Economic Assessment and Review of Waterless Fracturing Technologies in Shale Resource Development: A Case Study

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ABSTRACT: Our database tracking of USA water usage per well indicates that traditionally shale operators have been using, on average 3 to 6 million gallons of water; even up to 8 million for the entire life cycle of the well based on its suitability for re-fracturing to stimulate their long and lateral horizontal wells. According to our data, sourcing, storage, transportation, treatment, and disposal of this large volume of water could account for up to 10% of overall drilling and completion costs. With increasingly stringent regulations governing the use of fresh water and growing challenges associated with storage and use of produced and flowback water in hydraulic fracturing, finding alternative sources of fracturing fluid is already a hot debate among both the scientific community and industry experts. On the other hand, waterless fracturing technology providers claim their technology can solve the concerns of water availability for shale development. This study reviews high-level technical issues and opportunities in this challenging and growing market and evaluates key economic drivers behind water management practices such as waterless fracturing technologies, based on a given shale gas play in the United States and experience gained in Canada. Water costs are analyzed under a variety of scenarios with and without the use of (fresh) water. The results are complemented by surveys from several oil and gas operators. Our economic analysis shows that fresh water usage offers the greatest economic return. In regions where water sourcing is a challenge, however, the short-term economic advantage of using non-fresh water-based fracturing outweighs the capital costs required by waterless fracturing methods. Until waterless methods are cost competitive, recycled water usage with low treatment offers a similar net present value (NPV) to that of sourcing freshwater via truck, for instance.

KEY WORDS: shale gas, gas exploration, fracturing technology, fracturing fluid, waterless fracturing.

0 UNDERSTANDING THE CHALLENGES

In the eight to ten years, it is estimated that more than 100 000 wells and between one- to two-million hydraulic fracturing stages could be executed, resulting in close to one trillion dollars in industry spending (Ahmed and Methan, 2016). The US Environmental Protection Agency predicts that between 70 and 140 billion gallons of water are needed annually for hydraulic fracturing operations in the US alone (EPA, 2011). Our database tracking of USA water usage per well indicates that, on average, a well requires 3 to 6 million gallons of water, even up to 8 million for the entire life cycle of the well based on its suitability for re-fracturing (Oraki Kohshour et al., 2016). This depends on the number of fracturing stages and particular characteristics of the producing formation. Since 2008, the development pace and accelerated production rate of North American unconventional resources have surged rapidly (Fig. 1) and has played a vital role in the regional economy of the producing states.

It has even created a desire for the region to become

energy-independent. These practices started in the Barnett shale play in 1980s and soon spread out to other shale plays across North America. Today, there is a significant level of interest and motivation to evaluate and exploit these resources in worldwide basins such as China, Argentina, Middle East, and elsewhere (Alderete et al., 2017; Oraki Kohshour et al., 2016; Bonapace, 2015; Casey et al., 2015; Mauter et al., 2014; Meehan, 2014; Olivas et al., 2013; Nuyens et al., 2012). In order to sustain the trend and accelerate oil and gas production, billions of barrels of water would be needed, and billions barrels of water will be produced, which would require responsive and effective water management solutions (Akhmadullin, 2017; Dunkel, 2017). This is caused by two factors: the increase in the number of wells per year during reasonable commodity prices and the trend of increased water use per well for fracturing for several shale plays in the US (Fig. 2). The trend of increased water use per well is an almost universal combination of factors in any given field development plan in any formation: longer horizontal lateral lengths versus time, larger fractures per stage versus time, larger amount of water and proppant per stage versus time, more stages per well versus time, and thus a higher water and proppant intensity per well versus time. Similar trend is also evident in the produced and flowback water (Oraki Kohshour et al., 2016). In some cases, these challenges are extremely hard to manage. This is especially true with the future water demand and the expected trends in shale oil and gas production.

According to an industry report (Ceres, 2014), more than 55% of all U.S. wells are in areas experiencing drought, and 36% percent of all U.S. wells are in areas experiencing groundwater depletion. The effects of drought are unpredictable and in years when it affects the industry, the increased water use causes a larger impact. Operators who are active in these regions, especially in the Eagle Ford, Permian, and Barnett, must develop integrated water management solutions and implement operational practices in order to continue support their drilling and completion operations. In some shale plays in the USA, there is an integrated water management infrastructure, such as interconnected ponds in the field with pipelines between the pads, to minimize impact, maximize recycling of fracturing fluid, decrease truck traffic, increase safety, and decrease costs.

It is also important to realize the cost contribution of fracturing fluid in the drilling and completion as major costs categories in the low oil price environment. Industry sources indicate that water management is a staggering $51 billion annual market, with $3.8 billion in the treatment and recycling of produced water (Navigant Research, 2016). Over 21 billion barrels of water per year are being produced only in the U.S. (Argonne National Lab., 2009). Our cost data shows that water management can take up to 10% of the drilling and completion costs in some cases, where transportation and disposal costs could be as high as $10 per barrel of water (Fig. 3).

A common trend in nearly all formations is that the wells were under-stimulated, particularly at the beginning of each field, as the reservoir was being proved up and optimization was not the goal. In many formations in North America, the learning curves demonstrated in our in-house fracture database show increased lateral lengths, more fracture stages, greater volume of water per fracture stage, and sometimes using slick-water instead of other fracturing fluid options. All of these