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CSP today
BUSINESS INTELLIGENCE

CSP in the USA

A Guide to Domestic Growth and Exporting American Know-how

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In association with:

CSP Today USA 2014

5-6 June, Las Vegas, Mandalay Bay Hotel & Casino

CSP Today is pleased to present you with this guide to CSP Growth in the United States and Exporting American Know-how, in conjunction with the exciting launch of **CSP Today USA 2014**, taking place in Las Vegas on 5-6 June.

CSP Today USA is the number one meeting place for the industry and will provide a platform for you to promote the value of your CSP technology to secure business at home and make big wins abroad.

This guide provides exclusive data on the current project pipeline in the United States, as well as the future growth potential of the domestic market. Furthermore, it examines the potential use of CSP in other niche markets and the opportunities for U.S. companies to export their know-how and technology into lucrative markets, such as South Africa, Chile and the MENA region.

For more details on CSP Today USA 2014 please visit: www.csptoday.com/usa

Introduction

With the Ivanpah, Solana, Mojave, Crescent Dunes and Genesis projects all having been completed or nearing completion it must now be speculated – is there a definable American model of CSP development? And if so, are established U.S. developers, EPC groups and suppliers that have been involved in landmark projects now in for an exporting boom, as the rest of the world turns to the U.S. to share its CSP technology and experience?

In this guide CSP Today explores the current status of CSP technology in the United States and provides a breakdown of five plants that have transformed the industry. It then goes on to explore how these plants will impact the CSP market at home and abroad, focusing on how US companies can use their experience in developing these projects in key emerging markets, such as South Africa, MENA and Latin America.

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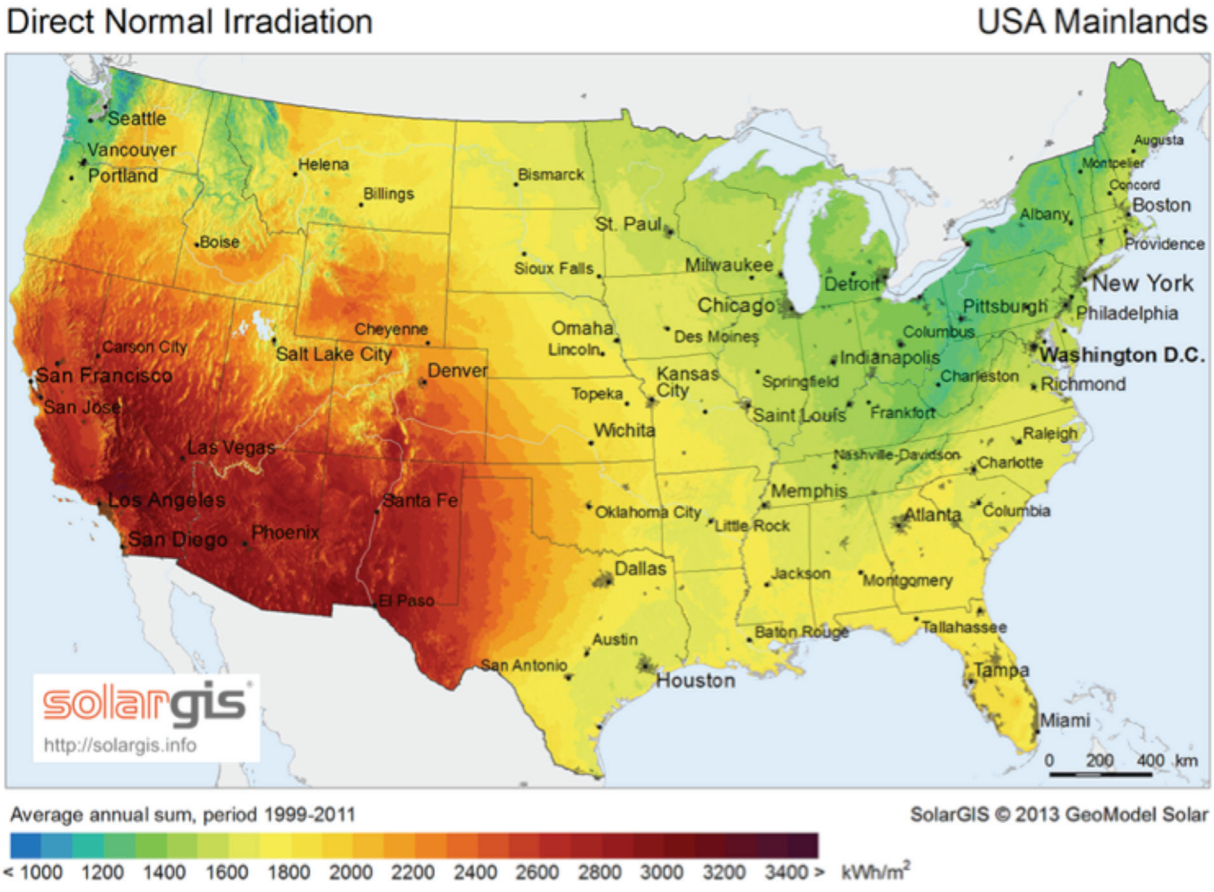


MARKET OVERVIEW

CSP technology is well known and developed in the United States. The first modern plants, the Solar Energy Generating Systems (SEGS), were built by Luz Industries and commissioned between 1984 and 1991 in California.

However, following the SEGS projects CSP experienced a dark period of decline in the U.S., until the last quarter of 2010, when two plants of 'never-seen before' dimensions obtained conditional loan guarantees from the Department of Energy: Solana and Ivanpah (See figures 1 and 2 for an overview of these plants).

The novelty of Solana and Ivanpah was the size and innovation incorporated in their designs. Solana integrated 6 hours of molten salt storage and dwarfed any parabolic trough plant under development or operating elsewhere in the world, with a total capacity of 280MW. In addition, Ivanpah (three towers totalling 392MW) was also a leapfrog advance in technology, scaling up 6.5 times the size per tower that had been achieved previously by PS20, a 20MW tower plant in Sevilla (Spain).

Significantly, Solana and Ivanpah were followed by three more projects that obtained conditional loan guarantees in the United States, the Mojave Solar Project and the Crescent Dunes and Genesis plants (See figures 3, 4 and 5 for an overview of each plant).

These plants have resulted in an unprecedented build-out of next-generation CSP technologies in the United States and this build-out will be important in three particular areas. To begin with, as these technologies are deployed, they will help to significantly reduce overall costs. In addition to this the five plants will provide operational data to prove the commercial deployment of next generation CSP technologies at scale. Finally, the plants will give developers the track record they need to overcome the financing hurdles for their next wave of projects in the United States and abroad.

Figure 1

IVANPAH SOLAR ELECTRIC GENERATING SYSTEM

Ivanpah Solar Electric Generating Station I

- Updated date: 20/12/2013
- Current Status: Commissioning
- Location: USA, California
- Land Area (acres): 1125
- Gross Capacity: 126.00 MW
- Technology:
  - Tower
  - Cooling: Dry
- Developers:
  - Brightsource Energy
  - Google
  - NRG

Source: CSP Today Global Tracker

Ivanpah Solar Electric Generating Station II

- Updated date: 20/12/2013
- Current Status: Commissioning
- Country: USA, California
- Land Area (acres): 1187
- Gross Capacity: 133.00 MW
- Technology:
  - Tower
  - Cooling: Dry
- Developers:
  - Brightsource Energy
  - Google
  - NRG

Ivanpah Solar Electric Generating Station III

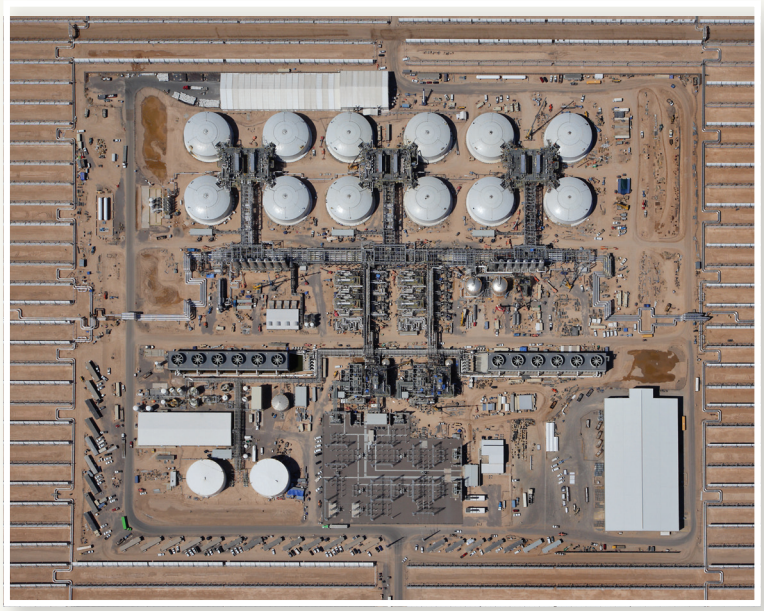
- Updated date: 11/11/2013
- Current Status: Commissioning
- Country: USA, California
- Land Area (acres): 1187
- Gross Capacity: 133.00 MW
- Technology:
  - Tower
  - Cooling: Dry
- Developers:
  - Brightsource Energy
  - Google
  - NRG

Incentive

- US Loan Guarantee
- Incentive details: US$ 1600 million. Total amount split between ISEGS I, II and III

Figure 2

SOLANA GENERATING STATION



Overview

- Updated date: 20/12/2013
- Current Status: Operating
- Commercial Operation Date (COD): 07/10/2013
- Location: USA, Arizona
- Land Area (acres): 1920
- Gross Capacity: 280.00 MW (Gross)
- Technology:
  - Parabolic Trough
  - Wet Cooling
  - Storage (Hours): 6.00
- Developer:
  - Abengoa

Incentives

- US Loan Guarantee
- Incentive details: US$ 1.45 Billion

Source: CSP Today Global Tracker

Figure 3

CRESCENT DUNES SOLAR ENERGY PROJECT

Overview

- Updated date: 20/12/2013
- Current Status: Construction
- Location: USA, Nevada
- Land Area (acres): 1500
- Gross Capacity: 110.00 MW
- Technology:
  - Tower
  - Cooling: Hybrid: Wet/Dry
  - Storage (Hours): 11.00
- Developers:
  - Cobra
  - Santander
  - SolarReserve

Incentives

- US Loan Guarantee
- Incentive details: US$ 737 million

Source: CSP Today Global Tracker

Figure 4

MOJAVE SOLAR PROJECT

Source: CSP Today Global Tracker

Overview

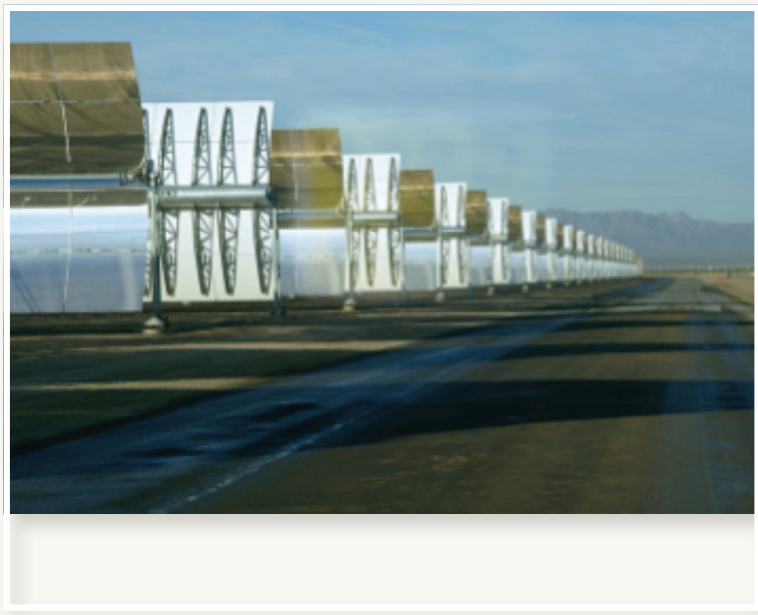
- Updated date: 20/12/2013
- Current Status: Construction
- Country: USA
- Land Area (acres): 1765
- Gross Capacity: 280.00 MW
- Technology:
  - Parabolic Trough
  - Wet Cooling
- Developers:
  - Abengoa
- Construction date – actual starting date: 29/08/2011

Incentives

- Incentive: US Loan Guarantee
- Incentive details: US$ 1200 million

Figure 5

GENESIS SOLAR ENERGY PROJECT



Genesis Solar 1

- Updated date: 20/12/2012
- Current Status: Construction
- Country: USA
- Land Area (acres): 975
- Gross Capacity: 125.00 MW
- Technology:
  - Parabolic Trough
  - Cooling: Dry
- Developers:
  - NextEra Energy Resources

Incentives

- Incentive: US Loan Guarantee
- Incentive details: US $ 852 million

Genesis Solar 2

- Updated date: 31/08/2012
- Current Status: Construction
- Country: USA
- Land Area (acres): 975
- Gross Capacity: 125.00 MW
- Technology:
  - Parabolic Trough
  - Cooling: Dry
- Developers:
  - NextEra Energy Resources

Incentives

- Incentive 2: US Loan Guarantee
- Incentive 2 details: US$ 852 million

Note: CSP Today has divided the overall costs, financing, land area etc in two to illustrate the data for each facility.

CSP PROJECT PIPELINE IN THE UNITED STATES

Since the inception of CSP in the United States some 29 years ago, the market has evolved slowly and has deceived most roadmaps announced by the industry. The cost reduction required by CSP technology to become competitive in the US electricity market has not yet been achieved and has hindered the deployment of CSP plants.

More recently, the lengthy and costly permitting process has also been an important hurdle for developers and therefore, the CSP sector has not grown as expected. The shale gas boom currently sustaining low gas prices, and the lower cost of PV technology are, again, seen as two prevalent barriers that CSP faces today.

That said, significant CSP capacity is currently being rolled out in the U.S. At the time of publication, there is 852 MW of CSP in operation in the U.S., with a further 393.5 MW in commissioning and 650 MW under construction. Furthermore, of all the CSP markets listed on the CSP Today Global Tracker, the U.S. has the largest pipeline of CSP projects under development and planning. Between October 2013 and Q2 2014 the operational capacity of CSP will increase by over 120%, making the United States a World lead in operational experience for CSP technology. (Please see figure 6 for an overview of the status of CSP projects in the United States).

Figure 6

Project Name	MW	Technology	Status	Developer	Storage
Holaniku at Keyhole Point	2	Parabolic Trough	Operating	Sopogy	2
Kimberlina	5	Fresnel	Operating	Areva Power / Clark Group	
Martin Next Generation Solar Energy Center	75	Parabolic Trough	Operating	Florida Power & Light	
Nevada Solar One	64	Parabolic Trough	Operating	Acciona	0.5
Saguaro Power Plant	1.16	Parabolic Trough	Operating	Arizona Public Service Company	
SEGS I	14	Parabolic Trough	Operating	Luz International	
SEGS II	33	Parabolic Trough	Operating	Luz International	
SEGS III	33	Parabolic Trough	Operating	Luz International	
SEGS IV	33	Parabolic Trough	Operating	Luz International	
SEGS V	33	Parabolic Trough	Operating	Luz International	
SEGS VI	33	Parabolic Trough	Operating	Luz International	
SEGS VII	33	Parabolic Trough	Operating	Luz International	
SEGS VIII	89	Parabolic Trough	Operating	Luz International	
SEGS IX	89	Parabolic Trough	Operating	Luz International	
SierraSunTower	5	Tower	Operating	eSolar	
Solana	280	Parabolic Trough	Operating	Abengoa	6
Chevron/ BrightSource Coalinga	29	Tower	Operating	BrightSource Energy	
Ivanpah Solar Electric Generating Station I	126	Tower	Commissioning	BrightSource Energy / Google / NRG	
Ivanpah Solar Electric Generating Station II	133	Tower	Commissioning	BrightSource Energy / Google / NRG	
Ivanpah Solar Electric Generating Station III	133	Tower	Commissioning	BrightSource Energy / Google / NRG	
Tooele Army Depot	1.5	Dish	Commissioning	Infinia Corporation	
Mojave Solar Project	280	Parabolic Trough	Construction	Abengoa	
Crescent Dunes	110	Tower	Construction	SolarReserve	11

Project Name	MW	Technology	Status	Developer	Storage
Genesis Solar 1	125	Parabolic Trough	Construction	NextEra Energy Resources	
Genesis Solar 2	125	Parabolic Trough	Construction	NextEra Energy Resources	
Keahole Solar Power	5	Parabolic Trough	Construction	Sopogy	
Sundt Solar Boost	5	Fresnel	Construction	TEP/Areva Power	
Crossroads Solar Energy Project	150	Tower	Development	SolarReserve	8
Palmdale Hybrid Gas-solar Project	50	Parabolic Trough	Development	City of Palmdale	
Quartzsite Solar Energy Project	100	Tower	Development	SolarReserve	
Rice Solar Energy Project (RSEP)	150	Tower	Development	SolarReserve	8
Saguache Solar Energy Project	200	Tower	Development	SolarReserve	15
Victorville 2 Hybrid Power Project	50	Parabolic Trough	Development	Inland Energy Inc.	
Chevron Hawaii CSP Process Steam		To Be Confirmed	Development	Chevron	
Cosumnes (CPP) ISCC	10	Tower	Planning	Sacramento Municipal Utility District	
Hyder Valley Phase 1	200	Parabolic Trough	Planning	Pacific Solar Investments	
Hyder Valley Phase 2	125	Parabolic Trough	Planning	Pacific Solar Investments	
Palen 1	250	Tower	Planning	BrightSource Energy	
Palen 2	250	Tower	Planning	BrightSource Energy	
Siberia 1&2	400	Tower	Planning	BrightSource Energy	
Sonoran West SEGS	540	Tower	Planning	BrightSource Energy	
Hidden Hills 1	250	Tower	On Hold	BrightSource Energy	
Hidden Hills 2	250	Tower	On Hold	BrightSource Energy	
Rio Mesa	500	Tower	On Hold	BrightSource Energy	
Fort Irwin	500	Parabolic Trough	On Hold	Acciona/Clark Group	
Kingman	200	Parabolic Trough	On Hold	Albiasa Solar	
Westside Solar Project	10	Parabolic Trough	On Hold	Pacific Light & Power	
Cameo Coal-Fired Hybrid Demonstration Project	2	Parabolic Trough	Decommissioned	Xcel Energy	

Source: CSP Today Markets Report 2014

CSP Today Markets Report 2014

'CSP in the USA: A Guide to Domestic Growth and Exporting American Know-how' was created by CSP Today using its latest business intelligence report: the **CSP Today Markets Report 2014**. The next section of this guide contains extracts from this report to explain the future potential for CSP in the United States energy market.

THE FUTURE OF CSP IN THE UNITED STATES

There are a number of compelling reasons why it makes sense for the United States to continue to pursue leadership in the development of CSP, including:

- The US has ample high-irradiation desert areas suitable for the development of large-scale CSP projects, particularly in California, Arizona and Nevada
- CSP can generate significant local employment, particularly during the construction phase of a plant
- CSP expertise is in increasing demand worldwide, particularly in developing regions such as Africa, Asia and Latin America, creating the opportunity to develop significant intellectual property export industries (this is discussed in greater depth in the next section of the guide)
- As demonstrated by SEGS, Solana, and other operational plants, CSP is a resilient and low-risk energy source with lower environmental impact than traditional generation technologies
- The prime materials for CSP plant construction are all readily available in the US and thus are not dependent on foreign trade relations
- CSP is a versatile energy generation technology that can be used to deliver process heat, as well as turbine power, making it a useful adjunct to hydrocarbon and mineral extraction processes

Furthermore, there are a number of reasons why utilities, CSP's ultimate customers, might continue to procure the technology.

In an environment where utilities are increasingly being required to meet renewable portfolio standards and embrace non-polluting generation technologies, many of the options available, such as wind or solar photovoltaic (PV) plants, are inadequate because of their output variability.

CSP, however, helps to overcome these challenges and can offer utilities reliable and dispatchable energy through thermal energy storage (TES).

The recent 1,325 MW storage mandate by the California Public Utilities Commission (CPUC) could spur on CSP development in California. With an increasing amount of renewables added to the grid, CPUC has highlighted the need for energy storage to match demand – after all, solar-PV produces only while the sun is shining and wind only produces when the wind is blowing.

While the ruling is directed towards utilizing the emerging energy storage technologies, such as batteries, flywheels and compressed air, projects that include storage, like CSP, are implicitly included in the ruling as well. Specifically, the mandate allows storage paired with renewables that is procured through the Renewables Portfolio Standard (RPS) program to count towards the 1,325 MW procurement target.

But despite these drivers for CSP in the U.S. several factors are limiting the deployment of future capabilities, mainly the competition from PV and cheap natural gas.

More recently, the lengthy and costly permitting and environmental processes have also been important hurdles for developers, and consequently the CSP sector has not grown as expected.

These environmental and permitting concerns have dominated news headlines in recent months. BrightSource Energy's proposed 500 MW Palen project (see figure 6 for details) has faced a significant stumbling block, with the California Energy Commission announcing that approval for the plant has been preliminarily rejected.

Last year the Commission presented a Presiding Member's Proposed Decision (PMPD) to deny the project's permit amendment, from trough to tower, on the grounds of mounting evidence of harm to wildlife. The Commission highlighted that Palen "would have significant environmental impacts in the area of visual resources" making it non-compliant with "all applicable laws, ordinances, regulations, and standards (LORS) in the area of visual resources".

At the time of publication the agency committee had granted BrightSource Energy's request that it be allowed additional time to gather information that could change the proposed rejection of the project.

In early 2013 BrightSource Energy also withdrew its permit application for the 500MW Rio Mesa project, and also suspended its proposed Hidden Hills plant, noting on-going permitting headaches and environmental challenges.

It is apparent that environmental concerns will remain high on the agenda for CSP in the United States, and issues such as water usage, the destruction of habitat and the land use requirements of projects could continue to pose significant threats to the future project pipeline.

Other Opportunities for CSP

The latest plants developed in the U.S. incorporate thermal energy storage units, which will enhance the capacity to serve base-load electricity demand. At the same time, there is a significant amount of research carried out by institutes like the National Renewable Energy Laboratory (NREL) and the Electric Power Research Institute (EPRI) on the potential use of CSP technology for other niche markets. The two most promising applications are described below.

Hybridization

Hybridization is one of the most promising CSP applications. The reason why there is an increasing interest in hybrid applications is because of the reduced investments needed to integrate a solar plant into an existing power facility. Furthermore, there is a greater capacity to follow the energy demand profile because of the existing conventional fuel plant replacing the need of any back-up fuel part. Therefore, whilst there is a reduced financial and technical risk, hybrid applications can be a suitable method of further demonstrating the full potential of CSP technology.

A recent NREL report concluded that there were between 11 and 21 GW of U.S. fossil plants available for CSP hybridization. Some companies are already moving ahead to develop hybrid CSP units to retrofit existing conventional power plants. For example the Martin Next Generation Solar Energy Center is a parabolic trough CSP plant integrated with a carbon-fired power station with a power output of 75 MW located in Florida, and its cost was approximately US$ 476 million (See figure 6 for more details).

Enhanced oil Recovery

A notable field of CSP deployment is Enhanced Oil Recovery (EOR). The main benefit of using CSP technology in this application is represented by economic savings, whether in terms of increasing the oil production, or saving fuel. EOR, also referred to as tertiary recovery, is commonly used in mature fields, where secondary techniques such as water flooding no longer produce economically viable quantities of oil. The most popular method currently employed in the industry is gas and steam injection, better known as thermal recovery. CSP technology can therefore contribute to the production of steam, replacing (at least partially) the need of conventional fuels.

According to a report by GDP Capital, the conventional steam generators employed for thermal EOR are nowadays more expensive than parabolic trough technology. This is particularly true when looking at the lifetime costs resulting from the high operating costs of current technology using expensive fossil fuels. The report mentions a current price of US$ 4-4.5 per million British Thermal Units (BTU) processed when using natural gas, compared with US$ 3-4 if CSP technology is employed. This competitive advantage is forecast to increase as the cost of fossil fuels rises, with the use of natural gas for EOR projected to move toward US$5.25 per million BTU extracted in the next decade. According to an analysis carried out by Visiongain, the global EOR market worldwide reached a production of approximately 3 million barrels per day in 2013. The market is expected to increase substantially over the next ten years and the U.S. is likely to play an important role within it. An analysis of the EOR market for the U.S. and Europe forecasts that revenues will increase from approximately US$ 410 million in 2012 to approximately US$ 1,775 million in 2019

In February 2011, Glasspoint, a California-based firm, launched a commercial application of CSP used for thermal EOR. Similarly, BrightSource Energy developed the 29 MWth Coalinga CSP project for EOR which was commissioned in 2011 (See figure 6 for further details).

COST REDUCTIONS AND EXPORTING AMERICAN KNOW-HOW

The United States has a history of exporting technologies and products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery.

It is therefore unsurprising that American developers and technology providers have set their sights on developing projects and selling their CSP technology in lucrative markets outside the United States.

But what will give American companies the edge in these markets?

Many analysts have highlighted the scale of projects coming online in the United States and see this as an important step for CSP technology that will undoubtedly define the global path of concentrated solar power for years to come.

The rest of the world is already looking to those involved in these era defining projects to learn about the key challenges faced, whether they are planning, financial, technical or other. What CSP has lacked thus far is experience and it is undeniable that the United States has gained unreplicable experience in the construction of large scale plants and reducing CSP's levelized cost of energy (LCOE).

The costs of CSP have declined significantly as a result of the recent project pipeline in the United States. The US Department of Energy's SunShot Initiative, a programme that aims to reduce the cost of solar power by 75%, has a cost trajectory for new plants of 6 cents a kilowatt by 2020. In 2010, when plants such as Ivanpah and Solana secured backing under the loan guarantee program, CSP costs were estimated at 21 cents a kilowatt hour without subsidies. However, CSP Today has recently reported that costs have already declined to as low as 13 cents a kilowatt hour and the U.S. project pipeline will continue to play a significant role in reducing these costs further.

If we look at the 392 MW Ivanpah Solar Electric Generating System in more detail it is evident that this project has already had a significant impact on the CSP learning and cost curve.

Ivanpah is unquestionably an engineering marvel that was developed by BrightSource Energy, a developer based in Oakland California. What is more the plant was built by Bechtel, the largest construction and engineering company in the United States.

During the design and construction of this project a number of financial and technical considerations were required. For example before construction could take place advanced simulation tools were used to predict the behaviour of various components based on the climate conditions specific to the site, in order to optimize plant level design. Furthermore, CSP Today recently highlighted the learning curve during the construction of the project, in terms of equipment supply and assembly at the site.

The solar field at Ivanpah represented a large portion of the total project costs, with over 170,000 heliostats installed at the site. During the construction phase of the plant BrightSource Energy and Bechtel optimized the mass production assembly of the 170,000 heliostats in a 48,000 square foot facility onsite, using automated machinery and a conveyor system. This resulted in the facility assembling 500 heliostats a day, which contributed significantly to meeting construction deadlines and reducing costs.

Back in 2010 the SunShot Initiative estimated that the cost of each heliostat in a CSP Tower plant would be $200 a meter square. Already analysts have this cost down to $135 a metre square, with the goal of reducing it even further, to less than $75.

Projects such as Ivanpah are now the blueprint for future CSP development and emerging markets such as South Africa, Saudi Arabia, China and Chile are already looking to draw on American expertise in order to facilitate the development of CSP projects.

Significantly, last year BrightSource Energy took steps to exporting its technology, when the company confirmed

that they had signed Memorandums of Understanding (MOUs) with different Chinese institutions to provide their expertise on concentrated solar power technology. Through these MOUs BrightSource aims to supply their CSP tower technology to commercial scale projects in China.

SolarReserve, developers of the 110 MW Crescent Dunes project, have also set their sights on using their expertise to develop projects outside the United States. The U.S. based developer has already entered the South African market, and have also highlighted their development activity in Australia, Chile, China, Egypt, India, Saudi Arabia and Turkey.

In addition to the experience gained in developing new generation CSP projects, the United States is also contributing significantly in the area of Research and Development. As previously mentioned in this section the SunShot Initiative is working hard to spur technological innovation within the US concentrated solar power sector. Research is focused on "component technologies" such as collectors, receivers, power block and heat transfer fluids. SunShot's sister organization, the Advanced Research Project Agency-Energy, also supports additional funding that is focused on thermal storage research and development.

The SunShot Initiative will surely have an impact on the global CSP industry. Since its conception the Department of Energy, along with key stakeholders such as the Ex-Im Bank, have highlighted their willingness to support the U.S. exports of clean energy technologies. It therefore goes without saying that the technological advancements and cost reductions achieved through the programme will have a significant impact on CSP markets worldwide for years to come.