



**DOW**

®

# Enhanced oil recovery solutions

## Generate more production, more efficiently, and in a more sustainable manner with Dow

New discoveries of reserves are becoming more difficult to find and access, while production from existing wells continues to decline. It is becoming imperative that operators employ enhanced oil recovery (EOR) methods to unlock bottled-up reserves for more productive fields. By some estimates, only about 30 percent of available oil has been recovered from wells currently in operation. To access the remainder, a variety of EOR techniques have been employed, with varying results. With a long history of innovation and technical expertise, Dow is pioneering the next generation of surfactants and other solutions that improve the performance of many current EOR methods in mature reservoirs, including miscible gas flooding, thermal methods such as steam flooding and steam-assisted gravity drainage (SAGD), and improved water flooding such as wettability alteration and chemical EOR. With a strong innovative R&D portfolio, Dow is poised to help operators maintain a productive edge for years to come. These methods hold the potential to boost productivity by up to 45 percent and improve water flooding through concepts like wettability alteration.

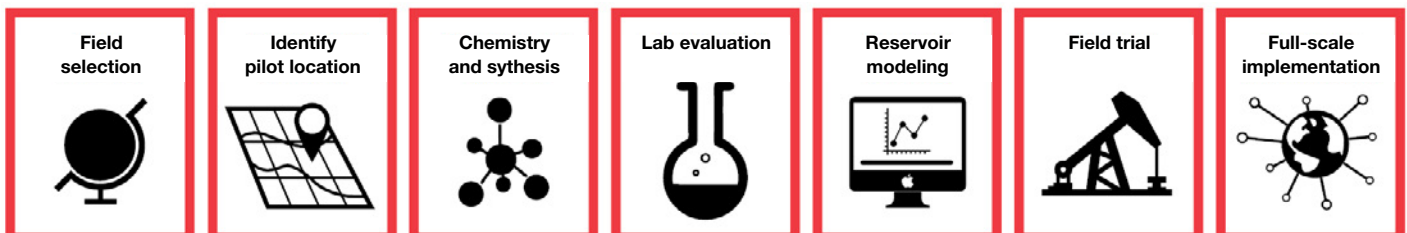
## Boost productivity with Dow EOR Solutions

### Working together to achieve more

What works at one well or field may not be the best solution for another. Dow takes a calculated approach to help each customer tailor solutions for their existing EOR method. Our experts work side-by-side with you every step of the way, from pilot site identification through final field implementation.

Our process starts with reservoir production analysis, followed by creating history matching or improving an existing reservoir model. Only then do we move forward to help determine which solutions will be the most effective in your EOR operation. When working with Dow, operators also are supported by extensive lab and research capabilities, including high throughput screening, lab scale synthesis and pilot-to-scale-up capabilities. In addition, Dow provides access to state-of-the-art surfactant characterization techniques, and is backed by the extensive Dow product portfolio for formulation optimization.

Add a world-class supply chain to the equation, and Dow is ready to help you achieve more, right now, in more places than ever before.



## Finding the most effective approach

Dow offers extensive expertise and solutions to help improve many of the EOR methods currently employed by operators around the world. Leading the way is a full-service evaluation and implementation model for our ELEVATE™ Miscible CO<sub>2</sub> Conformance Control Solution and thermal EOR technologies.

Dow also has solutions to improve water flooding, including additives for reservoir wettability alteration and chemical EOR processes. We stand ready to help in formulation of complex surfactant/co-surfactant/co-solvent mixtures.

## Miscible gas foam flood solutions

One of the most common EOR methods, miscible gas flooding is a highly effective and low operating cost option to enhance extraction. The ELEVATE™ Miscible Gas Foam Conformance Solution is the only deep conformance control solution proven to overcome implementation issues with gravity segregation and reservoir heterogeneity issues in water alternating gas (WAG) systems.

The ELEVATE™ Foam Conformance Solution is a line of formulated systems, tailored to the reservoir to generate water-scCO<sub>2</sub> foam, enabling deep penetration into reservoirs with minimal absorption. Solutions for a wide range of pressure, temperature and brine concentrations can be developed, ultimately leading to greater production.

In addition, ELEVATE™ Foam Conformance Solutions have been extended to cover unconventional gas EOR floods, in which the foam is generated in the fractures, preventing inter-fracture connectivity, and allowing the gas to be more effective thus increasing oil production.

ELEVATE™ Foam Conformance Solutions:

- Consist of surfactants that can be injected in scCO<sub>2</sub> or brine
- Feature preferential treatment of well swept high permeability channels
- Offer low surfactant adsorption on sandstone and carbonate
- Do not impact topside production facilities
- Generate stable foam in the presence of oil
- Can be winterized for cold or arctic climates.

## Chemical enhanced oil recovery

A significant amount of oil is produced during secondary recovery technologies such as water flooding. Improvements to traditional water flooding, whether through conformance control, reservoir wettability alteration, or via a full chemical EOR (CEOR) program are natural extensions to existing water flooding infrastructure. Dow is active in developing new technologies and products around improvement of water flooding.

A significant amount of oil remains in oil and mixed wet reservoirs, particularly carbonates. Studies have shown that surfactants can alter the wettability of the rock, to help release significant trapped oil. Dow's ELEVATE™ wettability alteration surfactants have been field tested in this low complexity EOR technique.

There are many combinations of chemicals used in CEOR. The most effective CEOR operations involve flooding a reservoir with either an alkaline-surfactant-polymer combination or an alkaline-polymer injection. These chemical injections interact with water in the reservoir, freeing the trapped oil and making it recoverable. Dow has a full product line of additives for CEOR, including co-solvents, co-surfactants, neutralizing amines, and chelants.

Dow's ELEVATE™ co-solvents and co-surfactants provide:

- Improved phase stability
- Lower injection slug viscosity compared to viscous emulsions formed by synthetic surfactants alone, which have high surfactant retention and high-pressure gradients
- Increased residual oil recovery rate compared to viscous emulsions, which tend to stagnate in the reservoir

In alkaline-polymer-only flooding operations, Dow can provide a customized ELEVATE™ co-solvent with phase behavior tailored to specific oil type, brine levels and temperatures that can be added to the injection to:

- Create ultra-low interfacial tension (ULIFT) without expensive synthetic surfactants (e.g., creating in situ surfactants via naphthenic acids in crude oil)
- Break viscous, unstable emulsions created from natural surfactants in the oil
- Enable injection of fluids insensitive to geochemistry and temperature
- Provide low adsorption, with no chromatographic separation

### Thermal EOR – Steam foam for conformance control

Thermal enhanced oil recovery methods, in particular those using steam, are the most effective way to increase production of heavy oils and bitumen. Steam-based systems, while very efficient, suffer from conformance control issues and the low solvency of water, just like other EOR processes. Dow has developed solutions for both conformance and solvency in high-temperature thermal environments.

While the inherent high temperatures under these harsh conditions can be challenging, Dow offers a new generation of ELEVATE™ additives that improve recovery in steam systems. For steam flood and SAGD, Dow offers the ELEVATE™ Steam Foam Conformance Solution. For SAGD systems, Dow has also developed high-temperature volatile surface active agents to improve recovery rate and therefore reduce the steam-to-oil ratio (SOR). ELEVATE™ additives:

- Resist degradation at high temperatures
- Exhibit minimal absorption in the reservoir formation
- Perform well in laboratory core flood experiments
- Have been tested to show minimal impact to topside processes and equipment, including boilers

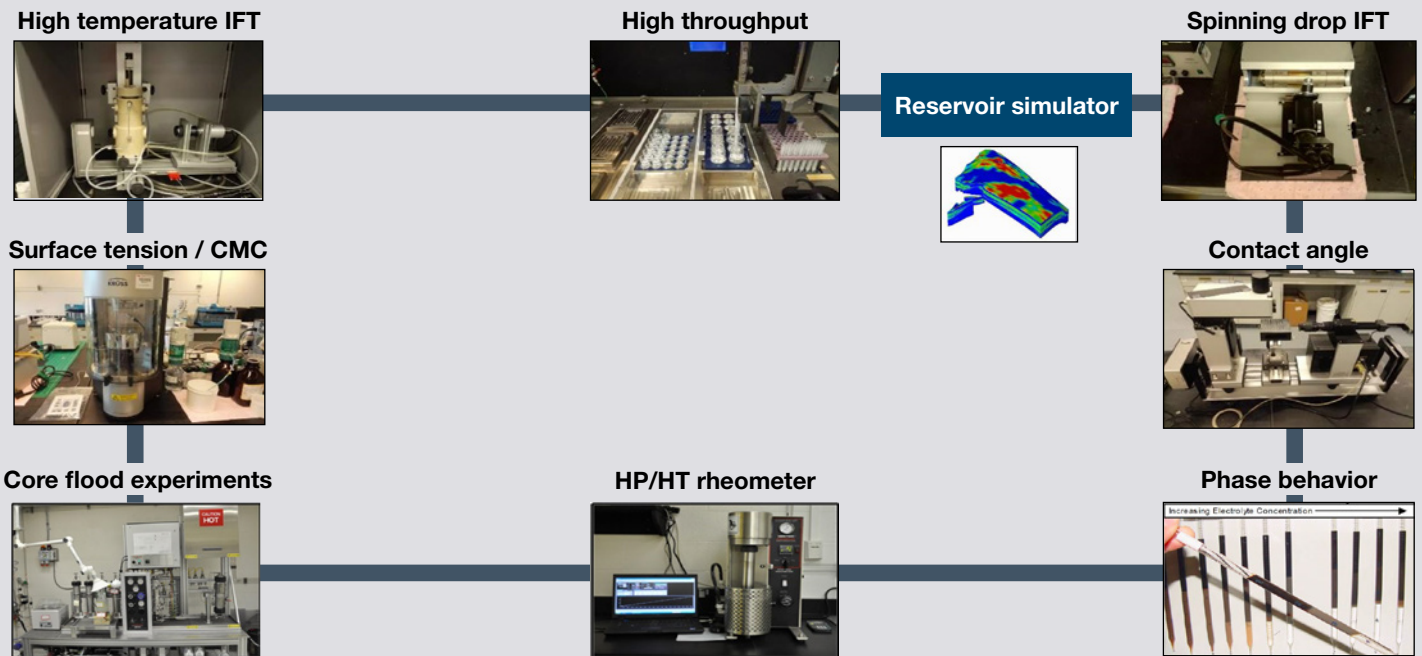
### Expertise born in the lab

Dow has developed rigorous internal laboratory evaluation processes and reservoir simulation capabilities to make implementation of pilot to commercial scale solutions more effective and efficient. Dow’s EOR lab is capable of performing experiments under many reservoir conditions using:

- Multiple core flood set-ups (formation response testers)
- PVT cells
- Phase behavior equipment
- Interfacial tension measurement equipment

All of Dow’s testing is conducted using reservoir rock and fluid samples from the actual reservoir. The Dow foam implementation process is unique, allowing testing and modeling of foam capillary performance, foam quality and oil saturation robustness under reservoir conditions.

## EOR capabilities



## Our field experience

With a total 30 years of EOR experience, Dow's EOR business model is that of technology enabler in strong collaboration with its customer and provide an optimal solution using a holistic approach.

**Contact a Dow expert** to discuss how we can help you increase gas utilization today.

## Product stewardship and safety

Dow has a fundamental concern for all who make, distribute, and use its products, and for the environment in which we live. This concern is the basis for our product stewardship philosophy by which we assess the safety, health, and environmental information on our products and then take appropriate steps to protect employee and public health and our environment. The success of our product stewardship program rests with each and every individual involved with Dow products – from the initial concept and research, to manufacture, use, sale, disposal, and recycle of each product.

Dow strongly encourages its customers to review both their manufacturing processes and their applications of Dow products from the standpoint of human health and environmental quality to ensure that Dow products are not used in ways for which they are not intended or tested. Dow personnel are available to answer your questions and to provide reasonable technical support. Dow product literature, including safety data sheets, should be consulted prior to use of Dow products. Current safety data sheets are available from Dow.



## Dow's commitment to sustainability

Dow's commitment to sustainability is infused into the very DNA of our Company. In 2006, we launched our 2015 Sustainability Goals, which focused not only on the Company's footprint in our own operations but also our handprint through the positive impact of Dow products and their role in global sustainable development. Now we have introduced our 2025 Sustainability Goals. With these Goals, Dow seeks to advance the wellbeing of humanity by helping lead the transition to a sustainable planet and society. The seven commitments that comprise the 2025 Sustainability Goals represent the next step in our long-term strategic journey. For more information on how sustainability is integrated into all aspects of our business and operations, please visit [dow.com/sustainability](http://dow.com/sustainability).

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