

# SolarTAC

Technology Acceleration Center



## PROGRESS REPORT.



**Above is an aerial view of the SolarTAC facility. SolarTAC's mission is to increase the performance, cost effectiveness and reliability of solar energy products for rapid deployment in the growing commercial market.**

## About SolarTAC

In the rapidly expanding solar market, there exists a need to fine tune early commercial and near-commercial technologies before deploying them in the field. To be successful, some of the most promising technologies can benefit from further field testing to demonstrate reliability, optimize performance and secure financial backing. The Solar Technology and Acceleration Center (SolarTAC) was developed to provide a real-world testing environment that can fulfill these requirements and take emerging technologies to the next level.

Today, SolarTAC is recognized globally as the largest outdoor test facility for solar technologies in the United States. With access to the electric grid, this 74-acre facility located in Aurora, Colo., now hosts photovoltaic, concentrating photovoltaic and concentrating solar thermal technologies, as well as battery storage and other grid management systems. Member companies and other participants are validating, testing and demonstrating technologies and sharing data. These efforts improve their products and help bring the technologies to market faster.

As the original founding member, Xcel Energy, a public utility serving eight Midwestern and Western states, provided the initial funding and grid interconnection to make testing possible. The City of Aurora provided the land and an expedited permitting process to make it easier for testing to happen. Two leading solar companies, Abengoa Solar and SunEdison, signed on as founding members and agreed to develop the first 10 acres for their technologies. MRIGlobal became responsible for site development and ongoing operations, as well as organization of the legal structure. Together, these organizations have made it possible for other companies to join and benefit from all that SolarTAC has to offer.

### **SolarTAC's Climate Conditions**

With more than 300 days of sunshine a year, and exposure to temperature extremes, SolarTAC provides insight on how solar technologies will perform in a variety of weather conditions.

# SolarTAC's Evolution



## Decathlon House Exhibit

Before moving to SolarTAC, this zero-energy home competed in the 2007 Solar Decathlon in Washington D.C. A team of University of Colorado students designed and built the home sponsored by Xcel Energy. It runs on solar power using 48 storage batteries that provide backup energy storage.

TIME LINE

## A need for a solar test and demonstration facility is identified.

- Summer 2005 – Xcel Energy explores concepts for a solar demonstration facility in the Rocky Mountain Front Range.
- Spring 2007 – The City of Aurora offers space on its Renewable Energy Campus southeast of Denver International Airport.

## A solar test and demonstration facility becomes a reality.

- Fall 2009 – More than 100 guests and dignitaries attend the SolarTAC groundbreaking ceremony. Xcel Energy, Abengoa Solar and SunEdison formally join as founding members and become members of the executive board. The Electric Power Research Institute (EPRI) and National Renewable Laboratory (NREL) announce their intention to join as sponsoring members of SolarTAC, and MRIGlobal is contracted to manage operations and the physical development of the facility.

## Electricity generation begins at the site.

- Fall 2010 – Awareness of the center grows with Amonix joining SolarTAC and quickly becoming the first member to generate electricity at the facility.
- Summer 2011 – The “Powering Up” grand opening ceremony is held and SolarTAC now hosts testing from 11 organizations, including companies from Japan, Brazil, France and Spain. Hittite Solar, a Turkish company, joins as a sponsoring member.
- Fall 2011 – SolarTAC members and other supporters honored retiring Xcel Energy CEO, Dick Kelly, by dedicating the SolarTAC grounds as the “Richard C. Kelly Solar Center for Excellence.”

## SolarTAC becomes financially sustainable and members utilize more than 90 percent of its current 74 acres.



Dustin Smith is executive director of SolarTAC, and is proud of the innovation and success of the flexible business model that has made the nation's largest test facility for solar technologies possible.

## Executive Director's Message

The vision for today's SolarTAC grew from the need to expedite the development, deployment and commercialization of emerging and near-commercial solar technologies. Since increased use in solar technology is a fundamental shift in how America is powered, the industry realized the benefit of a place where large-scale systems could be implemented and operated to better understand how higher penetrations of solar energy can be integrated within the power grid. Some of the key components of the overall success at SolarTAC include:

- Developing a flexible business model that allows for both proprietary and collaborative work, and continues to evolve with the needs of our members and the solar industry;
- Allowing members to use the facility in different and more advanced ways that maximize individual company benefit; and
- Providing a one-of-a-kind, expedited permit process that allows large, utility-scale, experimental systems/components to be constructed, modified and operated in a matter of weeks instead of years.

SolarTAC has achieved a number of milestones since its groundbreaking in 2009, including:

- More than doubling the membership in the last four years;
- Sustainable revenue and cost structure;
- Grid interconnection;
- Custom purchased power and interconnection agreements with Xcel Energy for utility-scale research systems; and
- Strong support from federal, state and local government officials.

SolarTAC continues to develop, build and operate an organization never before thought possible — a private and sustainable facility where companies in the solar industry can drive their own product/service business models while also seeking to move the entire industry forward. Today, through the hard work of hundreds of people from our member organizations, MRIGlobal and the City of Aurora, SolarTAC has become a world renowned facility. I encourage each of you to study this report and visit us on our website ([www.solartac.org](http://www.solartac.org)) to learn more about the amazing things going on at our site, and the bright future for the solar industry.



“It’s important for people to understand that SolarTAC represents the success of hundreds of people working together to develop a place to demonstrate their technologies, as well as collaborate and share data, all in a cost-effective way.”

Dustin Smith

### **SolarTAC's Expedited Permitting Process**

The City of Aurora custom designed an ordinance for the SolarTAC facility that takes into consideration the special needs of large-scale research in the solar industry and allows testing of utility-scale systems without the typical permitting restrictions. This allows companies to install experimental systems and make modifications in a matter of weeks, instead of months or years.



# Letter from the Mayor of Aurora



Dear Reader,

In 2008, our city won the National Civic League's "All America City" award. This award is given to cities that demonstrate innovation and cross-sector collaboration, among other high character qualities, and to cities that use those qualities to tackle community-wide challenges to achieve uncommon results. At about the same time, Xcel Energy, MRIGlobal and other partners came to the city with an idea that would change the world of collaborative, large-scale research: The Solar Technology Acceleration Center (SolarTAC). This world-class center has led the way for new solar technologies and services to quickly enter the market, right here in Colorado. I am proud to say that our City Council and staff tackled serious challenges to such an endeavor by working to develop the now world's largest (74 acres), private utility-scale systems research and demonstration center located on the Aurora Campus for Renewable Energy (ACRE) site, and to create a stream-lined permitting process that saves these companies years of development time and millions of dollars. I believe the work being done at this site is unique in the world and is a key component of our nation's energy future.

This project has brought companies, revenue and jobs to the city and our state, but more importantly, it has brought recognition that



Colorado, and specifically the City of Aurora, is an ideal place where far-reaching ideas can be made into a reality, benefitting our citizens as well as our country. I believe SolarTAC is a shining example of the "All America City" quality of our city, and on behalf of our citizens, City Council and our city staff, I congratulate all who have made this facility successful. I am very proud of SolarTAC and offer my sincere hope that by working together, we continue to grow and expand SolarTAC to new heights!

Warm Regards,

A handwritten signature in black ink, reading "Stephen D. Hogan".

Honorable Mayor Stephen D. Hogan

**Founding Members:** SolarTAC's three founding members (SunEdison, Xcel Energy, Abengoa Solar) share their stories about the benefits and use of SolarTAC, as well as insights into the industry's future. These members have a seat on the Executive Board and Scientific Advisory Board with a full vote in planning the build out of the test site; additionally they have access to SolarTAC's shared testing and R&D portfolio.

## SunEdison's Perspective

### What are the benefits to SunEdison?

SolarTAC has provided SunEdison with two primary benefits. First, the site serves as an initial quality assurance laboratory and test facility for our company to try new technology and to revise current technologies in a low-risk setting, since the facility can be quickly disconnected from the grid if any issues arise. Second, the idea that SolarTAC is a membership organization allows companies and other organizations to collaborate and exchange data. We appreciate having the ability to foster relationships with a variety of other organizations, non-profits, research entities and utility companies.

Through these benefits, SolarTAC has proven itself as a valuable, long-term benefit to SunEdison, and we will continue to use the site as our primary location for demonstrating new technologies and reducing the cost of current technologies.



**Steve Voss is director of Applied Engineering at SunEdison**, which is headquartered in Belmont, Calif. SunEdison is a global leader in delivering solar power, with solar installations, manufacturing plants, and 39 offices located throughout North America, Europe and Asia. The company prides itself in understanding what it takes to achieve solar success, from solution design to deployment to on-going management; the company also applies "lessons learned" to optimize each new deployment.

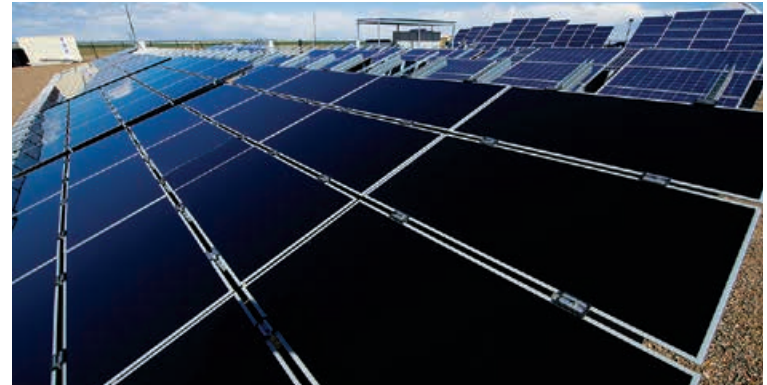
### **What are some of SunEdison's current projects at SolarTAC?**

Currently, SunEdison is testing a variety of technologies on the site including, approximately 12 different module technologies, more than seven inverter technologies, three tracking and control systems, as well as some monitoring systems. By the end of 2012, we also plan to have our next generation of internal tracking set up on the site.

We continue to make cost-reduction adjustments and design changes at SolarTAC before deploying these revisions on large-scale systems, such as the New Mexico installation that serves Xcel Energy customers. SunEdison has been pleased with the ease in which we can quickly test at SolarTAC before deploying the technologies in the field and can continue to work to bring down the cost of solar technologies for consumers.

### **In your opinion, how is SolarTAC making an impact on commercializing solar technology?**

The market for solar technologies has great potential, and SolarTAC continues to prove its value for the industry. By allowing companies to test and showcase their technologies, SolarTAC gives members the ability to gain exposure with investors and accelerate deployment at a larger scale. As the solar market continues to grow, the more companies that join this collaborative effort, the better.



 **SunEdison solar panels**  
 **A SunEdison technician makes adjustments to an installation at SolarTAC.**



# Xcel Energy's Perspective

## What are the benefits to Xcel Energy?

Xcel Energy is a major user of solar energy technology, ranking fifth nationally for installed solar generating capacity. We have more than 11,000 customer-sited photovoltaic (PV) systems connected to the grid. As the original Founding Member of SolarTAC, Xcel Energy recognizes that we represent the interests of millions of electricity customers, and we have an ongoing responsibility to ensure the solar energy we acquire on behalf of our customers is reliable and cost-effective.

Solar energy technologies are diverse and continue to evolve rapidly. As a result, choosing appropriate solar technologies continues to be a complex decision since solar plants must operate successfully for 20 to 30 years. At this collaborative site, Xcel Energy can work directly with solar industry leaders who are evaluating and validating the most advanced solar technologies.

## In your opinion, how is SolarTAC making an impact on commercializing solar technologies?

SolarTAC helps solar technologies move to a quicker deployment in the market by providing companies and partners with the opportunity to test solar technologies on a large scale before they become commercial.



■ **Jack Ihle is manager of Environmental Policy at Xcel Energy**, a public utility serving eight Midwestern and Western states. The company is committed to environmental leadership through its use of advanced, clean energy technologies and continues to demonstrate renewable energy through facilities such as SolarTAC. As a member of the Dow Jones Sustainability Index in North America for six years, Xcel Energy is focused on providing customers clean, reliable and affordable energy.

Testing at SolarTAC can also help solar developers secure funding and attract new investors by providing actual field and operational data. Members have been able to improve their designs as they learn from field conditions. All SolarTAC members have the option of working collaboratively or setting up their own testing programs.

### **How is Xcel Energy using SolarTAC to benefit their customers?**

We are using SolarTAC to study grid integration issues that can occur with solar energy. Xcel Energy is examining how battery energy storage could potentially mitigate the integration issues that may occur when high amounts of solar energy are introduced onto our electric system. In addition, the facility is connected to a distribution grid in the City of Aurora and solar levels and various reliability factors are measured. Safety features have been added to the distribution line, which allows members to “push the envelope” without affecting other customers.

SolarTAC also affords Xcel Energy customers, utility regulators, government officials and other interested parties a readily accessible location to see the wide array of solar technologies that will help meet our country’s future energy needs.

### **What is Xcel Energy demonstrating at the SolarTAC facility?**

Xcel Energy has two solar-to-battery projects on the site to study solar grid integration. In one case, we are testing how a large 1.5-MW battery can smooth fluctuations that may occur with large-scale solar PV installations (e.g. community solar gardens) when solar output changes rapidly due to cloud cover or other factors. In the second case, we are examining how smaller battery technology can mitigate the effects of high solar penetration in residential areas. A 25-kW battery is connected to four simulated homes powered by photovoltaic panels, modeling solar integration in a neighborhood.

Additionally, EPRI is working with Xcel Energy and other members on a smart inverter project that will improve PV integration. Xcel Energy has given EPRI access to one of its batteries to help with this demonstration.



#### **Xcel Energy Battery Project**

Xcel Energy's 1.5-MW Xtreme Power battery at SolarTAC is testing how battery backup can smooth fluctuations in large-scale installations.

# Abengoa Solar's Perspective

## What are the benefits of SolarTAC to Abengoa Solar?

SolarTAC gives us the opportunity to test new technologies in the United States and is our only U.S. testing location. At the SolarTAC facility, we have had the ability to refine two generations of parabolic trough collectors, a primary component of concentrating solar technology.

SolarTAC's proximity to our U.S. headquarters in Denver, Colo., and diverse weather conditions allow us to test the strength of our prototypes against strong winds and very extreme temperatures that testing in Spain cannot provide. Additionally, having SunEdison and Xcel Energy in the same facility has been an added value to our company. At SolarTAC, we can deploy commercial technologies and show fellow members what we are learning and how well the deployments are performing in Colorado's climate.

## How does your technology work?

In Abengoa's parabolic trough plant, a set of parabolic-shaped mirrors rotates on a structure to track the movement of the sun and concentrates solar radiation onto a receiving tube filled with heat-absorbing fluid. This fluid flows inside the tube and reaches high temperatures, transferring thermal energy into steam to generate electricity through a turbine.



**Diego Arias is manager of R&D at Abengoa Solar**, an international company headquartered in Seville, Spain, that applies innovative technology solutions for sustainable development in the energy and environment sectors, generating electricity from the sun, producing bio-fuels, desalinating sea water and recycling industrial waste.

## In your opinion, how is SolarTAC making an impact on commercializing solar technology?

SolarTAC is an excellent opportunity for companies, like Abengoa Solar, to showcase their current technologies and provide the possibility of deploying new technologies in extreme conditions helping to demonstrate the durability and bankability for commercial projects.

### What are some of Abengoa Solar's projects at SolarTAC?

Abengoa Solar is currently working to deploy a large aperture parabolic trough collector prototype at SolarTAC. Typically, most collectors on the market are approximately 19-feet wide, but this collector will be approximately 27-feet in aperture. This will be the first of its type in the United States and one of the largest in the world. The company will soon be deploying it outdoors to test the durability of the components and optics under the high wind conditions at SolarTAC.

Abengoa Solar uses a tall fabric building at SolarTAC to construct and test the optics of its collectors. The enclosed environment allows for testing without wind influence.

Currently, Abengoa is testing the collectors without heat transfer fluid, but plans to add a high temperature fluid test, once we characterize the optics of the new collector prototype. Adding the fluids adds a lot of technical challenges, but it will be a good test of the technology and SolarTAC provides easy accessibility to make adjustments. The large aperture parabolic trough prototype at SolarTAC has been partially funded by a U.S. Department of Energy grant.



#### Abengoa Solar technology

Abengoa's parabolic trough plant technology can be integrated with a thermal storage system that allows power to be dispatched enabling operation under cloud cover and at night.

**From Abengoa Solar's Henry W. Price, vice president of Technology:** "SolarTAC is an important part of Abengoa's U.S. development approach to new technologies. The facilities and infrastructure at the site allow us to test and then demonstrate key components under development. New technology development is critical for Abengoa to deploy large-scale plants, such as Solana in Arizona and industrial solar installations. SolarTAC provides a mechanism to advance solar technology deployments and an environment for collaboration among industry, academic and public laboratories."

**Other Members:** SolarTAC has four sponsoring members who conduct research and testing on the site, have representation on the Executive Board and the Scientific Advisory Board and have access to SolarTAC's shared testing and R&D portfolio. Other companies also participate in various on-site projects.

## EPRI

The Electric Power Research Institute (EPRI) conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. As an independent, non-profit organization, EPRI brings together scientists and engineers, as well as academia and industry experts, to address challenges in electricity, including reliability, efficiency, health, safety and the environment. EPRI's members represent approximately 90 percent of the electricity available in the United States, as well as 30 countries internationally.

At the SolarTAC facility, EPRI is working collaboratively with 12 electric utilities and energy companies that are funding two projects at the site. Testing will include up to four different types of concentrating photovoltaic technologies and approximately ten 10-kilowatt flat-plate photovoltaic arrays. Through EPRI's research activities, utilities will be able to evaluate the performance and reliability of several different technology types and products, which is important to organizations acquiring solar resources.



### EPRI demonstration arrays

EPRI's 60-kW flat-plate photovoltaic demonstration arrays began generating electricity at SolarTAC at the end of November 2012. The demonstration is the first of two projects that will assess the performance of advanced solar generation technologies under actual operating conditions over a two-year period using modules from both U.S. and non-U.S. suppliers.



## Amonix

Founded in 1989, Amonix is headquartered in Seal Beach, Calif., and designs and manufactures concentrating photovoltaic (CPV) commercial solar power systems. With the longest track record of deployments in the solar industry, the company has installations in Arizona, California, Nevada, Colorado and Spain. Amonix has approximately 70 MW of CPV deployed in utility-scale systems, accounting for more than 80 percent of all CPV deployed around the world.

The company prides itself in producing a product that can be rapidly deployed with low capital costs. The system is easily upgradable and can be deployed on a large scale for utility company use. Amonix's involvement at SolarTAC has been beneficial to their recent deployments, including systems that provide power to Xcel Energy customers. SolarTAC has also allowed the company to test their technology in a harsh climate, upgrade its design based on real-life performance, and provide long-term reliability test results for customers.



### Amonix Technology

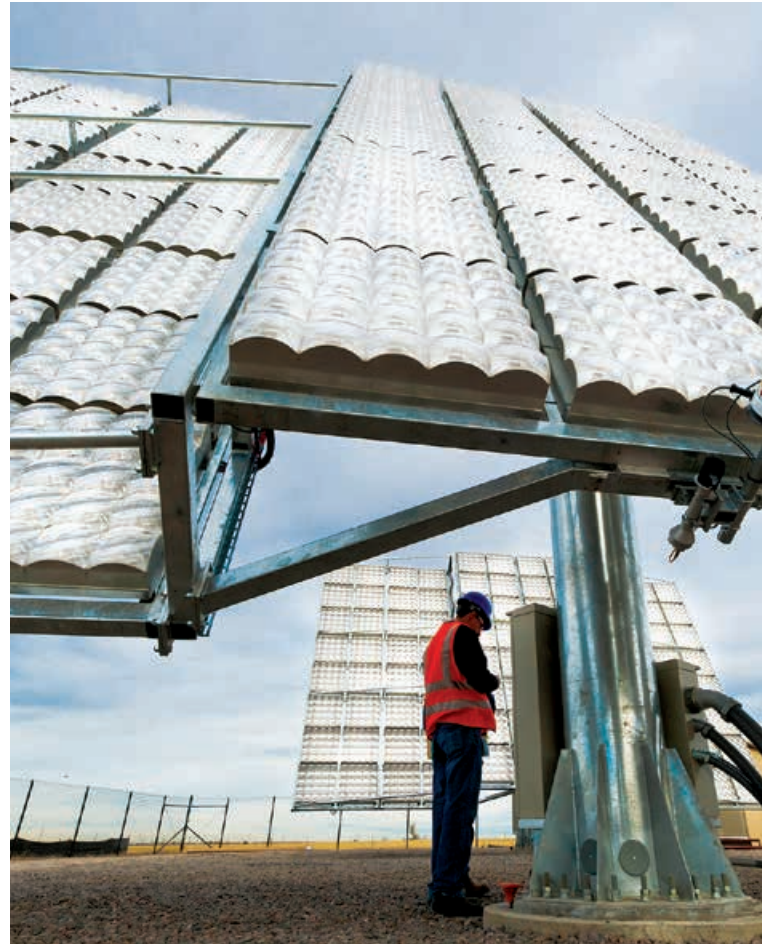


Amonix was the first to deploy their solar technologies at SolarTAC. They have gained valuable knowledge from this demonstration and continue to make adjustments to improve other installations around the world.

## National Energy Renewable Laboratory (NREL)

NREL is the U.S. Department of Energy's primary national laboratory for renewable energy and energy efficiency research and development and is headquartered in Golden, Colo. On behalf of the Alliance for Sustainable Energy, LLC, which is a joint partnership between the Battelle Memorial Institute and MRIGlobal that manages NREL, the organization has three projects at SolarTAC.

The first is a concentrated solar power photovoltaic (PV) project in conjunction with Daido Steel that has installed three modules at SolarTAC identical to an installation in Japan to test the technology under different weather conditions. The other two projects are still under construction and include an American Recovery and Reinvestment Act of 2009 investment in a thermal storage technology project, as well as a photovoltaic regional test center funded by the U.S. Department of Energy. The test center will initially showcase three to four companies' photovoltaic arrays amounting to approximately 300 kilowatts of solar energy PV capacity.



### NREL Japanese solar project

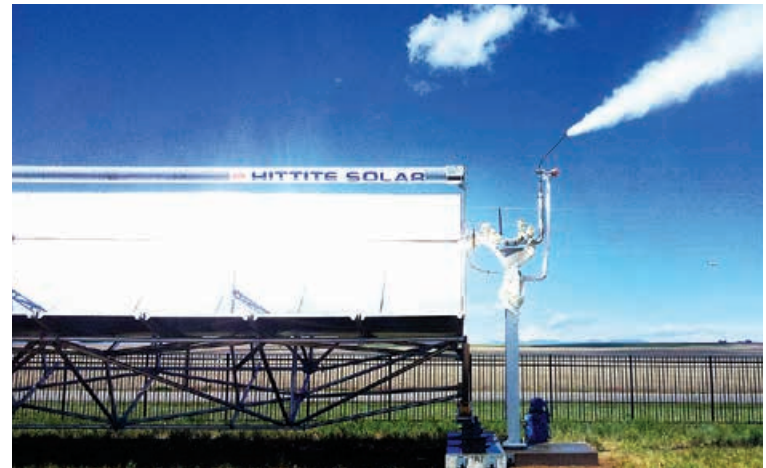
NREL has partnered with Daido Steel, a Japanese Company, to test a concentrated solar power project at SolarTAC.

## Hittite Solar Energy

Headquartered in Istanbul, Turkey, Hittite Solar Energy has developed a solar thermal energy technology capable of directly producing steam at a high enough temperature and pressure to power large, utility-scale steam turbines. Hittite's parabolic trough concentrating solar power design employs a fixed receiver and is unique among parabolic trough-based solar technologies.

In 2011, after extensive testing in Turkey, Hittite Solar Energy determined its technology was ready for commercialization, and in early 2012, Hittite selected SolarTAC as the first location in the U.S. to implement an operational system for field validation and for demonstration to the American market. The proximity to support from NREL, the shared resources available at the site, and the opportunity to interact with other site users and potential customers were all factors that attracted Hittite to membership at SolarTAC.

After less than a month of construction, Hittite Solar Energy produced its first solar-generated steam in North America in May 2012. Hittite now plans to expand its initial implementation at SolarTAC by adding a patented solar integrated water treatment technology and new solar thermal energy storage system.



### Hittite technology

 As SolarTAC's newest member, Hittite Solar Energy has developed a technology to generate steam directly without the need for oil.



## MRIGlobal

Established as the Midwest Research Institute, MRIGlobal is a non-profit research and development organization headquartered in Kansas City, Mo. that manages daily operations at SolarTAC. As one of the nation's leading research institutes, the organization conducts research programs in a variety of areas including energy and environment, life sciences, security and defense, and transportation. After developing SolarTAC's infrastructure as a membership organization, MRIGlobal laid the ground work for the members to ensure a developed, operational site.

With the help of the SolarTAC facility, MRIGlobal has developed productive and collaborative relationships with solar companies, so they can more effectively provide applied research support to energy companies. The organization sees a lot of opportunity for SolarTAC to continue to expand, since the members gain positive benefits from their involvement and can demonstrate their technologies in a visible, successful facility. MRIGlobal is also hoping that this facility will provide a successful model to use for other technology demonstration test centers across the United States.



# Continued Innovation

Applying SolarTAC lessons at a larger scale for Xcel Energy customers

Amonix's demonstration at SolarTAC was its first application in Colorado. The company modified its design to adjust to more extreme weather conditions and continued to refine the design as the product was manufactured for a large system deployment in Alamosa, Colo. The Alamosa project is the largest concentrated photovoltaic project in the world with 30 megawatt under a purchased power agreement.



SunEdison has used the information they have gained from their prototype demonstrations at SolarTAC to develop a more reliable, cost effective technology for MEMC, SunEdison's parent company. The MEMC module is deployed at SunEdison's most recent deployment in Lea County, New Mexico and provides power for Xcel Energy. The multi-site, 53.5-MW solar project, is expected to generate more than 1.9 million megawatt hours of renewable energy over 20 years — enough energy to power more than 250,000 homes for one year.





# SolarTAC Quick Facts

- Approximately \$30 million has been invested at SolarTAC as of summer 2012.
- Technologies being tested include photovoltaic, concentrated photovoltaic, battery systems, thermal energy, and solar system integration.
- In 2011, testing at SolarTAC generated enough excess solar energy to power 90 houses.
- The facility has the benefit of being connected to the electric grid serving Aurora, Colo.
- Currently, the facility sits on the original 74 acres, with approximately 90 percent of the space designated for existing members.
- The City of Aurora has set aside approximately 300 more acres for future site development, so SolarTAC has room to grow.
- As a multi-user site, SolarTAC encourages collaboration and research among its members and has already seen a number of companies successfully working together.



## Founding Members



**ABENGOA SOLAR**

Innovative technology solutions for **sustainability**



## Sponsoring Members



**SolarTAC is managed and operated by:**

