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Today I have been asked to focus on the impact shale gas production will have on water resources, especially in the Eastern United States. It is a topic I care passionately about, and I believe it is a fundamental piece of ensuring the future health of our families and the economic strength of our country. Some however, are convinced that shale gas production will ruin everything they cherish. The task before us is to envision a much more positive outcome, and ensure that we get there.

Shale gas development offers America an opportunity to demonstrate what it does best. It will improve living standards in many communities by expanding employment in a variety of industries and provide income to royalty owners and tax revenues to state and local governments. It will be done responsibly, and the process will drive a lot of innovation, while setting new standards for environmental sustainability. Already a lot of that is underway. The ultimate timeline may be the next 100 years, but industry appreciates the imperative of getting things right, and is rapidly moving forward to respond to the challenge. For our discussion today, some areas are of general priority interest: protecting water resources from chemical pollution, balancing competing needs for water resources, providing perspective on what alternatives we have or in other words investigating how water requirements for natural gas stack up compared with other major players in the energy and power sector.

Protecting water resources

Protecting water resources, especially drinking water from chemical pollution is part of our fundamental commitment to safe operations and protecting the communities where we live and work. In traditional oil and gas states, the safest, most efficient and economical way to deal with water is not so practical in many areas of the Marcellus. Generally water is sourced from surface or groundwater, and after use all flow-back and produced water is disposed of into state permitted deep injection wells.

In the Marcellus area there are very few disposal wells and initially the industry disposed of produced water by trucking it to treatment plants. With the scale-up of operations this has proved unsustainable. Now nearly all operators report that they store, treat and re-use water, putting it into next frac job a mile below the surface. As operations expand toward Ohio and western West Virginia, geology is likely to be more conducive to deep subsurface injection of waste water.

Many have asked me why companies didn't re-cycling water to start with. A couple of factors played a major role. Operators were familiar with the chemistries and functional expectations of using "fresh" water, and facilities to treat water for re-use were rare and costly. It takes treatment to make flow-back and produced waters suitable as base fluids for fracturing. As the saying goes necessity is the mother of invention, and there has been a lot of innovative problem solving in this area.

Others have addressed this committee about chemical disclosure and the merits of the IOGCC- GWPC FracFocus.org website. From an industry insiders perspective, this effort has also encouraged companies to think more about why they use specific chemicals and how they can minimize risks by changing chemical components. Several major vendors have developed more environmentally sensitive formulations and some have developed scoring systems to better quantify and communicate the advantages of particular chemicals. Nation-wide there is a lot of variability in the specific chemical needs based on problems of local geology, reservoir temperature and pressure and the presence of specific minerals or metals in the reservoir rocks or fluids. In addition operators have conducted performance-based comparisons to aid in the selection of chemical additives. Basically, no one wants to pay for chemicals they don't need, and we have found that we can often replace non-biodegradable biocides with much less intrusive chemicals or even with ultraviolet light in some circumstances. We frequently eliminate clay control additives without detrimental reactions.

The slick-water fracs for dry gas common in the Marcellus lend themselves to simpler formulations.

Balancing competing needs for water resources

No doubt, hydraulic fracturing requires a lot of water, and the amount depends on the size and depth of the well, and the specifics of the competition technique. Water is a local resource and withdrawal must be managed on a local basis to ensure that the ecological health of riparian systems and the needs of other major users are met. All states have significant powers and organizations in place to protect these rights.

In the Marcellus area most operators report frac jobs requiring 4-8 million gallons of water. That sounds huge considered in isolation, but compared with the estimates exceeding 3 trillion gallons of water per year used by people and industry in the Marcellus basin it not so big even if done 1000 times. Another way to think about it is that a typical frac job uses 1.5 seconds of the Mississippi River discharge into the Gulf of Mexico. In the Eastern US, the volumes of water required for hydraulic fracturing are not likely to dominate decisions about water use except in very local circumstances. Texas on the other hand is not so lucky; record drought is impacting everything.

Apache operates in states and provinces where we are permitted to re-inject 100 percent of flow-back and produced water into deep underground reservoirs completely isolated from freshwater aquifers. In

Oklahoma and Texas, we normally make-up our frac fluids by mixing fresh water produced from shallow groundwater sources and surface sources that are purchased from land owners. Recently, we have learned a great deal from our Canadian operations about using relatively high saline water instead of fresh water, contrary to the general practices and expectations of the industry. In the Horn River Basin, working with our partner EnCana, we have developed a system for extracting water from a saline aquifer in the Debolt formation and treating it in a built for purpose plant to eliminate H_2S. The water is piped to our well pad where we add a minimum of chemicals to create an effective frac fluid. After fracing we then re-inject the flow-back and produced water into the Debolt formation in a closed-loop system. This water source provides many operational advantages, and compliments efficiencies provided by innovative high-density well pads that allow a minimum surface footprint. We intend to continue to innovate to protect a pristine environment using a minimum of surface water and disposing of none into waterways.

High-flow-rate brackish or salt water aquifer systems are not present everywhere. In the Permian Basin, Apache believes the brackish Santa Rosa groundwater system can be adapted for a similar purpose as the Debolt in parts of the Horn River Basin. We are currently investigating tests of our concept for frac systems in oil reservoirs using recycled brackish water as a base fluid. This has many environmental advantages, and well as practical reservoir management efficiencies, but it is especially good because if we are successful, we will minimize our need for fresh water. This is a clear example where technology enables our business and we aggressively explore what is possible in order to succeed. So do many others, and we all benefit.

Hydraulic Fracturing, water and power

Although I'm not an expert in power generation, it seems especially pertinent for this committee to consider the water budget of energy from shale gas compared with other sources. The natural gas revolution is about providing power to America. Natural gas from shale powering a NG combined cycle power plant requires less than half the water used for fuel and cooling of IGCC and Coal steam Power plants (without CCS), less than a third of Nuclear steam turbine requirements, and an even smaller fraction of water required by solar condensing plants.

Consider water requirements for other fuels. Natural gas, from both shale gas and conventional reservoirs requires less water per MMBtu of energy generated from combustion than any other common fuel.[1]

The real water "water-hog" it seems is not hydraulic fracturing, but biofuels derived from irrigated corn ethanol or irrigated soy biodiesel.

Thank you for allowing me to share some of my thoughts with you today. Certainly shale gas has reputational issues, but a closer examination of the facts and consideration of the alternatives underscores what a giant and positive opportunity shale gas production will have for the eastern United States and the country as a whole.

[1] http://www.sandia.gov/energy-water/docs/121-RptToCongress-EWwEIAcomments-FINAL.pdf