

A Novel Approach to Reducing Water and Energy Consumption in Oil Production

M.R. Pavia

Glori Energy, Houston, TX, USA, mpavia@glorienergy.com

ABSTRACT

Oil will remain an important piece of the worldwide energy mix for the foreseeable future. Massive quantities of known, but unrecoverable oil exists in worldwide reservoirs. There is a strong need for novel approaches to recover this trapped oil economically.

Glori Energy's AERO™ Technology (Activated Environment for Recovery of Oil) has demonstrated the ability to increase oil production while reducing water and energy usage, making the process economical in today's oil price environment. Upon application of AERO, microbes indigenous to the reservoir mobilize oil by reducing interfacial tension and modifying water pathways through the rock matrix.

Results from a reservoir in Alberta, Canada illustrate both enhanced oil recovery and the economic benefit.

AERO Technology can help assure a stable, economic supply of low cost oil while conserving water and energy.

Keywords: enhanced oil recovery, microbial, energy conservation, water use

1 INTRODUCTION

When an oil well is first drilled, oil is produced by natural reservoir pressure; this is called primary recovery. This phase is only capable of recovering about 10% of the original oil in place (OOIP). Once the primary phase is no longer effective, the oil producer typically decides whether to switch to enhanced recovery methods such as waterflooding (water is pumped into an injection well to flush oil from the reservoir) or decide to abandon the reservoir for economic reasons. In either case, when enhanced recovery is no longer effective or economic, typically 60-70% of original oil in place remains trapped in the reservoir. Worldwide this represents in excess of 2.4 trillion barrels of known but unrecovered reserves [1].

Typically, enhanced recovery using waterflooding becomes economic because waterflooding uses enormous amounts of water and energy while producing increasingly little oil. It is not uncommon for mature fields undergoing waterflooding to require 98 barrels of water to produce just one barrel of oil. This water must be constantly recirculated throughout the reservoir, requiring very large quantities of

energy. This energy cost constitutes one of the largest operating expenditures for mature oil fields undergoing waterflooding, causing oil producers to plug and abandon fields that still have 60-70% of OOIP.

There is a strong need for a novel technology to recover this trapped oil economically.

Glori Energy's AERO Technology is capable of recovering an additional 9-12% of the OOIP compared to traditional waterflooding techniques while making recovery economical by significantly reducing water and energy use.

2 TECHNOLOGY

Glori Energy's AERO Technology [2][3] is a biological enhanced oil recovery technology that increases oil production from waterflooded sandstone reservoirs by stimulating a reservoir's naturally occurring microbes with a custom-designed blend of inorganic nutrients.

These microbes, already present in the reservoir, thrive and grow on trapped oil deposits at the oil/water interface upon AERO treatment and exhibit several important mechanisms for oil recovery. First, the system activates specific microbes that disrupt the interfacial tension between oil and water, freeing trapped oil. In addition, biomass from microbial growth is produced where the oil is trapped. This biomass results in dynamic and continuous changes of water flow patterns at the reservoir's pore-throat level, freeing up more pathways for oil flow

Once the nutrient formulation is developed for the reservoir the project moves into field deployment. The field units have been designed to integrate with industry standard oil field waterflood equipment to simplify installation with minimal additional footprint. The field module is installed adjacent to the water injection system and a continuous flow of the customized nutrient formulation is injected into the water stream going to several injector wells.

3 FIELD RESULTS – MORE OIL WHILE REDUCING WATER AND ENERGY USE

Field data shows that when AERO is deployed from initiation of a waterflood or when used in waterflooding mature oil reservoirs, the total water circulated throughout the reservoir for oil recovery is significantly reduced. Not only does this finding reduce water use, but it concurrently

cuts the energy costs required to circulate the previous large quantities of water.

Statoil has reported offshore data demonstrating delayed water breakthrough using its version of AERO (AERO has been developed in collaboration with Statoil). The reported results demonstrate up to 16-fold less water lifted for each barrel of oil produced [4].

Glori has demonstrated a similar finding in a client project in southern Alberta, Canada undergoing a waterflood recovery method [5]. Prior to AERO application the reservoir was producing 21 barrels of oil per day (BOPD) and declining at a rate of 34% per year. To produce a bbl oil the field was utilizing/circulating 2000 barrels of water per day (BWPD).

At the existing rate of decline the field was rapidly approaching the limits of its economic lifetime due to operating costs. A major operating cost was the energy required to move the large quantities of water.

Upon AERO implementation oil production rose from 21 BOPD to 60 BOPD, which was >400% the predicted rate of 14 BOPD. Production in this field was restored and

maintained at or above where it was eleven months before the application of AERO.

In a little over a year of continuous nutrient injection AERO had stimulated 13,591 incremental bbl of oil, a 256% increase over the modeled baseline production. Oil production, water injection rates, and water cut are summarized in Figure 1. As seen in Figure 2, even with increasing oil production the water use was constant at 2000 BWPD. With the increased production and oil cut, this represents an approximately four fold reduction in barrels of water required per barrel of oil produced. The energy required to move water in a waterflood is directly proportional to the volume of water moved. This four-fold reduction in the amount of water that must be moved results in a proportional reduction in the amount of energy required for water movement per barrel of oil produced.

The overall effect of AERO treatment was a reversal of the decline trend and a stabilized water:oil ratio. It is predicted that over 68 Mbo additional oil could be recovered by continuing to apply AERO, equaling 5-8% of OOIP. The field's economic life increased 5-8 years.

Figure 1: Average Daily Oil Production Rate, Oil Cut, and Water Injection Rate

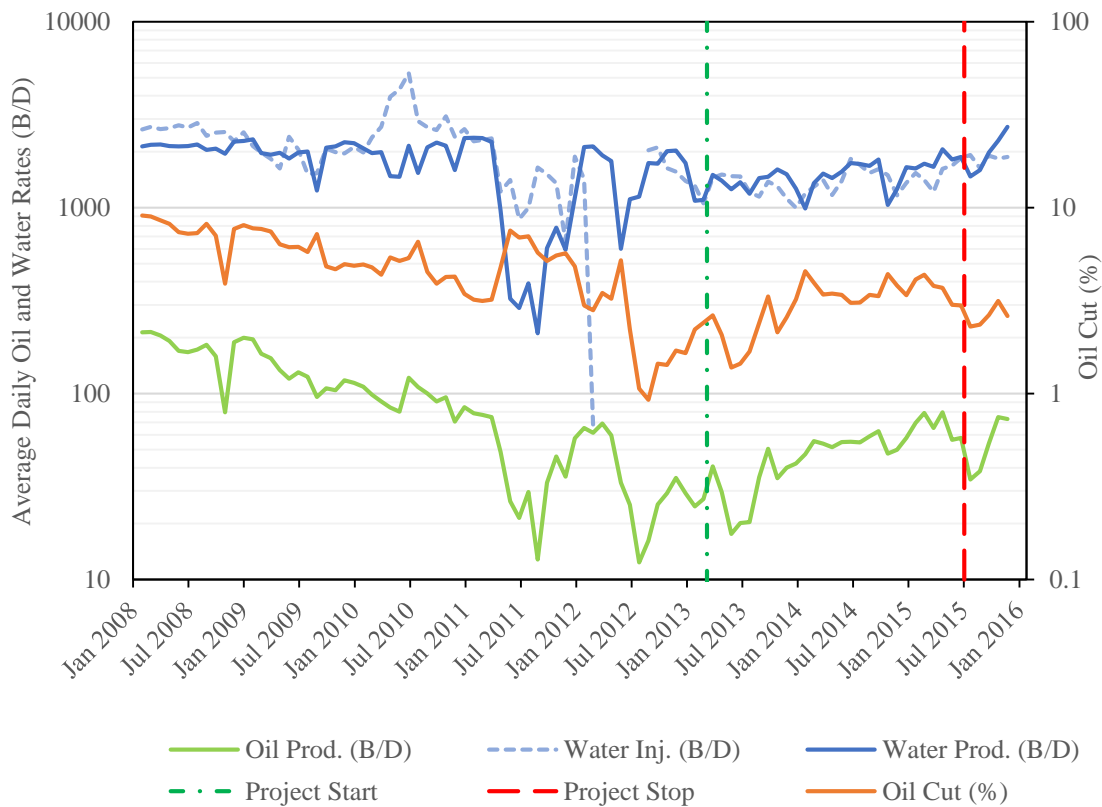
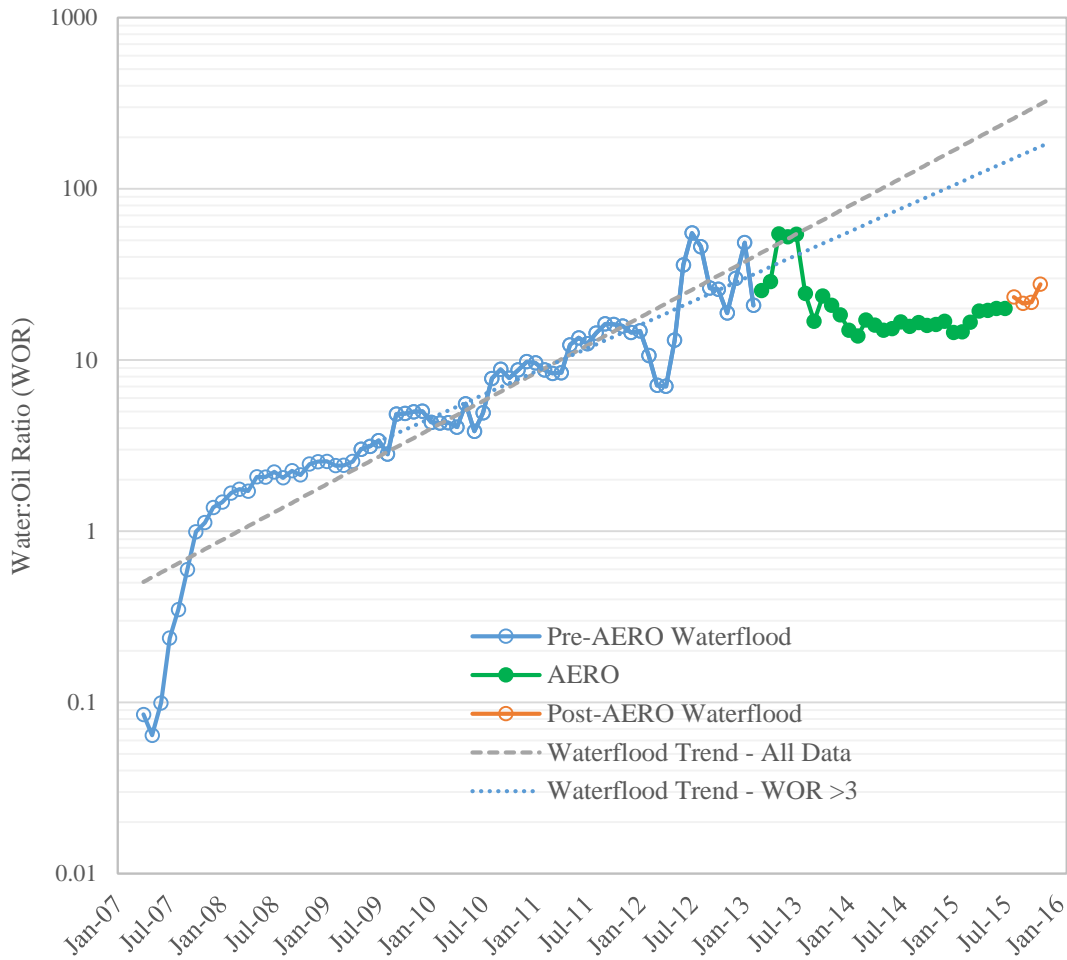


Figure 2: AERO Alberta Project: Decreased Lifting Cost



4 CONCLUSIONS

AERO Technology can help assure a stable, economic supply of oil while conserving water and energy. The key benefits of the technology are:

- Improved oil recovery
- Higher oil rate
- Increased oil cut
- Reverse production declines and significantly increase ultimate reserve recovery
- Uses less water per barrel of oil recovered, requiring much less energy consumption resulting in a longer economic life of the field
- Low incremental cost per barrel (approximately \$10 per incremental barrel of oil produced)

- Uses existing wells, infrastructure and water resulting in no additional impact to the environment.

Solar, biofuels, wind and other renewable energy sources are the world's energy future. However, these energy sources are still in the distance.

Glori Energy's AERO Technology represents a bridge to a renewable energy future by leveraging a natural ecosystem to yield more oil, assuring a low cost, stable supply of oil in an environmentally sustainable manner.

More oil from known sources with less natural resources used. A win for everyone.

REFERENCES

- [1] Program Facts - Oil Exploration & Production Program, Enhanced Oil Recovery, National Energy Technology Laboratory, U.S. Department of Energy and EIA International Energy, U.S. Department of Energy, Office of Fossil Energy, National Energy Technology Laboratory, June 2005.
- [2] Bauer BG, O'Dell RJ, Marinello, SA et al. 2011. Experience from a Biotechnology Approach to Water Flood Improvement. Presented at the SPE Enhanced Oil Recovery Conference, 19-21 July, Kuala Lumpur, Malaysia. SPE 144205-MS. <http://dx.doi.org/10.2118/144205-MS>
- [3] Pavia M.R., Ishoey T, Page SM, Sunde E, Sept 9, 2014. US Patent 8.826.975, Systems and Methods of Microbial Enhanced Oil Recovery.
- [4] Grabowski D and Maldal, T, 2014. Statoil experience on MEOR for Norne. http://www.force.org/Global/Seminars/2014/13_MEOR_From_theory_18.11.14/Presentations/MEOR_Norne_Force%20seminar_18%20Nov%202014.pdf
- [5] Havemann GD, Clement BG, Kozicki KM. et al. 2015. New Microbial Method Shows Promise in EOR. *J Pet Technol.* 67(3): 32-35.