OPTIMIZING PRODUCTION OF HYDROCARBONS AND WATER: INCENTIVES FOR GOODS AND BADS

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Overview

Many western states have relatively abundant energy but scarce water resources. The nexus between these energy resources, the required water to complete wells, and the concurrent water produced with the hydrocarbon results in complex resource and disposal problems. The produced water is of low quality, containing a variety of contaminants, for example, hydrocarbons, total dissolved solids, or salts. While the regulations vary by state, in many cases, produced water is classified as a hazardous waste and must be disposed of, or cleaned in order to re-use. Because of the availability of alternative water sources, the high cost of treatment, and regulations that often make it difficult to even consider beneficial use of the water, most produced water is disposed of, often through injection wells (although some operators are now augmenting with produced water). This can result in high production costs for hydrocarbons, as disposal costs are not trivial. And in some cases, unexpected consequences in the form of increased seismic activity add to the complexity. In the arid west, where water supplies are fixed, demand is increasing, drought is a common occurrence, and the effects of climate change may potentially be severe, so the practice of disposing of produced water may need to be re-examined.

Water demands in the west are much further reaching than the oil field and increased water scarcity may suggest the value of water is substantially higher than what we traditionally consider. For example, a 2014 Arizona State University study estimated a 10% decrease in water availability in the Colorado River Basin would result in a total economic cost to the states involved of $143 billion. This equates to a value of over $80 per barrel for water in some areas. It should be noted that their modeling approach is very restrictive and most certainly these values over-estimate the value, but given reported costs of up to $10 per barrel for treatment, there is the potential that produced water may be a good rather than a bad. This research considers the potential for produced water as both a by-product for the private, profit-maximizing firm, as well as its production from a social perspective.

Methods

We develop a set of theoretical models with which to consider oil and water production. The first models the status quo, that is, water used to complete is a good but water produced increases the cost of production through disposal and transportation costs. Second, we model water as a by-product of optimally producing oil. Third, develop a model of water as a co-product, where both water and the primary product are optimally produced. Finally, we develop a production model from the social perspective. We can then compare the conditions in which the optimal production of water is a "good" rather than a "bad."

We then simulate these models utilizing existing data and information on produced water quantities, costs of disposal, treatment, and/or transport in order to analyse the incentives provided by current regulations and counterfactual alternatives aimed at providing incentives for efficiency. This allows us to consider potential opportunity costs, including transaction costs, as well as the impact of regulation on our rapidly changing energy, water, and environmental mix.

Results

Our theoretical results indicate the costs to dispose of produced water (where produced water is correlated to oil production) impact the optimal production path for oil. Thus, optimal management requires consideration of both the marginal net value of oil and the marginal costs of disposal. Depending on the quantity of produced water, optimal oil production can, in effect, be a water management plan.

When produced water is considered a potential "good" for the profit-maximizing firm, the optimal oil production path is qualitatively altered, and the optimal quantity of produced water that is recycled will be determined by equating the sum of the marginal value of recycled water and the marginal cost of water disposal with the marginal cost of recycling. Finally, when the total social value of water is considered rather than simply the market price recycled water, we find optimal production from the social perspective is characterized by larger marginal disposal costs due to the external effects as well as a larger marginal value of recycled water.

Conclusions

Produced water usually adds to the cost of production of hydrocarbons because of disposal costs. While the technology exists to treat and clean the water, the cost is often prohibitive as alternative fresh water sources are less expensive. However, given the increased demands for fresh water supplies, coupled with increasing scarcity of this supplies, produced water may, under certain conditions, provide an additional supply source. However, in order for this to be the case, regulations and incentives will need to be aligned to allow the possibility of efficient treatment and re-use.

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