Period	24 Years
Percent Reduction in Annual Utility Costs	47%
Percent Reduction in Annual Energy Consumption	32%

Additionally, Yearout Energy Services provided the breakdown of project components and the anticipated utility savings as well as the simple payback for the project. Note in Table 14 a solar PV system has an anticipated annual savings of $121,343 but the payback period for the project is 21 years. As the solar PV project is blended with other facility improvements (HVAC equipment, LED lighting, vacuum sanitation system, roofing improvements and landfill gas

boiler) the overall payback period is 15.6 years. Per ESCO interviews, ESPCs model the facility energy savings prior to determining the size of the solar PV system. The facility improvements lead to significant reductions from prior energy usage, therefore the solar PV project is smaller in size and saves the agency further as result.

TABLE 14 ESPC Project Details for Bernalillo County.

ECM No.	ECM Name	Guaranteed Annual Utility Savings	Annual O&M Savings	Total Annual Savings	ECM Labor, Equip & Material Budget Cost	Estimate Incentives	Net ECM Cost	SPB (Years)
1.00	HVAC Equipment and Controls	$247,204	$22,292	$269,496	$2,990,363	$45,442	$2,944,922	10.9
2.00	LED Lighting	$110,394	$26,611	$137,005	$2,115,259	$94,446	$2,020,813	14.7
3.00	Vacuum Sanitation System	$0	$0	$0	$113,355	$0	$113,355	----------
4.00	Solar PV System	$121,343	$0	$121,343	$2,549,526	$0	$2,549,526	21.0
5.00	Roofing Improvements	$0	$30,000	$30,000	$1,253,006	$0	$1,253,006	41.8
6.00	Landfill Gas Boiler	$17,271	$0	$17,271	$109,022	$0	$109,022	6.3
ECM Totals		$496,212	$78,903	$575,115	$9,130,532	$139,887	$8,990,644	15.6
Pre-Construction Fees								$559,125
Construction Fees (Includes ECM Labor Equipment & Materials Costs)								$10,108,806
Post-Construction Fees								$78,520
Project Total								$10,746,451

PPA Viability by IOU Utility

Of the three IOU utilities that serve New Mexico, PNM was the utility that demonstrated a positive savings for NMDOT facilities at each PV site scale. Table 15 shows that PNM provides a positive cost savings for all project sizes based on a default PNM rate structure (based on a GS – general services rate structure). Rate structures vary by location and based on the amount of energy a facility uses. Larger solar project sizes were not evaluated because there was no indication that NMDOT has the amount of load to develop a project of this scale.

TABLE 15 PPA Feasibility by Investor Owned Utility.

	Average IOU Bundled PPA ($0.10 kWh)		PNM Bundled		El Paso Electric Bundled		Xcel Energy Bundled	
	1st Year Savings/Cost	20 Year Savings/Cost	1st Year Savings/Cost	20 Year Savings/Cost	1st Year Savings/Cost	20 Year Savings/Cost	1st Year Savings/Cost	20 Year Savings/Cost
System Size								
10 kW Facility-level	-$410	-$2,837	$621	$22,539	-$894	-$14,766	-$956	-$16,283
75 kW Facility-level	-$3,366	-$28,533	$782	$73,588	-$4,605	-$59,027	-$6,276	-$100,161
200 kW Facility-level	-$9,679	-$91,509	$4,414	$255,441	-$14,602	-$212,695	-$18,850	-$317,272
500 kW Facility-level	-$23,644	-$215,137	$12,364	$671,321	-$36,260	-$525,725	-$47,036	-$791,007

PPA Viability by Rural Electric Cooperative

The research team assessed the viability of solar PV projects for the utilities that solar developers indicated are the most active in developing solar projects for each of the different system sizes of

10kW to 500kW. Table 16 and Table 17 show that of the six rural co-op utility districts, Continental Divide, Farmers' Electric, Jemez Mountains, Kit Carson, and Otero County each showed viable solar project potential for a combination of PV solar sized systems, as indicated by the positive savings (highlighted in green).

TABLE 16 PPA Feasibility by Rural Cooperative Utility.

	Average Rural Co-op Bundled PPA ($0.10 kWh)		Central NM Bundled		Continental Divide Bundled		Farmers' Electric Bundled	
	1st Year Savings/Cost	20 Year Savings/Cost	1st Year Savings/Cost	20 Year Savings/Cost	1st Year Savings/Cost	20 Year Savings/Cost	1st Year Savings/Cost	20 Year Savings/Cost
System Size								
10 kW Facility-level	-$70	$5,459	-$748	-$11,179	-$54	$5,920	$23	$7,816
75 kW Facility-level	$283	$61,290	-$2,101	$2,610	-$404	$44,394	$174	$58,610
200 kW Facility-level	-$63	$145,238	-$7,886	-$47,366	-$1,091	$119,924	$469	$158,328
500 kW Facility-level	-$1,862	$321,086	-$19,614	-$115,937	-$2,726	$299,812	$1,173	$395,820

TABLE 17 PPA Feasibility by Rural Cooperative Utility.

	Average Rural Co-op Bundled PPA ($0.10 kWh)		Jemez Mountains Bundled		Kit Carson Bundled		Otero County Bundled	
	1st Year Savings/Cost	20 Year Savings/Cost	1st Year Savings/Cost	20 Year Savings/Cost	1st Year Savings/Cost	20 Year Savings/Cost	1st Year Savings/Cost	20 Year Savings/Cost
System Size								
10 kW Facility-level	-$70	$5,459	-$211	$1,595	$138	$10,652	$435	$17,950
75 kW Facility-level	$283	$61,290	-$804	$34,537	$1,038	$79,874	$3,793	$147,717
200 kW Facility-level	-$63	$145,238	-$3,801	$53,200	$2,803	$215,770	$9,131	$371,570
500 kW Facility-level	-$1,862	$321,086	-$9,428	$134,824	$7,007	$539,426	$12,415	$672,572

PPA Viability for NMDOT and Solar Developer

One of the clear challenges to PPA project viability is the financial viability it provides for NMDOT as well as the solar developer or partner. Many of the PPA projects scenarios assessed both at the higher level for different PV scale, as well as site scale for specific NMDOT District facilities are not financially viable given the PPA price parameters that solar developers have shared to the research team. An additional step of analysis performed was to ascertain the PPA price that would result in positive savings to NMDOT facilities based on the project scale, their utility rate schedule, and current electricity usage.

Table 18 outlines the PPA electricity price that makes a project viable for NMDOT. These prices vary between $0.042 and $0.132. The research team then used the PPA break-even prices for NMDOT to determine the project viability for the solar developer. The research team discovered that the majority of projects that break even for NMDOT result in losses and long project paybacks making these projects infeasible for the developer. It is worth noting that all of the financial runs the research team performed on the behalf of the potential developer included capturing the Investment Tax Credit and Modified Accelerated Cost Recovery System project incentives. The takeaway from this table is that many of the projects that are breakeven for NMDOT Districts are not viable for a solar developer and therefore are unlikely to happen.

TABLE 18 Break-Even PPA Price for NMDOT Facilities.

		NMDOT Breakeven PPA Price ($ per kWh)	NMDOT 30 Year NPV ($)	Developer 30 Year NPV ($)	Developer Payback Period (years)
District 1					
District office (D1) Deming	200 kW	$0.123	$153,076	$22,498	12
Scenic View Rest Area, Las Cruces (D1)	15 kW	$0.062	$5,553	-$22,493	>30
Las Cruces Patrol Office (D1)	25 kW	$0.062	$9,254	-$32,645	>30
Solano Office, Las Cruces (D1)	120 kW	$0.047	$31,669	-$239,479	>30
District 2					
District Office/Complex (D2)	250 kW	$0.080	$118,669	-$216,151	19
Mesa Rest Area (D2)	50 kW	$0.132	$38,905	$10,917	11
District 3					
District Office (D3)	500 kW	$0.052	$166,865	-$677,441	>30
District 4					
District Office (D4)	250 kW	$0.064	$93,175	-$296,660	>30
Maintenance Patrol (D4)	15 kW	$0.127	$11,135	-$3,289	13
Rest Area (D4)	5 kW	$0.101	$2,982	-$8,754	>30
District 5					
District Office (D5)	300 kW	$0.061	$162,461	-$473,153	>30
Maintenance Patrol (Cerrillos) (D5)	10 kW	$0.124	$7,673	-$4,365	14
Rest Area Facility (La Bajada) (D5)	15 kW	$0.121	$11,196	-$3,855	13
District 6					
District Office (D6)	75 kW	$0.065	$27,620	-$82,914	>30
IT Building (D6)	35 kW	$0.066	$13,458	-$41,872	>30
Service Center (D6)	75 kW	$0.068	$26,070	-$78,432	>30
Milan Project Office (D6)	20 kW	$0.090	-$5,644	-$17,480	18
Milan Project Office 2 (D6)	10 kW	$0.065	$3,866	-$17,353	>30
Lab - Project Office (D6)	10 kW	$0.068	$3,887	-$16,755	>30
Pavement Crew (D6)	5 kW	$0.065	$3,737	-$17,353	>30
Heavy Maintenance (D6)	10 kW	$0.065	$3,851	-$17,353	>30
Cuba Patrol Main (D6)	10 kW	$0.090	$5,124	-$12,373	>30

Note: Green cells for NMDOT in the 30 Year NPV column result in negative values for the developer on a 30-year NPV and long payback periods that would impede a potential deal. Rest area projects are possible for NMDOT; therefore, they are included in the results.

PPA AND LEASE DISTRICT SUMMARY AND COMPARISON TABLE

District PPA Comparison

Table 19 shows an overview of each of the NMDOT District facilities and their level of project viability for a single PPA project ($0.13 for systems between 5kW and 75kW) and bundled PPA projects ($0.10 for systems larger than 120kw). Based on the values provided by solar developers only three of district facilities evaluated are viable for a single PPA project and six are viable for a bundled multi-project approach.

TABLE 19 PPA Comparison by District.

		Single Project PPA Price	Single PPA Project (20 Year Cash Flow)	Bundled Multi-Project PPA Price	Bundled Multi-Project PPA (20 Year Cash Flow)
District 1					
District office (D1) Deming	200 kW	$0.10	$190,065	$0.09	$258,073
Scenic View Rest Area, Las Cruces (D1)	15 kW	$0.13	-$33,006	$0.10	-$17,970
Las Cruces Patrol Office (D1)	25 kW	$0.13	-$55,009	$0.10	-$29,949
Solano Office, Las Cruces (D1)	120 kW	$0.10	-$200,278	$0.09	-$161,514
District 2					
District Office/Complex (D2)	250 kW	$0.10	-$136,653	$0.09	$9,875
Mesa Rest Area (D2)	50 kW	$0.13	$11,436	$0.10	$60,176
District 3					
District Office (D3)	500 kW	$0.10	-$784,825	$0.09	-$612,941
District 4					
District Office (D4)	250 kW	$0.10	-$274,439	$0.09	-$193,129
Maintenance Patrol (D4)	15 kW	$0.13	$765	$0.10	$15,401
Rest Area (D4)	5 kW	$0.13	-$3,943	$0.10	$848
District 5					
District Office (D5)	300 kW	$0.10	-$321,521	$0.09	-$219,715
Maintenance Patrol (Cerrillos) (D5)	10 kW	$0.13	-$289	$0.10	$9,802
Rest Area Facility (La Bajada) (D5)	15 kW	$0.13	-$2,054	$0.10	-$50,452
District 6					
District Office (D6)	75 kW	$0.13	-$149,514	$0.10	-$79,042
IT Building (D6)	35 kW	$0.13	-$68,884	$0.10	-$34,449
Service Center (D6)	75 kW	$0.13	-$143,723	$0.10	-$75,252
Milan Project Office (D6)	20 kW	$0.13	-$23,644	$0.10	-$4,424
Milan Project Office 2 (D6)	10 kW	$0.13	-$19,912	$0.10	-$9,503
Lab - Project Office (D6)	10 kW	$0.13	-$19,113	$0.10	-$9,503
Pavement Crew (D6)	5 kW	$0.13	-$9,159	$0.10	-$4,353
Heavy Maintenance (D6)	10 kW	$0.13	-$19,931	$0.10	-$10,321
Cuba Patrol Main (D6)	10 kW	$0.13	-$11,851	$0.10	-$2,527

District Airspace/Land Lease Comparison

Identifying the potential value of leasing NMDOT ROW or surplus property for larger-scale projects is a much simpler exercise. The value of money for leasing one acre in New Mexico per year was provided by solar developers is $250 to $750 per acre. The $250 per acre value may be offered but given the low amount of money that it would generate over a 20-year agreement and the transaction cost of developing the agreement for NMDOT staff is not worthwhile. Part of the low cost of airspace/land leases in New Mexico is the competition from other public and private landowners also interested in offering land for leasing to solar projects. About one-third of New Mexico's land is federally administered, and the state is second only to Wyoming in the number of producing oil and natural gas leases on federal land.

NMDOT's property management group provided airspace/land lease values for six NMDOT sites and Table 20 outlines airspace/land lease values which were provided by NMDOT properties staff. Note, the column "10% calculation value" is an internal NMDOT calculation. In the final row, are the solar values based upon the $250 to $750 per acre. While the values for solar are lower than other current NMDOT airspace/land leases, the sheer project scale of leasing an acre rather than a smaller area, in addition to leasing what would be a rural location, makes the $250 to $750 value reasonable.

The District level sections provide more detail on the scale of properties available for solar projects that could provide leasing revenue.

TABLE 20 Airspace Values for Current NMDOT Properties.

Lessee	Purpose	Market value ($ per ft^2/year)	Leased Area (ft^2)	Annual Value ($)	10% Calculation Value
Chase Oil	Landscaping	$0.80	2,665	$2,132	$213
Everyone's Federal Credit Union	Parking	$0.74	11,532	$8,500	$850
Willbanks Commercial Holdings	Parking	$0.80	2,840	$2,272	$227
United Church of Santa Fe	Landscaping	$3.25	4,574	$14,865	$1,487
India House Restaurant	Sign	$28.50	100	$2,850	$285
Solar Developer	*Solar*	*$0.057 to $0.17*	*43,650*	*$2,500 to $7,500*	*$250 to $750*

Results by District

This section provides results by NMDOT District "chapters" to show where the best value is possible in each NMDOT District. The focus of each of these chapters is on the PPA outputs given that they contain more complexity. Leasing projects are possible at any of the NMDOT Districts provided there is land available to develop a solar project. Note that while ease of implementation may be possible to assess at the partner and partnership type, financial feasibility may not be possible in all NMDOT Districts and specific on-site technical and site parameters will be unknown as they are outside the bounds of this scope of work. Sometimes these variables make or break a business model's feasibility and can include grid connection, security costs, or future land use considerations.

District 1

District 1

PPA Results:

The District 1 Office is the only facility the research team assessed for a NMDOT District that could save money over the course of a 20-year agreement. Note that the Deming office would make a favorable amount of money whether it is a single standalone project or bundled with other projects. The maximum amount of savings is estimated to be $258,073 over a 20-year period using a bundled PPA.

TABLE 21 District 1 PPA Results.

Facilities	Utility	Annual Usage (kWh)	Array Size (kW)	Avg Cost of Electricity to NMDOT	Current Annual Cost ($ per year)	Single PPA Savings ($ per year)	Single PPA Savings - 20 Years ($ per year)	Bundled PPA Savings ($ per year)	Bundled PPA Savings - 20 Years ($ per year)
District 1									
District office (D1) Deming	PNM	318,720	200 kW	$0.1293	$41,208	$7,770	$190,065	$11,123	$258,073
Scenic View Rest Area, Las Cruces (D1)	El Paso Electric	26,052	15 kW	$0.1960	$5,107	-$1,686	-$33,006	-$945	-$17,970
Las Cruces Patrol Office (D1)	El Paso Electric	43,825	25 kW	$0.1851	$8,113	-$2,810	-$55,009	-$1,575	-$29,949
Solano Office, Las Cruces (D1)	El Paso Electric	230,962	120 kW	$0.1464	$33,822	-$10,216	-$200,278	-$8,305	-$161,514

District Opportunities:

- **Land for PPA or leasing project:** The NMDOT District 1 has 9 parcels for a total of 28 acres available for development, with larger parcels available for solar development including: 11 acres (Santa Teresa Port of Entry – 10-2-NRW-1) and 3 acres (Santa Teresa Port of Entry#2 5-NRW-2). Average parcel size is approximately three acres.
- **Energy study:** District 1 had an energy study completed in 2012 and solar was addressed in that study.
- **Renewable energy policy:** In April 2018, Las Cruces City Council committed to 100% renewable energy generated for the community by 2050, with a 25% goal by 2022 (48).
- **Transmission line project:** A recently approved $2 billion-dollar transmission line project (SunZia Transmission Project) will be exporting power outside of the state. District 1 is situated in proximity to the transmission line and therefore could potentially provide electricity to this line (Figure 15). The map below shows the path of the transmission line going through the communities of Socorro, Truth or Consequences, Deming, and Lordsburg (46).
- **Solar potential:** The Deming Office has some of the highest solar potential in the state of New Mexico.
- **IOU site locations:** Significant number of PNM (Bayard, Belen, Cliff, Deming, Lordsburg and Silver City) and El Paso Electric (Anthony, Hatch, Las Cruces) locations.
- **Rural cooperative utilities**:
    - Columbus Electric
    - Sierra Electric
    - Socorro Electric

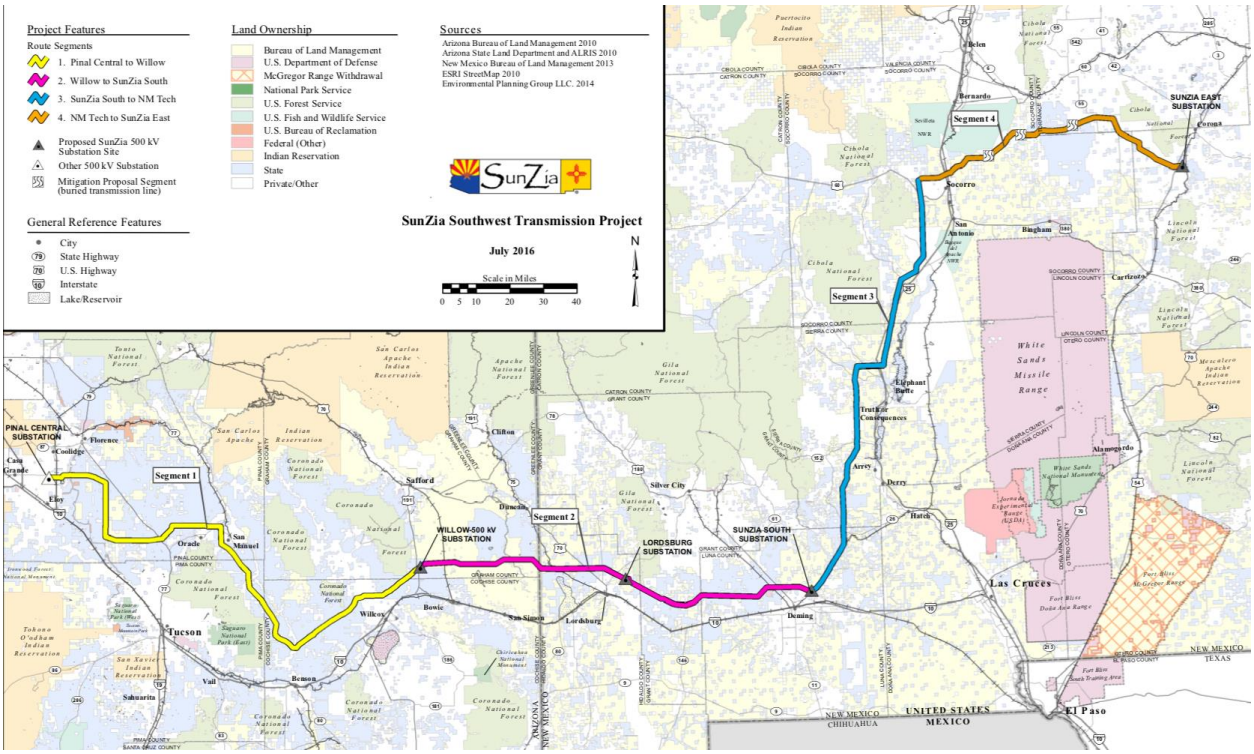

FIGURE 15 SunZia Transmission Project

District 2

District 2

PPA Results:

Both the NMDOT District 2 Office and the Mesa Rest Area could save money for NMDOT District 2 over the course of a 20-year agreement. Note that these projects would need to be bundled to achieve savings based on lower PPA price per kWh of $0.09 and $0.10, respectively. The maximum about of savings at NMDOT District 2 for a Bundled PPA over a 20-year period is $60,176 at the Mesa Rest Area.

TABLE 22 District 2 PPA Results.

Facilities	Utility	Annual Usage (kWh)	Array Size (kW)	Avg Cost of Electricity to NMDOT	Current Annual Cost ($ per year)	Single PPA Savings ($ per year)	Single PPA Savings - 20 Years ($ per year)	Bundled PPA Savings ($ per year)	Bundled PPA Savings - 20 Years ($ per year)
District 2									
District Office/Complex (D2)	Xcel Energy	414,564	250 kW	$0.0970	$40,213	-$7,977	-$136,653	-$4,020	$9,875
Mesa Rest Area (D2)	Central NM Co-op	80,016	50 kW	$0.1320	$10,562	$155	$11,436	$2,557	$60,176

District Opportunities:

- **Land for PPA or leasing project:** The NMDOT District 2 has 95 parcels for a total of 405 acres available for development, with larger parcels available for solar development

including: 63 acres (Roswell Bypass #2), 56 acres (Clovis Overpass), 43 acres (US 70 Kenna, NM), 32 acres (Roswell Bypass), and 20 acres (Alamo Relief/US70-US82). Average parcel size is approximately four acres.

- **IOU site locations:**
  - Alamogordo, Ruidoso, Tularosa (PNM)
  - Clovis, Portales, and Roswell (Xcel)
- **Rural cooperative utilities**:
  - Otero County
  - Central New Mexico
  - Central Valley Electric
- **NMDOT owned systems:** NMDOT District 2 expressed interest in NMDOT owner-operator PV systems.

Unique Challenges:

- **Served by multiple utilities:** Eight different utilities service NMDOT District 2 (two IOUs and six rural co-ops), the most of any district except for NMDOT District 5, which increases the complexity of completing a project. In order to manage this complexity, the research team recommends engaging one utility at a time, such as PNM.
- **Damage to panels from hail:** NMDOT District 2 mentioned the damage of hail to rooftops from prior year's storm events and was concerned about the potential of this causing operational issues with solar panels.

District 3

District 3

PPA Results:

The NMDOT District 3 office is the only facility that the research team evaluated for District 3 and is not a viable site for solar under a $0.09 or $0.10 PPA price per kWh. Given the scale of the array, it might be possible to negotiate with the solar developer for a lower PPA price. The research team analysis shows that a PPA price of $0.052 would be needed for NMDOT to break even the first year of the project and lead to savings over the 20-year period. This PPA price of $0.052 is highly unlikely to achieve.

TABLE 23 District 3 PPA Results.

Facilities	Utility	Annual Usage (kWh)	Array Size (kW)	Avg Cost of Electricity to NMDOT	Current Annual Cost ($ per year)	Single PPA Savings ($ per year)	Single PPA Savings - 20 Years ($ per year)	Bundled PPA Savings ($ per year)	Bundled PPA Savings - 20 Years ($ per year)
District 3									
District Office (D3)	PNM	1,074,560	500 kW	$0.1001	$107,569	-$40,401	-$784,825	-$31,929	-$612,941

Distinct Opportunities:

- **Urban District:** NMDOT District 3 is the most urban district and therefore has site locations near both the district facilities and nearby resident load.
- **IOU site locations:** Albuquerque, Los Lunas, and Rio Rancho (PNM)
- **Land for PPA or leasing project:** NMDOT District 3 has 59 parcels for a total of 47 acres available for development, with larger parcels available for solar development including: 8 acres (Los Lunas Main Street), 5 acres (Paseo Del Norte), and 4 acres (Paseo Del Norte #2). Average parcel size is less than one acre.

Unique challenges:

- NMDOT District 3 mentioned that facility buildings may be 40-50 years in age.

District 4

District 4

PPA Results:

The NMDOT District 4 office in Las Vegas is not viable to NMDOT at $0.09 and $0.10 PPA price per kWh. In order for this district to break even, it would require a $0.06 PPA price per kWh. Additionally, NMDOT District 4's maintenance patrol site has the potential to save the district close to $15,000 over the 20-year term of the agreement.

TABLE 24 District 4 PPA Results.

Facilities	Utility	Annual Usage (kWh)	Array Size (kW)	Avg Cost of Electricity to NMDOT	Current Annual Cost ($ per year)	Single PPA Savings ($ per year)	Single PPA Savings - 20 Years ($ per year)	Bundled PPA Savings ($ per year)	Bundled PPA Savings - 20 Years ($ per year)
District 4									
District Office (D4)	PNM	430,080	250 kW	$0.1042	$44,819	-$14,517	-$274,439	-$10,509	-$193,129
Maintenance Patrol (D4)	PNM	26,904	15 kW	$0.0752	$2,023	-$80	$765	$641	$15,401
Rest Area (D4)	Farmers	8,197	5 kW	$0.1960	$1,607	-$225	-$3,943	$11	$848

District opportunities:

- **Rural cooperative interest in solar:** The rural co-ops Farmer's Electric and Kit Carson Electric are interested in increasing solar in their portfolios. Kit Carson set a goal in 2017 of serving its customers' electricity demand on sunny days with 100 percent solar energy by 2022; however, Kit Carson is developing most of its projects in coordination with Guzman, LLC so they are unlikely to work on projects outside of offsetting NMDOT facility electricity usage.
- **IOU site locations:**
    - Clayton and Las Vegas (PNM)
    - Santa Rosa and Tucumcari (Xcel)
- **Rural cooperative utilities**:
    - Farmers' Electric
    - Kit Carson Electric
    - Mora-San Miguel Electric

- Southwestern Electric

Unique Challenges:

- **Land for PPA or Leasing Project:** NMDOT District 4 has 9 parcels for a total of 1.34 acres available for development. The average parcel size is less than a quarter acre.

District 5

District 5

PPA Results:

The NMDOT District 5 office, the district's largest user of electricity, is not a viable site for solar under a $0.09 or $0.10 per kWh PPA price. However, given the proposed 400kW system, it might be possible to negotiate with the solar developer for a lower kWh PPA price that would provide a worthy return. Our analysis shows that a PPA price of $0.061 per kWh would be needed for NMDOT to break even the first year of the project and lead to savings of $9,800 over the 20-year period.

TABLE 25 District 5 PPA Results.

Facilities	Utility	Rate Schedule	Annual Usage (kWh)	Array Size (kW)	Array Cost	Avg Cost of Electricity to NMDOT	Current Annual Cost ($ per year)	Single PPA Savings ($ per year)	Single PPA Savings - 20 Years ($ per year)	Bundled PPA Savings ($ per year)	Bundled PPA Savings - 20 Years ($ per year)
District 5											
District Office (D5)	PNM	3B	646,400	300 kW	1,039,973	$0.1104	$71,388	-$17,128	-$321,521	-$12,110	-$219,715
Maintenance Patrol (Cerrillos) (D5)	PNM	2A	16,343	10 kW	$42,420	$0.1316	$2,150	-$94	-$289	$403	$9,802
Rest Area Facility (La Bajada) (D5)	PNM	2A	23,493	15 kW	$58,543	$0.1410	$3,312	-$218	-$2,054	-$2,487	-$50,452

District Opportunities:

- **Santa Fe population and resource load:** Covering the Santa Fe area and having available property in such close proximity to an urban population and electricity demand should reflect the opportunity for specific projects that could offset not just NMDOT electricity usage but also that of the adjacent population. These projects could be located in cloverleaves or be local solar gardens similar to the work Minnesota DOT is planning in urban centers.
- **Land for PPA or leasing project:** NMDOT District 5 has 81 parcels for a total of 144 acres available for development, with larger parcels available for solar development including: 24 acres (Santa Fe Relief - PH1 - NM599), and 6 acres (Santa Fe Relief #2). The average size of a parcel is 1.78 acres.
- **Rural cooperative solar interest:** The rural co-ops Central New Mexico, Kit Carson, and Continental Divide Electric are interested in increasing solar in their portfolios.
- **IOU site locations:**
  - Santa Fe (PNM)
- **Rural cooperative locations**:
  - Central New Mexico
  - Jemez Mountains Electric Cooperative
  - Kit Carson Electric
  - Mora-San Miguel Electric
  - Northern Río Arriba Electric

Unique Challenges:

- **Served by multiple utilities:** Six different utilities service NMDOT District 5, the most of any district except for District 2, which increases the complexity of completing a project. In order to manage this challenge, the research team recommends engaging one utility at a time, such as PNM.

District 6

District 6

PPA Results:

For NMDOT District 6, the research team assessed the largest number of facilities; however, most of the facilities are small in scale and energy usage and were difficult to establish financial feasibility. In order to break even, these sites would need to pay a $0.06 to $0.09 per kWh for solar produced electricity. Based upon this analysis, no NMDOT District 6 sites are viable under a PPA partnership, given the PPA pricing that developers provided.

TABLE 26 District 6 PPA Results.

Facilities	Utility	Rate Schedule	Annual Usage (kWh)	Array Size (kW)	Array Cost	Avg Cost of Electricity to NMDOT	Current Annual Cost ($ per year)	Single PPA Savings ($ per year)	Single PPA Savings - 20 Years ($ per year)	Bundled PPA Savings ($ per year)	Bundled PPA Savings - 20 Years ($ per year)
District 6											
District Office (D6)	Continental Divide	LPS	109,960	75 kW	$252,023	$0.1200	$13,195	-$7,699	-$149,514	-$4,192	-$79,042
IT Building (D6)	Continental Divide	LPS	57,788	35 kW	$123037	$0.1100	$6,357	-$3,537	-$68,884	-$1,841	-$34,449
Service Center (D6)	Continental Divide	LPS	142,500	75 kW	$252,023	$0.1400	$19,950	-$7,394	-$143,723	-$4,012	-$75,252
Milan Project Office (D6)	Continental Divide	LPS	26,748	20 kW	$74,667	$0.1000	$2,675	-$1,275	-$23,644	-$328	-$4,424
Milan Project Office 2 (D6)	Continental Divide	LPS	20,536	10 kW	$42,420	$0.1100	$2,259	-$1,021	-$19,912	-$510	-$9,503
Lab - Project Office (D6)	Continental Divide	LPS	20,520	10 kW	$42,420	$0.1100	$2,257	-$983	-$19,113	-$510	-$9,503
Pavement Crew (D6)	Continental Divide	LPS	13,369	5 kW	$42,420	$0.1100	$1,471	-$473	-$9,159	-$236	-$4,353
Heavy Maintenance (D6)	Continental Divide	LPS	15,532	10 kW	$42,420	$0.1200	$1,864	-$1,022	-$19,931	-$549	-$10,321
Cuba Patrol Main (D6)	Jemez Mountains	3	17,790	10 kW	$42,420	$0.1600	$2,846	-$639	-$11,851	-$179	-$2,527

Distinct Opportunities:

- **Rural co-ops:** The rural co-ops Continental Divide Electric is interested in increasing solar in their portfolio.
- **Land for PPA or leasing project:** NMDOT District 6 staff mentioned the possibility of utilizing adjacent property to the district office for a solar array. Additionally, there are a couple of interchange locations that could serve as ROW sites; however, those sites are far from nearby load.
- **Rural cooperative locations**:
    - Continental Divide
    - Navopache
    - Socorro Electric

Unique Challenges:

- **Limited ROW:** NMDOT District 6 mentioned that much of the highway ROW area is restricted to clear zone only.

- **Limited surplus properties:** NMDOT District 6 has a limited amount of surplus property to establish solar projects. Projects would therefore need to focus on rooftop systems given the limitation of space for ground mounted systems.
- **No IOU coverage:** NMDOT District 6 is the only district not to have any of its facilities with major IOU providers such as PNM, El Paso Electric or Xcel.
- **Large territory to cover:** NMDOT District 6 covers 6,000 square miles of territory thus increasing the costs of maintenance as many sites are located in rural locations.
- **Vandalism concern:** NMDOT District 6 expressed concern over existing vandalism at schools targeting solar lighting.

PRIORITY NMDOT DISTRICTS

PPA Project Ranking

For the purposes of developing PPA related projects, the following are the most likely projects in the amount of savings potential and should be prioritized for consideration by NMDOT.

- District 1 Office in Deming: ~$258,000 savings over 20-year period
- District 2 Mesa Rest Area: ~$60,000 savings over 20-year period
- District 4 Maintenance Patrol: ~$15,000 savings over 20-year period

Airspace/Land Lease Projects

The following are the best opportunities for airspace/land leasing projects by NMDOT District based on the amount of available land. The NMDOT Right of Way Bureau Property Management Unit has details on the following surplus property parcels:

- NMDOT District 1 has 9 parcels for a total of 28 acres available for development.
- NMDOT District 2 has 95 parcels for a total of 405 acres available for development.
- NMDOT District 3 has 59 parcels for a total of 47 acres available for development.
- NMDOT District 4 has 9 parcels for a total of 1.3 acres available for development.
- NMDOT District 5 has 81 parcels for a total of 144 acres available for development.
- NMDOT District 6 has 2 parcels for a total of 0.35 acres available for development.

ESCO

Based on interviews with ESCOs serving the State of New Mexico, solar projects can be included in ESPCs as long as the $1 million overall project threshold is met. There are facility upgrades that would constitute utility and operation and maintenance savings that could assist in solar project inclusion. Nearly every NMDOT District that the research team interviewed indicated that building facilities were in significant need of upgrades, so it is extremely likely that either at an individual district level, but certainly at the agency level, there are enough facilities to warrant an ESPC project that can save money for NMDOT Districts.

CONCLUSION AND RECOMMENDATIONS

CONCLUSIONS

Solar is Feasible for NMDOT

NMDOT solar projects are feasible in the highway ROW, in addition to NMDOT properties and facilities. Additionally, each of the three partnership types are feasible; however, each of these project site contexts (ROW, surplus property, facilities) and partnership types (PPA, airspace/land lease, ESPC) are viable only in certain specific areas and locations.

Preferable Applications for Solar Based on Location

ROW and Surplus Properties

ROW and surplus property projects will generally be feasible for the large project size. 1MW or larger PV systems are ideal but necessitate four acres or more. State DOTs that have had the most success have developed large systems with partners. Solar developers prefer to do projects of 1MW or larger as well, given that the transaction costs for developing a project are similar for a small system as they are for larger systems. Certainly, large systems will take more staff and calendar time, however, the proportion of those costs is smaller relative to the larger projects. Therefore, it is most advantageous to NMDOT, as well as the developer, to bundle projects together or select projects of larger size. If NMDOT modifies the utility accommodation policy to include renewable energy projects it will reduce the challenge to implementing rest area or highway ROW solar projects.

NMDOT Facilities

Facilities with energy usage patterns coupled with conducive utility rate schedules are viable for the NMDOT District 1 Office in Deming (~$258,000 in cumulative savings), NMDOT District 2 Mesa Rest Area (~$60,000 in cumulative savings), and NMDOT District 4 Maintenance Patrol (~$15,000 in cumulative savings) over 20-year periods using PPA agreements.

Preferable Applications for Solar Based on Partnership Type

Bundle PPA Projects with PNM

As part of this feasibility analysis, only a portion of NMDOT facilities were assessed for project feasibility. Rather than identifying individual solar projects, the research team recommends focusing on one utility where a bundled project or program could be aggregated. PNM serves five of the six NMDOT Districts, has the most conducive rate schedules of the three Investor Owned Utilities and could be a pathway to implement multiple solar projects programmatically rather than doing projects individually.

Lease Feasible Surplus Land and ROW Based on Developer Interest

Airspace/land leasing is a viable option for NMDOT, yet the agency is limited in its ability to initiate this type of opportunity and competes with other public and private landowners interested in leasing their own land for solar. Land leasing is dependent upon site conditions, available ROW areas and market prices. In some situations, the transaction cost associated with internal NMDOT staff and project coordination may be greater than the value of lease income. However,

the improved public relations due to visibility of projects to the traveling public is an important project goal. The research team modeled 1MW and 5MW systems and would provide NMDOT airspace/land lease income between ~$21,500 and ~$325,000 over a 20-year period.

ESPCs the Best Vehicle for Solar Deployment at DOT Facilities
ESPCs are the best short-term project opportunity, of the three partnership pathways assessed in this study. This ESPC approach could be used to retrofit and upgrade existing electrical, heating, and water infrastructure in NMDOT buildings facilities at a cost savings, while installing solar. ESPCs are the best agreements for smaller roof type solar systems of 10-500 kW capacity in which several maintenance facilities can be bundled together to achieve overall improved energy savings. Project investment by an ESCO would need to be $1 million or more to merit developing a project, which could encompass one project or multiple projects at either the district or NMDOT agency level throughout the state.

Critical Factors for Financial Feasibility of Solar PV Projects for NMDOT

NMDOT Vision and Support
Solar projects will require NMDOT project management time, direction, and support from the NMDOT general office. Other state DOTs have emphasized the need for programs to involve multiple levels of an organization to not only develop buy-in, but also to ensure that there is at least one project champion and a team that can bring a project through to completion. To achieve a successful project, a significant level of effort will be needed by the project manager and staff to coordinate project conceptualization, procurement, developer selection, legal assessment, site selection, NEPA impacts (if any) and overall contractor management.

Utility Pricing and Utility Specific Rate Schedules
Perhaps the most significant challenge to the financial feasibility of solar projects for NMDOT, is the shift in utility rate schedules. In New Mexico, and in other states, electric utilities are experiencing the erosion of energy demand, as customers continue to develop net-metered distributed solar PV, reduce their demand through efficiency measures, and the use of other onsite power generation. This shift in how people power their homes, businesses, and industrial facilities is leading to utilities losing revenue. As a result, utilities have shifted their rate schedules to move the cost of electricity from the price for consumption to demand charges in order to cover the cost of distribution. Utilities are using the rationale that customers, whether they are using electricity or producing it, require the distribution and transmission capability of the utility and that cost should be shared. For the average customer, the shift in utility rate schedules does not generally mean more cost, however for the solar producer, the benefit projects made before the shift in rate schedules was much higher, leading to positive cash flow projects. This is why only 3 of the 22 facilities demonstrated a positive savings for NMDOT, based on the thresholds the PV developers need to make projects financially feasible for their companies.

Utilities to Engage
- For the three IOUs in New Mexico – PNM has the most conducive rate structure for the NMDOT facilities assessed.

- For rural electric cooperatives – Continental Divide, Farmers' Electric, Jemez Mountains, Kit Carson, and Otero County are the most viable for the NMDOT facilities that the research team assessed.
- Rural coops can only supply so much renewable electricity given the 5% cap.

Electricity Load and Site Conditions
Solar project feasibility is contingent on the viability of a project to either offset energy costs or provide energy to an offtaker that uses that energy. Additionally, site locations and their associated opportunities or constraints will dictate feasibility.

- Compared to other state DOTs that have implemented solar projects, NMDOT has relatively low electricity demand near the highway ROW because NMDOT is generally not responsible for roadway lighting costs in urban areas.
- Some NMDOT Districts have ample ROW and surplus property, while others do not. Identifying which of these sites meet project requirements is key to project development. NMDOT's property management and utility sections both affirmed that some New Mexico roadways do not have available ROW outside of the clear zone to facilitate a solar system. Both sections mentioned that interstate highway ROWs are wider (150-400 feet) than state highway's (30-40 feet) ROW parcels. An additional consideration is the makeup of ownership of adjacent parcels to the ROW or surplus properties as there is a significant amount of land in public or tribal ownership, which could complicate project development.
- During the site assessment phase, outlined in the Narrative Guide, NMDOT should consider identifying which stretches of roadway are conducive for solar projects.
- Most NMDOT Districts mentioned the challenge of facility and administrative buildings that need significant maintenance including electrical, heating, and water systems. It is possible for some of these sites the condition of the roof structure would not be adequate to install solar either due to structural integrity and/or the need for a new waterproof surface. These facilities may need new roofs, more structure or these sites could utilize ground mounted solar systems.

RECOMMENDATIONS

Focus Near Term Project Development in PNM Territory

One of the challenges in New Mexico is the large number of investor owned utilities (IOUs) and rural cooperatives. Rather than identifying individual solar projects, the research team recommends a project focusing on one utility where projects could be bundled into an aggregated program. The logical place to start is with PNM, because PNM serves five of the six NMDOT Districts and is the largest utility and balancing authority in the state. Also, PNM has demonstrated interest and novel approaches in working with solar advocates and the large-scale solar project with Facebook. As a first step, NMDOT should consider collecting all of the current facility usage information for each district facility in PNM territory. With this information in hand, NMDOT can begin conversations with PNM and a local solar developer capable of this project scale to roll up multiple NMDOT facilities.

Pursue an ESPC

Implement an ESPC via a local ESCO and the EMNRD's program, that either bundles projects at the District level or does some on behalf of NMDOT as an entire agency, to improve District

facilities and reduce overall operating costs for each District while deploying solar that offsets energy use. Hiring a facility asset management position at the General Office would be a prudent option to not only engage large untapped savings for building improvements but could also coordinate some of the tasks necessary to develop priority solar projects.

Conduct Site Assessments and Engage Solar Developers for One-Off Solar Development
Initiate a conversation with a solar developer (Affordable Solar, Positive Energy, RES), preferably local, and share the results of this financial analysis as well as the identification of priority PPA locations for project development. Determine if the solar developer is interested in evaluating the potential to develop individual projects and whether they will conduct some of the due diligence to establish project feasibility and assist with prioritization of site assessments.

If NMDOT prefers to not engage a solar developer initially, the agency could conduct the site assessment with internal staff and resources or involve a solar advocate or consultant/contractor. Regardless of whether NMDOT engages a solar developer or solar advocate, the agency should continue to stay in contact with specific utilities that could serve as potential partners, including PNM and select rural cooperatives that are interested in solar (Central New Mexico Electric, Continental Divide Electric, Jemez Mountains Electric Cooperative, Farmers' Electric, Kit Carson Electric, Northern Río Arriba Electric, Otero County Electric).

Air/Land Lease Opportunity
To establish interest in larger project from a solar developer or utility, NMDOT should declare its interest to solar developers and utilities that NMDOT has land available to lease. This interest was communicated during this research plan via communication with potential partners, however a worthwhile next step for NMDOT would be to formally communicate with partners and confirm interest in using NMDOT property for larger scale solar PV projects.

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APPENDICES

Appendix A contains links to reference documents that will aid the reviewer in developing a solar program. For hard copies of these cited documents please contact NMDOT's research team at New Mexico Department of Transportation's Research Bureau at 7500B Pan American Freeway NE, Albuquerque, NM 87109 (PO Box 94690, Albuquerque, NM 87199-4690). Appendix B contains a listing of lessons learned from the eleven solar projects discussed in the main document. Appendix C is a stand-alone Narrative Guide that provides a step by step process on how to initiate a solar project. Appendix D provides copies of financial model runs for the feasibility analysis.

APPENDIX A. A COMPILATION AND SUMMARY OF DOT POLICY DIRECTIVES AND CONTRACT AGREEMENTS FOR SOLAR ENERGY PROJECTS

State DOT and FHWA Solar Reference Information

This appendix provides an overview of reference information that will aid in developing a solar project within the NMDOT ROW. This section will discuss and provide links to case studies, DOT projects, reference manuals, utility accommodation plans, procurement materials, PPA templates and contractual agreements. Many of these documents are pdf files and can be obtained from the New Mexico Department of Transportation's Research Bureau at 7500B Pan American Freeway NE, Albuquerque, NM 87109 (PO Box 94690, Albuquerque, NM 87199-4690).

As part of the initial policy reviews, eleven (11) state DOT and tollway projects were identified that have implemented or are actively developing solar projects. Please see the State DOT and Tollway Best Practices (main document) and State DOT and Tollways Lessons Learned Project Details (Appendix B) for specific information and lessons learned from those state DOTs and tollways.

Case Studies and State DOT Solar PV Projects

- **FHWA Headquarters:** The FHWA manages a mapping tool that visually displays the state DOT highway renewable energy projects in the United States. The map identifies projects by renewable energy type (solar, wind, hydro) and location (ROW, rest area) as well as providing a thumbnail description of the project. Source: https://www.fhwa.dot.gov/real_estate/right-of-way/corridor_management/alternative_uses.cfm
- **AASHTO Center for Environmental Excellence:** AASHTO has published case studies of energy and GHG reduction projects online highlighting work by Massachusetts, Oregon, and Vermont. Source: https://environment.transportation.org/environmental_topics/energy_greenhouse/case_studies.aspx#bookmarksubCaltransWorkstoAdvanceSmartMobilityApproach

State DOT manuals and case study information

Most state DOTs do not have a significant amount of information related to their solar PV sites on their agency websites; however, a few state DOTs post their solar development plans and related information to the public.

- **Florida Department of Transportation:** FDOT commissioned a study to evaluate the project viability for the Turkey Lakes project. Solar Power at the Turkey Lake Service Plaza: A Project Analysis and Best Practices Guide. http://www.fdot.gov/research/Completed_Proj/Summary_TPK/FDOT-BDV24-977-01-rpt.pdf
- **Oregon Department of Transportation:** Oregon DOT developed the first solar development manual with support from USDOE and updated the manual in November 2016. http://www.oregon.gov/ODOT/Programs/Solar%20Highway%20documents/Solar-Highway-Program-Guidebook.pdf

- **State Smart Transportation Initiative (SSTI):** In 2016, SSTI published a compendium of materials gathered from state DOTs siting solar PV projects in the highway ROW. Their website provides a database of materials on the following project aspects: easements, environmental impacts, guidance, health and safety, legislation, PPAs, RFPs and similar documents (RFIs, RFRs, RFOs), and site characteristics. Source: https://www.ssti.us/2016/09/renewable-energy-in-the-right-of-way/
- **Vermont Department of Transportation:** In December 2016, VTrans published a solar development plan to outline their agency's intent and policies, key considerations for solar PV projects in the Vermont context, and implementation, in addition to guidance documents for FHWA and procurement. Source: http://vtrans.vermont.gov/sites/aot/files/VTrans-SolarPlan-2016-12-08-FINAL.pdf

Utility Accommodation Plan

NMDOT is currently updating its UAP and the research team shared two examples with ROW staff. Additionally, we are sending those documents to the NMDOT research team for future use.

- Massachusetts Department of Transportation: 5 – Telecommunication and Renewable Energy, pages 32-49 https://www.massdot.state.ma.us/Portals/8/docs/utilities/UAP.pdf
- Vermont Agency of Transportation: Chapter Two: Location and Design Standards ("Utility Accommodation Plan") http://vtrans.vermont.gov/sites/aot/files/highway/documents/rightofway/UAP%20Final%20March%202016.pdf

Procurement Materials (RFR, RFP and RFI)

To aid in the announcement and procurement of solar projects for NMDOT, the research team has complied RFR, RFP and RFI and contractual agreement template documents for reference.

- Arizona Department of Transportation: Request for Information RFI P3-16-03 – Solar P3 Project (provided as a pdf to NMDOT team)
- Caltrans: Green Highways Solar solicitation (provided as a pdf to NMDOT team)
- Florida Department of Transportation and Florida's Turnpike Enterprise: RFP For Ground Mounted Photovoltaic System FPID: 429985-1-B2-01 (provided as a pdf to NMDOT team)
- Maryland: Request for Proposal – https://emaryland.buyspeed.com/bso/external/bidDetail.sdo;jsessionid=5081621B4AAD4EFA2D7F0E7D290E20FB?bidId=MDJ0131033497&parentUrl=activeBids
- Massachusetts Department of Transportation: Request for Response https://www.ssti.us/wp/wp-content/uploads/2016/09/MassDOT_2013EnergyProgram_RFR_MA.pdf
- Massachusetts Department of Transportation: Request for Proposals – Solar Photovoltaic Project (provided as a pdf to NMDOT team)
- Michigan Department of Transportation: Request for Proposal (provided as a pdf to NMDOT team)
- Minnesota Department of Transportation: Request for Proposals – Solar Array Installation and Lease (provided as a pdf to NMDOT team)
- New York Thruway and NYSDOT Region 5: Request for Proposal and PPA Agreement Template

https://www.dot.ny.gov/portal/pls/portal/MEXIS_APP.BC_CONSULTING_NONAE_ADMIN.VIEWFILE?p_file_id=20403

- Ohio Department of Transportation: RFP Evaluation of Advance Energy Gateway Rest Areas (provided as a pdf to NMDOT team)
- Sacramento Municipal Utility District. Request for Offer: Sacramento Solar Highways (provided as a pdf to NMDOT team)
- Xcel Energy and Soltura REC Purchase Contract (provided as a pdf to NMDOT team)

Contractual Agreements

The following documents and agreements can provide guidance to NMDOT on other state DOT and government examples.

- Interstate Renewable Energy Council: Solar Power Purchase Agreements – A Toolkit for Local Governments, example PPA and site agreements. https://irecusa.org/wp-content/uploads/2015/07/Solar-Power-PPA-Toolkit_FINAL_041015.pdf
- Massachusetts Department of Transportation: Solar License and Power Purchase Agreement. https://www.ssti.us/wp/wp-content/uploads/2016/09/MassDOT_Draft_SolarLicensePPA_MA.pdf
- Oregon Department of Transportation: Generic Site License Agreement (provided as a pdf to NMDOT team)
- Vermont Agency of Transportation: Power Purchase Agreement and Lease Agreement with AllEarth Renewables (provided as a pdf to NMDOT team)

APPENDIX B. STATE DOT AND TOLLWAYS LESSONS LEARNED PROJECT DETAILS

State DOTs (listed alphabetically)

1. Hawaii (HDOT)- Hawaii Airport Solar Project
2. Massachusetts DOT- Bundled ROW
3. New York (NYSDOT)- Region 5 Solar Program
4. New York Thruway Solar Program
5. Oregon (ODOT)-I-5/I-205 Solar Project
6. Oregon (ODOT)- Baldock Safety Rest Area
7. Vermont (VTrans)- Fair Haven Welcome Center
8. Utah (UDOT)- Rampton Motorpool Project

Tollways

9. Florida Turnpike Enterprise- Turkey Lake Service Plaza
10. Northwest Parkway- Colorado
11. E-470 Tollway Solar Program- Colorado

Hawaii DOT Airport Energy Savings Project

- **Project name**: Hawaii DOT Airport Energy Savings Project
- **Agreement or partnership type**: Energy Performance Savings Contract (20-year performance period)
- **Transportation entity**: Hawaii DOT (Airport Division)
- **Overview:** In December 2013 the Hawaii DOT (HDOT) entered into an energy savings contract with a third-party, energy savings company Johnson Control, Inc. This performance-based contract guaranteed an energy use reduction by 49% by installing energy efficiency measures that included solar energy generation. The project bundled 12 state airports. Total payments to the contractor cannot exceed total savings; therefore, if HDOT savings are not achieved annually Johnson Controls will pay the shortfall. Overall for Phase I, nine,100 PV panels were installed at airports that in total generated 2.6 megawatt of solar energy. Phase II is installing 15,683 roof mounted panels producing 5.3 megawatts of power; therefore, in total 8 megawatts of electrical power will be generated. HDOT did not pay any upfront cost and Johnson Controls guarantees contract established savings. Solar energy provided the least 7-10% percent return on the contract value whereas lighting improvements generated the highest percent return.
- **Solar system type**: Roof Mounted
- **Project driver**: Governor directive of 70% clean energy use for the entire State of Hawaii by 2030; 100 percent renewable energy generation by 2045. The sustainable generation of solar energy with infrastructure efficiencies led to significant cost savings to HDOT.
- **Cost incentives**: Guaranteed energy cost savings from contract agreement; $167.7 million of bond certificates sold and receiving $1.1 billion from investors.
- **Partners to the agreement**: Johnson Controls, Inc.
- **Utility partner**: Hawaiian Electric Company
- **Party responsibility for infrastructure ownership, security, installation and long-term maintenance costs, liability for damage and vandalism**: Johnson Controls, Inc.
- **Agreement specify responsibility for ownership and buyback**: 20- year performance with the potential for HDOT acquisition specified in the contract.
- **Copies of actual agreements**: Contract was over 1,000 pages and was not provided by Hawaii DOT.
- **Anticipated costs and revenues prior to the construction as well as actual (post-implementation) costs and revenues (identify if no data and why)**: HDOT expected an energy cost savings (electricity and water) for the first year at $15.9 million with $22.4 million average annual savings after first year. The overall contract guaranteed HDOT a savings of $776 million. This project is the largest performance savings contract in the USA. Solar energy is 5-7% of the total savings and is not a major savings component.
- **Project meet expected outcomes and/or reasons for failing to meet expected outcomes**: Project met all cost saving projections identified by Johnson Controls and HDOT and the project is very successful. The project is now into a second phase of work.
- **Agency, local, state, federal legal/regulatory constraints and how addressed and overcome**: No federal money was used in this project and a NEPA assessment was not needed. The project was deemed a retro fit that eliminate some regulatory requirements. Overall there were no major regulatory constraints.

- **Main lessons learned**:
    - Contractor performance and responsiveness may decrease over time due to the nature of the performance contract. Write in responsiveness expectations into the contract.
    - Be aware of unnecessary energy savings verification actions written into the contract by contractors; they are expensive and may be unnecessary in some areas.
    - Be aware that Energy Performance Savings contractors operate under risk and will strive to take advantage of any cost opportunity.
    - Be aware of cost contingency plans in the contract and ensure unused funds are returned by the contractor to the client.
    - Ensure contractor has a transparent subcontractor program that specifies bids and expenditures.

- **Project contact:** Jeff Chang, Engineer and Project Manager; jeff.chang@Hawaii.gov, 808-838-8835

Massachusetts DOT- Bundled Right of Way Project

- **Project name**: Massachusetts DOT- Bundled Right of Way Project
- **Agreement or partnership type**: Power Purchase Agreement with a master license agreement (MLA) that provides airspace/land lease income.
- **Transportation entity**: Massachusetts DOT
- **Overview**: MassDOT has implemented the largest state solar generation project within the state highway ROW with eight bundled solar projects completed with a total capacity of 4.3 MW and six additional sites of 3.5 MW to be completed in a future phase. The future Phase 2 will be started once net metering rules are finalized in at the state level. MassDOT and its project/program manager took a lot of their learning from the Oregon DOT solar experiences and have since shared a considerable amount of experience from their own project implementation. Massachusetts developed Phase IA and IB of a highway ROW bundled project with Ameresco and Table 27 outlines the projects included in that bundle. MassDOT developed a request for response (RFR) which identified 16 of the most suitable MassDOT properties for solar development after a site selection process. MassDOT started with more than 600 potential properties. The list was reduced from 600 to 60 and then MassDOT staff prioritized the list further to 16 locations. The main factor responsible for narrowing the list of potential sites was interconnection proximity. The RFR outlined generation capacity, potential site locations, interconnection readiness, and local permitting processes. Ameresco worked in two different utility districts to install solar systems in the highway ROW at 10 different site locations. The PPA and lease agreement covered each of these sites under one agreement. Subsequent implementation of solar projects under Phase 2 is waiting for net metering changes at the state level.
- **Solar system type**: 10 ground mount solar PV systems for a total capacity of 5.4 MW. Systems sizes range from 271 kW to 649 kW.
- **Project driver**: The state of Massachusetts has a very aggressive statewide GHG reduction target of 80% by 2050 and there is an effort by state agencies to lead by example in installing solar projects. In order to meet the GHG reduction targets, the state has developed a suite of mandates and incentives to implement solar projects.
- **Cost incentives**: MassDOT purchases power at a reduced price for the duration of the 20-year agreement. MassDOT also receives a small amount of income from the airspace/land lease portion of the agreement. Figure 16 shows the financial benefit of the PPA agreement to MassDOT (SSTI, 2016). The developer benefits by retaining all incentives associated with the generation of solar energy, including tax incentives, particularly the Solar Renewable Energy Credits (SRECs) that are available in the State of Massachusetts. Additionally, Massachusetts net metering policy allows qualified customers to obtain net metering credits (NMC) for exporting excess power to the grid via virtual net metering, a policy not available in most states. Figure 1 shows the amount of PPA payments that MassDOT pays Ameresco annually for the electricity it uses (shown in red) in contrast to the net metering credits that MassDOT receives from electricity sold back to the utility (shown in light green) and the lease payment income from Ameresco (shown in dark green). On net, MassDOT is making money on its Phase I projects.
- **Partners to the agreement**: Ameresco, an ESCO
- **Utility partner:** Eversource Energy (Phase IA) National Grid (Phase IB)

- **Party responsibility for infrastructure ownership, security, installation and long-term maintenance costs, liability for damage and vandalism**: As part of the master airspace/land lease agreement with Ameresco the agreement is a public-private partnership which requires the contractor to finance, build and maintain the project, as well as satisfy the necessary operations and maintenance of the facilities.
- **Agreement specify responsibility for ownership and buyback**: Per the contract with Ameresco, the developer is obligated to decommission the solar farms, remove everything they have installed on MassDOT properties and restore the sites to their original state at the end of the 20-year contract period. However, MassDOT has the option at the end of year 15 to decide whether it is in our interest to purchase the systems at the end of the 20th year, and if it is, MassDOT will negotiate with the developer on the acceptable prices. The RFP for the Phase I bundle and the technical requirements in the agreement were specified (general photovoltaic requirements, PV racking requirements, land use requirements/ civil requirements, electrical equipment requirements, electrical design requirements, energy production modeling, regulatory requirements). This document can be accessed via links provided in Appendix A.
- **Anticipated costs and revenues prior to the construction as well as actual (post-implementation) costs and revenues (identify if no data and why**): MassDOT did not complete a rigorous financial analysis prior to engaging Ameresco. Instead MassDOT staff calculated the savings in electricity price and modeled future pricing to ensure that the PPA price would continue to benefit the DOT financially. The additional financial incentive structures in Massachusetts make a project there much more financially feasible than other states. A cost forecast spreadsheet was not available from MassDOT.
- **Project meet expected outcomes and/or reasons for failing to meet expected outcomes**: Phase I project installations have met expected financial outcomes. However, MassDOT is currently waiting for the decision on net metering policies that may affect future project implementation. MassDOT was not able to provide specific financial details for individual projects but is willing to talk to NMDOT staff or interested parties by phone regarding financial details.
- **Agency, local, state, federal legal/regulatory constraints and how addressed and overcome**: MassDOT worked closely with the FHWA regional office from the beginning. FHWA was very supportive of projects and objections related to safe access. MassDOT does charge the developer a market rate for the airspace/land lease and MassDOT's real estate office does market evaluation prior to proposal release in order to address this potential constraint. Utility type and location is another constraint referred to in the main plan.
- **Main lessons learned**: MassDOT mentioned that the following were important lessons learned:
    - Internal coordination important in project acceptance
    - Utility interconnection location critical
    - Physical constraints on sites with low population nearby with no load and expensive studies can derail potential projects.
- **Project contact:** Hongyan (Lily) Oliver, Ph.D., Environmental & Energy Analyst / Planner, 857-368-9025, hongyan.oliver@state.ma.us

Table 27: MassDOT Phase 1A and 1B Locations.

Phase IA Locations	Installed Capacity (kW DC)	Projected Annual Output (kWh)	CO2 Emission Reduction (MT)
Framingham I90 Interchange 13 N	649	845,647	369
Framingham I90 Interchange 13 S	649	845,647	369
Framingham I90 WB Service Plaza	318	417,216	182
Natick I90 WB Embankment	271	355,552	155
Plymouth Route 3 Exit 5	567	728,028	317
Salisbury, District 4 Depot	649	845,647	368
Phase IB Locations			
Stockbridge I90 @ Interlaken East 1	649	845,647	368
Stockbridge I90 @ Interlaken East 2	417	472,711	236
Stockbridge I90 @ Interlaken West	649	845,647	368
West Stockbridge I90 Exit 1	649	845,647	368
Total	**5,467**	**7,125,967**	**3,102**

FIGURE 16 MASSDOT PPA-LEASE FINANCIAL ANALYSIS

NYSDOT – Region 5 Solar Project

- **Project name**: New York State Department of Transportation (NYSDOT) Region 5 Solar Project
- **Agreement or partnerships type**: Power Purchase Agreement
- **Transportation entity**: NYSDOT Buffalo Region 5
- **Project overview**: The NYSDOT Region 5 solar project is the first of several solar projects created by the NYSDOT. The solar project provides power to both engineering resident and maintenance facilities. Twelve sites were bundled into one pilot project under a 15-year PPA with up to five 2-year renewals. Total solar power generated by NYSDOT is 1,400 KW capacity resulting in 1.6 million kWh production. The project is part of a statewide solar program that will generate 20 million kWh of electrical production. The statewide solar program addresses solar energy generation in both state and interstate ROWs.
- **Solar system type**: Ground mounted and roof installations (12 locations bundled).
- **Project driver**: The main project driver was not energy cost reduction. The governor and New York state legislature has passed legislation for a 40% reduction in greenhouse gases by 2030. In an effort to provide sustainable energy as dictated by the Governor, 20% of the electrical energy used state wide by NYSDOT will be provided by solar energy. The main driver is to reduce carbon emissions to mitigate climate change conditions. Overall NYSDOT strives to be a leader in clean energy by leveraging DOT owned assets to enhance the use of solar energy and to support state solar businesses.
- **Cost incentives**: Business Energy Investment Tax Credit provided 30% tax credit to the developer. No energy rebates were used by NYSDOT or the developer. Under the Modified Accelerated Cost Recovery System equipment depreciation is allows over five years.
- **Partners to the agreement**: Solar Liberty Services, Monolith Solar Associates
- **Utility partner**: New York State Electric & Gas, Rochester Gas & Electric
- **Party responsibility for infrastructure ownership, security, installation and long-term maintenance costs, liability for damage and vandalism**: The 15-year PPA specifies that the developer is responsible for these infrastructure items. No project costs were paid by NYSDOT for the entire project.
- **Agreement specify responsibility for ownership and buyback**: The PPA requirements specified that the developer is responsible for all upfront ownership costs such as capital costs and long-term maintenance. There is no text in the PPA template regarding system buyback over a given period of time.
- **Copies of actual agreements:** The PPA agreement template is incorporated within the provided RFP document can be found via links referenced in Appendix A. Actual formal contract agreements between NYSDOT and selected developers were not obtained.
- **Anticipated costs and revenues prior to the construction as well as actual (post-implementation) costs and revenues (identify if no data and why):** No cost models were used by NYSDOT and cost estimations were provided by developers based upon bundled projects. Power costs were expected to be less than current utility rates.
- **Project meet expected outcomes and/or reasons for failing to meet expected outcomes**: The project was initiated in 2016. To date, NYSDOT believes that the project

is progressing towards meeting its goals to reduce carbon emissions while providing lower cost electrical energy. Data is limited in the reduction in greenhouse gas emissions.

- **Agency, local, state, federal legal/regulatory constraints and how addressed and overcome**: Gaining FHWA approval on the placement of solar systems within the interstate system was an initial obstacle. Access issues along the interstate mainline and interchange ramps was a major concern to FHWA. It was important for NYSDOT to be strategic with FHWA and not to approach them too soon in the project conceptualization stage. NYSDOT gave FHWA an argument that according to New York State Article 9 Energy Law energy development would reduce operational costs.
- **Main lessons learned**:
  - Anticipate a lot of project manager and staff time to coordinate development of RFPs, contracts, coordinate with procurement and manage solar developers.
  - There was a lot of variability in cost energy savings associated with different regions and bundling by developers.
  - Developing good relationships with FHWA and utilities is important towards gaining approvals.
  - Be prepared to have solar sites selected before meeting with FHWA; NYSDOT pre-screened 50 potential sites before FHWA would buy off on the overall solar strategy and approach.
  - Work with safety engineering to obtain a 50-foot clear zone for solar installation.
  - Learn how to talk solar development with developers and utilities.
  - Anticipate working closely with legal counsel about ROW usage and PPA contract agreements.
- **Project contact:** Mark Grainer, Community Development & Technical Assistance Unit Statewide Planning Bureau, Project Manager, Mark.Grainer@dot.ny.gov

New York Thruway Solar Project

- **Project name**: New York Thruway Solar Project
- **Agreement or partnership type**: Power Purchase Agreement
- **Transportation entity**: New York Thruway Authority
- **Overview**: The New York Thruway Authority in partnership with the New York State Department of Transportation's Solar Initiative is developing solar generation systems at six locations. These six locations are being designed and constructed by two different solar developers. The solar projects are currently in the design phase; it is expected that the construction will start in July 2018.
- **Solar system type**: Ground mounted
- **Project driver**: The main driver was not energy cost reduction. The governor and New York state legislature has passed legislation for a 40% reduction in greenhouse gases by 2030. In an effort to provide sustainable energy as dictated by the governor, 20% of the electrical energy statewide by NYSDOT will be provided by solar energy. The ultimate driver is to reduce carbon emissions to mitigate climate change conditions. Overall the New York Thruway with NYSDOT strives to be a leader in clean energy by leveraging owned assets to enhance the use of solar energy and to support state solar businesses.
- **Cost incentives**: Business Energy Investment Tax Credit provided 30% tax credit to the developer No energy rebates were used by NYSDOT or the developer. Under the Modified Accelerated Cost Recovery System equipment depreciation is allows over five years.
- **Partners to the agreement**: Solar Liberty Services, Monolith Solar Associates, LLC
- **Utility partner**: New York State Electric & Gas, Rochester Gas & Electric
- **Party responsibility for infrastructure ownership, security, installation and long-term maintenance costs, liability for damage and vandalism**: The responsibility for these items is carried by the solar developer as per PPA.
- **Agreement specify responsibility for ownership and buyback**: 180-day notice of intent to purchase at full market value.
- **Copies of actual agreements**: See Appendix A for PPA and RFP template documents.
- **Anticipated costs and revenues prior to the construction as well as actual (post-implementation) costs and revenues (identify if no data and why)**: No initial cost estimates were developed by the New York Thruway for potential financial returns. Developers were expected to generate financial information at part of the PPA.
- **Project meet expected outcomes and/or reasons for failing to meet expected outcomes**: The project is finishing up the design phase and just initiating construction; therefore, no metrics for success have been developed or achieved to date.
- **Agency, local, state, federal legal/regulatory constraints and how addressed and overcome**: FHWA did not approve of two potential solar sites within the interstate due to access issues. No access would be allowed from the mainline or ramps within interchanges. Worked closely with FHWA to gain approval on six solar sites.
- **Main lessons learned**:
    - Sites within the ROW requires a NEPA process such as a categorical exclusion which can add time and resources to a project.

- Expect to manage unknown elements since this is new to DOTs; therefore, be flexible and anticipate potential problems.
- New types projects for procurement and contracts that can increase project timelines.
- Take advantage of other state agencies who have expertise in energy and utilities discussions and negotiations since they are familiar with technical and legal aspects of energy projects.
- Consider a solar project as an interdisciplinary project; therefore, many internal departments and resources need to be part of the overall project process early and often.
- Watch out for unknown costs such as potential large grid connection fees by utilities that may get passed onto the DOT via electrical rate charges.
- Important to have an executive level champion that will help drive the project through many departments and other bureaucratic areas
- Expect extended time to work with internal and external attorneys for RFP development and contract development and party negotiations

- **Project contact**: Elizabeth Novak, Project Manager; Elizabeth.Novak@thruway.ny.gov, 518/436-3046.

New York Thruway Solar Project Area

Oregon DOT- Interstate-5/Interstate-205 Solar Project

- **Project name**: Interstate-5/Interstate-205 Solar Project
- **Agreement or partnerships Type**: Power Purchase Agreement
- **Transportation entity**: Oregon Department of Transportation (ODOT)
- **Overview**: Oregon was the first state DOT to implement a solar PV project and received positive attention nationwide; however, the project was challenged by learning via trial and error. ODOT have worked hard to share these lessons to move the solar deployment faster by issuing solar development guidance. The solar program started via interest and direction generated by state leadership such as former Secretary of State Bill Bradbury to reduce greenhouse gases and to slow climate change. The 104-kW dc ground mounted solar array consists for 594 175-watt dc solar panels and produces about 130,000 kWhs annually, which meets about 1/3 of interchange lighting needs. The solar project supported the green technology, one of the mandates for the state. In addition, having the solar array located in a prominent cloverleaf interchange of two major freeways (I-5/I-205) served a public education and public relations benefit.
- **Solar system type**: Ground mounted
- **Project driver**: Reduce carbon emissions for climate change mitigation which was driven by the Governor and legislature.
- **Cost incentives**: The State of Oregon legislature provided $1 million to build the solar program and another appropriation was received from the United States Department of Energy (USDOE) as a 50%-50% matching grant. The State of Oregon portion was paid by the state transportation budget. The Oregon Business Energy Tax Credit covered 50 percent of the project cost, an incentive that is no longer available the state level. A federal tax credit covered 30 percent and offered accelerated depreciation for the solar panel owners. The Energy Trust of Oregon provided a grant of $175,000 from a fund paid by Oregon electric utility customers.
- **Partners to the agreement**: Bank of America, SolarWorld and PV Powered
- **Utility partner**: Portland General Electric (PGE).
- **Party responsibility for infrastructure ownership, security, installation and long-term maintenance costs, liability for damage and vandalism**: The PV solar producer was required to warranty the panels 25 years as stipulated in the RFP. Bank of America and PGE are responsible for ownership for the project. ODOT is not responsible for maintenance for the duration of the agreement. This agreement is not publicly available nor is the specific financial analysis that was used to evaluate the project.
- **Agreement specify responsibility for ownership and buyback**: The duration of the agreement is a 25-year timeframe with the potential for two additional individual year periods under renewal terms identified in the site license agreement. There is no buyback option in the agreement.
- **Copies of actual agreements**: ODOT has made agreements available to the research team including the site license agreement and RFP evaluation criteria and these documents are included in Appendix A. Additionally resources for Oregon's program are included on page 58 of Oregon's Solar Highway manual and this solar manual's link is provided in Appendix A.

- **Anticipated costs and revenues prior to the construction as well as actual (post-implementation) costs and revenues (identify if no data and why):** Due to the involvement of third-party private entity partners, the details of the cost analysis are mostly confidential. However, ODOT's cost of electricity purchase for solar was pegged at the same value that it pays for electricity from PGE at $0.06 per kWh and annually this figure amounts to $6,700.
- **Project meet expected outcomes and/or reasons for failing to meet expected outcomes**: The project met the public education benefit by promoting solar throughout the U.S. and the world by sharing information on their program with 34 states and 14 countries. Carbon emissions were reduced but not quantified.
- **Agency, local, state, federal legal/regulatory constraints and how addressed and overcome**: ODOT did confront challenges internally. Even though the project did not require large amounts of capital from ODOT, some ODOT staff believed solar energy generation was not part of the DOT's mission.
- **Main lessons learned**:
  - Solar projects take time and require a project champion.
  - Challenge of mission alignment from some state DOT staff to see the connection between solar and transportation.
  - Depending upon site locations, the public can be challenging to work with and may push back based on aesthetic impacts and safety, therefore it might be best to site solar systems away from neighborhoods.
- **Project contact:** Geoff Crook, Sustainability Program Manager; (503) 881-8358, Geoff.s.crook@odot.state.or.us

Oregon DOT-Baldock Solar Safety Rest Area

- **Project name:** Baldock Solar Safety Rest Area
- **Agreement or partnership type:** Power Purchase Agreement
- **Transportation entity:** Oregon Department of Transportation (ODOT)
- **Overview:** The Baldock Solar Station is a 1.75-megawatt solar array of nearly 7,000 solar panels across seven acres of the Baldock Safety Rest Area, located on Interstate 5. Portland General Electric (PGE) operates and maintains the Baldock array under a lease arrangement with Bank of America, which financed and owns the project. The energy goes into the PGE grid to serve PGE customers, including the State of Oregon and ODOT. Visitors to the rest area can learn about solar power and Oregon's solar highway installations through a variety of interpretive displays. Construction began in August 2011 and was completed on January 2012.
- **Solar system type:** Ground mounted
- **Project drivers:** Reduce carbon emissions for climate change mitigation which was driven by the Governor and legislature. The main focus was to reduce carbon emissions to address climate change, assist solar companies in the state using green technologies and offer public education on solar technologies.
- **Cost incentives:** The ODOT project garnered a significant amount of grant funding given that it was an early adopter of solar in the highway ROW. The project benefited from the following funding sources: (1) $1 million from State of Oregon legislature to build solar program, (2) appropriation from the USDOE was a 50%-50% matching grant, (3) state portion paid by state transportation funding, (4) Oregon Business Energy Tax Credit covered 50% of the project cost, (5) federal tax credit covered 30% and offered accelerated depreciation (MACRS) for the solar panel owners, (6) The Energy Trust of Oregon also provided a grant of $175,000, from a fund paid by Oregon electric utility customers.
- **Partners to the agreement:** Portland General Electric, Bank of America, SolarWorld, Aadland Evans Constructors, Moyano Leadership Group, Advanced Energy Systems
- **Utility partner:** Portland General Electric (PGE)
- **Party responsibility for infrastructure ownership, security, installation and long-term maintenance costs, liability for damage and vandalism:** The PV solar producer was required to warranty the panels 25 years as stipulated in the RFP. Bank of America and PGE are responsible for ownership for the project. ODOT is not responsible for solar system maintenance for the duration of the agreement.
- **Agreement specify responsibility for ownership and buyback:** The duration of the agreement is a 25-year timeframe with the potential for two additional, individual year periods under renewal terms identified in the site license agreement. There is no buyback option in the agreement.
- **Copies of actual agreements:** ODOT has made agreements available to the research team including the site license agreement and RFP evaluation criteria and these documents are included in Appendix A. Additionally resources for Oregon's program are included on page 58 of Oregon's Solar Highway manual and this solar manual's link is provided in Appendix A.

- **Anticipated costs and revenues prior to the construction as well as actual (post-implementation) costs and revenues (identify if no data and why):** Due to the involvement of third-party private entity partners the details of the cost analysis are confidential.
- **Project meet expected outcomes and/or reasons for failing to meet expected outcomes:** The solar highway program met some of the intended outcomes that it set out to accomplish but at a basic level the vision of the program was to deploy solar on multiple locations within the highway ROW which it did not achieve because ODOT did not see the mission alignment given the significant amount of staff time and agency oversight to bring a project to bear.
- **Agency, local, state, federal legal/regulatory constraints and how addressed and overcome:** ODOT did incur project development challenges that many other state DOTs have learned to streamline and better understand prior to engaging a program or project. Oregon worked with the Department of Justice to define and develop a utility accommodation plan that could accommodate the solar project. ODOT is challenged by mission alignment as ODOT staff do not see the connection between solar and transportation. ODOT has decided to sell properties rather than to deploy its staff resources to implementing future solar projects.
- **Main lessons learned:**
    - Solar projects take time and require a project champion.
    - The Baldock project required tunneling under the highway to ensure that it had the proper interconnection which was expensive.
    - Depending upon site locations, public can be challenging to work with and may push back on aesthetic impacts and safety, therefore it might be best to site solar systems away from neighborhoods.
- **Project contact:** Geoff Crook, Sustainability Program Manager; (503) 881-8358, Geoff.s.crook@odot.state.or.us

Vermont Transportation – Fair Haven Welcome Center

- **Project name**: Fair Haven Welcome Center
- **Agreement or partnership type**: Purchase Power Agreement
- **Transportation entity**: Vermont Transportation (VTrans)
- **Overview**: VTrans developed a single-axis 75kW system at Fair Haven Welcome Center using a net metering, no-cost approach in partnership with AllEarth Renewables. This is the only project that VTrans developed in the highway ROW with a third-party developer that had a statewide pricing agreement with the state of Vermont. The rest of VTrans solar projects were financed, installed and maintained by VTrans staff.
- **Solar system type**: Ground mounted
- **Project driver**: VTrans pursued solar development to reduce costs, stabilize budgets, increase operational resiliency, reduce GHGs, and demonstrate leadership to peer agencies.
- **Cost incentives**: Traditional private-side solar incentives were available to commercial private developer including investment tax credit and Modified Accelerated Cost Recovery System.
- **Partners to the agreement**: AllEarth Renewables
- **Utility partner**: Fair Haven
- **Party responsibility for infrastructure ownership, security, installation and long-term maintenance costs, liability for damage and vandalism**: AllEarth Renewables was responsible for these items via the PPA.
- **Agreement specify responsibility for ownership and buyback**: VTrans has the option of buying the solar array at year seven for a fair market value based on a negotiated price agreement between AllEarth and VTrans. If VTrans does not purchase the array, the PPA agreement is for a 20-year term, which can be extended based on negotiation.
- **Copies of actual agreements**: AllEarth Renewables agreement with VTrans (see Appendix A).
- **Anticipated costs and revenues prior to the construction as well as actual (post-implementation) costs and revenues (identify if no data and why)**: Costs were not evaluated by the VTrans project team prior to the beginning of the project. VTrans relied upon the expertise of the state of Vermont's Buildings and General Services to develop cost estimates. The developer gets a significant enough return that at Year 7 they can sell the depreciated value to the state of Vermont and see a return on investment (ROI) of 14-20%. This arrangement provides the state an additional 15 years of free electricity at a minimum. For the purposes of the 2016 solar plan, Good Company developed the financial analysis comparing owner-operator (VTrans owned) systems and compared those to developer financed and owned systems. The findings are shared in Table 28. A VTrans owned system is less advantageous than a developer system. In large part, the rationale for this difference is that the third-party developer captures the tax incentives. VTrans projects did financially work over a 20-year timeframe due to the PPA pricing, the reduced costs of solar infrastructure and the staff labor to construct and maintain the solar systems.
- **Project meet expected outcomes and/or reasons for failing to meet expected outcomes**: According to Dan Dutcher (VTrans), the project has only earned $6,500 since its installation in 2016; however, the project is meeting desired outcomes as the agency

sees them as "good policy as long as there is some positive return on investment over time." However, the time and process to build this project was meant to fore runner to other Vermont agency solar projects, which has not yet occurred due to net metering constraints.

- **Agency, local, state, federal legal/regulatory constraints and how addressed and overcome**: In their process, VTrans needed to amend their Utility Accommodation Plan by adding a new section on renewable energy generation using MassDOT's plan as a guide for specific language. VTrans discovered following the installation at Fair Haven Rest Area their legal limitation in participating in any further net metered projects; therefore, VTrans is currently identifying larger sites that might be viable to partnerships with utilities or third-party developers. To that end, VTrans is conducting a site assessment of properties that are between 1-50 acres on highway ROW that have three-phase power nearby. VTrans may be a good point of contact moving forward as they are planning on approaching no-cost solar projects similar to NMDOT interest.
- **Main lessons learned**:
  - VTrans published a solar development plan in 2016 which included a financial assessment of different approaches. One unique option was a hybrid approach to project development whereby the state DOT would use a third-party to finance and develop the project. After a select timeframe, for example, five to seven years, the state DOT would have the option of purchasing the solar PV project at a price that was much more reasonable for the DOT. The price would be more reasonable because by that point in the project the developer would have already recuperated project costs via project incentives.
  - Most of VTrans solar PV projects have been installed at maintenance facilities or airports. The owner-operator approach reduces the costs to the agency for a solar project using internal staff resources; however, the VTrans was not able to take advantage of financial incentives that were only available to taxable entities such as developers. Project overview provided at https://www.ssti.us/wp/wp-content/uploads/2016/06/VTrans-Solar-Initiative-SSTI-June-15-2016.pdf
  - Leverage assistance from other agencies. VTrans relied upon the assistance of Vermont's Buildings and General Services.
- **Project contact**: Dan Dutcher, Senior Environmental Policy Analyst 802-498-4540, daniel.dutcher@vermont.gov

Table 28 Financial Analysis Input and Results.

Inputs

Category	Owner Operator Net Metered	3rd Party Developer 20-Year Contract	3rd Party Developer w/Year 7 Buyback	
System Info	Value	value	value	Unit
System Size - Installed Capacity	61	61	61	kW DC
Site Category	Category II	Category II	Category II	category designation
Annual System Output - Year 1	1,100	1,100	1,100	kWh / kW AC
Annual System Output - Year 1	67,100	67,100	67,100	kWh / year 1
Annual Degradation Rate	0.5%	0.5%	0.5%	annual % decrease
Useful Life of System	30	20	30	years
Cumulative System Output	1,867,058	1,278,255	1,867,058	kWh / useful life
Cost of Electricity	value	value	value	unit
Annual Onsite Load	40,260	40,260	40,260	kWh / year
Cost of Grid Power / Blended Residential Rate	$ 0.1480	$ 0.1480	$ 0.1480	$ / kWh
Grid/Blended Cost Escalation Rate	1.3%	1.3%	1.3%	annual % increase

Results

Category	Owner Operator Net Metered	3rd Party Developer Net Metered 20-Year Contract		3rd Party Developer Net Metered w/Year 7 Buyback	
Costs and Payback	VTrans	VTrans	3rd Party	VTrans	3rd Party
Project First Costs ($)	($132,000)	$ -	($178,059)	$ -	($178,059)
Buyback Cost - Year 7 ($)				($68,671)	$ 68,671
O&M Costs ($ / project life)	($44,853)	$ -	$27,584	($36,254)	($8,600)
Simple Payback (years post VTrans investment)	10.5			4.9	
Levelized Cost of Energy ($ / kWh)	$ 0.09		$ 0.12		
Net Present Value (NPV)					
Year 7	($59,631)	$5,915	$7,637	($46,503)	$8,617
Year 10	($35,694)	$8,156	$8,442	($22,566)	
Year 20	$8,993	$11,926	$5,708	$22,453	
Year 30	$41,709	$14,777	$22,791	$55,751	
Internal Rate of Return (IRR)					
Year 7	-10.0%				
Year 10	-1.2%				
Year 20	5.8%				
Year 30	7.7%				
Summary of Project Values ($)					
Electricity - Year 1	$ 10,602	$ 998	$ 9,603	$ (4)	$ 10,606
Electricity - Useful Life	$ 397,718	$ 19,626	$ 226,618	$ 318,766	$ 78,952
Renewable Energy Certificates (year 10)	$ 19,677		$ 19,677	$ 5,797	$ 13,880
Federal Tax Credits			$ 50,213		$ 50,213
Depreciation			$ 65,468		$ 59,176
Estimate of Avoided External Labor Cost	$ 48,119				

Florida Turnpike Enterprise – Turkey Lake Service Plaza

- **Project name**: Turkey Lake Service Plaza
- **Agreement or partnership type**: Direct capital expense in panel purchase construction and maintenance (Owned and operated by Florida Department of Transportation (FDOT) and Florida Turnpike Enterprise).
- **Transportation entity**: Florida Turnpike Enterprise and Florida FDOT.
- **Overview:** In 2012, the Florida Turnpike Enterprise and FDOT completed the installation of a ground mounted system at its Turkey Lake Service Plaza Facility located near Orlando, Florida. The system generates 112 kW DC and offsets energy usage for the service plaza buildings. 468 SolarWorld SunModule Plus SW240 mono PV modules, covers a half an acre and produces 167,500 kWh/year. A contract was awarded for the 112-kW size PV system at a cost of $450,000, with the construction schedule starting in January 2012 and completion was scheduled for March 2012. The project was completed and connected to the utility grid in August 2012. After completing the FDOT punch list, the project was deemed ready for operation in October 2012.
- **Solar system type**: Ground mounted
- **Project driver**: FDOT and Florida Turnpike Authority were interested in solar ROW projects to reduce state DOT costs, offset state DOT energy use, and showcase solar projects to public for education and outreach.
- **Cost incentives:** The incentive for the solar PV installation was being able to acquire an $127,920 rebate from Duke Energy which represented 28% of the project cost.
- **Partners to the agreement**: Florida Turnpike Enterprise and FDOT. The University of Florida provided assistance in a research study published in 2010: https://www.slideshare.net/SrikanthMadala1/a-comprehensive-solar-energy-power-system-for-the-turkey-lake-plaza.
- **Utility partner:** Duke Energy
- **Party responsibility for infrastructure ownership, security, installation and long-term maintenance costs, liability for damage and vandalism:** A turnkey PV system was provided by the contractor using a standard state contact who was responsible for all aspects of the project; design, component selection, engineering, permitting, site preparation, construction, installation, and performance verification.
- **Agreement specify responsibility for ownership and buyback:** Florida DOT owned the entire project and the PV system had a 10-year guarantee on materials and panels.
- **Copies of actual agreements:** The research team did not receive actual agreements, however, the FDOT commissioned the report *Solar Power at the Turkey Lake Service Plaza: A Project Analysis and Best Practices Guide* that provides useful information to the project responsibilities and lessons learned. http://www.fdot.gov/research/Completed_Proj/Summary_TPK/FDOT-BDV24-977-01-rpt.pdf
- **Anticipated costs and revenues prior to the construction as well as actual (post-implementation) costs and revenues (identify if no data and why):** The project was initiated with a $500,000 budget ($50,000 held in contingency) which was allocated to the FDOT Research Center. The total estimated cost to FDOT was to be $322,080 which included the $127,920 rebate. Once the contractor was selected, an additional $19,245 was allocated to the project to add 9.36kW of installed PV capacity. Additionally, $10,255 was allocated to install fencing to protect the site. After all costs, the project came to a total of $351,580 or

$3.13 per watt in DC nameplate rating. Post-construction analysis indicated that given the total cost, anticipated generation, and electricity cost displacement would result in a payback period beyond 25 years.

- **Project meet expected outcomes and/or reasons for failing to meet expected outcomes**: The project met financial goals broadly with a payback period of 25 years of a project lifetime of 25 years. Although the project did not represent a significant savings overall and part of the rationale for this was the much higher solar costs in 2012. The commissioned report indicates that future projects should be more successful financially.
- **Agency, local, state, federal legal/regulatory constraints and how addressed and overcome**: Florida doesn't allow public agencies to enter into PPAs; therefore, FDOT had to purchase the solar panels with agency funds. This requirement for the agency to use budgetary funds significantly hindered the agency as it meant prioritizing solar projects over DOT direct mission projects.
- **Main lessons learned:**
    - Assign staff members to be in charge of project management and as a project liaison.
    - Procurement took more time and staffing costs were higher than anticipated at the beginning of the project.
    - Ensure that performance guarantees in the agreement stipulate responsibilities and confirm the use of high-quality equipment and its proper installation.
    - PV solar systems do require maintenance and the cost associated for maintenance was estimated to be $8 per kW annually.
    - PV solar projects may find challenges with internal and external staff and stakeholders. FDOT staff noted that electric utilities may not be interested in solar projects due to their lack of business and environmental interest.
    - Conduct a feasibility study on specific sites and potential projects to reduce the risk of entering projects that may incur more costs than they save.
- **Project contact:** Jon Heller, MRP and Roadside Manager Jon.Heller@dot.state.fl.us (The research team conducted an email exchange with Jon but was not able to interview him by phone)

Utah DOT- Rampton Motorpool Carports

- **Project name:** Rampton Motorpool Carports
- **Agreement or partnership type:** Owned and Maintained by Utah Department of Transportation (UDOT)
- **Transportation entity:** Utah Department of Transportation (UDOT)
- **Project overview:** The concept of generating solar energy generation within the UDOT ROW was started by Governor Huntsman in 2006. It was then realized that Utah had extensive solar energy resources in solar insolation, available land resources and wind potential. Initially wind turbines were evaluated for energy generation; however, the amount of area needed for turbines base foundations was too large to fit outside the clear zone area. PV systems were then evaluated due to smaller area requirements and ease of implementation. Phase 1 of the Rampton Project was started in February 2017 and completed in November 2017. Phase I generated 93 kW with total project cost of $214,791. Phase 2's total funding of $371,000 was received in February 2018 and will generate 270 kW. UDOT worked with the local utility who funded the projects via grants of 75% of the total project cost. It is envisioned that UDOT will be using a PPA agreement for Phase 2 to reduce or eliminate maintenance costs and improve site selection. There is interest on rest area solar power generation for public visibility in addition to other ROW areas.
- **Solar system type:** Roof mounted (buildings and car ports)
- **Project driver:** Making the most efficient use of solar resources within the State of Utah to improve the environment and being energy cost effective.
- **Cost incentives:** Local utility provided 75% of project costs for Phase I and 2. No tax rebates were used.
- **Partners to the agreement:** Rocky Mountain Power
- **Utility partner:** Rocky Mountain Power, no developer identified to date for Phase 2.
- **Party responsibility for infrastructure ownership, security, installation and long-term maintenance costs, liability for damage and vandalism:** Expected to be covered within the PPA.
- **Agreement specify responsibility for ownership and buyback:** Expected to be covered within the PPA.
- **Copies of actual agreements:** No agreements established yet for Phase 2.
- **Anticipated costs and revenues prior to the construction as well as actual (post-implementation) costs and revenues (identify if no data and why):** No costs are available at this time. UDOT will hire an outside consultant or developer to do a cost feasibility study.
- **Project meet expected outcomes and/or reasons for failing to meet expected outcomes:** Rampton Project Phase 1 has been successful in providing UDOT visibility to the public and providing energy for electric vehicle charging.
- **Agency, local, state, federal legal/regulatory constraints and how addressed and overcome:** FHWA is supportive of the project as long as safe access to the solar power system site can be demonstrated.

- **Main lessons learned:**
  - Candidate solar sites need to consider interconnection capabilities and transmission line capacity within corridors.
  - Important to have an internal site approval process that includes impacted DOT departments (environmental, maintenance, ROW management, engineering).
  - Identify success metrics early to measure success of the project.
  - Give developers flexibility in identifying potential solar locations in addition to identifying desired DOT locations.
  - Expect a procurement learning process to initiate PPA projects for solar development.
  - Ensure flexibility in the solar site location for future highway expansion.
- **Project contact:** Tim Ularich, PE, Deputy Maintenance Engineer, timularich@utah.gov

Northwest Parkway-Colorado (Tollway)

- **Project name**: Northwest Parkway Solar Project Colorado
- **Agreement or partnership type**: Power Purchase Agreement
- **Transportation entity**: Northwest Parkway (NWP), Broomfield Colorado
- **Project overview**: The NWP solar project represents a total investment of about $350,000 entirely funded by the solar developer at no cost to the NWP. Seven solar energy systems with 62 kW power capacity with an annual generation estimated at 91,000 kwh along the toll road were installed in 2011. The project benefited from the Renewable Energy Credits (RECs) generated and locked rebate and purchase agreements offered by Xcel Energy. Besides its economic value, NWP was mostly driven by its social and environmental value. Thus far the project produced about 654,000 kWh, offsetting the equivalent of about 589 tons of CO2 emissions.
- **Solar system type**: Ground mounted (seven individual areas)
- **Project driver**: Internal NWP Sustainability Program
- **Cost incentives**: Xcel rebate, RECs
- **Partners to the agreement**: Soltura Energy Capital
- **Utility partner**: Xcel Energy
- **Party responsibility for infrastructure ownership, security, installation and long-term maintenance costs, liability for damage and vandalism**: The PPA specifies that the developer is responsible for these items.
- **Agreement specify responsibility for ownership and buyback**: Developer contractually responsible for all upfront capital costs and long-term maintenance. An option for a buy back was after 6 years of solar system operation.
- **Copies of actual agreements:** Requested and considered confidential.
- **Anticipated costs and revenues prior to the construction as well as actual (post-implementation) costs and revenues (identify if no data and why):** A rough internal desk top spreadsheet was developed by the project manager; however, the developer calculated projected and actual costs and revenues. PPA agreement specifies energy cost to NWP from developer at $0.052/kWh with a 3.5% escalation rate.
- **Project meet expected outcomes and/or reasons for failing to meet expected outcomes**: The project met expected outcomes in energy cost and carbon emission reductions. Project reduced energy costs by 37% between 2008 and 2017 with a projected 20-year savings of approximately $250,000. Project is consistent with the internal sustainability program that provided a reduction in carbon dioxide emissions and great public relations benefit as being the first solar highway in Colorado. Annual energy cost savings from 2011 to 2016 ranged from $1,997 to $4,940.
- **Agency, local, state, federal legal/regulatory constraints and how addressed and overcome**: City of Broomfield was concerned about solar panel aesthetics and NWP worked with city officials to alleviate any potential concerns. No FHWA involvement occurred in this project since the project was within the private right of way of the Northwest Parkway Authority.

- **Main lessons learned**:
  - Location of solar ground mounted panels is critical for optimum energy development. Solar panel direction and alignment important in the efficient collection of solar energy. Placement of solar ground mounted systems in the south facing direction is optimum for direct sunshine.
  - Solar ground mounted panels must be located near electrical connection to reach the electrical grid.
  - Large number of solar panels along the right of way may be perceived by the local public and officials as a visual impact. Work closely with local municipalities to address potential environmental and aesthetic impacts and mitigation strategies.
  - Identify potential utility rebates that will reduce electrical energy purchase costs. These rebates may be limited by electrical utility providers.
  - Anticipate using internal legal analysis of PPA and other contractual agreements. This action can take a significant level of effort by the energy generator (developer) and ROW owner.
  - Ensure there is contractual agreement flexibility in case road configuration changes in future. This change can impact the location and orientation of the solar ground mounted systems.
- **Project contact:** Mark Shotkoski, Lead Tollway Engineer; mark@nwpky.com

E-470 Tollway Solar Project

- **Project name**: E-470 Solar Project
- **Agreement or partnerships type**: Power Purchase Agreement
- **Transportation entity**: E-470 Tollway Authority (Aurora, Colorado)
- **Project overview**: E-470's Solar Powered Toll Road is one of the largest renewable energy installations on any tolled facility in the United States and one of the few that rely extensively on solar energy. Ground mounted solar panels were placed within a 17 mile stretch along the E-470 Tollway just east of Denver, Colorado on June 26, 2012. The project was conceived during a time in which Xcel Energy was offering tax incentive rebates. Along the 17 mile stretch of ROW 22 solar sites were developed to power streetlights, variable message signage, former toll plazas, maintenance facilities and administrative headquarters at a reduced energy rate. One third of the energy consumed by the entire tollway is provide via solar energy. During the first year of full operation over one million kilowatt hours was generated. It is estimate that over 20 years of operation over 24,000 metric tons of CO2 emissions will be eliminated. The project involved three counties without experiencing any regulatory or political problems or challenges.
- **Solar system type**: Ground mounted and some roof mounted installations
- **Project driver**: Energy cost savings using tax and utility incentives; cut rising energy cost, utilize large amount of open space to productive use, and promote long-term sustainability.
- **Cost incentives**: Xcel Energy rebates
- **Partners to the agreement**: Adamas Energy Investments and Martifer Solar USA
- **Utility partner**: Xcel Energy
- **Party responsibility for infrastructure ownership, security, installation and long-term maintenance costs, liability for damage and vandalism**: PPA specifies that developer responsible for these items. No project costs were paid by E-470 for the entire project.
- **Agreement specify responsibility for ownership and buyback**: Developer contractually responsible for all upfront capital costs and long-term maintenance. An option for a buy back was after 6 years of solar system operation.
- **Copies of actual agreements:** Requested and was not provided by E-470 after repeated requests.
- **Anticipated costs and revenues prior to the construction as well as actual (post-implementation) costs and revenues (identify if no data and why):** A no-cost model was used by E 470 and cost estimations were provided by developer. E 470 estimated that over the first six years, the solar panels will save about $70,000 on energy costs. Fixed electricity price of 6.2 cents per kilowatt hour, compared to a market price of 11.5 cents as of April 2014. Anticipate revenues prior to construction was requested and was not provided by E-470 after repeated requests.
- **Project meet expected outcomes and/or reasons for failing to meet expected outcomes**: Project has met the goal of reduced energy costs for the tollway while reducing carbon emissions. The investors got to write off the depreciation on the equipment, and E-470 gained a fixed electricity price of 6.2 cents per kilowatt hour (versus 11.5 cents) for the first seven years which resulted in significant energy cost

reductions. Additional cost information was requested and not received from E 470 after repeated requests.

- **Agency, local, state, federal legal/regulatory constraints and how addressed and overcome**: The E-470 project is within the confines of three counties and no permitting challenges were encountered on the project. No FHWA involvement occurred in this project since the project was within the private right of way of E-470.
- **Main lessons learned**:
    - Anticipate potential solar panel relocations due to roadway modifications and lane expansion. This may be important when developing long term contracts with developers.
    - Work closely with energy providers on terms and conditions of energy agreements.
    - Try to lock in fixed energy cost rate for six years and then a fix annual rate increase for the remainder of the agreement.
    - Solar ground mounted panels must be located near electrical connections to reach the electrical grid.
    - Anticipate using outside legal analysis for PPA and other contractual agreements. This action can take a significant level of effort by the energy generator (developer) and ROW owner.
    - Look for utility and government rebates whenever possible which are difficult to find.
- **Project Contact:** Dave Kristick, Project Manager and Deputy Executive Director and Director of Operations, DKristick@e-470.com

NEW MEXICO DEPARTMENT OF TRANSPORTATION

RESEARCH BUREAU

Innovation in Transportation

APPENDIX C: NARRATIVE GUIDE

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In cooperation with:
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INTRODUCTION

The purpose of this Narrative Guide is to provide an easy-to-follow guide that explains the steps and process for NMDOT to implement solar projects that meet the conditions and business models described in the Free Energy Solar Highway research project final report. This guide provides a consistent and basic step-by-step approach to implement a solar project for all NMDOT Districts. This guide also identifies the administrative resources, staff, legal expertise, and other resources required to carry out these steps. The guide is tailored to the context of NMDOT, reflecting information gathered in interviews with key senior district and general office staff. Prior to starting a project, the NMDOT project team should understand the nature and timing of project elements so they are collectively prepared and coordinated. The type of partnership and scale of solar projects (individual, district, agency-wide) will dictate the level of effort and the complexity of tasks that each of these steps illustrate.

This guide provides a step-by-step overview of the process of developing a solar PV project at NMDOT and includes the following steps:

- **Step 1 – Project purpose and management:** Communicate between NMDOT general office management and district office personnel for the intent of developing and implementing no-cost solar projects and the breakdown of responsibilities and duties by the department and district to gain leadership and staff support.
- **Step 2 – Project team assembly:** Review the needed staff and associated responsibilities to develop a successful project. A project champion or point person at the general office and at each district office is essential to ensure that individual and programmatic solar projects are efficiently guided and managed through implementation.
- **Step 3 – Preliminary site assessment and evaluation**: Use site selection criteria identified for specific NMDOT District sites, in addition to any supplementary evaluation criteria that NMDOT or partner developers deem important to the selection process. Project sites will include two main categories: facility level systems that will offset generation demand at NMDOT facilities and larger ROW or surplus NMDOT properties that could be used by a solar developer partner to serve a non-DOT load with a airspace/land lease payment to NMDOT.
- **Step 4 – Determine appropriate model and partnership:** Evaluate project sites and determine the size and scale of the project (facility-level, ROW) and the associated third-party partners (e.g., solar developer, utility, ESCO) and partnership models (e.g., power purchase agreement, airspace/land lease, andenergy service performance contract). Based on the project type, use the financial modeling spreadsheet and either NREL's System Advisor Model (SAM) or Energy Toolbase to establish the rough financial potential for NMDOT over the project life, or contract term. Choose a contracting pathway to develop a project including either: (1) partnering with a developer to bid on a utility RFP or contract for generation, (2) releasing an RFP, RFQ or RFI to identify interested third-party developers, (3) directly communicate with third-party developers to determine the level of interest in developing a NMDOT facility-level project, or (4) completing the necessary steps to develop an energy services performance contract with a pre-approved ESCO.

- **Step 5 – Due diligence of priority sites:** Once a partnership is agreed upon, NMDOT and its partner will conduct the necessary due diligence of sites to ensure they meet the characteristics necessary for a feasible project.
- **Step 6 – Project development and maintenance:** Regardless of project approach, this stage provides the steps needed for final design, construction, long-term maintainance, and transfer ownership/decommissioning.

The process diagram below provides a high-level structure to the tasks involved in each stage of the process.

Figure 17 Overview of NMDOT Process to Implement Solar Program

STEP 1 – PROJECT PURPOSE AND MANAGEMENT

This stage should focus on the need to obtain executive management support within NMDOT or external support from the Governor or legislature. This research project has demonstrated that it is financially feasible and cost-effective to develop solar energy at certain scales given certain assumptions such as grid access, and space beyond the clear zone. NMDOT is exploring the possibility of developing no-cost solar projects; however, NMDOT needs to build a compelling vision to generate and maintain support within the agency and among stakeholders. Part of this effort is to clearly determine the program approach and the division of responsibilities at the NMDOT general office and district level offices to ensure successful project management. In interviews, the NMDOT district personnel indicated that district level staff need direction from NMDOT general office management, and perhaps even the subsecretary of transportation to provide a path forward, define the overarching mission and approach, and breakdown of responsibilities and duties by general office and district. Additionally, NMDOT should consider identifying a project champion or champions at the general office and at each district.

A project champion is a staff member that either serves as a project manager who is empowered by management or is an upper level manager who provides project support, resources and direction. A successful project champion will rely upon a team of skilled agency staff and partners that provide the necessary support, technical expertise, and resources and coordinate their work. Without an empowered project manager, the tasks of overseeing, coordinating, and integrating disparate tasks and driving the schedule will be absent, creating an inefficient, longer project development schedule or it will "fall apart." Although the scale and timeline for solar projects can necessitate a dedicated full-time employee, the research team recommends identifying an already existing NMDOT staff member that will be directed to manage solar projects for a defined period or developing a specific position that manages this effort.

STEP 2 – PROJECT TEAM ASSEMBLY

A multi-disciplinary team is needed to provide the technical competency needed to bring a project to development. Planning, design, financing, and construction of solar PV projects are not complex tasks compared with traditional DOT transportation project development; however, the specifics are new given the traditional procurement methods and experience of a transportation department. Most agencies benefit from the advice and expertise of others within the agency as well as external partners that can share expertise and opportunities for avoiding project pitfalls. As a first step in program development, it is important to assess the technical assistance needs and begin connecting with other state and federal agencies to fill knowledge gaps, navigate project elements, and streamline the process and project timeline.

It should be noted that in order to initiate a solar project it will take a signficant amount of project management time and resouces. The project manager needs to understand and orchestrate the numerous elements of developing a solar program as identified in Table 29. Much of the effort will be reduced once the developer is selected and contracts are completed.

The table below outlines the technical skillsets and project staff and external stakeholders needed depending on the project type.

Table 29: NMDOT Staff and Solar Partners by Technical Expertise.

Technical Competency	Partners/Sources of Expertise
Site Selection	NMDOT staff • District engineers at each district • Property Management • Utilities Section Manager • Right-of-Way • Maintenance • Planning External stakeholders • Solar PV developers • Electric utilities • FHWA Division Office • Energy, Minerals and Natural Resources Department (EMNRD)
Environmental Due Diligence	NMDOT staff • District engineers at each district • Environmental External stakeholders • Energy, Minerals and Natural Resources Department • FHWA Division Office
Utility Policy	NMDOT staff • Utilities Section Manager External stakeholders • Electric utilities • New Mexico Public Regulation Commission
Legal	NMDOT staff • Right of Way • Legal • Procurement External stakeholders • Energy, Minerals and Natural Resources Department
PV System Design and Engineering	NMDOT staff • Utilities Section Manager

	External stakeholders • Solar developers • Electric utilities • Electrical engineers for grid connection
Public Involvement and Stakeholder Engagement	NMDOT staff • Public outreach staff • District engineers at each district External stakeholders • Solar advocacy groups • Public Information Officers (solar developers, utilities)
Contracting and Procurement	NMDOT staff • Legal • Procurement • District engineers at each district External stakeholders • Energy, Minerals and Natural Resources Department
Right-of-Way	NMDOT staff • Right-of-Way • Planning • Safety Engineering External stakeholders • FHWA Division Office

STEP 3 – PRELIMINARY SITE ASSESSMENT AND EVALUATION

This section outlines important criteria and steps to assess viable project sites to conduct a preliminary screening of NMDOT properties and sites. The purpose and outcome of this section is to outline a process that will produce a shortlist of potential sites that meet key criteria to satisfy general DOT project requirements (e.g., free of the clear zone and close grid connection) and specific solar requirements (e.g., solar potential). The research team recommends convening the project team to determine which criteria or steps should be added to this list and include them in the process. *District field staff know the sites better than most and should be consulted in the site selection and site review processes to ensure site specific conditions are considered.*

The preliminary screening should consider:

- Property location, sizes and project types
- Solar energy generation potential
- Proximity to electric grid
- Conflicting conditions that would compromise the safety and functionality of the ROW
- Future DOT use and neighboring communities

- Access and safety
- Stakeholder identification
- Cultural, historical and archaeological
- Environmental features and viewshed
- Overlapping easements

Property Locations, Sizes and Project Types

The type of sites will dictate the type of project (highway ROW or at the facility scale) and the extent of site due diligence that is required. Generally speaking, highway ROW or surplus property sites will require additional evaluation given that smaller scale systems located at or adjacent to NMDOT facilities will not be subject to the same level of assessment. The following is a list of potential properties by project type:

- Right-of-way and DOT properties
  - Interchanges or cloverleaf quadrants
  - Right-of-way outside clear zone parallel to highway or roadway
  - Surplus, larger DOT properties away or on road systems
    - Material supply yards
    - Former quarry or gravel sites (above ground)
    - Brownfield sites
    - Inactive or abandoned weigh stations
  - Roadside rest areas and federal considerations
  - Park and ride areas
  - Sound walls on the North side of East-West corridors
- Facility systems
  - Office buildings
  - Maintenance yards and facilities
  - Other transportation assets and locations: airports, truck inspection facilities

The space required for solar projects is dependent on whether the project is meeting on-site electricity demand and whether there is sufficient area of available rooftop or adjacent property to physically accommodate an installation. The approximate scale of space required by solar PV system of differing solar capacities is the provided in Table 4.

Table 30 Solar PV Systems by Scale and Production Output

Array Size *kW/MW*	Module area *square feet*	Total Land Area *acres*	Annual Production *kWh*
2 kW	211	0	3,451
10 kW	421	0	17,256
20 kW	1,053	0.1	34,511
50 kW	2,737	0.2	86,279
75 kW	4,211	3	126,583
100 kW	5,476	0.4	167,563
200 kW	11,161	0.9	351,812
500 kW	28,219	2.2	902,526
1 MW	56,439	4.3	1,764,785
2 MW	113,090	8.7	3,534,244
5 MW	282,829	21.7	8,837,939
10 MW	565,658	43.3	18,022,926

Note: Numbers differ based on type of solar placement (rooftop vs. ground mount) and racking system types (fixed vs. tracking). These array sizes use PVWatts for smaller systems (>75 kW) and larger systems (NREL SAM model). Rows that are highlighted green are the array sizes used for the purposes of NMDOT district analysis.

Solar Potential

Good solar potential (insolation) is predicated on site location oriented toward the sun's path (southern exposure) and direct access to the sun over the course of the day without shade from topography, natural features (trees) or built infrastructure. Insolation is the amount of solar radiation received on a given surface area per unit of time (kWh/m2/day). NREL's PV Watts calculator and SAM model both provide information on solar potential based on a location's address. Solar potential in New Mexico is exceptional and should not be a concern as long as there are not obstructions to solar exposure on the site over the course of the day.

The characteristics that best access solar potential include:

- **Good southern exposure:** Systems should optimize their ability to capture more sunlight and be oriented south.
- **No topographic or other shading:** Nearby hills, vegetation, and the built environment can cast a shadow across a surface thereby impeding PV panels from generating electricity.
- **Limited site preparation:** Sites should also have limited vegetative coverage as extensive clearing will add to site preparation and possible environmental mitigation costs.
- **PV array does not shade the ROW:** The shading of the highway ROW in patches provides a visual disturbance for drivers, but more importantly it will maintain a patch of ice while the surrounding ice may have melted from sunshine, causing a safety hazard.

Proximity to the Electric Grid

One of the most critical aspects for siting solar is whether it is located in close proximity to the electrical grid, three-phase power or a substation. It is important to contact a utility's distributed generation department in the site's region to determine the level of interest and motivation to site a solar PV project in their utility area. Depending on site locations and proximity to power, and if the project potential cost savings is large enough, it may be prudent to complete an interconnection study to safeguard future complications. Smaller-scale projects will support the

grid to offset electricity load and will be found more commonly in urban rather than rural sites. Note that an interested solar developer can make this determination quickly but cannot represent the utility's interest in partnering. It is also important to determine the available electrical capacity of the power lines that would facilitate the interconnection.

Future DOT Use and Neighboring Communities
The initial site screen should also consider whether the site will be needed for future projects (e.g., highway widening, maintenance facility expansion, etc.) and whether covenants, easements, and agreements are in place that might create a conflict. Additionally, as mentioned in stakeholder identification above, it is important to determine whether neighboring communities and property owners are amenable to solar sited in adjacent NMDOT property.

Access and Safety
Traffic and highway safety are a primary concern. Site access for construction, operations, and maintenance may require right of way access and potentially additional facilities, such as temporary or permanent gravel access roads. As always, if the project is in the highway ROW, safety controls must be used during construction and will need to be considered by the developer and NMDOT. Ideally, site access would not be directly from the highway itself but from frontage roadways or existing access breaks. The clear zone should be avoided unless an approved barrier is already installed to protect motorists. It is recommended that coordination with NMDOT Safety occur during site placement. It is important to note that if panels are close to traffic, shadows from the panel should be considered to avoid ice patches and visual disturbances caused by shading.

Stakeholder Identification
As part of the preliminary site assessment, NMDOT can begin to identify which stakeholders may play an important role in the project. This step can help determine which stakeholders are relevant to the site, whether they would support or object to the project and anticipate whom to engage. These actions can serve as the basis for building community support and appreciation for the project. The engagement with these stakeholder groups will be conducted by a third-party developer in close coordination with NMDOT to identify which stakeholders should be connected to in the process.

The stakeholders list could include:
- Adjacent neighbors and property owners particularly tribal lands and pueblos
- Local officials and jurisdictional partners
- Nearby businesses
- Impacted transportation users
- Nonprofit and environmental interest groups
- Those that object to government behavior generally
- Those that would like to maintain a viewshed in its current form

Cultural, Historical and Archaeological
Another step in the site assessment process is to determine if there might be sites that have cultural and archeological resources that may not be suitable for a solar project. This is especially relevant in NMDOT where tribal artifacts are abundant and not well documented.

Environmental Features and Viewshed

It is important to consider whether a project would result in changes in the character of sensitive environmental resources and natural features. Major natural features should be considered as well for their community viewshed value. Some stakeholders and neighbors may not appreciate their views including PV solar arrays. The preliminary screen should also consider whether threatened and endangered species are cause of concern in the area. The intention at this stage of site evaluation is not to make a definitive determination about potential impacts, but to avoid sites that pose obvious risks of complex and costly environmental reviews or the need to mitigate future impacts. The intent is not to trigger a NEPA Environmental Assessment (EA) or an Environmental Impact Statement (EIS) but use a NEPA Categorical Exclusion where minimal impact will be experienced on the ROW. The most common environmental impacts to consider are erosion from water coming off panels, stormwater detainment and infiltration from the "roof-like" impervious surface, obstruction of wildlife migration corridors, and the loss of habitat for threatened and endangered (T&E) species. At this stage the team is setting the stage but not performing a NEPA study; this will be done at the due diligence step.

Solar Glare

Glare is a common concern that originates from the reflection of a light source, usually the sun, off any reflective service (e.g., windows, chrome automobile bumpers, water, vegetation). This glare (or "glint") can serve as a potential hazard or distraction for motorists and nearby residents. The solar glare associated with each PV design will be different but is not a concern since solar panels are designed to absorb and not reflect light energy. The reflectivity of a surface, or albedo, varies with the type of material that covers that surface. Based on ODOT's Solar Highway Program: From Concept to Reality, solar panels typically have an albedo of ~ 30% – compared to surface materials such as dry sand at 45%, needle-leaf coniferous trees at 20%, grass-type vegetation at 25% and broadleaf deciduous trees at 10%. The solar panels therefore do not noticeably alter the site's current amount of reflected, indirect sunlight. Often, only sites that are much higher in elevation will experience direct reflection from the incident angle; therefore, being aware of surrounding topography and potential neighbors and stakeholders is important. There is *some* glint, which requires assuring neighbors, local permitting offices and aviation officials near airports of the intensity of the glare and when it will be noticeable.

- **Factors:** Panel tilt, height, orientation, and reflectivity all must be taken into consideration with respect to solar glare to neighboring structures, ground, and air traffic.
- **Analysis:** NREL developed the Solar Glare Hazard Analysis Tool (SGHAT), a web-based platform for solar glare analysis, which can be helpful to ascertain to what extent a PV solar array will exhibit solar glare. This tool is available for free to public government agencies: https://share.sandia.gov/phlux

Further Resources

In addition to the information provided here in this section, Oregon DOT siting criteria and the approach shared by New York State DOT (NYSDOT) could prove useful to NMDOT project staff conducting site evaluations:

- Oregon DOT Siting Criteria Source: https://www.ssti.us/wp/wp-content/uploads/2016/09/Solar_Highway_General_Siting_Criteria_2010_OR.pdf

- NYSDOT provided potential project developers site information bundled by region within New York state to illustrate potential site options. https://www.dot.ny.gov/portal/pls/portal/MEXIS_APP.BC_CONSULTING_NONAE_ADMIN.VIEWFILE?p_file_id=20365

STEP 4 – DETERMINE APPROPRIATE BUSINESS MODEL AND PARTNERSHIP

Once the list of potential sites is defined, the site and scale of the projects will largely define the type of project partners and model pathway that can be used for a project. *The inventory of potential sites, their sizes, and locations corresponding to utility districts will assist in defining the level of potential for solar projects.* For example, if site screening determines that there are a limited number of sites that meet the constraints of property sizes between 4 to 20 acres, NMDOT should evaluate and prioritize those sites if projects greater than 1MW are possible (best financial return and feasibility) and could possibly conduct this site analysis with the assistance of a solar developer.

Engage Solar Developers or Partners via Request for Information (RFI) Process

NMDOT should also interact with potential partners to discuss and ensure understanding of these topics:

- Interests of the third-party and of NMDOT
  - Where interests align or conflict
  - Where might either party accommodate the other
- Early project timelines and multi-year involvement
  - Near-term project expectations
  - Identifying potential of the relationship over time and if an initial project or bundle is developed to determine partnership efficacy
- Define the roles of the developer and NMDOT
- Share the full extent of what NMDOT will be providing in kind to make the project happen beyond property and the potential to buy power. This includes:
  - Coordination of efforts by all public agencies needed
  - Site due diligence and environmental screen
  - Negotiation with third-parties and / or contracting
  - Final due diligence
  - Contracting
  - ROW safety support during construction
  - Public engagement and PR as needed
- Performance requirements for the third-party
  - Define outcomes and consequences for not achieving agreed upon requirements and expectations. Also define what happens under a scenario in which the DOT must retake the property for highway transportation use before the term of the agreement is done. Ideally this is avoided entirely with thoughtful site selection, but a written contingency plan is essential.

Facility-level projects can be either completed via an ESPC define this agreement with an ESCO or a PPA set up with a third-party developer. Larger properties in the highway ROW and surplus properties will be developed under airspace/land lease agreements unless there is nearby electricity load from NMDOT to offset. A PV developer may be interested in developing a

portfolio of project sizes that meets NMDOT's project interests, while ensuring the scale and return necessary for project implementation. Smaller projects are not as viable from a financial perspective. Some of these smaller projects could be "tucked in" to bundles of larger projects. Model pathways and their applicability are described in greater detail in the Feasibility Analysis of the main report.

- Facility-level projects:
    - Type of installation: rooftop solar or ground mount adjacent to facility
    - Financing model: third-party PPA or ESPC
    - PV project sizes: 10kW to 500 kW
- ROW or surplus property projects:
    - Type of installation: ground mount solar PV
    - Financing model: third-party airspace/land lease agreement and a PPA if there is a DOT electricity load on-site or nearby
    - PV project sizes: 200kW to 5MW

At this stage, the financial analysis and approach that accompanies this solar plan can be used to understand potential project value. If project scale and specifics are not available, the financial modeling tool can be reviewed for values included for different sized projects for each of the three types of models.

Contracting Pathways

In this stage of the process, NMDOT will determine the best method for developing a third-party partnership based on sites available and the extent to which the agency would like to do a project (i.e. one site versus multiple sites projects). This step will serve as a challenge for NMDOT as this type of procurement is unfamiliar and will require internal education and additional effort to implement solar projects.

Based on conversations with other state DOTs, EMNRD, and solar developers, the following is a list of potential approaches for developing third-party projects for NMDOT:

- Release an RFP or an RFQ to identify interested third-party developers, and then directly negotiate after selection or take the best of what is offered.
- Develop an energy services performance contract with a pre-approved ESCO.

Engage Third-Party Developers via RFI Process

Perhaps the most accessible approach to NMDOT is to identify project developers interest directly and share the scale and availability of sites and receive bids and pricing from select developers in order to determine their level of interest and identify creative approaches to agreements. Solar developers are generally interested in larger scale projects but are also agreeable to developing a portfolio of various project sizes based on NMDOT needs and project goals. One of the benefits to working with solar developers earlier in the process is to gauge interest, reduce NMDOT staffing time, and allowing for the developer to assist in the due diligence and site assessment stages. Examples RFI templates are provided in Appendix A.

RFP Process to Identify Third-Party Partners

A RFP process is the next best approach for NMDOT to develop a third-party partnership. Several other state DOTs have released RFPs following site selection and due diligence. One of

the main reasons to complete this due diligence before releasing the RFP is to ensure that the contract parameters are favorable to third-party developers so that they participate. Developing an RFP that outlines multiple sites simplifies the RFP process but can lead to a more complicated project development process due to pricing difference and the number of change orders. A public RFP process does not ensure that best-in-class parties will participate, or a good deal will be offered. Other state DOTs have released RFPs or RFIs with little response from vendors. The RFP should be paired with directly contacting best-in-class vendors to call their attention to the RFP. Reaching out to vendors after the RFP will help determine why or why not they chose to participate and will improve future RFPs. If NMDOT decides to issue a public RFP, the research team recommends reviewing these resources in Appendix A.

Develop an ESPC with an ESCO

For smaller facility-level projects, where a solar developer will not be as interested in implementing, the use of the ESPC model with an ESCO to complete the project development. EMNRD has developed contracting agreements with pre-approved ESCOs. The general process entails:

(1) NMDOT selects one of the seven pre-approved ESCOs and notifies EMNRD
(2) EMNRD will request the ESCO's updated qualifications for review and approval
(3) NMDOT and ESCO agree to an Investment Grade Energy Audit contract
(4) EMNRD selects a Third-Party Reviewer to be assigned to NMDOT's project
(5) EMNRD reviews and certifies the Investment Grade Energy Audit
(6) NMDOT, Owner, and ESCO agree to a Guaranteed Utility Savings Contract
(7) Energy savings are ensured by regular monitoring

Choosing a third-party developer and negotiating agreement components

If possible, use a best value scoring methodology, rather than focusing bid selection on lowest cost. Bid evaluations should really be about maximizing the project value to NMDOT whether that is in electricity price savings or a new revenue stream in the form of a lease. Take the time to include careful review of specifications and consider requiring the proof of qualifications, experience and references, and design ability to deliver at the desired scale. Other state DOTs have noted that sometimes a solar PV developer will not survive the time needed to reach the project implementation phase due to long procurement times. It is important to identify and partner with stable companies that have demonstrated expertise and have been in business for a decade. Here are the fundamentals of what needs to be discussed in the draft third-party agreement:

General system size and productivity:

- PV system capacity or size (AC kW system nameplate)
- Annual system output (kWh)
- Annual degradation rate of solar panels (e.g., 0.5% annually)
- Warrantied life of PV solar system (e.g., between 20 and 33 years)
- Cost of electricity ($/kWh) versus grid power. Fixed value versus escalated versus indexed.
    - Fixed price – The electricity price will stay the same price per unit over the term of the agreement. This condition is ideal for NMDOT.
    - Escalator – Price can go up or down over the term of the agreement and is often tied to an inflation estimation per year (e.g., 1%) rather than pegged to varying electricity

prices. The U.S. Energy Information Administration (EIA) forecasts that electricity prices will start to go down in 10-15 years due to the increase of renewables in the energy mix.

- Indexed – The contract offers a fixed discount of whatever the variable rate of power is over the time detailed; therefore, a 10% discounted indexed price would be $.09/kWh if the traditional price was $0.10/kWh. If the regional or local price of power goes up or down, the DOT has a lower price.

Operations and Maintenance (O&M) Costs:
Given NMDOT's no-cost directive of this study, the following are the potential maintenance items to ensure are the responsibility of the developer and/or operator:

- Periodic washing to remove dust and bird's nests – especially in the dry seasons
- Mowing or vegetation control to avoid animal attraction and shading of the panels
- Inspection of connections and panel integrity – especially after hailstorms
- Panel replacement with failures
- Replacement of inverters – typically at year 15.
- Mechanical failure of "trackers"
- Response to vandalism or theft
- Security infrastructure and procedures
- Overall system risk and liability

End of Contract Term Conditions:
For each project, a 15 to 30-year term agreement will likely be established. When negotiating terms, these items should be considered so that the agreements end in a controlled way that is beneficial to NMDOT:

- Transfer of ownership to DOT in years 5-7 for a nominal price after third-party earns the tax credit income. Ensure there is enough NMDOT resources to manage the solar system.
- Transfer of ownership to the DOT after the contract term – 15-30 years. Often the warranty extends beyond the term of the contract. Frequently, there is a low- to no-cost transfer of ownership. After 20 years, the panels still produce approximately 80% of the original potential. Consider whether a maintenance group can be hired. Be sure to develop a financial model/pro forma to look at value of energy in contrast with maintenance costs and replacement of inverters and or panels as they are needed. Write into the contract that the third-party will release factually accurate records of expenses for O&M over their ownership period at the end of the contract.
- Responsibility and actions for the deconstruction of solar facility, restoration of site, gifting useful panels to others and/or proper disposal.

System Warranty periods: These apply only to those systems that are being owned or transferred to the DOT:

- Ideally, the technology components have warranty beyond the moment of transfer from the developer/operator to NMDOT. Make sure there is a clear understanding of which components have continuing warranties and are likely to perform beyond the warranty and what the total replacement costs will be for the future system ownership.

STEP 5 – DUE DILIGENCE OF PRIORITY SITES

Solar Potential

While the potential sites have already been preliminarily screened at the macro level for solar exposure, the site's solar exposure must be analyzed by a solar professional. This information will drive the design and layout of the arrays, the tilt angle of the arrays and the potential for tracking as well as the financial productivity of the proposed system. The solar site evaluator will use a specialized instrument to take a series of measurements at various positions across the site to identify shading and the Total Solar Resource Fraction (TSRF). Some financial incentives require that projects meet a minimum TSRF threshold and the higher the ratio values the better. While utility and incentive conditions vary, most viable project should have a TSRF not less than 75%.

Topography Considerations

Walking the site carefully with the right professionals also provides information about system layout given the need to safely access the site for construction and maintenance, as well as determining racking types. Seeing the slopes and understanding the soil types will direct whether driven piles are needed, or if a system can be mounted on concrete footings or ballasted on eco-blocks or retired median barrier.

Verifying Grid Connection

The site analysis should document the potential electrical grid interconnection points and the adjacent electrical distribution system. This knowledge will help the third-party select the appropriate interconnection equipment and hardware upgrades on the utility side that may be required. Both MassDOT and Oregon DOT had delays and cost overruns associated with this concern. MassDOT asked developers to include a $50,000-line item in the financial proposals to cover interconnection application costs for the sites specified in their proposal. For Oregon DOT's first demonstration project, the site required a boring robot to cut a tunnel underneath the highway to provide a conduit access to guarantee proper connection.

Environmental Impact Analysis

Ideally, the sites initially selected are free from the concerns of obvious environmental conflicts. Based upon the work done during the preliminary site assessment (Step 3), environmental impacts should be minimal and a NEPA Categorical Exclusion should be developed by NMDOT. The following lists outline the federal permits and aspects that need to be considered to comply with state and federal regulations:

Federal Permitting

- NEPA Documentation via FHWA (23 C.F.R. Part 771.117)
- NEPA Documentation via FAA
- Section 106 Evaluation (16 U.S.C. National Historic Preservation Act)
- Section 4(f) Evaluation (23 U.S.C. 138 Preservation of Parklands & 49 U.S.C. 303)
- Section 6(f) Evaluation (16 U.S.C. Ch 1, Section 4601-4 Land & Water Conservation Fund)
- 401 Water Quality Certificate (33 U.S.C. Ch 26, Clean Water Act, Section 401)
- 404 Corps of Engineers Permit (33 U.S.C. 1344 Clean Water Act, Section 404)
- Fish & Wildlife Coordination Act (16 U.S.C. Part 661 – 666)

- Endangered Species Act (16 U.S.C. Section 1531 – 1534) – USF&W Service Section 7 consultation

Representatives from the NMDOT Environmental Bureau should be consulted to ensure NEPA compliance. It is suggested that the Environmental Bureau webpage (http://dot.state.nm.us/content/nmdot/en/Program_Management.html) be consulted for procedures associated with Categorical Exclusions such as the Categorical Exclusion Checklist Instructions and other NMDOT specific NEPA guidance.

Public Involvement and Stakeholder Engagement

For small ground mounted or rooftop projects, public involvement and stakeholder engagement is mostly an opportunity for goodwill and press coverage. For larger projects, the outreach effort may be welcomed or rejected. If the DOT is drawing an airspace/land lease payment only and the project is developed, owned and operated by other parties and is selling power to non-DOT entities, generally the public engagement should be done by the third-party. If NMDOT stands to gain substantially from the project via energy and renewable energy credits and wants to solicit feedback from the public, then NMDOT may want to engage the public directly.

The plan should contain several components including:

- Identification of stakeholders and their issues or concerns
- Clear and compelling project description and case statement
- Description of planned outreach strategies and activities to the stakeholders in advance of public information releases
- NMDOT follow up on public questions and concerns and requests for additional information

Mostly, solar projects are welcomed by the public and they are properly contacted and informed about the project. It is a plus solar and environmental groups are informed of the solar efforts and help promote the project. Oregon DOT created a list of "green media" to share the early solar development stories to position or promote the project as an exciting innovation by an unusual party – the DOT.

When solar projects are not welcomed, it is usually a case of Not In My Back Yard (NIMBY) that is driven by aesthetics, viewshed concerns or just resistance to change. For many people, a simple vegetative screen that will not grow tall enough to shade the panels but obstructs the view of the panels serves the purpose to address their concerns. For others, concerns of all types are brought to bear either for genuine concern or as excuses for NIMBY. The best practice is to create a platform by which interested or concerned parties can register their interest with the development team and get a call back. These calls are a great check on the effectiveness of the deliberate outreach and can serve as the base material for a Frequently Asked Question (FAQ) information paper. Many other concerns come from either a lack of understanding or spurious concerns propagated by a party that objects to the system. Whenever possible, address all of these concerns via mass and direct communication from the experts that can answer the questions the best, especially in any public forums that are held by NMDOT. For example, if people are concerned about fires that may be started from a spark off the electrical panel, create the forum for the local fire marshal to answer the question.

Some of the common public concerns include:

- Visual impacts and aesthetics
- Glare from the panels
- Electromagnetic fields (EMFs)
- Tree removal and the benefit costs of trees versus solar for climate change
- Whether panels contain hazardous materials
- Use of electricity generated
- Site preparation necessary and expected length of noise
- Use of public funds for non-essential purpose
- Solar as imperfect power generation source due to it only being peak matched and does not provide continuous 24-7 power.

Review and Revise Financial Analysis

After a thorough vetting of all project benefits, risks and costs, NMDOT and the third-party developer should revisit the financial performance and time cost expectations both internally and together. Based on the discoveries there may be new understandings that make the project more attractive or less attractive. In a joint meeting, expect that both parties will need to balance, trade or change the expectations of the project to ensure its still worth committing to and pursuing.

STEP 6 – PROJECT DEVELOPMENT AND MAINTENANCE:

Regardless of contracting pathway, this stage provides the steps needed for final design and build, construction, and maintainance.

Final Design, Permitting and Approval

The next step is to finalize the design and engineering plans including schematics detailing the placement of all array and balance of system components with the stamp and seal of a licensed professional engineer. If applicable, the final plans should also include a traffic control plan that addresses temporary construction and project maintenance related site access. NMDOT should review these plans to spot any conflicts with the uses of DOT property.

At this stage the project developer, whether NMDOT or a third-party should also begin to seek out the necessary approvals and local, state and federal permits. Commonly required approvals and permits include:

- Land use approvals and design review permits
- Utility interconnection approval
- Utility accommodation permit or airspace/land lease
- Traditional building code and local and state jurisdiction permits such as fire and structural requirement
    - Construction stormwater permit
    - Electrical and or construction permit from local jurisdiction

Construction

With all DOT conflicts resolved in the solar design, the construction follows a predictable schedule that includes:

- Materials procurement and site mobilization
- Site preparation

- Pouring foundations, slabs and footings, driving pile and the assembly of support structures
- Mounting PV modules and connecting strings of panels with wire
- Installing power inverters and grid connection
- Erecting security fencing and installing security systems if needed (sometimes right after site preparation)
- Temporary stabilization and restoring impacted vegetation
- Vegetation management can be a problem or not depending on seed mix or cloth and gravel

Commissioning

Project commissioning is the process of assuring that all systems and components of the solar system are designed, installed, tested, operated, and maintained according to the operational requirements of the owner or client. This commissioning process includes:

- Check structural integrity
- Check the arrays to determine if they meet all applicable electrical codes and standards and are properly labeled
- Test to ensure the arrays perform as expected and named in the contract
- Authorization by electric utility

When these tasks are complete the third-party should submit a letter to NMDOT that the system is performing according to the agreement which commences the agreement.

Long-term maintenance and decommissioning are covered in prior sections.

APPENDIX D. NMDOT FINANCIAL MODEL RUNS

INTRODUCTION TO ANALYSIS TOOL

The research team used two primary tools to develop and analyze the different NMDOT site locations and solar project sizes. Initially, the research team planned to use NREL's System Advisor Model (SAM) but Energy Toolbase became the primary tool platform due to its ability to catalog and analyze a significant number of different project scenarios and do so faster than the SAM model. Energy Toolbase does charge a monthly fee so NMDOT may choose to use the SAM tool for future analysis. Projects of similar size and project variables produced similar results between the two tools. The analysis in this appendix and most of the feasibility analysis in the main body of the report are compiled by using Energy Toolbase and can be accessed at https://www.energytoolbase.com. The research team developed an Excel spreadsheet to support the feasibility modeling and evaluations.

OVERVIEW OF SCENARIOS AND CALCULATIONS

- **Size of PV System:** Project solar PV projects were sized to match current usage for the NMDOT facility. Solar PV systems are measured in capacity by kW (e.g., 200kW).
- **Bundled Project Detail by Facility:** The research team assessed two different types of project scenarios per facility. The summary tables in the main section of the research plan included both the single standalone (<1MW) and bundled projects (>1MW). Given the extent of the tables and detail in this section, the research team chose to use to only show the detail for bundled projects.
- **Calculation steps and process:** Financial feasibility of an individual solar project is conducted by three main calculation steps to produce a set of metrics that can be used to compare projects side-by-side.
    - First, the size of the proposed PV solar project is determined. The research team modeled the size of the proposed array based off of the historic electricity demand for NMDOT district level locations. The size of the PV system and corresponding infrastructure provided an initial first cost associated with the design and build of the solar array. Energy Toolbase is connected to NREL's PVWatts calculator which provides the estimated cost for different systems based on their robust database of PV panel producers and equipment providers.
    - Second, the research team modeled the annual production of the proposed solar array based upon on the solar insolation or the availability of sunlight and its direct relation to the amount of solar energy that could be produced at that specific location or region. The amount of electricity produced and the timing of that electricity production, which fluctuates over the course of a year based on weather and cloud cover, provides the basis for meeting the demand curve for electricity at that stage of the year as well as attributing a price for that electricity.
    - Third, with the cost and production parameters in place, the next step develops the specific calculations and results of cash flow, net present value, developer payback period, and breakeven PPA price.
        - The cash flow represents the annualized inflow or outflow of cash for NMDOT which is the addition of the PPA payments NMDOT makes to its PPA partner and the electricity bill savings. For a positive cash flow project,

the electricity bill savings should be higher than the PPA payments, both annually and cumulatively over the agreement lifetime.

- Net present value measures the present-day value of a project considering the anticipated inflows of revenue in comparison to investing that same amount of money at compound interest. For the purposes of this study, the research team used a discount rate of 5%, which indicates that the proposed solar project is compared against investing the same amount of capital with an interest rate of 5%. The research team calculated the NPV for both NMDOT and the project developer. Projects that showed a positive NPV for both NMDOT and the developer are the most likely to be developed.
- Given that many of the projects did not meet these criteria, the research team ran an additional analysis to determine the breakeven PPA price, or the blended value of electricity the developer would charge NMDOT which would result in the developer covering their initial investment.
- Payback period measures the number of years that it takes for the project developer's initial investment to be returned. The research team measured the number of years that it would take to recoup the third party's initial investment. The timeframes for these projects ranged from 12 to 30 years based on a breakeven PPA price. Following the initial set of calculations to see if the project was viable for NMDOT, the research team determined the level of benefit and payback for the developer.

OVERVIEW OF VARIABLES

- **PPA Contract Specifics:**
  - *Escalation rate:* the rate of annual increase of the PPA price
  - *Starting PPA rate:* the initial PPA price
  - *Upfront payment:* the initial payment (for all scenarios assumed zero due to no-cost solar)
  - *Term of agreement:* used 20 years as the base case for each scenario but Energy Toolbase also calculates a 30-year net present value
- **Associated PV System Equipment and Anticipated Lifespans:** The number of years equipment is anticipated to function – 30 years for solar array and 15 years for inverters.
- **Energy Production of System over the Course of the Year:** The number of kWh a solar PV system produces over the course of the year in a specific location based on the site's insolation.
- **Facility Energy Usage over Course of Year:** The number of kWh the NMDOT District facility has used historically.

OVERVIEW OF RESULTS

- **Summary Tables by District:** Overview of current usage and proposed solar project variables and outcomes by District facility. Summary table cells that are highlighted green denote positive savings to NMDOT.
- **Agreement Outcomes**
  - *Total payments by NMDOT District*

    - *Electricity bill savings*
    - *Net present value of agreement over 20 and 30-year terms*: The summary table provides 20-year agreement and Energy Toolbase provides a 30-year timeframe). Most solar projects are anticipated to meet a 30-year lifetime. Recognizing the difference – the added benefit of 10 years of solar production – represents additional financial project benefit.
- **Graphic of Cumulative Energy Savings over 30-year Period:** This graphic provides a high-level view of the utility payments by NMDOT and the forecasted solar PPA costs. If the blue-grey coloring is visible the solar project generates savings, otherwise if the light green is completely visible the project does not demonstrate a project savings over current costs.
- **Energy Consumption Mix:** This pie chart shows the breakdown of how much of the NMDOT facility electricity is provided by solar produced power versus electricity provided an electric utility.
- **Monthly Energy Use vs. Solar Generation:** This bar and line graph shows the relative energy use in blue bars over the course of the year and the fluctuation of solar production over the course of the year.

SUMMARY TABLE DESCRIPTIONS

Descriptions of columns in results table:

- **Facilities:** name of NMDOT facility (e.g., district office, rest area, patrol office)
- **Utility:** name of IOU or rural cooperative utility
- **Rate schedule:** name of utility rate schedule
- **Annual usage:** number of kWh used by NMDOT facility for the last year (2017 or last 12 months)
- **Array size:** size of PV array based on the amount of electricity used by NMDOT facility
- **Average cost of electricity:** this is the average cost of electricity by kWh based on total usage and total annual cost
- **Current annual cost:** total cost of electricity for the last year (2017 or last 12 months)
- **Single PPA savings – annual:** The annual amount of savings in one year for NMDOT for standalone projects (<1MW), which is the difference in what is currently paid annually with the reduction in cost from the solar PPA.
- **Single PPA savings – 20 years**: The cumulative amount of savings for NMDOT over 20 years for single standalone projects that are less than 1MW.
- **Bundled PPA savings – annual:** The annual amount of savings in one year for NMDOT for bundled projects (>1MW), which is the difference in what is currently paid annually with the reduction in cost from the solar PPA.
- **Single PPA savings – 20 years:** The cumulative amount of savings for NMDOT over 20 years for projects that are over 1MW or smaller projects that are bundled together that add up to over 1MW (which garner a lower PPA price).
- **Breakeven PPA price:** This is the PPA price that results in a breakeven project for the solar developer. This project value provides an indicator as to whether a project is financially viable for not only NMDOT but also for the solar developer.

DISTRICT 1

Summary

Facilities	Utility	Rate Schedule	Annual Usage (kWh)	Array Size (kW)	Array Cost	Avg Cost of Electricity to NMDOT	Current Annual Cost ($ per year)	Single PPA Savings ($ per year)	Single PPA Savings - 20 Years ($ per year)	Bundled PPA Savings ($ per year)	Bundled PPA Savings - 20 Years ($ per year)	Breakeven PPA Price (per kWh)
District 1												
District office (D1) Deming	PNM	3C	318,720	200 kW	$696,707	$0.1293	$41,208	$7,770	$190,065	$11,123	$258,073	$0.123
Scenic View Rest Area, Las Cruces (D1)	El Paso Electric	3 SGS	26,052	15 kW	$58,543	$0.1960	$5,107	-$1,686	-$33,006	-$945	-$17,970	$0.062
Las Cruces Patrol Office (D1)	El Paso Electric	3 SGS	43,825	25 kW	$90,790	$0.1851	$8,113	-$2,810	-$55,009	-$1,575	-$29,949	$0.062
Solano Office, Las Cruces (D1)	El Paso Electric	4 GS	230,962	120 kW	$493,873	$0.1464	$33,822	-$10,216	-$200,278	-$8,305	-$161,514	$0.047

District office (D1) Deming

PPA Escalation Rate	1%
Starting PPA Rate	$0.09/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$612,070
30-Year Electric Bill Savings	$1,336,665
30-Year LCOE PV	$0.069
30-Year NPV	$292,608

Combined Solar PV Rating
Power Rating: 200,000 W-DC
Power Rating: 174,212 W-AC-CEC

General Information
Facility: District Office (D1)
Address: Deming NM 88030

Solar PV Equipment Description
Solar Panels: 200.0kW-DC Standard Modules
Inverters: Standard Inverter

Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

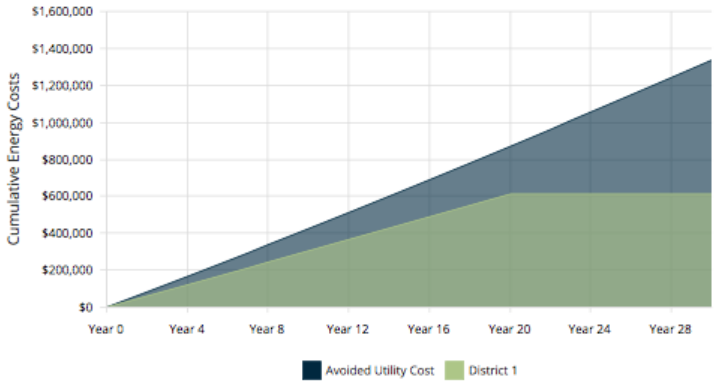
Solar PV System Cost	$696,707
Net Solar PV System Cost:	**$696,707**

Solar PV System Rating
Power Rating: 200,000 W-DC
Power Rating: 174,212 W-AC-CEC

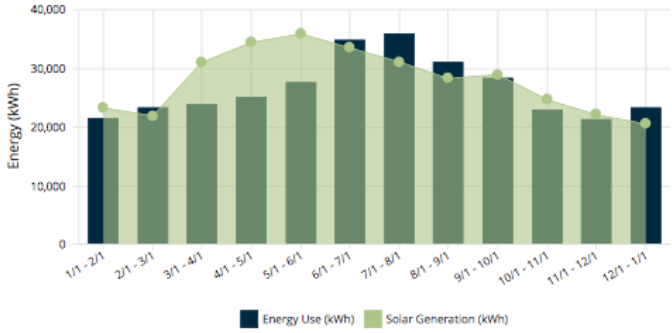
Energy Consumption Mix
Annual Energy Use: 318,718 kWh

Utility -16,505 kWh (0.00%)
Solar PV 335,223 kWh (100.00%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



Scenic View Rest Area, Las Cruces (D1)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$50,122
30-Year Electric Bill Savings	$49,392
30-Year LCOE PV	$0.076
30-Year NPV	($6,291)

Combined Solar PV Rating
Power Rating: 15,000 W-DC
Power Rating: 13,066 W-AC-CEC

General Information
Facility: Rest Area - Las Cruces (D1)
Address: Las Cruces NM

Solar PV Equipment Description
Solar Panels: 15.0kW-DC Standard Modules
Inverters: Standard Inverter

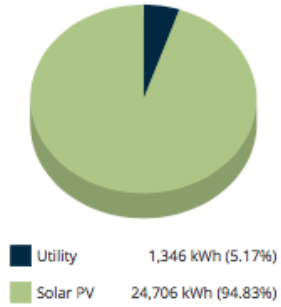
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

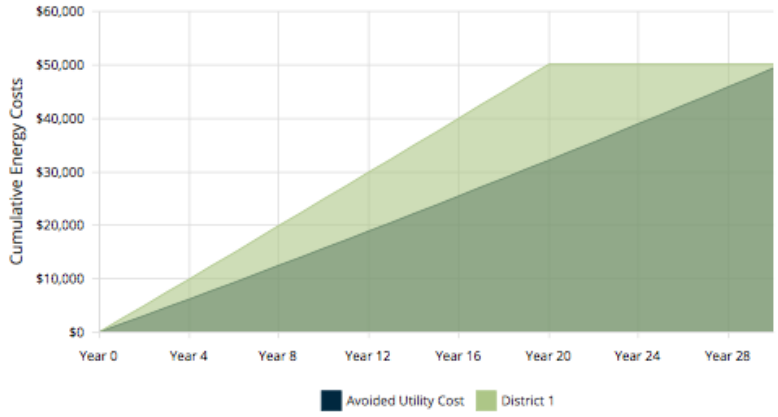
Solar PV System Cost	$58,543
Net Solar PV System Cost:	**$58,543**

Solar PV System Rating
Power Rating: 15,000 W-DC
Power Rating: 13,066 W-AC-CEC

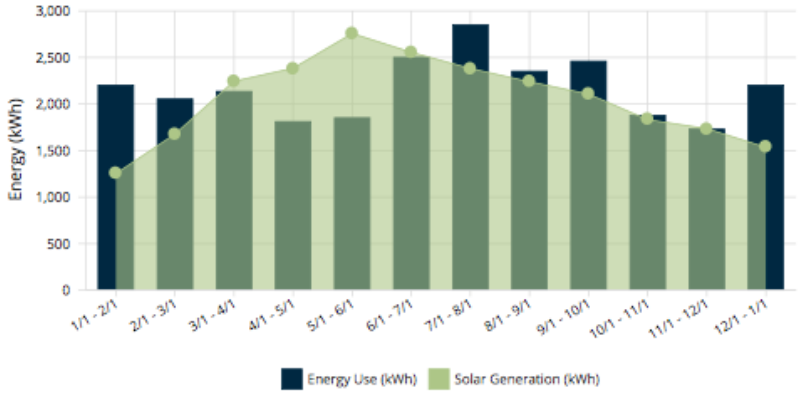
Energy Consumption Mix
Annual Energy Use: 26,052 kWh



Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



Las Cruces Patrol Office (D1)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$83,535
30-Year Electric Bill Savings	$82,319
30-Year LCOE PV	$0.076
30-Year NPV	($10,484)

Combined Solar PV Rating
Power Rating: 25,000 W-DC
Power Rating: 21,777 W-AC-CEC

General Information
Facility: Las Cruces Patrol Office (D1)
Address: Las Cruces NM

Solar PV Equipment Description
Solar Panels: 25.0kW-DC Standard Modules
Inverters: Standard Inverter

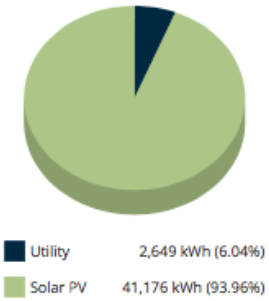
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

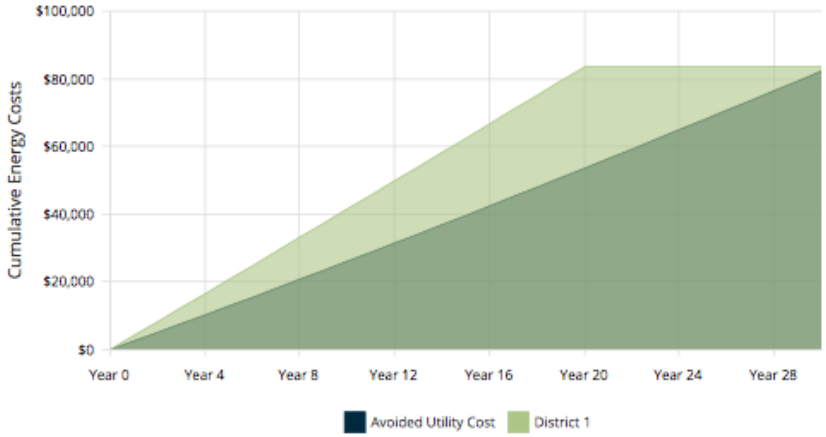
Solar PV System Cost	$90,790
Net Solar PV System Cost:	**$90,790**

Solar PV System Rating
Power Rating: 25,000 W-DC
Power Rating: 21,777 W-AC-CEC

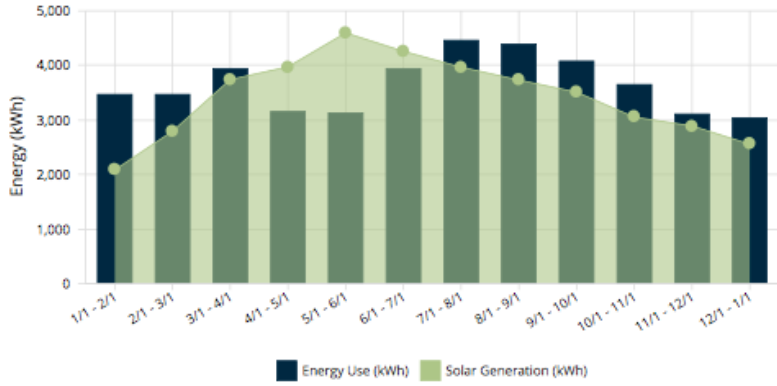
Energy Consumption Mix
Annual Energy Use: 43,825 kWh



Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



Solano Office, Las Cruces (D1)

PPA Escalation Rate	1%
Starting PPA Rate	$0.09/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$348,870
30-Year Electric Bill Savings	$287,815
30-Year LCOE PV	$0.069
30-Year NPV	($71,977)

Combined Solar PV Rating
Power Rating: 120,000 W-DC
Power Rating: 104,527 W-AC-CEC

General Information
Facility: Solano Office, Las Cruces (D1)
Address: Solano NM 87746

Solar PV Equipment Description
Solar Panels: 120.0kW-DC Standard Modules
Inverters: Standard Inverter

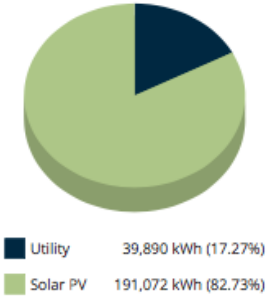
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

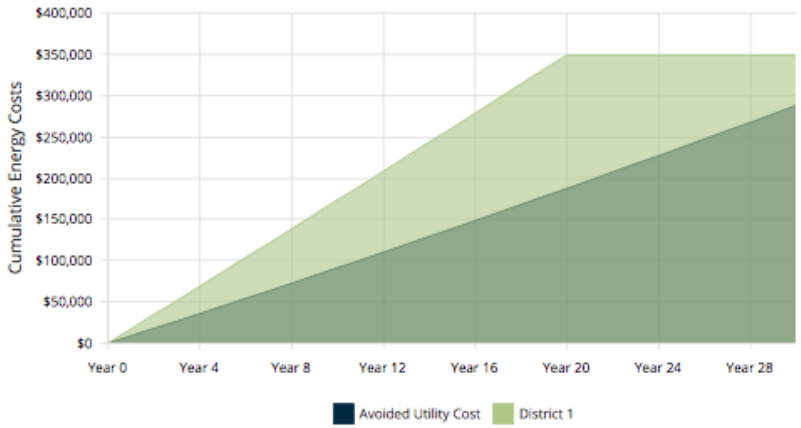
Solar PV System Cost	$493,873
Net Solar PV System Cost:	**$493,873**

Solar PV System Rating
Power Rating: 120,000 W-DC
Power Rating: 104,527 W-AC-CEC

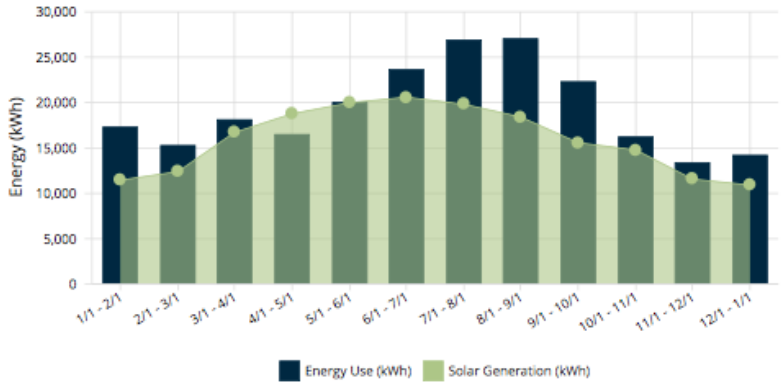
Energy Consumption Mix
Annual Energy Use: 230,962 kWh



Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



DISTRICT 2

Facilities	Utility	Rate Schedule	Annual Usage (kWh)	Array Size (kW)	Array Cost	Avg Cost of Electricity to NMDOT	Current Annual Cost ($ per year)	Single PPA Savings ($ per year)	Single PPA Savings - 20 Years ($ per year)	Bundled PPA Savings ($ per year)	Bundled PPA Savings - 20 Years ($ per year)
District 2											
District Office/Complex (D2)	Xcel Energy	SGS	414,564	250 kW	$868,340	$0.0970	$40,213	-$7,977	-$136,653	-$4,020	$9,875
Mesa Rest Area (D2)	Central NM Co-op	GS	80,016	50 kW	$171,407	$0.1320	$10,562	$155	$11,436	$2,557	$60,176

District Office/Complex (D2)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$812,322
30-Year Electric Bill Savings	$1,037,957
30-Year LCOE PV	$0.076
30-Year NPV	$17,646

Combined Solar PV Rating
Power Rating: 250,000 W-DC
Power Rating: 217,765 W-AC-CEC

General Information
Facility: District Office/Complex (D2)
Address: Roswell NM

Solar PV Equipment Description
Solar Panels: 250.0kW-DC Standard Modules
Inverters: Standard Inverter

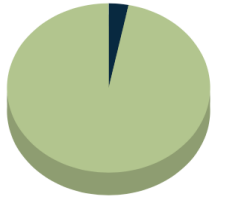
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$868,340
Net Solar PV System Cost:	**$868,340**

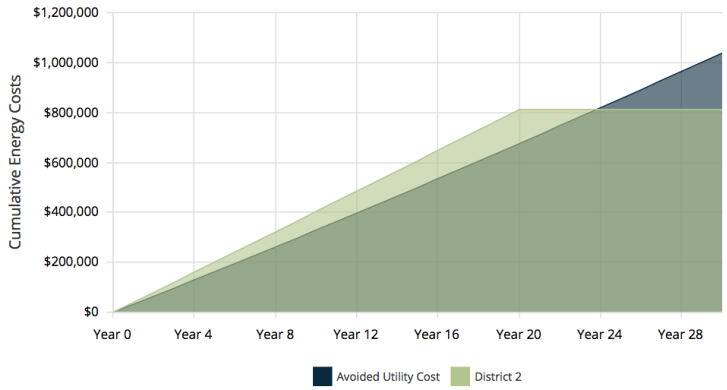
Solar PV System Rating
Power Rating: 250,000 W-DC
Power Rating: 217,765 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 413,484 kWh

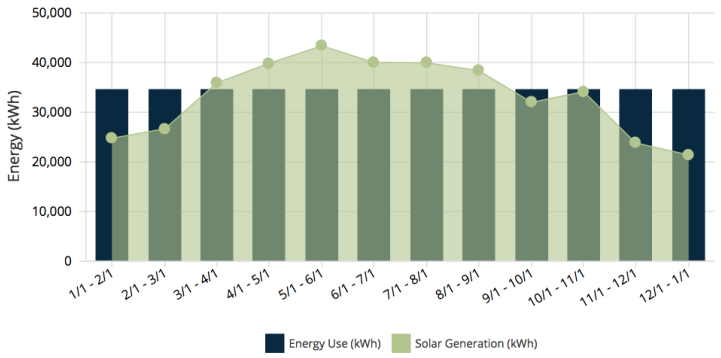


Utility 13,075 kWh (3.16%)
Solar PV 400,409 kWh (96.84%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



Mesa Rest Area (D2)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$162,465
30-Year Electric Bill Savings	$342,018
30-Year LCOE PV	$0.076
30-Year NPV	$71,232

Combined Solar PV Rating
Power Rating: 50,000 W-DC
Power Rating: 43,553 W-AC-CEC

General Information
Facility: Mesa Rest Area (D2)
Address: Roswell NM

Solar PV Equipment Description
Solar Panels: 50.0kW-DC Standard Modules
Inverters: Standard Inverter

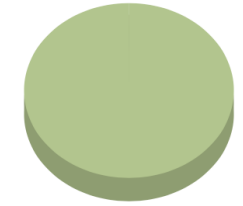
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$171,407
Net Solar PV System Cost:	**$171,407**

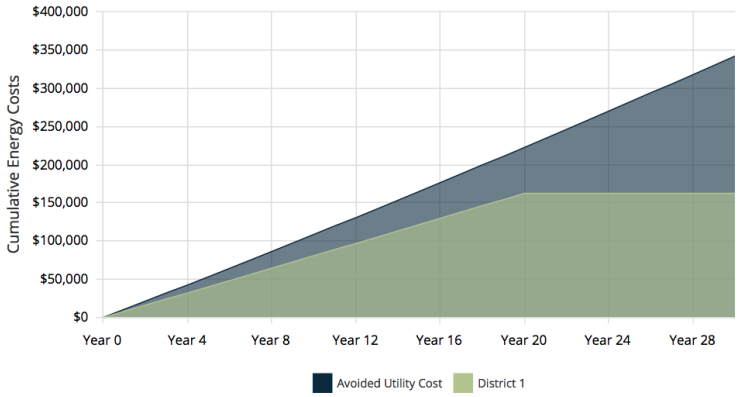
Solar PV System Rating
Power Rating: 50,000 W-DC
Power Rating: 43,553 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 80,016 kWh

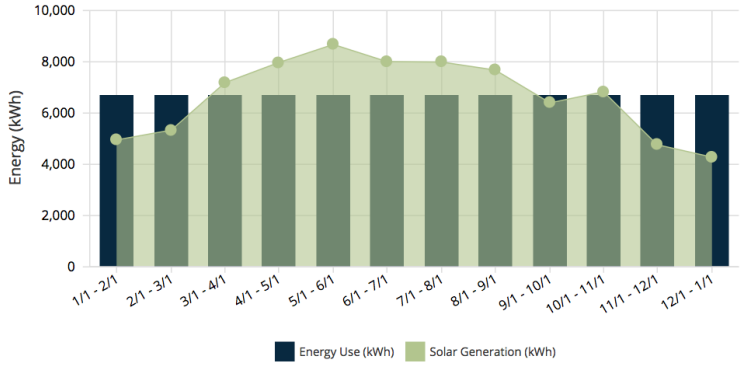


Utility	-66 kWh (0.00%)
Solar PV	80,082 kWh (100.00%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



DISTRICT 3

Facilities	Utility	Rate Schedule	Annual Usage (kWh)	Array Size (kW)	Array Cost	Avg Cost of Electricity to NMDOT	Current Annual Cost ($ per year)	Single PPA Savings ($ per year)	Single PPA Savings - 20 Years ($ per year)	Bundled PPA Savings ($ per year)	Bundled PPA Savings - 20 Years ($ per year)
District 3											
District Office (D3)	PNM	3B	1,074,560	500 kW	$1,726,507	$0.1001	$107,569	-$40,401	-$784,825	-$31,929	-$612,941

District Office (D3)

PPA Escalation Rate	1%
Starting PPA Rate	$0.09/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$1,546,961
30-Year Electric Bill Savings	$1,434,832
30-Year LCOE PV	$0.069
30-Year NPV	($239,280)

Combined Solar PV Rating
Power Rating: 500,000 W-DC
Power Rating: 435,530 W-AC-CEC

General Information
Facility: District Office (D3)
Address: Albuquerque NM

Solar PV Equipment Description
Solar Panels: 500.0kW-DC Standard Modules
Inverters: Standard Inverter

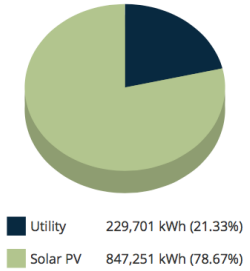
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$1,726,507
Net Solar PV System Cost:	**$1,726,507**

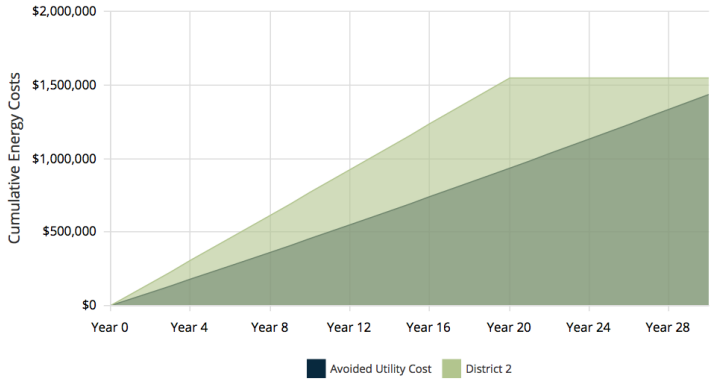
Solar PV System Rating
Power Rating: 500,000 W-DC
Power Rating: 435,530 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 1,076,952 kWh

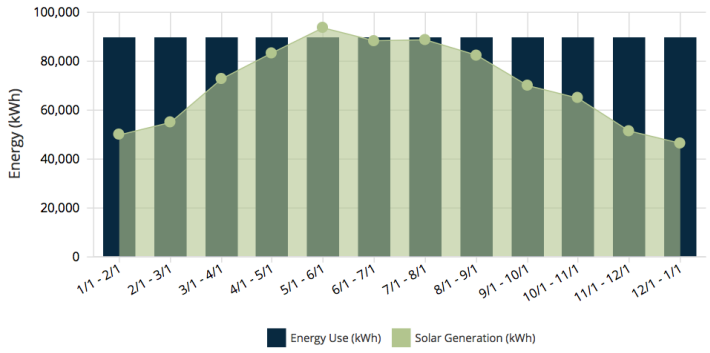


Utility 229,701 kWh (21.33%)
Solar PV 847,251 kWh (78.67%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



DISTRICT 4

Facilities	Utility	Rate Schedule	Annual Usage (kWh)	Array Size (kW)	Array Cost	Avg Cost of Electricity to NMDOT	Current Annual Cost ($ per year)	Single PPA Savings ($ per year)	Single PPA Savings - 20 Years ($ per year)	Bundled PPA Savings ($ per year)	Bundled PPA Savings - 20 Years ($ per year)
District 4											
District Office (D4)	PNM	3B	430,080	250 kW	$868,340	$0.1042	$44,819	-$14,517	-$274,439	-$10,509	-$193,129
Maintenance Patrol (D4)	PNM	2A	26,904	15 kW	$58,543	$0.0752	$2,023	-$80	$765	$641	$15,401
Rest Area (D4)	Farmers	5	8,197	5 kW	$26,297	$0.1960	$1,607	-$225	-$3,943	$11	$848

District Office (D4)

PPA Escalation Rate	1%
Starting PPA Rate	$0.09/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$731,791
30-Year Electric Bill Savings	$827,488
30-Year LCOE PV	$0.069
30-Year NPV	($38,280)

Combined Solar PV Rating
Power Rating: 250,000 W-DC
Power Rating: 217,765 W-AC-CEC

General Information
Facility: District Office (D4)
Address: Las Vegas NM 87701

Solar PV Equipment Description
Solar Panels: 250.0kW-DC Standard Modules
Inverters: Standard Inverter

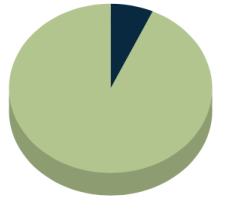
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$816,340
Net Solar PV System Cost:	**$816,340**

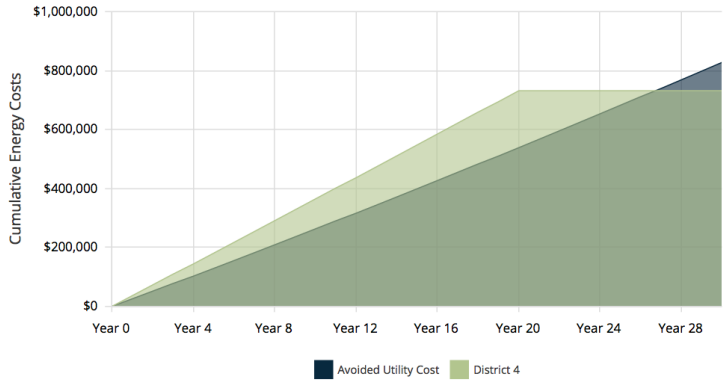
Solar PV System Rating
Power Rating: 250,000 W-DC
Power Rating: 217,765 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 430,080 kWh

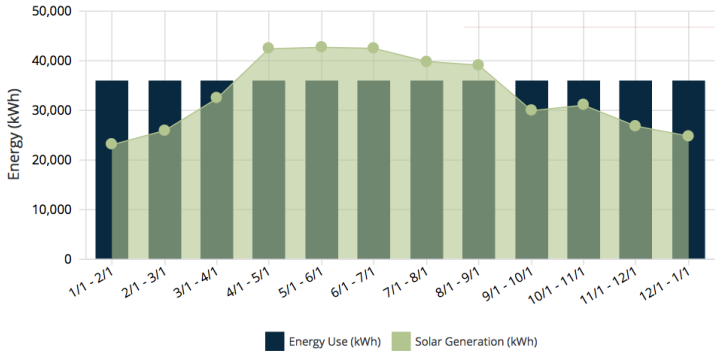


Utility 29,287 kWh (6.81%)
Solar PV 400,793 kWh (93.19%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



District Office (D4)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$48,787
30-Year Electric Bill Savings	$98,606
30-Year LCOE PV	$0.076
30-Year NPV	$19,326

Combined Solar PV Rating
Power Rating: 15,000 W-DC
Power Rating: 13,066 W-AC-CEC

General Information
Facility: Maintenance Patrol (D4)
Address: Las Vegas NM 87701

Solar PV Equipment Description
Solar Panels: 15.0kW-DC Standard Modules
Inverters: Standard Inverter

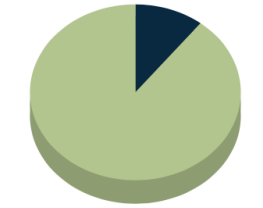
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$58,543
Net Solar PV System Cost:	**$58,543**

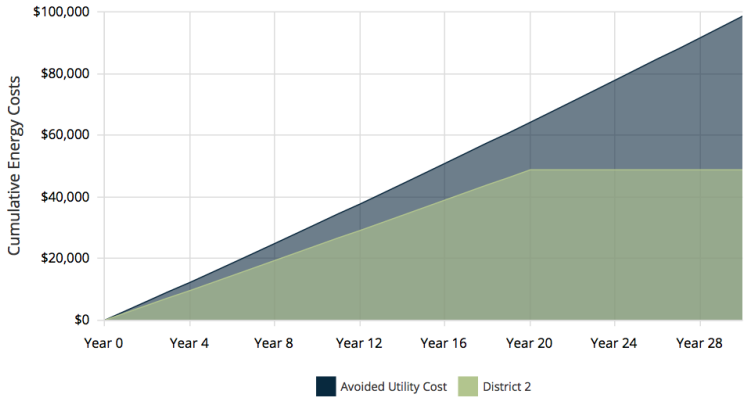
Solar PV System Rating
Power Rating: 15,000 W-DC
Power Rating: 13,066 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 26,904 kWh

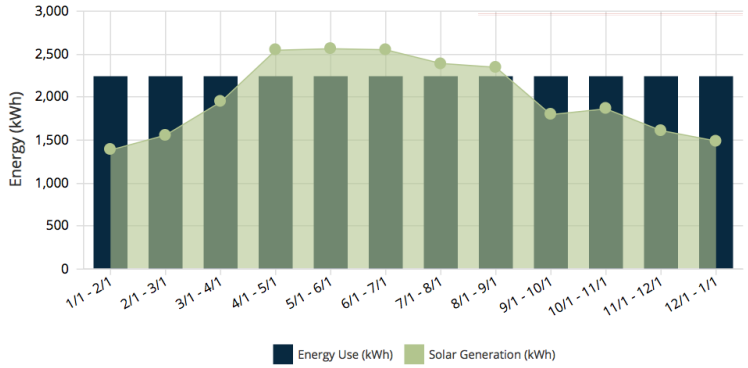


Utility 2,856 kWh (10.62%)
Solar PV 24,048 kWh (89.38%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



DISTRICT 5

Facilities	Utility	Rate Schedule	Annual Usage (kWh)	Array Size (kW)	Array Cost	Avg Cost of Electricity to NMDOT	Current Annual Cost ($ per year)	Single PPA Savings ($ per year)	Single PPA Savings - 20 Years ($ per year)	Bundled PPA Savings ($ per year)	Bundled PPA Savings - 20 Years ($ per year)
District 5											
District Office (D5)	PNM	3B	646,400	300 kW	1,039,973	$0.1104	$71,388	-$17,128	-$321,521	-$12,110	-$219,715
Maintenance Patrol (Cerrillos) (D5)	PNM	2A	16,343	10 kW	$42,420	$0.1316	$2,150	-$94	-$289	$403	$9,802
Rest Area Facility (La Bajada) (D5)	PNM	2A	23,493	15 kW	$58,543	$0.1410	$3,312	-$218	-$2,054	-$2,487	-$50,452

District Office (D5)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$15,970
30-Year Electric Bill Savings	$25,836
30-Year LCOE PV	$0.076
30-Year NPV	$3,082

Combined Solar PV Rating
Power Rating: 5,000 W-DC
Power Rating: 4,355 W-AC-CEC

General Information
Facility: Glen Rio Rest Area (D4)
Address: Glenrio NM 88434

Solar PV Equipment Description
Solar Panels: 5.00kW-DC Standard Modules
Inverters: Standard Inverter

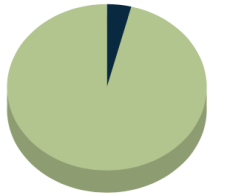
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$26,297
Net Solar PV System Cost:	**$26,297**

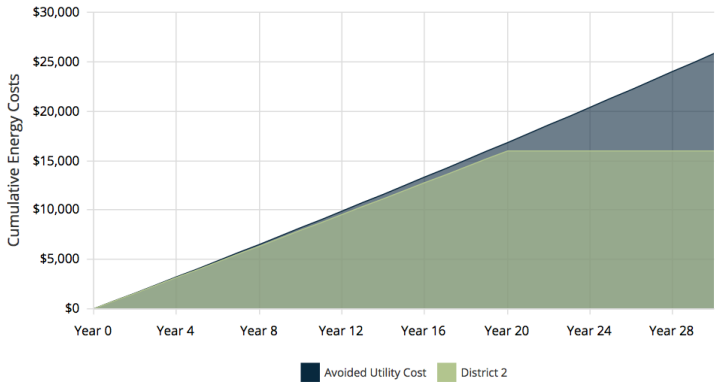
Solar PV System Rating
Power Rating: 5,000 W-DC
Power Rating: 4,355 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 8,196 kWh

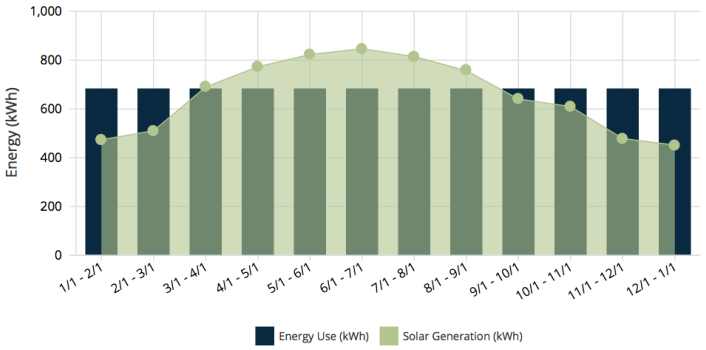


Utility 324 kWh (3.95%)
Solar PV 7,872 kWh (96.05%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



District Office (D5)

PPA Escalation Rate	1%
Starting PPA Rate	$0.09/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$916,254
30-Year Electric Bill Savings	$1,070,016
30-Year LCOE PV	$0.069
30-Year NPV	($30,834)

Combined Solar PV Rating
Power Rating: 300,000 W-DC
Power Rating: 261,318 W-AC-CEC

General Information
Facility: District Office (D5)
Address: NM NM

Solar PV Equipment Description
Solar Panels: 300.0kW-DC Standard Modules
Inverters: Standard Inverter

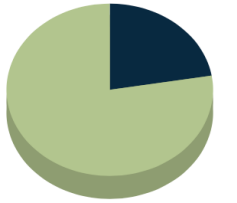
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$1,039,973
Net Solar PV System Cost:	**$1,039,973**

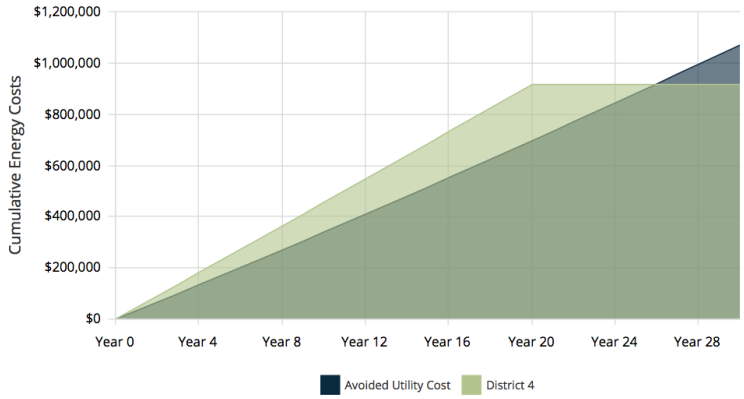
Solar PV System Rating
Power Rating: 300,000 W-DC
Power Rating: 261,318 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 646,403 kWh

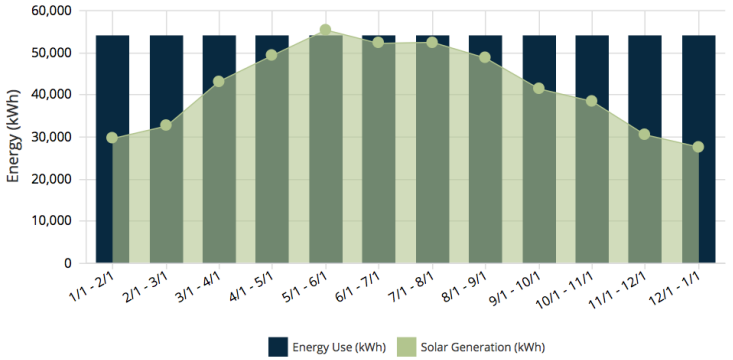


Utility 144,582 kWh (22.37%)
Solar PV 501,821 kWh (77.63%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



Maintenance Patrol (Cerrillos) (D5)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$33,636
30-Year Electric Bill Savings	$66,730
30-Year LCOE PV	$0.076
30-Year NPV	$12,692

Combined Solar PV Rating
Power Rating: 10,000 W-DC
Power Rating: 8,711 W-AC-CEC

General Information
Facility: Cerrillos Maintenance Patrol (D5)
Address: Los Cerrillos NM

Solar PV Equipment Description
Solar Panels: 10.00kW-DC Standard Modules
Inverters: Standard Inverter

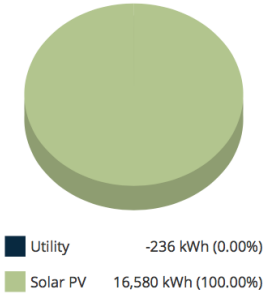
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

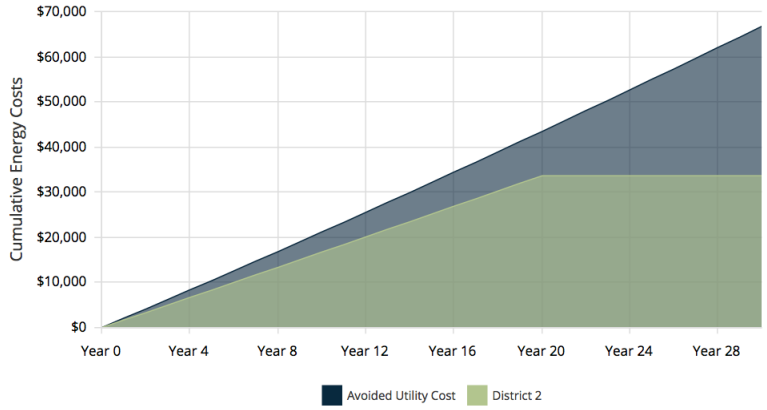
Solar PV System Cost	$42,420
Net Solar PV System Cost:	**$42,420**

Solar PV System Rating
Power Rating: 10,000 W-DC
Power Rating: 8,711 W-AC-CEC

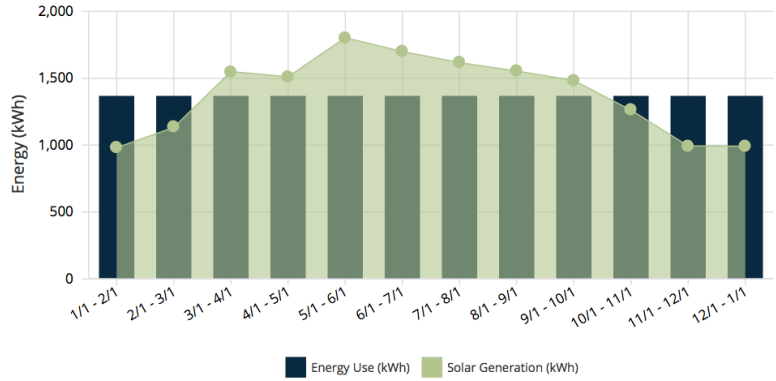
Energy Consumption Mix
Annual Energy Use: 16,344 kWh



Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



Rest Area Facility (La Bajada) (D5)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$50,452
30-Year Electric Bill Savings	-
30-Year LCOE PV	$0.076
30-Year NPV	($31,372)

Combined Solar PV Rating
Power Rating: 15,000 W-DC
Power Rating: 13,066 W-AC-CEC

General Information
Facility: La Bajada Rest Area Facility (D5)
Address: La Bajada NM 87052

Solar PV Equipment Description
Solar Panels: 15.0kW-DC Standard Modules
Inverters: Standard Inverter

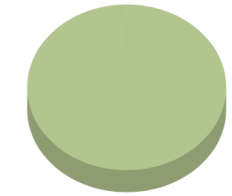
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$58,543
Net Solar PV System Cost:	**$58,543**

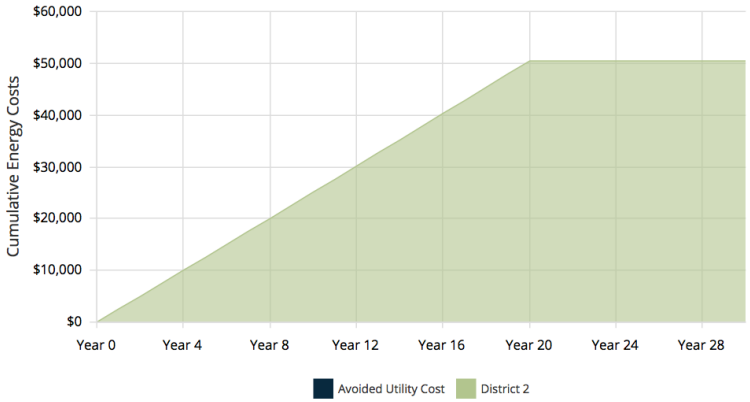
Solar PV System Rating
Power Rating: 15,000 W-DC
Power Rating: 13,066 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 0 kWh



Utility -24,869 kWh (0.00%)
Solar PV 24,869 kWh (100.00%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation

DISTRICT 6

Facilities	Utility	Rate Schedule	Annual Usage (kWh)	Array Size (kW)	Array Cost	Avg Cost of Electricity to NMDOT	Current Annual Cost ($ per year)	Single PPA Savings ($ per year)	Single PPA Savings - 20 Years ($ per year)	Bundled PPA Savings ($ per year)	Bundled PPA Savings - 20 Years ($ per year)
District 6											
District Office (D6)	Continental Divide	LPS	109,960	75 kW	$252,023	$0.1200	$13,195	-$7,699	-$149,514	-$4,192	-$79,042
IT Building (D6)	Continental Divide	LPS	57,788	35 kW	$123037	$0.1100	$6,357	-$3,537	-$68,884	-$1,841	-$34,449
Service Center (D6)	Continental Divide	LPS	142,500	75 kW	$252,023	$0.1400	$19,950	-$7,394	-$143,723	-$4,012	-$75,252
Milan Project Office (D6)	Continental Divide	LPS	26,748	20 kW	$74,667	$0.1000	$2,675	-$1,275	-$23,644	-$328	-$4,424
Milan Project Office 2 (D6)	Continental Divide	LPS	20,536	10 kW	$42,420	$0.1100	$2,259	-$1,021	-$19,912	-$510	-$9,503
Lab - Project Office (D6)	Continental Divide	LPS	20,520	10 kW	$42,420	$0.1100	$2,257	-$983	-$19,113	-$510	-$9,503
Pavement Crew (D6)	Continental Divide	LPS	13,369	5 kW	$42,420	$0.1100	$1,471	-$473	-$9,159	-$236	-$4,353
Heavy Maintenance (D6)	Continental Divide	LPS	15,532	10 kW	$42,420	$0.1200	$1,864	-$1,022	-$19,931	-$549	-$10,321
Cuba Patrol Main (D6)	Jemez Mountains	3	17,790	10 kW	$42,420	$0.1600	$2,846	-$639	-$11,851	-$179	-$2,527

District Office (D6)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$240,246
30-Year Electric Bill Savings	$247,641
30-Year LCOE PV	$0.076
30-Year NPV	($24,666)

Combined Solar PV Rating
Power Rating: 75,000 W-DC
Power Rating: 65,329 W-AC-CEC

General Information
Facility: District Office (D6)
Address: Milan NM

Solar PV Equipment Description
Solar Panels: 75.0kW-DC Standard Modules
Inverters: Standard Inverter

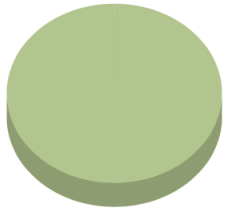
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$252,023
Net Solar PV System Cost:	**$252,023**

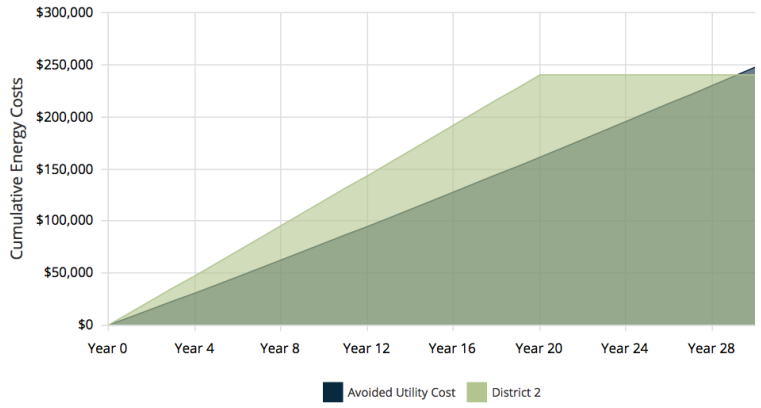
Solar PV System Rating
Power Rating: 75,000 W-DC
Power Rating: 65,329 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 109,956 kWh

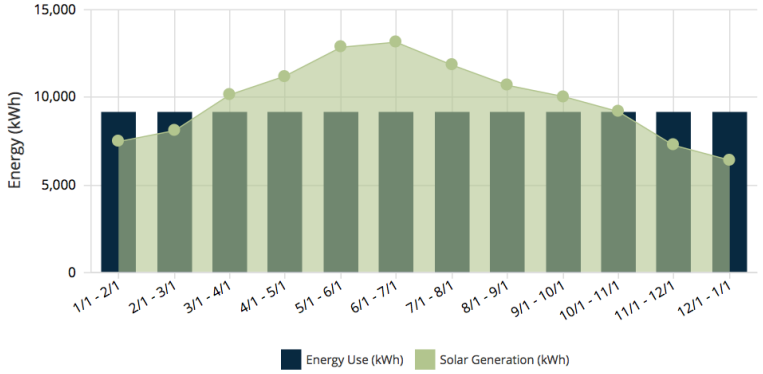


Utility -8,466 kWh (0.00%)
Solar PV 118,422 kWh (100.00%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



IT Building (D6)

PPA Escalation Rate	1%
Starting PPA Rate	$0.13/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$145,748
30-Year Electric Bill Savings	$118,077
30-Year LCOE PV	$0.099
30-Year NPV	($31,159)

Combined Solar PV Rating
Power Rating: 35,000 W-DC
Power Rating: 30,487 W-AC-CEC

General Information
Facility: IT Building (D6)
Address: Milan NM

Solar PV Equipment Description
Solar Panels: 35.0kW-DC Standard Modules
Inverters: Standard Inverter

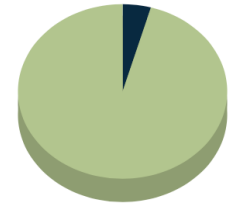
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$123,037
Net Solar PV System Cost:	**$123,037**

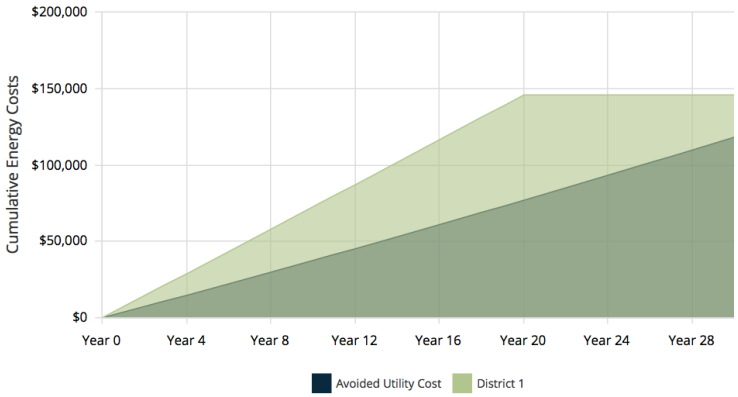
Solar PV System Rating
Power Rating: 35,000 W-DC
Power Rating: 30,487 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 57,792 kWh

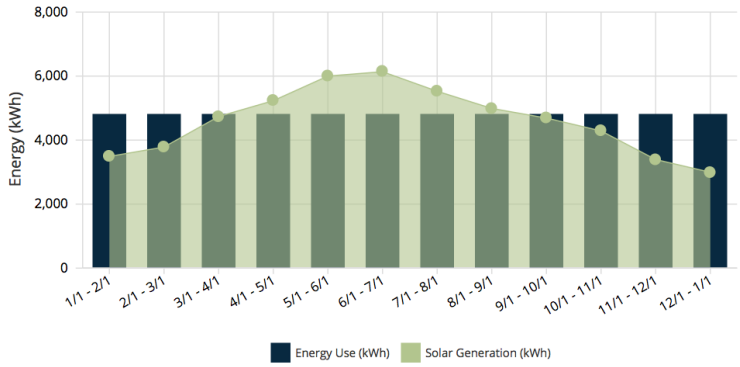


Utility	2,529 kWh (4.38%)
Solar PV	55,263 kWh (95.62%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



Service Center (D6)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$240,246
30-Year Electric Bill Savings	$253,463
30-Year LCOE PV	$0.076
30-Year NPV	($21,734)

Combined Solar PV Rating
Power Rating: 75,000 W-DC
Power Rating: 65,329 W-AC-CEC

General Information
Facility: Service Center (D6)
Address: Milan NM 87021

Solar PV Equipment Description
Solar Panels: 75.0kW-DC Standard Modules
Inverters: Standard Inverter

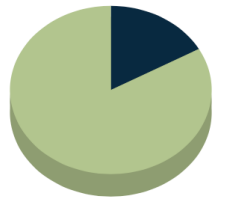
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$252,023
Net Solar PV System Cost:	**$252,023**

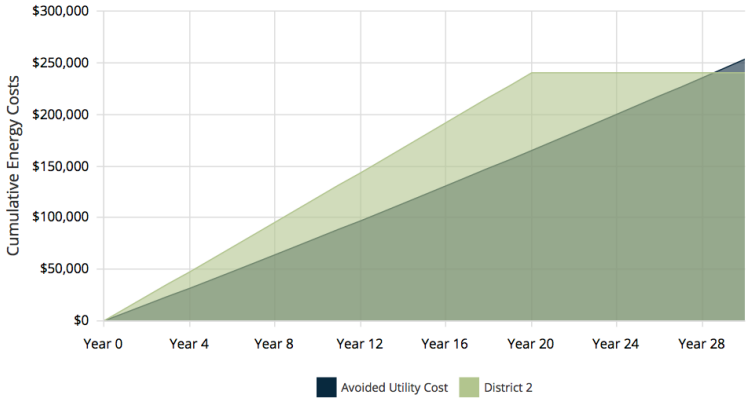
Solar PV System Rating
Power Rating: 75,000 W-DC
Power Rating: 65,329 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 142,500 kWh

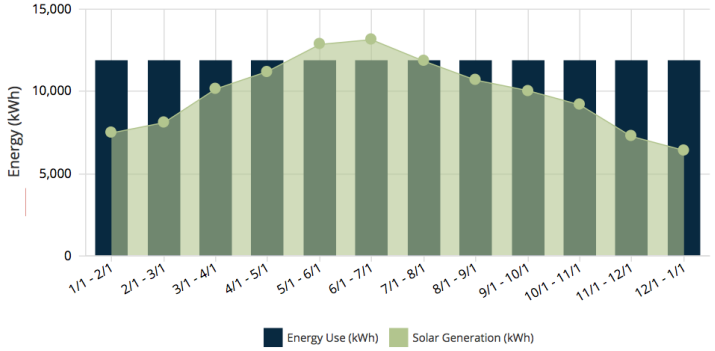


Utility 24,078 kWh (16.90%)
Solar PV 118,422 kWh (83.10%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



Milan Project Office (D6)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$64,065
30-Year Electric Bill Savings	$91,620
30-Year LCOE PV	$0.076
30-Year NPV	$6,307

Combined Solar PV Rating
Power Rating: 20,000 W-DC
Power Rating: 17,421 W-AC-CEC

General Information
Facility: Milan Project Office (D6)
Address: Milan NM

Solar PV Equipment Description
Solar Panels: 20.0kW-DC Standard Modules
Inverters: Standard Inverter

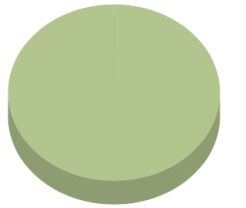
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$74,667
Net Solar PV System Cost:	**$74,667**

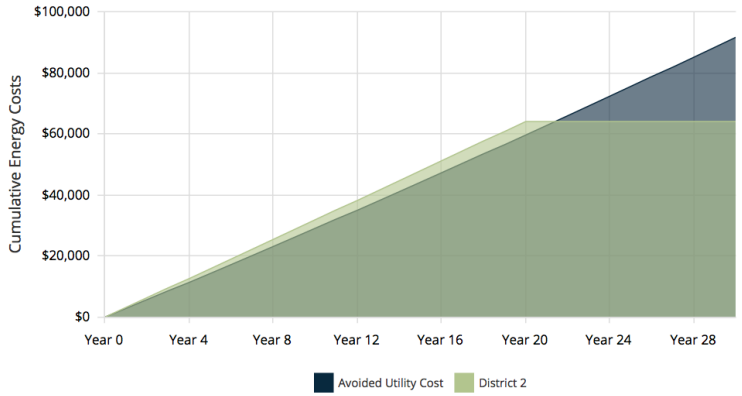
Solar PV System Rating
Power Rating: 20,000 W-DC
Power Rating: 17,421 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 26,748 kWh

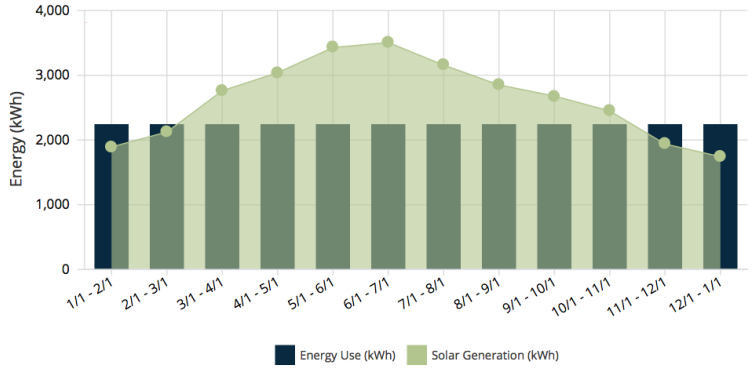


Utility -4,831 kWh (0.00%)
Solar PV 31,579 kWh (100.00%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



Milan Project Office 2 (D6)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$32,034
30-Year Electric Bill Savings	$34,612
30-Year LCOE PV	$0.076
30-Year NPV	($2,487)

Combined Solar PV Rating
Power Rating: 10,000 W-DC
Power Rating: 8,711 W-AC-CEC

General Information
Facility: Milan Project Office 2 (D6)
Address: Milan NM 87021

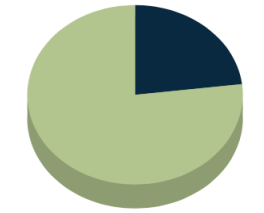
Solar PV Equipment Description
Solar Panels: 10.00kW-DC Standard Modules
Inverters: Standard Inverter

Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives	
Solar PV System Cost	$42,420
Net Solar PV System Cost:	**$42,420**

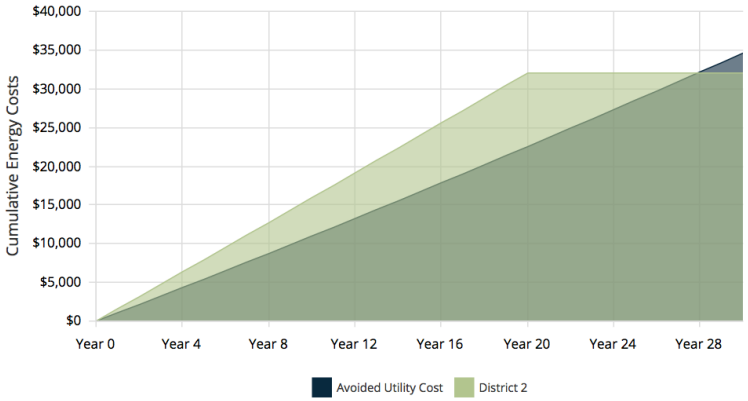
Solar PV System Rating
Power Rating: 10,000 W-DC
Power Rating: 8,711 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 20,532 kWh

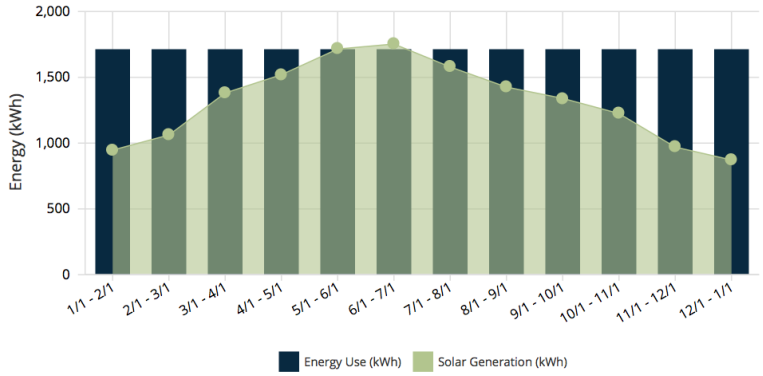


Utility	4,742 kWh (23.10%)
Solar PV	15,790 kWh (76.90%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



Lab - Project Office (D6)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$32,034
30-Year Electric Bill Savings	$34,612
30-Year LCOE PV	$0.076
30-Year NPV	($2,487)

Combined Solar PV Rating
Power Rating: 10,000 W-DC
Power Rating: 8,711 W-AC-CEC

General Information
Facility: Lab - Project Office (D6)
Address: Milan NM

Solar PV Equipment Description
Solar Panels: 10.00kW-DC Standard Modules
Inverters: Standard Inverter

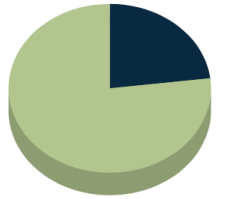
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$42,420
Net Solar PV System Cost:	**$42,420**

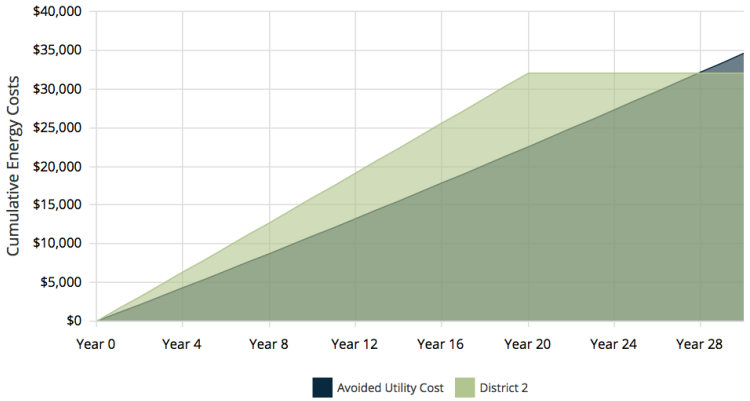
Solar PV System Rating
Power Rating: 10,000 W-DC
Power Rating: 8,711 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 20,532 kWh

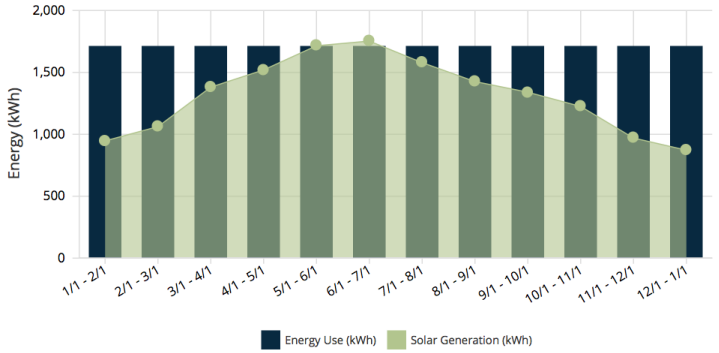


Utility 4,742 kWh (23.10%)
Solar PV 15,790 kWh (76.90%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



Pavement Crew (D6)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$16,021
30-Year Electric Bill Savings	$17,925
30-Year LCOE PV	$0.076
30-Year NPV	($934)

Combined Solar PV Rating
Power Rating: 5,000 W-DC
Power Rating: 4,355 W-AC-CEC

General Information
Facility: Pavement Crew (D6)
Address: Milan NM

Solar PV Equipment Description
Solar Panels: 5.00kW-DC Standard Modules
Inverters: Standard Inverter

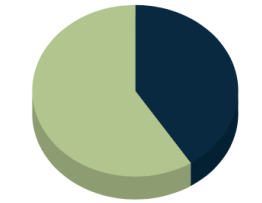
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$26,297
Net Solar PV System Cost:	**$26,297**

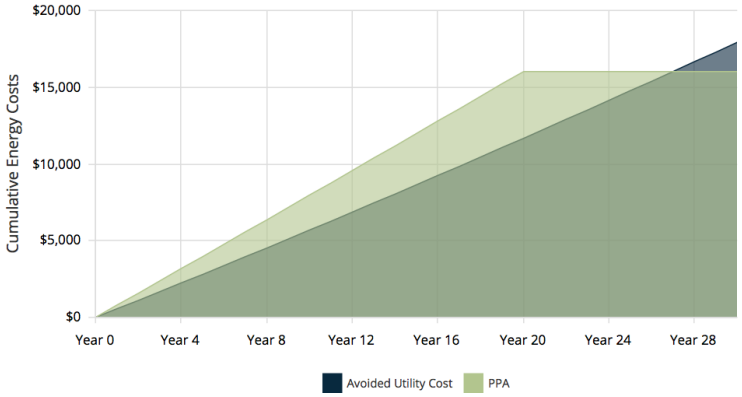
Solar PV System Rating
Power Rating: 5,000 W-DC
Power Rating: 4,355 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 13,368 kWh

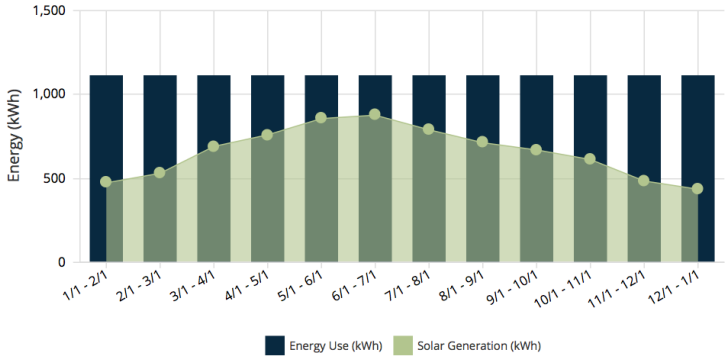


Utility 5,471 kWh (40.93%)
Solar PV 7,897 kWh (59.07%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



Heavy Maintenance (D6)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$32,034
30-Year Electric Bill Savings	$33,354
30-Year LCOE PV	$0.076
30-Year NPV	($3,120)

Combined Solar PV Rating
Power Rating: 10,000 W-DC
Power Rating: 8,711 W-AC-CEC

General Information
Facility: Heavy Maintenance (D6)
Address: Milan NM

Solar PV Equipment Description
Solar Panels: 10.00kW-DC Standard Modules
Inverters: Standard Inverter

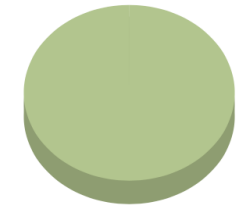
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$42,420
Net Solar PV System Cost:	**$42,420**

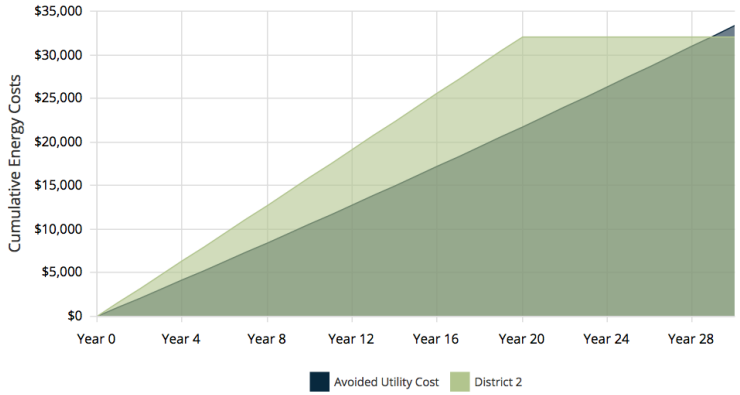
Solar PV System Rating
Power Rating: 10,000 W-DC
Power Rating: 8,711 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 15,528 kWh

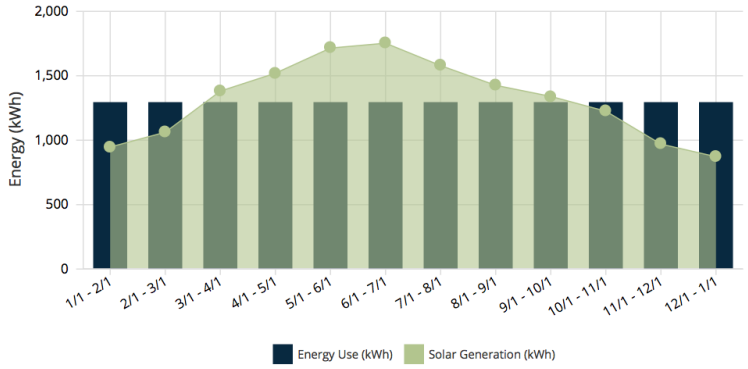


Utility -262 kWh (0.00%)
Solar PV 15,790 kWh (100.00%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



Cuba Patrol Main (D6)

PPA Escalation Rate	1%
Starting PPA Rate	$0.1/kWh
Upfront Payment	-
Term	20 Years
Total Payments	$32,034
30-Year Electric Bill Savings	$45,328
30-Year LCOE PV	$0.076
30-Year NPV	$2,910

Combined Solar PV Rating
Power Rating: 10,000 W-DC
Power Rating: 8,711 W-AC-CEC

General Information
Facility: Cuba Patrol Main (D6)
Address: Milan NM

Solar PV Equipment Description
Solar Panels: 10.00kW-DC Standard Modules
Inverters: Standard Inverter

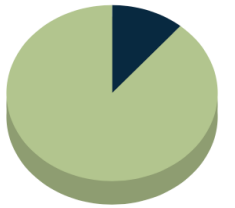
Solar PV Equipment Typical Lifespan
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost And Incentives

Solar PV System Cost	$42,420
Net Solar PV System Cost:	**$42,420**

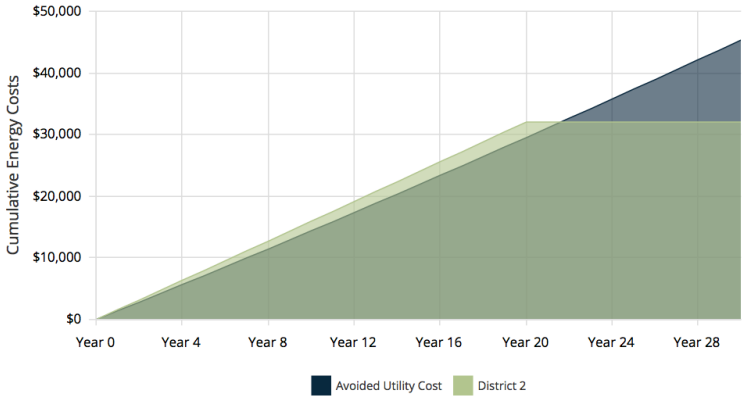
Solar PV System Rating
Power Rating: 10,000 W-DC
Power Rating: 8,711 W-AC-CEC

Energy Consumption Mix
Annual Energy Use: 17,784 kWh

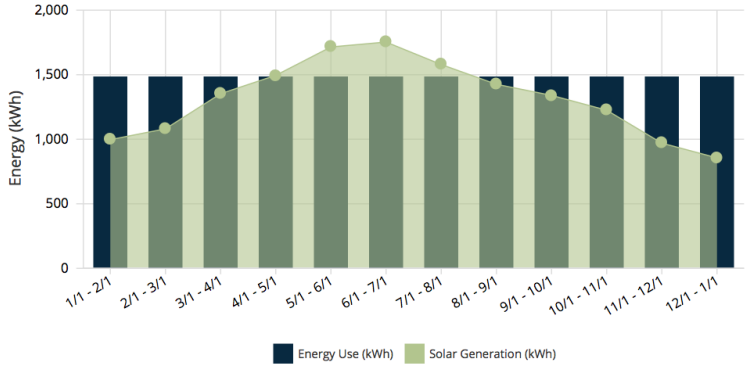


Utility	1,994 kWh (11.21%)
Solar PV	15,790 kWh (88.79%)

Cumulative Energy Costs By Payment Option



Monthly Energy Use vs Solar Generation



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