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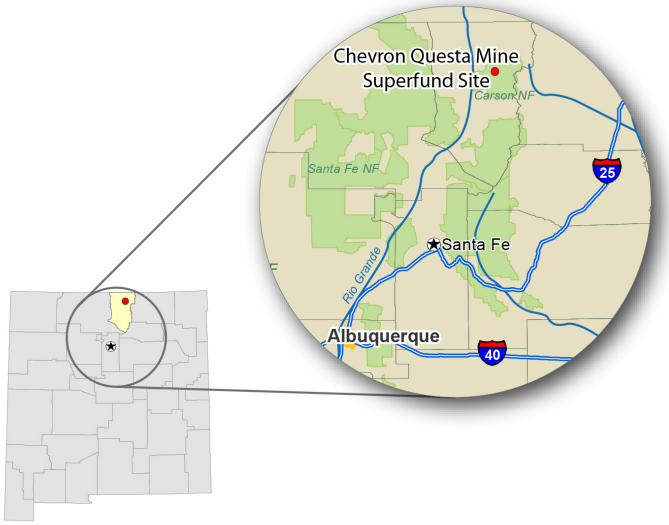
New Energies: Utility-Scale Solar on a Tailing Disposal Facility Chevron Questa Mine Superfund Site in Questa, New Mexico

Introduction

Emerging technologies are making it possible to collect and convert the sun's energy more efficiently, helping to meet ever-increasing energy demands. A 21-acre facility under northern New Mexico's endless blue sky demonstrates one of these solar technologies in action. With over 300 sunny days each year, Questa, New Mexico, provides an ideal location for a concentrated photovoltaic (CPV) system. The system carefully follows the sun, concentrates its light, and converts it into electrical energy, generating one megawatt of power, enough to power 150 homes.

The facility also illustrates how private parties can work with the U.S. Environmental Protection Agency and state agencies to incorporate renewable energy development at mining and Superfund sites and creatively reuse former mine waste disposal areas. CPV technology uses lenses to collect and focus direct sunlight onto layers of high-efficiency solar cells, making it more efficient than conventional photovoltaic arrays. It works best at high elevations where solar radiation is strongest. Working with the EPA, Chevron Technology Ventures (CTV) located the solar facility on a portion of a mine tailing facility at the Chevron Questa Mine Superfund site. French industrial company Soitec produced the CPV technology.

At the time of installation, the solar facility was one of the largest CPV installations in the world. It joins a series of renewable energy facilities on current and formerly contaminated lands nationwide. CTV, a sister company of Chevron Mining Inc. (CMI), developed the facility as a CPV technology demonstration project. CTV sells the electricity generated to the Kit Carson Electric Cooperative; on sunny days, it provides enough energy to power the Questa community.



The project joins a series of large-scale CPV projects across the southwest. These include a completed 5-megawatt facility in southern New Mexico, and a 150-megawatt facility under construction in the Mojave Desert that will also use Soitec CPV technology.

This case study explores the key factors, tools and partnerships that led to the successful solar project at the site. In particular, the case study focuses on how CTV and CMI worked with the EPA and state regulatory agencies to build support for the project and incorporate an innovative soil pilot study as part of it. In the following pages, the case study discusses the evolution of solar energy reuse efforts at the site from initial planning activities in 2008 to operation and grid connection in 2011. The case study provides key information and lessons learned from solar reuse of the Chevron Questa Mine Superfund site to companies, localities, communities, utilities and regulators interested in supporting emerging solar technologies on contaminated lands.

Solar energy demonstration project at the Chevron Questa mine tailing facility, 2011

Site History, Contamination and Remediation

Molycorp (originally the Molybdenum Corporation of America) began mining in New Mexico's Sangre de Cristo Mountains in 1920. By 1954, mining operations had grown to include over 35 miles of underground mine workings. From 1964 to 1983, open pit mining resulted in over 328 million tons of acid-generating rock in nine piles surrounding the open pit mine. Underground mining most recently resumed in 1996. The Union Oil Company of California (UNOCAL) took ownership of Molycorp in 1977. Chevron Corporation acquired Molycorp through a corporate merger with UNOCAL in 2005. In 2007, Chevron Corporation combined its mining subsidiaries Molycorp and the Pittsburg and Midway Mining Company to create CMI.

The Chevron Questa Mine Superfund site

The State of New Mexico regulates the mine through mining and ground water discharge permits that include mine reclamation and closure requirements as well as ground water protection and abatement. The EPA proposed the site for listing on the National Priorities List (NPL) in May 2000.

Superfund site investigations found that mining operations, as well as past disposal and discharge practices of impacted water and mining wastes led to soil, sediment, ground water and surface water contamination. Tailing seepage and runoff from the tailing ponds and weathering of the tailings piles resulted in ground water and soil contamination. Impacted ground water from the Mine Site Area reaching the Red River, as well as breaks in the tailings pipelines result in degradation of Red River habitat and sediment and surface water quality. Contaminants include polychlorinated biphenyls (PCBs), heavy metals, fluoride, sulfate, molybdenum, sulfuric acid and total dissolved solids. Different contaminants are present in different areas of the site. For example, PCBs do not reach the Red River nor have they been identified at the Tailing Facility Area.

Superfund Site Area of Interest	Status
Mill Area	CMI has removed PCB-contaminated soil in the Mill Area and treated and disposed of it off site.
Mine Site Area	The EPA is negotiating the agreement that will guide cleanup of this part of the site.
Tailing Facility Area	Placement of piping along a portion of the Eastern Diversion Channel to prevent unused irrigation water from infiltrating through tailings in the Tailing Facility Area is scheduled for summer 2013.
Red River, Riparian and South of Tailing Facility Area	Cleanup of historic tailing spill deposits along the Red River started in February 2013. The EPA estimates this work will be completed by August 2013. The EPA is negotiating the agreement that will guide the cleanup of the South of Tailing Facility Area.
Eagle Rock Lake	Installation of inlet storm water controls at Eagle Rock Lake was completed in December 2012; removal of contaminated sediment is scheduled for August 2013.

The EPA selected the site's remedy in December 2010. The site's Record of Decision addresses ground water, surface water and sediment contamination resulting from waste rock at the Mine Site Area and tailings in impoundments at the Tailing Facility Area. It also includes ground water treatment, removal of PCB- and molybdenum-contaminated soils, and dredging and removal of metal-contaminated sediment.

The EPA placed the site on the NPL in September 2011. As part of the listing, the EPA changed the name of the site from Molycorp, Inc. to Chevron Questa Mine based on public comments. In March 2012, CMI agreed to conduct short-term cleanup actions under an EPA administrative order. In July 2012, CMI started the cleanup actions. CMI is also currently evaluating operational changes that will lead to new underground mine areas and closure of the tailing impoundments west of Questa. CMI employs about 270 people at the mine.

Project History

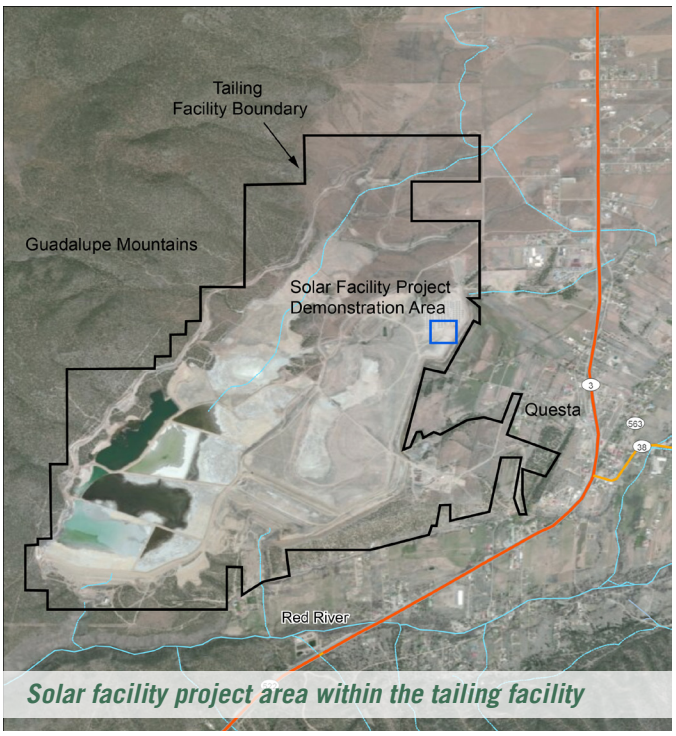
2008 – 2009

Starting with a Bright Idea

The tailing facility at the Chevron Questa mine is located just west of State Highway 522 and the Village of Questa. Mine operations have deposited over 100 million tons of fine-grained tailings at the facility since 1966. The tailing deposit is over 200 feet deep in places. CMI's state mining permit requires reclamation activities in a closeout plan for the tailing facility. CMI and its predecessor have placed interim covers on the tailing facility impoundments since the 1970s to control blowing tailing materials.

Molycorp completed the site's closeout plan in 1998. Requirements include draining surface ponds and shaping the tailing surface topography to eliminate ponding, removing tailing piping, covering the tailing facility with at least 36 inches of alluvium, and revegetation. The cover would stop water from infiltrating into the underlying tailings. It would also support wildlife habitat. The EPA also anticipated that future use of parts of the tailing facility may be modified to incorporate light industrial, non-residential uses, including renewable energy opportunities.

In 2008, CTV, a Chevron company focused on development of new commercial technologies, began evaluating different solar technologies. CTV sought out Chevron properties as locations for solar demonstration projects. Speaking to Chevron's *Next* magazine in September 2012, CTV president Des King explained that "CTV is demonstrating and integrating these types of technologies to find out how we can help our core operations run more efficiently and in a more environmentally sustainable manner." The projects would improve its understanding of the technology and its potential applications in other Chevron business units, evaluate the transferability of the technology to other sites, and expand Chevron's portfolio of renewable energy projects. In addition, CTV hoped to showcase the beneficial reuse of impaired land for renewable energy production.



Solar facility project area within the tailing facility

Timeline of Events

1920:	Molycorp begins small-scale underground mining operations
1964:	Underground mining transitions to open pit mining
1983:	Open-pit mining ends and underground mining begins
1992:	Underground mining shuts down
1996:	Underground mining resumes
2000:	Site proposed for listing on NPL
2001:	Molycorp begins site's remedial investigation and feasibility study
2005:	Chevron Corporation acquires Molycorp through a corporate merger with UNOCAL
2007:	Chevron Corporation combines mining subsidiaries, creating CMI
2008–2009:	CMI/CTV begin planning solar facility
2010:	Construction of the solar facility begins; the EPA selects site remedy

Solar facility groundbreaking ceremony (May 2010)

2011:	Solar facility commissioned and operational; the EPA reproposes and finalizes site for listing on NPL

This effort coincided with an EPA and state-led conference in Santa Fe, New Mexico, in December 2008, which focused on transforming brownfields and other contaminated lands into locations for renewable energy projects. Agency officials and Chevron executives met to discuss possibilities for renewable energy projects on company-owned properties in New Mexico.

The EPA and Site Reuse: Renewable Energy

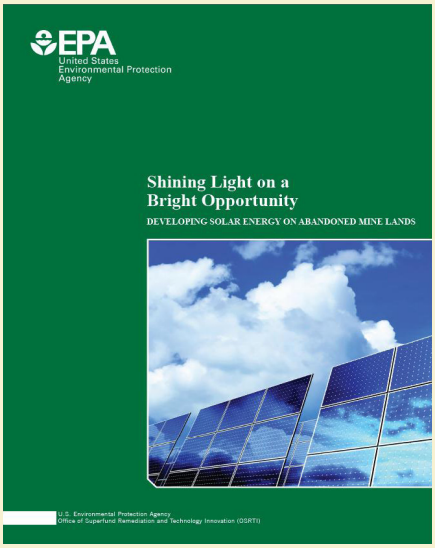
Since the inception of the Superfund program, the EPA has been building on its expertise in conducting site characterization and remediation to ensure that contamination is not a barrier to the reuse of property. Today, consideration of future use is an integral part of the EPA's cleanup programs, from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

EPA's Superfund Redevelopment Initiative and Abandoned Mine Lands Program began making tools and information available to encourage owners of Superfund sites and other impaired lands to consider beneficial uses of their properties following cleanup, including renewable energy projects in the late 1990s.

Brown to Green Conference: Making the Connection to Renewable Energy This conference in Santa Fe, New Mexico, brought together corporate executives, developers, financiers and the regulatory community. It provided an opportunity for stakeholders to discuss key issues associated with the development of renewable energy projects on contaminated lands.

EPA's RE-Powering America's Land Initiative identifies the renewable energy potential of contaminated lands and serves as a resource for parties interested in reusing these lands for renewable energy development. Through this initiative, the EPA and its federal, state, tribal, local, utility, community and private sector partners are exploring how new renewable energy facilities can be developed on these properties.

Please see the **Sources and Resources** section for more information.



EPA report on solar energy opportunities for abandoned mine lands

CPV Solar Technology

The CPV system at the 21-acre solar facility at the Chevron Questa Mine site uses lenses to concentrate sunlight onto solar panels and transform the sunlight into electricity. A CPV system is more efficient than a photovoltaic system because the lenses increase the amount and duration of solar radiation striking the solar cells. The 173 CPV tracking systems at the site contain sensors that look for shadows. If a shadow covers the sensors, the panel will adjust to a position where sunlight can focus directly on the panel's lenses. The site's location in northern New Mexico has high direct normal irradiance – the amount of direct solar radiation from the sun – making it a practical location to implement CPV technology.

Chevron Questa Mine was an area of particular interest, given the area's high level of solar radiation. CTV reached out to several other Chevron companies – CMI, Chevron Environmental Management Co., Chevron Energy Solutions and Chevron Energy Technology Company. Together, they worked to define the area and the type of solar technologies best suited for the location. CTV's technology of choice was CPV.

CTV selected an inactive portion of the tailing facility at the mine for the project. Interim soil covers with 6 to 9 inches of

Coordinating Superfund Cleanup at a State-Regulated Active Mine

In addition to Superfund-required cleanup actions, CMI is conducting actions required by the New Mexico Mining and Water Quality Acts and associated state regulations for site reclamation and closure as well as ground water abatement. The EPA coordinates Superfund cleanup requirements and activities at the mine with CMI's state permit requirements.

soil had been placed over the area and vegetative cover had been established. It also had a minimal gradient and a 12.5-kilovolt electrical distribution line nearby that could connect the project to an electrical distribution system operated by the Kit Carson Electric Cooperative. CTV anticipated the solar project would be one megawatt in size and cover up to 30 acres, including solar panels, electrical distribution systems, control buildings, weather stations and other equipment.

To determine the suitability of the tailing facility, CTV evaluated area soils, depth to ground water and climatic conditions and conducted a geotechnical investigation, a foundation feasibility assessment, a cover analysis and a ground water investigation. The geotechnical investigation found that the potential project would be feasible for solar energy systems set on shallow or deep foundation systems.

In addition to building a utility-scale solar facility, Chevron staff also proposed coupling the solar demonstration project with a soil cover depth (thickness) pilot study. The information from the study would help inform the amount of soil cover needed to appropriately close the tailing facility under state mining laws and meet Superfund requirements. The information from the alternative cover depth study would also help inform cover depth requirements for closure of additional portions of the tailing facility. Chevron proposed a five-year timeframe for the project.

2009 – May 2010

Building Support, Working with Public-Sector Partners

CTV, in collaboration with CMI and other Chevron divisions, first had to get company support and funding for the project. Staff prepared a proposal, conducted a detailed economic analysis and then participated in an internal review process.

CTV staff also had to convince external stakeholders. They identified key agencies and organizations as potential project partners. CTV and CMI then submitted their proposal to the EPA, the New Mexico Environment Department (NMED) and MMD. CTV and CMI worked closely with the EPA and the state agencies to clarify the objectives of the plan and address specific concerns. MMD was concerned primarily with surface reclamation; NMED focused on surface and ground water related impacts. MMD Senior Reclamation Specialist Joe Vinson explained that MMD's goal is to ensure that the tailings remain buried and there is sufficient cover to promote a good vegetative cover. NMED's goal is to minimize infiltration through the cover that might contaminate ground water. Both agencies are concerned about burrowing animals that may bring tailings to the surface and provide infiltration channels through the cover. Mr. Vinson added that the solar panels concentrate the flow of rainwater, but "as long as you don't get concentrated water coming off those solar panels, and as long as the soil cover depth is adequate to prevent contaminants from entering into ground water, this is a good idea."

In fall 2009, the EPA, NMED and MMD agreed on demonstration project success criteria and a monitoring plan

Terms to Understand

Kilowatt (kW): Unit of measure for the amount of electricity needed to operate given equipment.

Kilowatt-hour (kWh): Unit of measure indicating the amount of electricity consumed over time. One kWh means one kilowatt of electricity supplied for one hour.

Megawatt (MW): 1,000 kW or 1,000,000 watts.

Cover Depth Pilot Study: Measures of Success

In November 2009, the EPA, MMD and NMED agreed on measures of success for the cover depth pilot study in a joint letter to Chevron.

Annual Net Percolation: Chevron Mining shall provide a demonstration that the proposed cover depth will be protective of ground water. A successful demonstration will show that the cover system has the capacity to limit net percolation by storing precipitation within the cover system for a period long enough for water to be removed by evaporation and transpiration and that any net percolation will not cause an exceedance of ground water standards.

Molybdenum Uptake in Vegetation: No significant difference, as determined by an analysis of variance (ANOVA) test with a p-value of 0.05, between molybdenum concentrations measured in above-ground foliage collected from three or more locations from the 1-, 2-, and 3-foot cover test plots. T-tests shall show no significant differences between 1 and 3 feet of cover and between 2 and 3 feet of cover to demonstrate the adequacy of the 1- and 2-foot covers.

Contaminant of Potential Concern (COPC) Concentrations in Soil: No significant difference, as determined by an ANOVA test with a p-value of 0.05, in COPC concentrations in composite soil samples collected from three or more locations in the 1- and 2-foot cover test plots and composite samples collected from the 3-foot cover test plot. The composite samples shall be taken from 0 to 3 inches beneath the ground surface. T-tests shall show no significant differences between 1 and 3 feet of cover and between 2 and 3 feet of cover to demonstrate the adequacy of the 1- and 2-foot covers.

Power Purchase Agreements (PPAs)

Power purchase agreements are legal contracts between two parties. One party produces electricity for sale and the other party purchases the electricity. PPAs vary depending upon the technology used to generate the electricity and the type of financing needed to construct the power generating facility. For instance, some PPAs involve a financial arrangement in which a third-party developer owns, operates and maintains the energy generating system, and a host customer agrees to site the system on its property and purchases the system's electric output from the solar services provider for a predetermined period. The Questa solar facility did not require project financing or land purchase. As a result, CTV was able to enter into a direct PPA with the Kit Carson Electric Cooperative, under which the cooperative agreed to purchase the output from the CTV system for a predetermined period.

Once signed, a PPA is contractually binding. After the system is operational, the seller cannot sell its output to anyone but the purchaser. Prior to sale, the project must be fully tested and commissioned to make sure the system is reliable and meets standard commercial practices. PPAs typically extend until an agreed-upon date. However, the PPA may be broken if abnormal events occur or other circumstances arise and contractual obligations cannot be met. The seller is typically responsible for maintenance and operation of the renewable energy project. The seller is also usually obligated to install and maintain a meter to assess the amount of energy sold.

Other issues addressed by PPAs include pricing, billing and payments, and performance standards. The electricity rates negotiated serve as the basis for a PPA. The pricing, for example, may remain constant or gradually increase over time.

Adapted from: eMpasys Solutions. Power Purchase Agreement.

for collecting key data. Assuming the project met the criteria, the EPA and state agencies agreed to support potential changes in cover depth in federal Superfund requirements and state permits, which requires a 3-foot-thick soil cover on the tailing facility as well as grading and revegetation. Monitoring would be conducted to evaluate if the different soil covers are effective at preventing additional ground water contamination by limiting infiltration of precipitation, whether vegetation can be effectively established on top of the different soil covers and the potential for uptake of molybdenum by vegetation, whether the cover thickness can be maintained over time and whether the solar panels contribute to increased ground water contamination or negatively affect the plant growth.

In October 2009, the EPA, NMED and MMD released a joint press release confirming their support for the project. On November 13, 2009, the agencies stated in a letter to Chevron that if a 1- or 2-foot-thick cover was demonstrated to be successful in the five-year pilot, the Superfund remedy would be modified accordingly. The agencies also noted that in order for consideration of alternative soil cover depths as part of any Superfund response action or final closure under NMED's and MMD's permitting programs, the demonstration had to successfully protect human health as well as surface water and ground water resources and show that the alternative cover thickness can be maintained over time.

The EPA also affirmed its support for the project following questions from the Agency's National Remedy Review Board:

We believe that with this agreement there is a unique opportunity to demonstrate the use of contaminated mine lands for renewable energy, while ensuring protectiveness under CERCLA and the New Mexico Mining Act and Water Quality Act. We also believe that this pilot can be a success, not only for Chevron, but also for the New Mexico and EPA renewable energy initiatives and the community of Questa as well.

CTV also worked to address other concerns shared by local officials and residents, holding several town hall meetings to describe the project and answer questions. Key community concerns included the visibility of the facility from the highway and security.

Obtaining Necessary Permits, Securing a Power Purchase Agreement

With the site agencies on board and local support in place, CMI and CTV started work on the project. A key next step was securing a power purchase agreement with the local electric provider – the Kit Carson Electric Cooperative. Under the cooperative's PartnerShip Solar Program, a third party builds a solar energy array and the cooperative creates a partnership to make sure the array fits its system. The parties then negotiate a power purchase agreement.

For the cooperative, several issues had to be addressed, according to cooperative CEO Luis Reyes. These included the final location of the solar power facility and the capacity of

the cooperative's distribution system to absorb energy from the facility. "If there was a problem there [with the array], we wanted easy access to make sure we could ensure the delivery of power," he said. "If they had put the array far away, it would have driven up costs, and there may have been access issues." According to Mr. Reyes, the location of the facility also was also important for potential scalability. "If the project was scaled-up, we wanted to make sure that the area was expandable to accommodate more solar generation," he said. The cooperative also wanted to ensure worker safety at the solar facility. "We had meetings with Chevron initially to talk about any health issues and any environmental issues that we needed to be made aware of," he said. "After our discussions about the different layerings that would be placed over the tailings, we were satisfied that any potential health threats would be addressed."

CTV and the cooperative agreed to a 20-year contract. The cooperative had a range of experience with solar energy projects and proved to be a willing partner. According to Chevron Environmental Manager Cynthia Gulde, the cooperative was "very supportive and wanted to be involved in the project."

Another key step was to identify the most appropriate CPV system and provider. CTV visited several places to evaluate different CPV systems. CTV also identified several CPV system providers, ultimately choosing French industrial company Soitec. According to CTV, "there were numerous factors involved in the decision to work with Soitec, including technology development, stage, project cost, electrical output, project footprint and many others."

The Soitec Concentrix™ CPV system selected by CTV contains solar cells stacked on top of each other and placed inside modules covered with a lens plate. The Fresnel lenses concentrate the sunlight 500 times on the solar cells, which convert the concentrated sunlight into electricity. The modules are installed together in a series of rows to form a CPV panel. The panels are then placed on mechanical devices called trackers that include a gear and small motor. The trackers rotate the panels on two axes to follow the sun throughout the day.

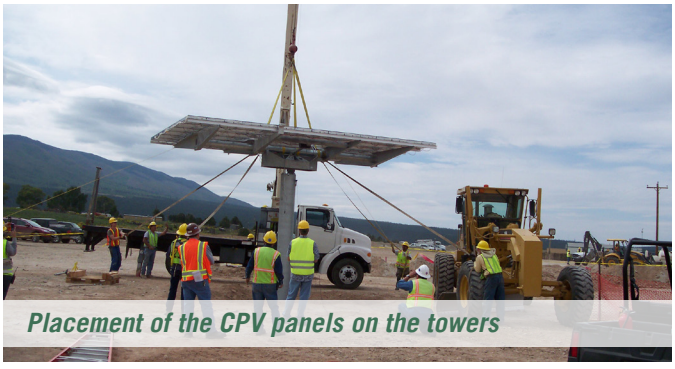
According to the manufacturer, Soitec Concentrix™ CPV systems have a low environmental footprint. In addition, the systems use high amounts of recyclable material and do not require water for ongoing operations. Moreover, according to Soitec, "because Soitec's CPV systems are pedestal-mounted, they are slope-tolerant and require no disruptive land grading. The pedestal foundations reduce the impact on native vegetation and allow for dual land use. Finally, their shallow foundation design provides site flexibility and requires minimal ground penetration, making utility-scale solar power installations even more cost effective." The individual modules also allow light to penetrate, supporting plant growth below them.

CTV worked with local authorities in Questa and Taos County and the State of New Mexico to get the permits needed for the facility. These included electrical and building permits from Taos County and an Interconnection Permit from the New Mexico Public Regulation Commission. CMI also had to request a modification to the mine's discharge permit from NMED. Prior to amendment, the discharge permit only allowed CMI to discharge mine-related water. As part of the project construction, CTV had to water new roads built in between the CPV panels. CTV also had to water the tailing facility for dust control during system construction. In addition, CTV had to request project construction approval from the Office of the State Engineer.

Moreover, prior to construction, CTV had to conduct additional geotechnical evaluations of the tailings. Based on the results, CTV modified the design of the CPV foundations to better account for wind and the possibility that the rotating solar panels would tip. CTV also had to develop a plan to use cranes to install the panels. Similarly, Chevron also had to evaluate how to safely install several large (46 feet by 66 feet) soil moisture measurement devices called lysimiters needed as part of the alternative soil cover depth study.

Securing a Workforce, Hiring Locally

CTV likewise had to secure its workforce, following Chevron's goal of using local contractors as much as possible. CTV successfully hired construction contractors from Questa, solar panel construction contractors from Questa and nearby Taos, and electrical contractors from Albuquerque. Many of the



Placement of the CPV panels on the towers

workers hired had previously worked in the Questa mine. To improve the chances that nearby residents could be hired, staff from CPV module maker Soitec provided local training on how to put the solar panels together.

May 2010 – January 2011

Building the Solar Facility

After obtaining the necessary permits and approvals, CTV and CMI hosted a groundbreaking ceremony in May 2010. Attendees included New Mexico's governor and cabinet representatives as well as local officials from Questa and Taos County. Construction followed and installation proceeded rapidly. CTV and its contractors had a detailed plan for construction that began with preparing the site, installing the solar equipment and electrical systems and concluding with commissioning, testing and startup procedures, including interconnection with the local utility.

After clearing the project area, contractors first applied varying levels of soil cover across the project area to match the requirements of the alternative soil cover depth demonstration study. CTV divided the project area into three 6-7 acre sections where the CPV panels were installed. Each section received the required 1, 2 or 3 feet of soil cover. In addition, CTV reserved part of each section to test the impact on these areas without CPV panels. Crews then installed the foundations for the CPV panels, followed by towers that would hold the panels. Once

CPV tracking system alignment

the CPV panels were assembled, crews used cranes to place the panels on the towers. The foundations were 9-foot squares, 3-feet in height, and installed directly into the tailings material. They were specifically designed to account for the geotechnical properties of the tailings material.

While installing the CPV panels, crews also installed the lysimeters. Crews placed two in each of the three main sections of the project area and one in each of the three cover depth test plots without the CPV panels. After construction

Lysimiter installation

and installation, Chevron tested all the components of the system, including electrical systems, control systems and other components.

Chevron completed the project in January 2011. The project covers 21 acres and includes 173 solar panels. CTV secured the facility with fencing and video cameras. The overall construction process was complex and required extensive coordination. At one point, 80 workers from 10 different companies were working on the site. It took more than 40,000 hours to complete the project. No major injuries were reported. According to Chevron, the construction project added nearly $3 million to the local economy, and an additional $2.5 million was spent on other contractors in the New Mexico area. In an April 19, 2011 Chevron press release, CMI president Mark Premo explained, "we made a concerted effort to use local resources and talent whenever possible, and I am convinced that this kind of community engagement was a crucial factor in getting the facility built safely and on time."

March 2011 – Present

Generating Solar Energy, Realizing the Benefits

The solar energy system first began sending electricity to the cooperative's electrical grid in March 2011. On April 19, 2011, Chevron held a ceremony to celebrate the start of solar facility operations. About 200 people attended the ceremony. Speakers included Questa's mayor, the presidents of CMI and CTV, the director of the New Mexico Energy, Minerals and Natural Resources Department, the New Mexico State Director for The Wilderness Society, and a Soitec executive. In an April 19, 2011 Chevron press release, Mayor Esther Garcia commented that "we're pleased Questa is a potential starting place for an emerging solar technology. This project goes a long way in demonstrating the unique solar resource we have in this part of New Mexico." New Mexico State Director for The Wilderness Society Michael Casaus noted that "the significant support for the project, ranging from the Town of Questa to the Governor's office to The Wilderness Society, shows the tremendous support that comes along with this kind of forward-looking approach."

Today, the facility generates about one megawatt of electricity. Over a year, according to Chevron, that approximates to over two million kilowatt hours, roughly equal to the average electricity requirements of 150 homes. Since April 2011, the facility and has met or exceeded the project's one megawatt expectations. As of March 2013, the facility has generated about 4.6 million kilowatt-hours of electricity.

Although the solar facility does not require personnel during normal operation, a local resident hired by CTV manages it. CTV also secures local contractors as needed for road maintenance and other efforts. Facility maintenance activities include preventative maintenance on mechanical and electrical systems, spare parts inventories, keeping vegetation mowed near the electrical equipment and solar panel towers, periodic inspections for erosion, and upkeep of the lysimiters. During project design, it was also anticipated that the panels may need periodic cleaning. However, they have not needed to be washed since facility operations began in 2011. According to Chevron's Cynthia Gulde, strong winds have been the only significant challenge. CTV adjusted the facility's operational plan to better match site conditions.

Several parties are now benefitting from the project. Chevron realizes a consistent source of revenue through its power purchase agreement with the Kit Carson Electric Cooperative. It also benefits from the state's Renewable Energy Production tax credit. Approved in June 2011, the credit lasts for 10 years.

The community also has a reliable source of power. The electricity from the project powers homes and businesses across Questa and other parts of northern New Mexico, enough to supply about 80 percent of the community's daytime power needs. The project may also stabilize and help reduce energy costs over time. Speaking to *The Taos News* in April 2011, Kit Carson Electric Cooperative CEO Luis Reyes explained, "the hope is that [the project] will help stabilize electric rates for Kit Carson customers over time" since the cost to provide solar energy will not change under the terms of power purchase agreement. The project is also contributing to the cooperative's efforts to reduce energy costs for its customers through renewable energy credits the cooperative earns from the solar energy it purchases and produces. The project is also helping the cooperative meet the State of New Mexico's Renewable Portfolio Standard.

Additionally, the system generates enough clean power to offset significant amounts of greenhouse gases and air-polluting and smog-causing chemicals that would have been emitted using power from plants burning fossil fuels. EPA's Power Profiler estimates the annual emissions saved by the project at 1,044 tons of carbon dioxide, 1.6 tons of nitrogen oxides and 0.7 tons of sulfur dioxide. With life expectancy of at least 20 years, the system will provide important environmental benefits.

The Village of Questa also benefits from the attention the project is bringing to the area. Kit Carson Electric Cooperative CEO Luis Reyes explained that the project provides an opportunity to draw attention to a new technology and make it accessible to the public. "It really has been a showcase to take people to and show them how to do it. Chevron has allowed us to show

Policies and Incentives for Solar Energy Development

Solar energy development incentives include both policy requirements (e.g., renewable portfolio standards) and financial incentives (e.g., tax credits and rebates).

Federal and state policies continue to play a major role in creating markets favorable for solar energy deployment. Solar energy's cost premium has declined in recent years due to technology improvements and the increased cost of fossil fuel-based energy generation. At the same time, a nationwide public policy focus on carbon-free, renewable energy has created a range of financial incentives to further lower costs.

At the state level, renewable portfolio standards (RPSs) are a powerful policy tool requiring that retail electric providers in a given political jurisdiction include a minimum amount of renewable power in their energy mix. As of September 2012, 36 states, plus the District of Columbia and Puerto Rico, have RPS policies in place.

Financial Incentives and Structures

State and Local Governments

- systems benefit charge (SBC) funds
- issuance of energy bonds
- clean renewable energy bonds (CREBs)
- federal renewable energy production incentives (REPIs)
- state or utility cash incentives and rebates
- solar renewable energy certificates (SRECs)
- net metering (banking excess electricity production for future credit)

Private Parties

- federal investment tax credit (ITC)
- accelerated depreciation under the federal Modified Accelerated Cost Recovery System (MACRS)
- state tax incentives and rebates
- state or utility cash incentives and rebates
- solar renewable energy certificates (SRECs)
- net metering

Please see the **Sources and Resources** section for more information.

Renewable Energy Incentives in New Mexico

The mine's location in New Mexico was one of the main reasons why CTV chose to develop the solar facility there. The state's abundant renewable energy resources provide economic and environmental benefits. In addition, the State of New Mexico has a variety of renewable energy development policies and programs.

In 2004, New Mexico's governor declared the state a "Clean Energy State" and adopted Executive Orders to promote and implement policies regarding renewable energy development, energy efficiency, conservation and greenhouse gases. The state's Climate Change Executive Order followed in 2005. Then, in 2007, the state set goals for reducing energy use per capita. These goals included reducing energy use by 10 percent below 2005 levels by 2012 and 20 percent below 2005 levels by 2020. The goals also directed state agencies to reduce their energy use by 20 percent by 2015.

Also in 2007, New Mexico established a renewable portfolio standard, or RPS. All investor-owned utilities must include renewable energy in their energy portfolio – 15 percent of total retail sales to New Mexico customers by 2015 and 20 percent by 2020. Investor-owned utilities must also fully diversify their renewable energy portfolio to include wind, solar, other technologies and distributed generation. The RPS also applies to rural electric cooperatives.

In addition, New Mexico has established renewable energy tax credits, most of which focus on solar power. The Renewable Energy Production tax credit, enacted in 2002, provides a $0.027/kWh (average) credit for industrial and commercial solar energy projects that are one megawatt in size or greater. The Advanced Energy tax credit, enacted in 2007, allows for a six percent tax credit against gross receipts, compensating, or withholding taxes for the development and construction costs of solar thermal electric plants and associated energy storage devices. In 2009, the provisions were extended to include some photovoltaic and geothermal electric generating facilities.

Other state programs include the Solar Market Development tax credit, which provides tax credits for homeowners, businesses and agricultural entities that install solar photovoltaic or solar heating systems; the Solar Gross Receipts Tax Exemption; the Solar-Ready Roofs Act; and the Solar Rights Act .

the public how solar energy really works." More broadly, the solar project is bolstering the State of New Mexico's economic development goal of becoming a leader in the solar energy industry.

Looking to the Future

CTV, in collaboration with federal and state agencies, scheduled the completion of the demonstration project for early 2016. As CTV operates the solar facility at Questa, it is evaluating its performance. CTV anticipates continuing to sell solar energy from the facility to the Kit Carson Electric Cooperative. CTV will also use the information generated from the solar demonstration project to determine whether it would be beneficial to apply the CPV technology at other Chevron sites. When the five-year demonstration project is over, CMI and Chevron Environmental Management Co. will evaluate if there is sufficient data to make a determination regarding a safe alternative soil cover depth of 1 or 2 feet, in collaboration with the EPA and state regulatory agencies.

CPV tracking system commissioning

Lessons Learned

Several factors contributed to the successful development of the 21-acre solar facility at the Chevron Questa Mine Superfund site.

- The portion of the tailing facility used for the project had minimal gradient, minimal obstructions, high direct solar radiation, numerous sunny days and close proximity to power lines with sufficient capacity.
- Through parent company Chevron, CMI had access to technical expertise in evaluating solar energy project locations and solar energy technologies and implementing renewable energy projects.
- Federal and state agencies facilitated the project by agreeing to a multi-year evaluation of alternative soil cover depths required for closure of the tailing facility. They committed to modify required cover depths in state permits and the site's cleanup plan if results indicate that a 1 to 2 foot cover depth provides the same level of protection as a 3-foot cover and that the alternative cover thickness can be maintained over time.
- The project included a power purchaser, the Kit Carson Electric Cooperative, experienced in solar energy projects and committed to redevelopment of impaired lands and solar energy projects.
- CTV's stakeholder outreach efforts enabled CTV to address potential issues, build support for the project, and move rapidly from the proposal stage to facility construction and operation.
- A broad commitment by the EPA, state agencies and other stakeholders to support the productive reuse of impaired lands helped facilitate regulatory support for the project.
- Because the owner/operator of the Chevron Questa Mine also owns, developed and now operates the solar facility, potential liability concerns were less of an issue. The owner also benefited from a thorough understanding of mine closure and Superfund cleanup requirements.
- Regional and state renewable energy policies and incentives have made the purchase of solar energy more attractive to energy utilities in New Mexico.

While these factors created an ideal climate for the successful reuse of a portion of the Chevron Questa Mine Superfund site, there are also a range of broader lessons learned that can help guide similar projects at contaminated lands across the country.

CPV panel prior to placement on tower

The Bigger Picture

The EPA works with potentially responsible parties and other stakeholders to support renewable energy development projects that are compatible with site cleanups.

The Agency places a high priority on the development of renewable energy opportunities as part of the reuse of contaminated lands. At the Chevron Questa Mine site, CTV, CMI, the EPA and state agencies worked together to agree on project requirements for permitting and installation. The EPA issued a cleanup plan that could accommodate reuse, while underscoring that changes to state closure and Superfund cleanup requirements would only be permitted if the same standards to protect human health and the environment could be met. New Mexico State Director for The Wilderness Society Michael Casaus added that "although we've heard some concern on other projects that cleanup standards may be lessened, these concerns generally ease when communities learn that any EPA-sponsored initiative to develop renewable energy on these sites will maintain cleanup standards. The Agency has clearly stated it will not stray from its rigorous environmental and cleanup standards."

CPV tracking systems in operation, April 2011

The reuse of Superfund sites, including mining areas, for renewable energy projects can have several important benefits.

The reuse of Superfund sites for renewable energy projects can reduce pressure to redevelop greenfields, make use of infrastructure already in place, such as roads and transmission lines, create local jobs, and help stabilize electricity rates for communities. Michael Casaus noted that "building renewable energy generation facilities on contaminated lands takes development pressure off greenfields and other undeveloped public lands." Doing this, according to Casaus, helps resolve or avoid "many of the concerns about siting renewable energy on public lands – such as protecting sensitive and endangered species, preserving carbon sinks, and sheltering unique ecological or cultural areas."

Mining areas are often well suited to support renewable energy projects.

Many mine sites are large, have infrastructure in place and are connected to the grid. Brian Johnson with the New Mexico Energy, Minerals and Natural Resources Department noted that "mine sites have the most potential because they have huge swaths of land, particularly for solar." He added that projects like the one in Questa "could be replicated at other sites, even other sites in New Mexico."

The EPA and states provide many tools and incentives that can make renewable energy projects at mine sites feasible.

The EPA has evaluated many mine sites for their potential to support renewable energy projects. This information is available on agency websites listed in the Sources and Resources section. In addition, states frequently have policies and incentives to support renewable energy projects. For example, in June 2011, Chevron qualified for New Mexico's Renewable Energy Production tax credit, which lasts for 10 years.

Early stakeholder outreach and engagement is important.

CTV reached out to state agencies, the EPA, the local electric cooperative and community stakeholders to review its plans and work out areas of potential concern. This included several meetings with all groups and town hall meetings with residents. These efforts resulted in significant support from a broad range of stakeholders for the project, culminating in the facility's official opening in April 2011 that was attended by over 200 people. According to Chevron Environmental Manager Cynthia Gulde, "getting the key stakeholders involved early and getting that buy-in is critical."

While the EPA provides tools and resources to support Superfund reuse, public and private sector organizations and communities make it happen.

The EPA's mission is to protect human health and the environment. The EPA relies on engaged stakeholders to bring their future land use goals and priorities to the table so that this information can be incorporated as part of the remedial process, linking cleanup and redevelopment. In northern New Mexico, CTV shared its solar energy plans and worked cooperatively with the EPA, state agencies, the local electric utility and the community, enabling the integration of reuse plans with the site's remedy. Future use plans should be shared with the EPA as early in the remedial process as possible.

Utility-scale renewable energy projects on mine lands are complex undertakings requiring diverse expertise.

The development of a solar energy project requires legal, technical, financial and policy expertise. According to state official Brian Johnson, "the idea of putting renewables on contaminated land is not necessarily a slam dunk – it takes a lot of hard work to figure it out and it has to be seriously studied." Chevron's Cynthia Gulde emphasized this point as well, noting that "even if early in the process you believe you have all the geotechnical information you need, make sure you fully evaluate and assess your site. It will probably save you money."

Utility-scale renewable energy projects on mine lands can provide an important economic boost for mining communities.

Active mines are often an important employer for nearby communities. For mines that are scaling back production or closing, utility-scale renewable energy projects can help return them to productive use and create construction jobs. At the Chevron Questa Mine site, Chevron committed to hiring locally, bringing in representatives from Soitec to teach local residents how to assemble the CPV panels. Residents gained new skills that can be used in New Mexico's burgeoning solar development and manufacturing sector.

Owning the land and having the capability to self-finance a utility-scale solar energy project can help speed the project's development.

In New Mexico, CTV already had access to a suitable area for renewable energy development at the Chevron Questa Mine site. Since CTV could fund the project, it did not need to secure a contract with a third-party developer for project planning and implementation.

Conclusions

The 21-acre solar demonstration project at the Chevron Questa Mine Superfund site illustrates how private sector leadership can lead to utility-scale solar facilities at mine sites, Superfund sites and other contaminated lands. CTV, an emerging technology division within a global energy company, developed the project at an inactive part of the tailing facility and coupled it with an innovative soil pilot study. CTV and its Chevron partners overcame potential obstacles by engaging key site stakeholders, including the EPA, state regulatory agencies, the local electric cooperative and the community, working through areas of potential concern and building support for the project over time.

The project has been fully operational since April 2011. As of March 2013, the facility has generated 4.6 million kilowatt hours of electricity, enough energy to power more than 150 homes annually. The system generates enough clean power to offset significant amounts of greenhouse gases and air-polluting and smog-causing chemicals otherwise emitted from fossil fuel-burning plants.

By early 2016, the project will help inform the amount of cover needed to protect ground water and support a suitable vegetative cover at the tailing facility. The study will also help clarify whether the solar panels contribute to increases in ground water contamination.

Today, the Chevron Questa Mine solar energy facility stands as a leading example of how former mine lands and Superfund sites can support renewable energy development. The facility serves as an inspiration for ambitious solar energy development efforts in New Mexico and has drawn nationwide attention from the renewable energy community. When the sun rises over Questa's mountains to the east tomorrow, 173 solar panels will carefully track the sun, adding clean power to the area's mix of energy resources for years to come.

This is the best thing that's happened to us since our layoffs two years ago. This was really positive. It helped our community a lot.

– Larry Sanchez,
Taos County Commissioner

(from "Chevron Builds Solar Field in New Mexico," April 2011 Chevron Video)

Sources and Resources

Sources

Images and maps for this case study were obtained from EPA Region 6 and Chevron.

Resources

Site-Specific

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EPA Region 6 Superfund program:
www.epa.gov/region6/6sf/6sf.htm
EPA Abandoned Mine Lands – Renewable Energy at Mining Sites:
www.epa.gov/aml/revital/renewable.htm
Chevron:
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General

Brown to Green: Make the Connection to Renewable Energy:
www.epa.gov/region6/6sf/revitalization/lrb2g_resources.htm
EPA Superfund Redevelopment Initiative – Alternative Energy Reuse at Superfund Sites:
www.epa.gov/superfund/programs/recycle/activities/altenergy.html
EPA's RE-Powering America's Land Initiative:
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