Kuwait is embarking upon some of the largest heavy oil developments globally. Operators will inject steam to heat the heavy oil, reducing its viscosity and enabling production. Fuel for steam generation makes up the majority of the operating costs of a heavy oil field. Just one of the planned full field developments would consume a quarter of the nation’s domestic natural gas production.

Kuwait’s abundant solar resource can be cost effectively captured to provide sustainable clean energy to fuel these developments and reduce fuel use. The application of concentrating solar directly to generate steam and supplement conventional boilers is considered in this paper.

The desert environment in Kuwait presents unique challenges for solar technology, in particular dust, wind and blowing sand. These operating challenges can be overcome, but only with specific solar technology designed for the harsh desert environment in the Gulf region.

The objective of thermal enhanced oil recovery (EOR) is to heat up the large volume of reservoirs. The reservoirs store vast quantities of thermal energy. As such, solar steam can be delivered when the sun shines without the need for expensive energy storage. Using the sun’s energy to produce and inject more steam during sunny hours could increase oil production fourfold without increasing the use of natural gas.

The Desert Environment

The Kuwait desert environment is very different from places where solar thermal has been deployed in the past. Traditional solar technologies with exposed mirrors are not suitable for desert oilfield deployment today. The key issues include:

Dust
Hundreds of tons of dust per square kilometer will fall on any solar array. This needs to be cleaned or performance will significantly drop. Automated wash cycles with water and direct contact are needed to maintain performance on a daily basis.

Wind
Strong winds fan northern Kuwait during sunlight hours, causing mirrors to bend and twist. This can reduce performance of exposed solar designs by up to 20% in prevailing conditions.

Solar Steam Generation for EOR

In solar EOR, solar steam generators raise high-pressure steam directly from concentrated sunshine. Mirrors track the sun focusing sunlight on a boiler tube carrying water. The concentrated sunlight boils the water to produce steam at the exact same pressure and quality as steam produced from fuel-fired boilers.

Blowing Sand
Blowing sand causes two problems: first, a large exposed solar field would require thousands of tons of sand to be removed from around the mirrors. Secondly, when wind speeds exceed 15 meters per second, sand abrasions can degrade performance of exposed mirrors.

Enclosed Trough
Enclosed trough technology is proven in desert oilfields to overcome these challenges. By enclosing the mirrors in a sealed glasshouse, the solar technology is completely protected from the effects of dust, wind and blowing sand. The glasshouse actually reduces the cost of the system by allowing the use of lightweight aluminum mirrors and structures.

Solar technologies with exposed mirrors would require extensive upgrades to operate in Kuwait’s oilfields.
Since the paper was written, and after extensive piloting, Petroleum Development Oman has sanctioned a giant solar EOR project in southern Oman. The project, called Miraah, will deploy GlassPoint’s enclosed trough technology to produce 6,000 tonnes of steam per day at the Amal field. Amal experiences high winds and sandstorms, similar to Kuwait oilfields.

Solar steam can expand Kuwait oil production fourfold
Variable-rate steaming allows large solar fraction without costly storage. The reservoir itself is massive and serves as a natural storage solution. Previous papers by PDO and Stanford describe this.

“From a sub-surface oil recovery point of view, solar-generated steam provides a viable alternative to constant rate steam injection derived from natural gas”
- SPE 129225, PDO and Shell

Replace Fuel for EOR by up to 75%

By applying variable rate steam, operators can steam more during the day using solar steam, and less at night with fuel-fired steam. Modeling for a specific field in Kuwait shows that solar steam can expand production by up to fourfold without increasing a field’s consumption of fuel gas.

Conclusions
• Kuwait oil producers have a significant opportunity to deploy solar steam for heavy oil production.
• Kuwait oilfields are prone to heavy dust and sand, creating unique operating challenges for solar.

Example of Modeling of Solar Steam for Kuwait Field

There is sufficient land available for large solar developments

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