United States
Environmental Protection
Agency

Evaluating Renewable Energy Opportunities

THE APACHE POWDER SUPERFUND SITE, BENSON, ARIZONA

U.S. Environmental Protection Agency
Superfund Redevelopment Initiative

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This document summarizes the renewable energy pre-feasibility analysis conducted at the Apache Powder Superfund Site.

Introduction

For over 10 years, the United States Environmental Protection Agency (EPA) has been working with communities to better understand how Superfund sites can be returned to beneficial uses and supporting Superfund site reuse nationwide. EPA also strongly supports the evaluation of sites for reuse through renewable and sustainable energy production. Through efforts such as the Superfund Redevelopment Initiative and Re-Powering America's Lands Initiative, EPA is providing resources to encourage alternative and renewable energy generation at these sites.

In 2008, the Apache Powder Superfund Site, located near Benson, Arizona, presented a unique opportunity for EPA to support the evaluation of renewable energy generation. Ground water and soil contamination from prior disposal practices was addressed by Apache Nitrogen Products, Inc. (ANP) with EPA oversight, and construction of the remedy was completed in 2008. ANP continues to manufacture chemical products on portions of the site and expressed interest in exploring opportunities for renewable energy generation on remaining areas of the site.

With the support of EPA's Superfund Redevelopment Initiative, EPA Region 9 began to look at the site's potential for renewable energy development. A preliminary screening identified the following key assets:

- Excellent solar power generation potential
- A large tract of available land ready for reuse
- Significant federal, state and local incentives for solar energy projects
- A willing and enthusiastic site owner

Based on these assets, EPA conducted a Renewable Energy Pre-Feasibility Analysis to provide ANP with information on the site's potential for renewable energy development that could be compatible with the site's remedy and the on-going manufacturing operations at the ANP facility. The process and findings of this analysis are summarized in this document.

Top: Example of solar arrays installed at Nellis Air Force Base, Nevada. Bottom: ANP facilities at the Apache Powder Superfund Site, 2008.

Renewable Energy Analysis: A Four-Step Process

A renewable energy pre-feasibility analysis assists site owners, stakeholders and EPA in determining whether a site may be a candidate for renewable energy technologies. Following the analysis, site owners may develop a more detailed feasibility study for a particular renewable energy technology or identify development partners and move forward with renewable energy development. At the site, the four-step process for the analysis included:

1 **Evaluate Renewable Energy Resource:** Determine the availability of renewable energy resources and identify the renewable energy opportunities requiring further analysis.

2 **Assess Site Suitability:** Identify site-specific considerations such as access, topography and slope, remedial components, infrastructure, the existing uses and facilities.

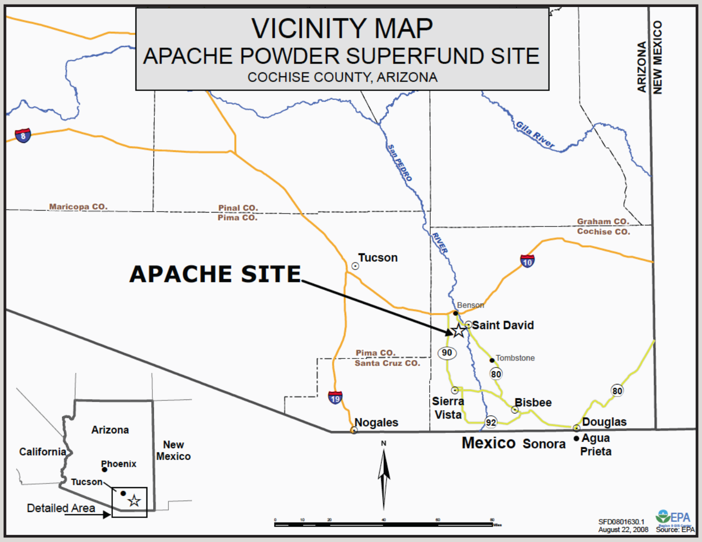
3 **Consider Technology-Specific Criteria:** Identify technology-specific considerations such as infrastructure requirements (including space and size requirements), energy generation and storage capacity, and costs for installation, operation and maintenance.

4 **Review Market and Incentives:** Assess the current renewable energy market and identify the federal, state and local incentives available to promote renewable energy generation.

Site Background

Since 1922, ANP (formerly the Apache Powder Company) has manufactured industrial chemicals and explosives. Historically, these operations produced both solid and liquid wastes which were disposed of on the property owned and operated by ANP, resulting in ground water and soil contamination.

Following initial investigations at the Site in the 1980s, ANP removed all contaminated soils, with the exception of sediments and soils in several evaporation ponds, which were covered, re-graded and capped in 2007. Deed restrictions in the form of a State of Arizona Declaration of Environmental Use Restriction (DEUR) were also placed on the ponds.



The Apache Powder Superfund Site encompasses approximately nine square miles and is located in a rural area of southeastern Arizona, southeast of Tucson.

To address ground water contamination in the shallow aquifer in the northern and southern areas of the site, cleanup activities are underway and long-term monitoring will continue. Cleanup activities utilizing green and renewable energy technologies include a constructed on-site wetland system. The constructed wetland system treats nitrate-contaminated ground water twenty four hours a day, 365 days a year. This approach avoids chemical usage, energy consumption and waste generation associated with traditional treatment methods. During the start-up phase of the wetlands, solar power was used to circulate water between the wetland ponds. Solar power is still used at the wetlands to power the flow meter for the system.

In September 2008, EPA completed its Construction Completion report for the site, describing all completed cleanup activities. The site is now in the long-term operations and maintenance phase of the Superfund cleanup process.

Step One: Evaluate Renewable Energy Resources

The renewable energy analysis for the site began with an assessment of available renewable energy resources, to identify which renewable energy resource(s) might merit further analysis. Solar and wind were identified using readily available information. Other renewable energy opportunities, such as biomass and geothermal energy, did not merit further analysis, due to limited availability or other restrictions.

Regional Energy Resources

Wind Energy

In general, wind power can be well-suited to Superfund sites because of the size of some sites and the presence of transmission lines from previous industrial facilities. However, the quality of wind resources varies significantly across the United States. According to current wind resource data from the National Renewable Energy Laboratory (NREL), the site is not located in an area with strong wind resources. Accordingly, the analysis concluded that the site is likely not well-located to support a financially viable location for a grid-connected wind turbine project.

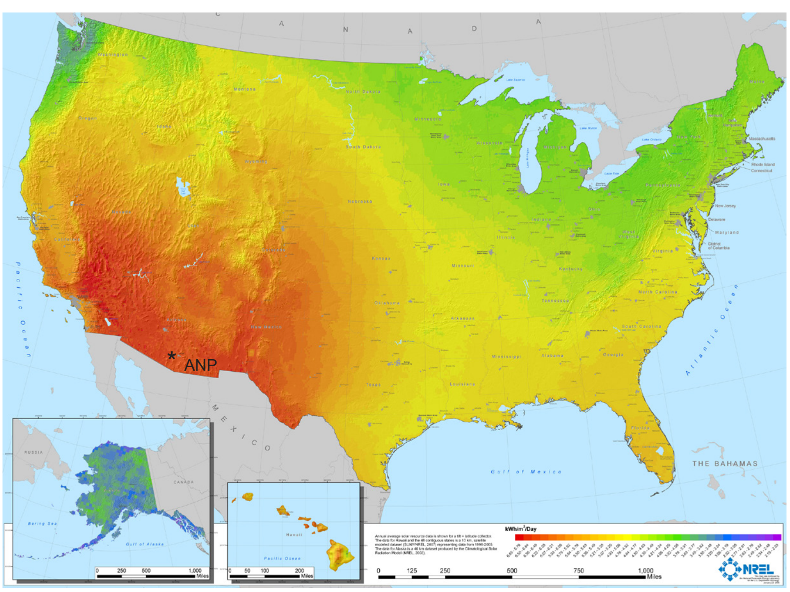
RE-Powering America's Lands Initiative

This EPA partnership with the Department of Energy and NREL is encouraging RE development on current and formerly contaminated land and mine sites. The initiative identifies the renewable energy potential of these sites and provides useful resources for communities, developers, industry, state and local governments and any other parties interested in reusing these sites for renewable energy development.

The initiative also provides the Renewable Energy Interactive Mapping Tool (See the *Resources* section). The Tool makes it possible to view EPA's renewable energy siting information for contaminated lands and mine sites alongside information on renewable energy resource availability and relevant Google Earth data.

Solar Energy

Most of the United States has access to adequate-to-good quality solar resources; all of Arizona, including the site, enjoys "excellent" quality resources, according to NREL. Arizona is also expected to rely heavily on solar energy in order to meet future renewable energy requirements like the state's renewable portfolio standard, which requires that electricity providers in the state obtain at minimum 15% of their power from renewable energy resources by 2025. Projections indicate that upwards of 65% of the state's renewable energy demand in 2025 will be met by solar energy projects. Accordingly, EPA's renewable energy analysis led to the development of a Solar Energy Information Memorandum in 2008, confirming the need to further investigate the potential for solar energy production at the site.



The Memorandum's findings indicated that the availability of excellent solar resources and available federal and state policies and incentives made solar energy development a potentially viable option at the site. Evaluating on-site energy demands and infrastructure is another important consideration in this first step of evaluating the energy resource.

Figure 1: National solar photovoltaics (PV) resource potential for the United States. Arizona and the Site have excellent solar potential. Source: NREL

Local Demand and Infrastructure

Energy Needs: ANP purchases all of its electricity from Sulphur Springs Valley Electric Cooperative (SSVEC). Manufacturing options at the site require a constant supply of 1MW to meet base energy demand, with a 2MW daily peak.

Transmission Capacity: Land on ANP property is leased by SSVEC for use by a 69kV electrical substation with a line capacity of 40MW. While the existing substation's capacity is adequate for current ANP operations, planned substation and line upgrades will have a 100MW capacity.

Based on this information, EPA developed two solar generation scenarios for further analysis:

On-site Use

- Provide ANP with an on-site energy source for all or a portion of the facility's electrical use
- Provide on-site steam to support manufacturing operations

Grid Use

- Generate utility scale energy for the grid with potential energy and economic benefits to ANP

To further evaluate these energy generation scenarios, the remaining steps of the analysis focuses on two types of solar technologies: photovoltaic (PV) and concentrating solar power (CSP).

Step Two: Assess Site Suitability

After determining resource availability and demand, EPA assessed the suitability of different site areas for solar development. First, the effort mapped existing site conditions. As illustrated in Figure 2, the site includes several large, flat contiguous areas unrestricted by natural or constructed features. Areas shown in green represent land with a slope of less than 5%. Paved roads are shown in grey and internal site roads are shown in tan. Remedial components are indicated in yellow and were excluded from the assessment due to potential regulatory conflicts. Additional infrastructure such as rail lines and site facilities are also shown.

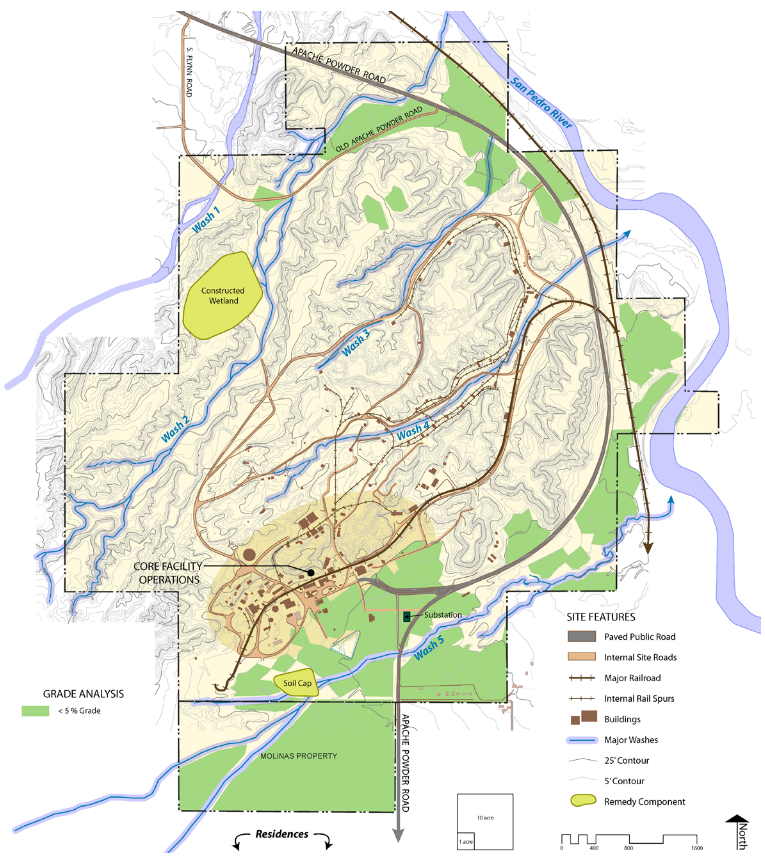


Figure: 2 Existing Conditions Suitability Analysis

Potential Solar Development Zones

Based on site features, six potential solar zones were identified (see Figure 3 below). Zone criteria included:

- Contiguous areas greater than 15 acres
- Areas with less than 5% slope
- Road access
- Proximity to infrastructure
- Areas with washes, remedy components and facilities excluded

At 25+ acres, Zones A, B and C were all large enough to support CSP technology. All six zones could support PV technology, which could be installed on areas as small as 15 acres. The resulting area with potential for either CSP or PV development totalled 185 acres (see table below for zone acreages).

Potential Solar Zones	
CSP Potential	
Zone A	70 acres
Zone B	25 acres
Zone C	35 acres
	130 Total Acres
PV Potential	
Zones A-C	130 acres
Zone D	15 acres
Zone E	20 acres
Zone F	20 acres
	185 Total Acres
Net PV/CSP Potential	
	185 Total Acres

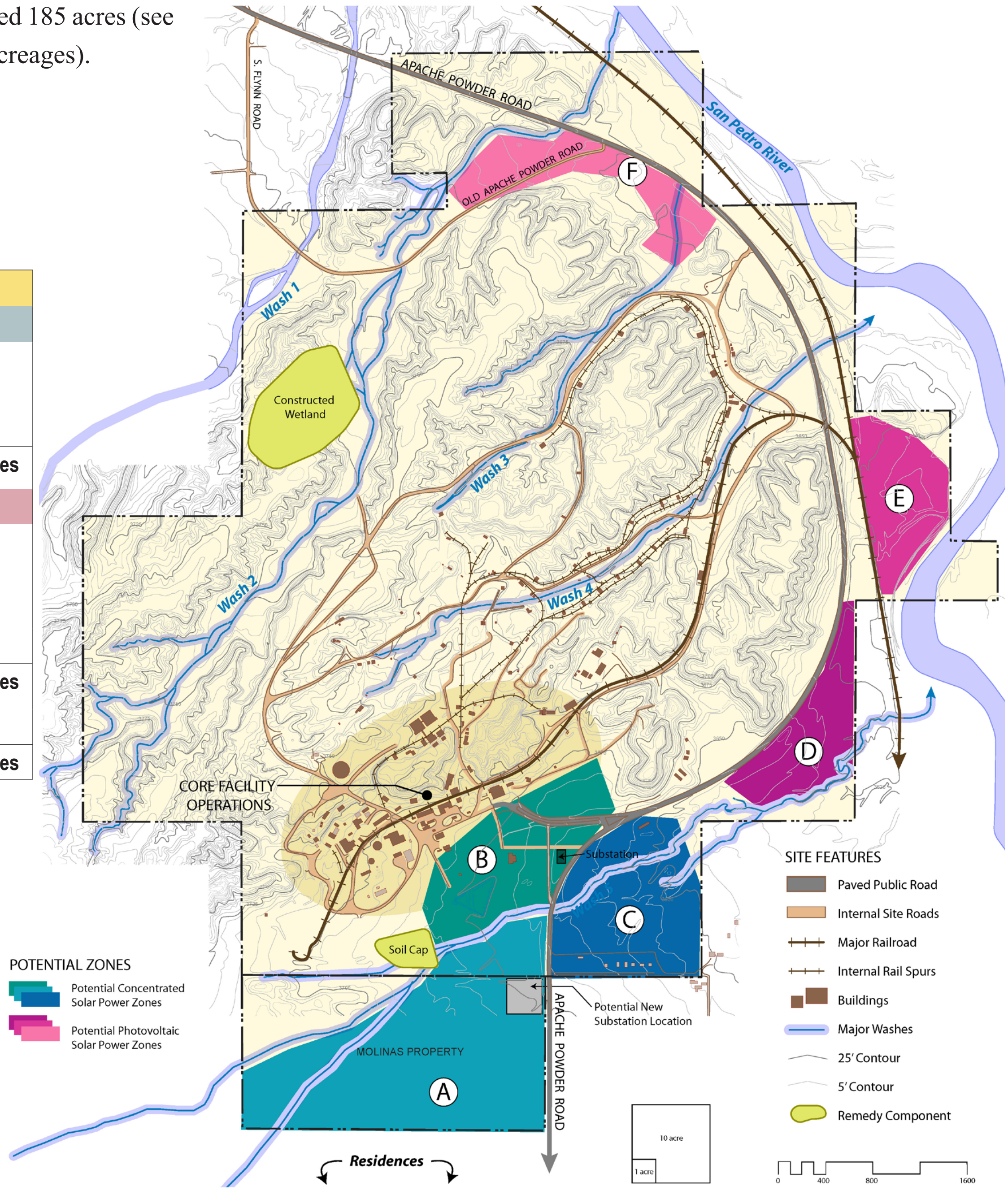


Figure 3: Potential Zones for Solar Development

Step Three: Consider Technology-Specific Criteria

The analysis next evaluated each solar technology based on technology-specific opportunities and constraints. PV systems use solar electric panels to directly convert the sun's energy into electricity. CSP systems generate electricity through the use of long mirrors that focus light on a tube of fluid. The concentrated rays boil the fluid (usually water), and the resulting steam drives turbines, generating electricity. Facilities at the site already rely on steam in production processes and could potentially use the steam produced by CSP systems to meet on-site production demand. PV systems and CSP systems could both take advantage of the abundant solar resources available at the site. However, each technology has specific requirements that may make it more or less suitable for use at the site. The table below summarizes some of the key differences in technology requirements for CSP and PV systems. CSP systems, for example, require large, contiguous land areas, use significant amounts of water, and can store energy. PV systems, in contrast, can be located on smaller land areas, do not use much water, and do not have any storage capacity.

Concentrating Solar Power (CSP) and Photovoltaic (PV): Key Differences

Solar Technology Type	Acres per MW	Minimum Practical Acreage	Site Needs	Storage Capacity	Estimated Annual Water Usage*
CSP	3 – 8 acres / MW	40 – 50 acres	Large, contiguous, level area	Yes	Significant
PV	4 – 10 acres / MW	N/A	Flexible	No	Negligible

**Estimates can vary based on specific technology*

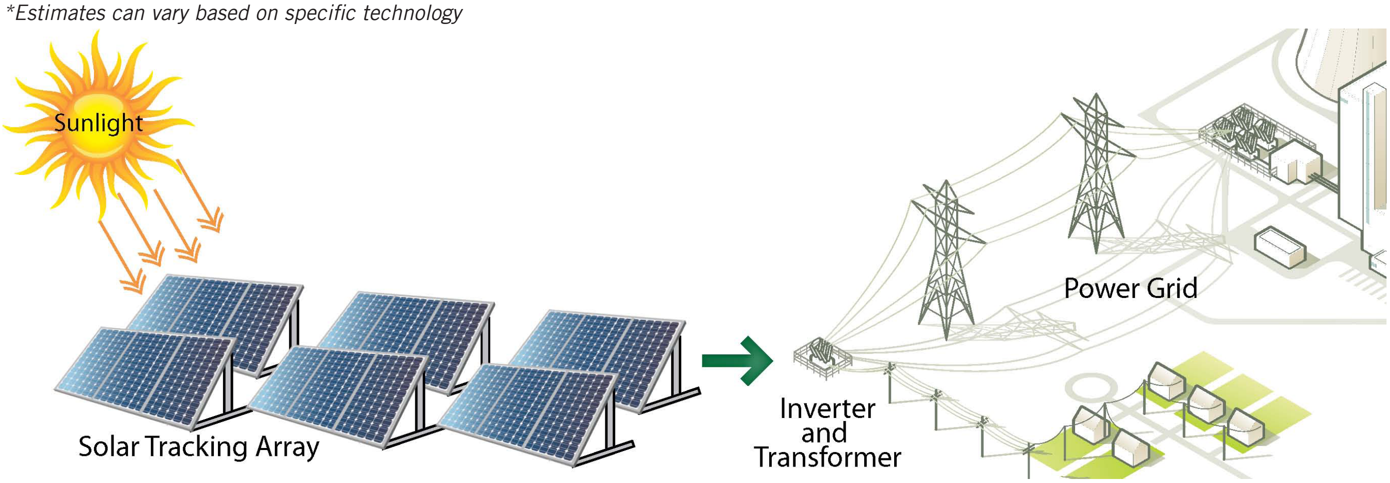


Image Source: U.S. EPA

Photovoltaic systems *make use of highly purified silicon that functions to convert sunlight directly into electricity, which can be used in place or supplied and distributed to the power grid, as depicted above.*

Concentrating solar power systems *indirectly generate electricity and essentially consists of two parts: one part that collects solar energy and converts it to heat and the other that converts the heat energy to electricity (see image to the right). This system can generate power around the clock through the use of its thermal storage capabiliies, not just when the sun is shining.*

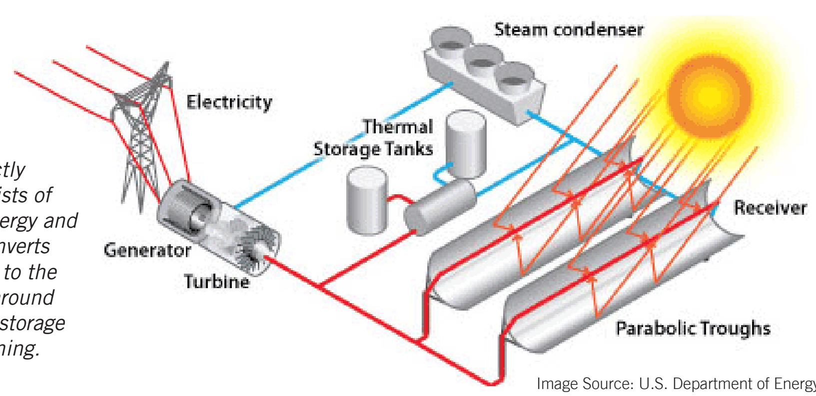


Image Source: U.S. Department of Energy

Comparative Analysis

To further understand the implications of CSP and PV systems for solar power generation at the site, EPA conducted a comparative analysis of capital and operations costs for a 5MW PV installation and a 10MW CSP installation. Findings from the analysis are presented in the table below.

Solar Technology Type	Acres per MW	Estimated Facility Size (MW)	Estimated Land Area Needed (acres)	Estimated Capital Cost ($ 1000)*	Estimated Annual O&M Cost ($ 1000)*	Estimated Annual Water Usage (gallons)
CSP Trough						
No Storage	5	10	50	$45,000 - 60,000	$1,250 - 1,500	20,000,000
No Storage Air Cooled	5	10	50	$65,000 - 70,000	$1,250 - 1,500	2,300,000
With Six-hour Storage	8	10	80	$50,000 - 65,000	$1,300 - 1,600	25 - 30,000,000
Linear-Fresnal Reflector	3	10	30	$30,000 - 35,000	$1,400 - 1,600	20,000,000
PV						
Thin Film (fixed axis)	6 - 8	5	30-40	$25,000 – 30,000	$400 – 600	Negligible
Crystalline Silicon (fixed axis)	4 – 5	5	20-25	$30,000 – 36,000	$450 – 600	Negligible
PV Tracking	8 - 10	5	40-50	$35,000 – 40,000	$900 – 1,100	Negligible

**Estimates based on 2009 cost approximations to provide a relative comparison of the two different technologies.*

As outlined in the table above, minimal capital investment anticipated for solar technology ranges from approximately $25 million for a 5MW PV facility to up to $70 million for a 10MW CSP facility. In general, CSP systems can generate more power on less land but require significant amounts of water in comparison with PV systems. Additional technology-specific considerations include:

- CSP economic viability is most likely achieved at 200-300MW facilities. However, the potential for re-purposing the steam produced by CSP technology could increase the viability of a smaller facility at the site.
- Facilities larger than 5MW would also require substation and line upgrades that could be met as part of planned upgrades.

Top: Tracking PV panels follow the sun to allow for increased solar capture. Bottom: Fixed axis PV panels aligned to be south facing.

Step Four: Review Market and Incentives

Finally, EPA's renewable energy analysis looked at market conditions and the availability of federal, state and local incentives to help make solar development at the site viable. The analysis found that the site is located in a growing solar market and ANP could benefit from both policy-based and financial incentives.

Solar Energy Market

In general, Arizona has excellent solar resources statewide and there are expectations for a growing market for renewable energy development, based on several factors:

- The state's dependence on natural gas as a source of electricity, given the price volatility of natural gas
- The state's proximity to large potential solar markets
- Intellectual capital resources at in-state universities and research centers

Across the state, the amount of installed grid-tied solar capacity has steadily increased:

- PV system installations quadrupled in Arizona between 2008 and 2009
- In 2009, 23MW of PV capacity was installed in Arizona. This capacity is expected to increase significantly in coming years, with large projects like the proposed 280MW Solana solar thermal project in Gila Bend
- Arizona ranked fourth nationally in installed solar energy capacity in 2009 (behind California, New Jersey and Colorado)

Generation and Sale of Electricity

Utilities or their affiliates provide power generation, high-voltage transmission lines and low-voltage distribution. Energy providers can sell their power in two primary ways: wholesale and retail. Power sold at "wholesale" is primarily done for large-scale utility providers. Power sold at "retail" is usually done for individual customers or facilities.

Two types of purchasing agreements are commonly used by energy generators and utilities:

- *Retail Purchasing Agreement:* May be advantageous for the provider and the buyer if an individual facility owner (such as ANP) can provide inexpensive land access to an energy developer in exchange for cheaper utility rates for a set number of years. Additionally, this option may work well if there are too many costs associated with the developer's ability to access the utility grid. In this case, the individual facility may benefit from consuming all energy generated on site.
- *Wholesale Purchasing Agreement:* May be more economically beneficial to a landowner/energy developer if a utility company is looking to increase its overall power generation.

Renewable Energy Incentives

The analysis found that, in Arizona, there are significant incentives available to facilitate the development of renewable energy projects for solar energy. Incentives are available at the local, state and federal levels and include both policy-based incentives (e.g., renewable portfolio standards) and financial incentives (e.g., tax credits and rebates). The incentives identified by the analysis are presented below.

	Incentive Description
Federal Incentives	• Business Energy Tax Credits: 30% tax credit to partially offset the upfront installed cost of a solar system. Also known as Investment Tax Credits (ITCs) • Modified Accelerated Cost Recovery: Current method of accelerated asset depreciation required by the United States income tax code • Clean Renewable Energy Bonds (CREBs): Bonds to provide a federal tax credit for the bond owner in lieu of interest payments from the issuer.
State Incentives	• Renewable Energy Standard (RES): Arizona has legislated a 15% RES by 2025. Investor-owned utilities serving retail customers will be subject to the standard. Further, by 2011, 30% of renewables must come from distributed generation sources such as commercial and residential projects. The 15% RES goal is mandatory for investor-owned utilities, energy cooperatives must also meet renewable energy goals. • Renewable Energy Credits (RECs): RECs are tradable commodities decoupled from electricity generation. An REC is equal to 1MWh of power generated in the course of one year from a renewable source. RECs can amount to 30-70% of a solar project's anticipated revenue stream. Market prices for RECs can vary significantly, Arizona's RES allows RECs to be banked and withdrawn at a later date. • Solar Energy Property Tax Exemption: Applies to "solar energy devices and any other device or system designed for the production of solar energy for onsite consumption." • Commercial/Industrial Solar Energy Tax Credit Program: 10% of the installed cost of a solar device, not to exceed $50,000 per business per tax year.
Local Utility Incentives	• Upfront incentives (purchase price incentives): One-time, upfront incentive or rebate based on the size of the solar system. SSVEC offers both commercial and residential solar rebates. • Production-based incentives: An incentive paid out based on actual kWh production of a renewable energy system over time instead of an initial, upfront incentive payment.

Summary of Findings

The Renewable Energy Pre-Feasibility Analysis for the Apache Powder Superfund site yielded several key findings, including:

- The site could potentially support direct use and utility-scale solar development (PV preferred)
- Solar energy development could be compatible with the site's existing characteristics
- A project would face high upfront capital costs for both CSP and PV systems (approximately $25 million for PV and $35 million for CSP)
- The ability to use incentives and obtain a long-term power purchase agreement would likely be critical for the economic viability of a utility-scale project at the site

Land Availability

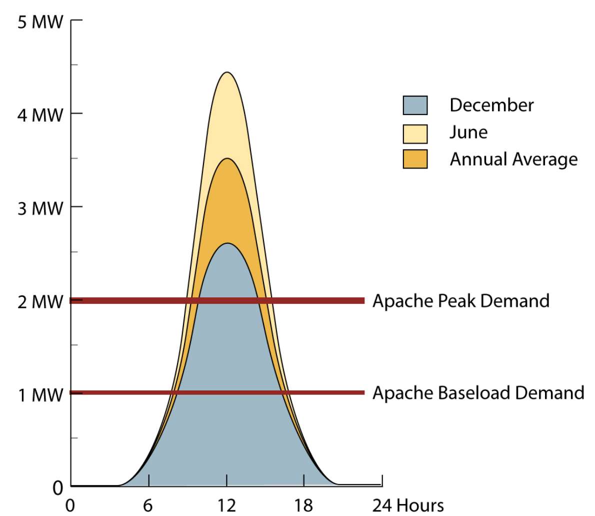
The site has sufficient acreage in areas with appropriate slope and infrastructure access to support a solar energy project. Analysis identified 100-130 acres of contiguous land and up to 185 acres of non-contiguous land that could be suitable. Analysis did not include remedy component areas, since sufficient acreage was available elsewhere on the site. The available acreage could support a 15-45MW PV facility. Alternatively, the acreage could support a 20MW CSP facility that includes a storage capacity of up to six additional hours or a 40MW facility with no storage capacity.

Potential solar energy generation scenarios include on-site use and grid use. On-site use will not cover all of ANP's energy needs but could provide ANP with an on-site energy source to reduce peak electricity demand. Grid use could generate utility-scale energy for the grid with potential energy use and economic benefits for ANP.

Solar Technologies

Analysis of solar technologies focused on a 5MW PV installation and a 10MW CSP installation. Currently, the economic viability of a CSP system is most likely achieved at 200-300MW facilities, although the potential for repurposing the steam produced by CSP technology could increase the viability of a smaller facility at the site. However, water resource availability and cost challenges in the southwest could make the technology difficult to implement due to its significant water requirements. The minimal capital investment anticipated for solar technology at the site range from approximately $25 million for a 5MW PV facility to up to $70 million for a 10MW CSP facility. Facilities larger than 5MW would also require substation and line upgrades.

In conclusion, the site could potentially support both CSP and PV technologies. Given the large amount of acreage available, solar energy development would be compatible with the site's existing characteristics. However, there are high-upfront capital costs for installation of both CSP and PV technologies. ANP's ability to use incentives and obtain a long-term power purchase agreement is likely critical to the economic viability of a utility-scale project at the site.



Hypothetical daily generation for a 5MW PV array demonstrates how an on-site facility could help reduce peak electricity demand.

Next Steps

Based on the potential opportunities highlighted in the Renewable Energy Pre-Feasibility Analysis, ANP moved forward with two potential solar projects: a solar awning and canopy for existing facilities and a utility-scale solar development.

Solar Awning and Canopy

In November of 2010, ANP completed construction of a 41 kW solar canopy. The solar canopy offsets approximately 45% of ANP's annual office energy use, saving $6,000 annually. ANP was able to construct this system utilizing various federal, state and local tax credits, resulting in minimal capital investment on the part of the company. The structure does not impact the integrity of the building and is designed to be completely free-standing on perimeter steel beams. The beams will be covered with stucco to blend with the existing architecture.

Utility-Scale Solar Project

Following discussions with an energy developer, the capped ponds on site were identified as an ideal setting for installing a solar project. The closed ponds are expected to support a 1MW facility. Further development would expand onto adjacent land included in the pre-feasibility analysis.

The technology being proposed by the developer is high concentration photovoltaic (HCPV) technology that uses a two-axis tracking system. This technology was chosen over CSP because of its low water use. ANP anticipates that five or more MW of power could be generated on the southern area of the site.

Two potential partners have been identified for the project – a local partner interested in sponsoring renewable energy projects and a manufacturer with a technology well-suited to the site. The next step will be to identify a utility interested in buying the electricity generated by the project.

Lessons Learned

The development of renewable energy technologies is a complex process reliant on available incentives, multiple parties, market conditions and other factors that have to be identified and managed throughout a project. As the Renewable Energy Pre-Feasibility Analysis for the Apache Powder Superfund site illustrates, contaminated lands can provide opportunities for significant renewable energy projects that contribute to a sustainable future. Key lessons learned from this process that could help guide similar projects at contaminated lands across the country include:

- A pre-feasibility analysis, as outlined here, can assist in determining whether a site might be a candidate for renewable energy technologies and merit additional evaluation.
- While utility-scale renewable energy projects can be complex, public-private partnerships and other resources help ensure that these complexities can be addressed and managed.
- Solar projects can be located in many places and at different scales

Since the inception of the Superfund program, EPA has been building on its expertise in conducting site characterization and remediation to ensure that contamination is not a barrier to the reuse of property. Today, consideration of future use is an integral part of EPA's cleanup programs, from initial site investigations and remedy selection through to the design, implementation, and operation and maintenance of a site's remedy. EPA is working nationwide with public and private partners like ANP to encourage solar and other renewable energy development opportunities on current and formerly contaminated lands. Please see the *Resources* section on the next page for additional information.

Resources

Region 9 Superfund: http://www.epa.gov/region9/superfund

Superfund Redevelopment Initiative: http://www.epa.gov/superfund/programs/recycle

Re-Powering America Renewable Energy Interactive Mapping Tool: http://epa.gov/renewableenergyland/mapping_tool.htm

Solar Energy Industries Association (SEIA) and the Prometheus Institute. "US Solar Industry: Year in Review." June 2009.

U.S. Department of Energy. National Renewable Energy Lab. "Power Technologies Energy Data Book." August 2006.

U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response. "Siting Clean and Renewable Energy on Contaminated Lands and Mining Sites." September 2008.

Solar Energy Industries Association: http://www.seia.org

Database of State Incentives for Renewables & Efficiency (DSIRE): www.dsireusa.org

EPA Renewable Energy Maps: http://www.epa.gov/renewableenergyland

DOE Solar Energy Technologies Program: http://www1.eere.energy.gov/solar

National Renewable Energy Lab (NREL) Solar Research: http://www.nrel.gov/solar

NREL Renewable Energy Resource Maps: http://www.nrel.gov/renewable_resources

NREL Solar Advisor Model: https://www.nrel.gov/analysis/sam

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