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Energy and Water - The Ignored Link

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Summary

This concept paper attempts to highlight an often neglected crucial link between energy and water in context of energy security. Water and energy use are mutually reinforcing. Water is essential to many activities including washing, cooking, drinking and recreation. Industrial processes rely on water for cooling, chemical solvents, cleaning, just to name a few. Oil industry is heavily dependent on water such as producing it through water injection for efficient recovery and to a significant extent in oil refineries. Aquifers are being targeted for injection of water in place of saline water in offshore fields to save cost and aquifers are also gaining environmental importance in terms of their potential for carbon dioxide storage. Coal Bed Methane (CBM) extraction is critically dependent on dewatering from coal seams. Dominant fossil fuel such as coal is dependent on water during beneficiation stage as well as for conversion to electricity in thermal power plants. Energy is a critical input to pump, transport and treat the water required by industries, agriculture and municipalities. Ironically, however, much of this energy would not be available without water to turn turbines, wash inputs, or cool equipment. Thus in many cases use of one resource is inextricably linked to use of the other. It is essential, therefore, to address all energy conservation measures in association with water use and all water conservation measures must have to be based on commercially viable renewable sources of energy. By targeting water use, energy use can also be reduced. This is critical to energy security.

1.0 Introduction

Understanding the vital link between fossil fuels and water is crucial to ensure energy security. Actions to improve resource use in one area may have a negative impact in other areas e.g. building a power plant to increase energy supply may increase demand for limited water resources. While ensuring adequate supply has been the goal of utilities for many decades, this approach must now become demand-side oriented, managing consumption and promoting conservation of these two vital resources - water and energy. Water ranks equally high on the international environmental and development agenda. But this can not be tackled as an isolated issue overlooking the numerous links to energy production. While the fossil-nuclear energy system amplifies the global water crisis, most renewable energy technologies do not consume water. Water crisis, therefore, cannot be solved without a complete shift of energy production to a predominantly renewable energy mode. Similarly, when discussing the energy used in municipal, industrial, and agricultural water sectors, one must closely examine water use itself. Often energy use is driven by water demand. If water consumption could be reduced, we would see a concomitant decrease in energy demand.

The paper discusses the role of water in energy production from various sources and puts special emphasis on role of water in oil and gas industry which is not appreciated by many oil men. The purpose is to achieve energy security through water security and vice versa.

2.0 Water-key to Energy

2.1 Electric power:

It is interesting to note that one of the largest uses of water is electricity production. Water is used in thermal, nuclear, and hydroelectric power generation. Power is produced via hydroelectric generation. This electricity is then used to

treat, pump, move, and heat water (among other things). Thus, the nexus comes full circle; water is used to produce the electricity which is used to consume water.

2.2 Fossil Fuels

Fossil fuels oil/gas and coal, apart from being close partners to water under in-situ reservoir conditions are immensely facilitated by water for economic recovery/production and beneficiation/refining.

2.2.1 Oil & Gas Production:

2.2.1.1 Water injection for oil production:

The water injection method used in oil production is where water is injected back into the reservoir usually to increase pressure and thereby stimulate production. Water injection wells can be found both on and offshore. This method is used to increase oil recovery from an existing reservoir. Water is injected for two reasons: 1. For pressure support of the reservoir (also known as voidage replacement). 2. To sweep or displace the oil from the reservoir, and push it towards an oil production well.

Existing water resources and electrical submersible pumping (ESP) technology are being used to extend the life of mature fields in addition to lowering operating expenses and minimizing impact to the reservoir.

2.2.1.1.1 Aquifer Injection system:

Water injection for reservoir pressure maintenance is nothing new in the oil industry, but traditional offshore seawater injection applications can be costly and can potentially damage the reservoir and well equipment. Use of compatible aquifer water for reservoir pressure maintenance provides a number of benefits that contribute to the optimization of the total asset value and return on capital investment in water flood projects. In addition to limiting reservoir damage, aquifer injection systems lower capital and operating expenses by eliminating water treatment facilities normally required for seawater injection.

Aquifer water requires minimal or no treatment facilities on the surface and can be directly re-injected into the injection wells. These systems include one or several aquifer production wells, each equipped with a high volume ESP, surface injection pumps and possibly de-gassing facilities prior to mixing aquifer water with produced water. Final injection pressure requirements are normally provided by surface water injection pumps.

Heavy oil fields require water flooding as a secondary oil recovery method, but the economics can be marginal. The lower initial capital investment necessary for an aquifer injection system, as well as the elimination of both regular scale squeezes and scale removal programs traditionally associated with seawater injection, can be the difference in making these types of fields economically feasible.

2.2.1.1.2 Produced Water injection

Water produced from the reservoir (at the same time as the oil) is preferred for use as an injection fluid. Using produced water avoids the potential of causing formation damage due to incompatible fluids. Also, the produced water, being environmentally unfriendly, must be disposed of in some manner, and this method has an economic benefit. As the volumes of water being produced are not sufficient to replace all the production volumes (oil & gas), make-up water must be used to ensure that all the reservoir voidage is replaced.

2.2.1.2 Aquifers- key to Reservoir Management

Due to the constantly increasing difficulty to discover new fields, it is necessary to dedicate every possible effort to optimize the exploitation of each reservoir. An important field condition that has been reported in the literature is that of several oil fields sharing a common aquifer. For these physical conditions, the reservoirs are in hydrodynamic communication and production from each oil field results in an interference, or pressure drop, with respect to the other neighboring reservoirs. This effect should be properly taken into account in all reservoir engineering studies, otherwise with all adverse consequences, performance predictions will fail to match field behavior. This particular field conditions require a special effort for the characterization of the reservoirs-aquifer system.

2.2.1.3 Hydrodynamic Flow as a trapping mechanism:

It is common observation that down dip flow of water augments the ability of a trap to hold oil while an up dip flow destroys it. This concept has been applied to several reservoirs. Abrupt differences in water salinity coincide with the abrupt pressure differences indicating no flow across the barrier.

At present, the most commonly used method to find oil in hydrodynamically active regions is to draw maps on the water salinity, looking for areas which were protected from flow.

2.3 Water & Coal Bed Methane (CBM) Production:

When the world is looking at pollution-free fuel, nature has already provided us with an alternative - coal bed methane (CBM). The gas, otherwise lost during coal mining activities, is capable of meeting some portion of our energy requirements.

Along with the natural gas produced from coal beds (CBM) water is also brought to the surface. The amount of water produced from most CBM wells is relatively high compared to conventional natural gas wells because coal beds contain many fractures and pores that can contain and transmit large volumes of water. In some areas, coal beds may function as regional or local aquifers and important sources for ground water.

The water in coal beds contributes to pressure in the reservoir that keeps methane gas adsorbed to the surface of the coal. This water must be removed by pumping in order to lower the pressure in the reservoir and stimulate desorption of methane from the coal. Over time, volumes of pumped water typically decrease and the production of gas increases as coal beds near the well bore are dewatered. It is, therefore, water that holds key to CBM production.

2.4 Nuclear energy and water:

Nuclear power plants use large quantities of water for steam production and for cooling. Nuclear power plants need more cooling water than fossil-fired power stations. This is because the steam in nuclear power stations is designed to operate at lower temperatures and pressures, which means they are less efficient at using the heat from the reactor and thus require more water for cooling. Depending on the cooling technology utilised, the water requirements for a nuclear power station can vary between 20 to 83 per cent more than for other power stations.

2.5 Hydrogen Economy and water:

In a hydrogen economy, hydrogen fuel would be manufactured from some primary energy source and used as a replacement for hydrocarbon-based fuels for transport. The hydrogen would be utilized either by direct combustion in internal combustion engines or as fuel in proton exchange membrane fuel cells. The primary energy source can then become a stationary plant which can use renewable, nuclear or coal-fired energy sources, easing the pressure on finite liquid and gas hydrocarbon resources. There is no carbon dioxide emission at the point of use. With suitable primary energy sources, greenhouse gas emissions can be reduced or eliminated.

A promising option for hydrogen production from renewable resources is electrolysis, in which electricity is used to disassociate water into hydrogen and oxygen.

3.0 Aquifers as carbon dioxide sink:

Several options for carbon dioxide storage are being considered world wide. Most of these involve pumping the gas underground or undersea into sites such as depleted or depleting oil and gas fields and deep saline aquifers.

The basic principle entails pumping carbon dioxide under pressure into pores in sedimentary rocks in both oil and gas fields and saline aquifers under the sea-bed.

Worldwide there are a number of planned and ongoing demonstration projects for storage in both oilfields and aquifers.

4.0 Conclusion:

Energy security rests on two principles – using less energy to provide needed services, and having access to technologies that provide a diverse supply of reliable, affordable and environmentally sound energy. Many forms of energy production depend on the availability of water e.g., the production of electricity at hydropower sites in which the kinetic energy of falling water is converted to electricity. Thermal power plants, in which fossil, nuclear and biomass fuels are used to heat water to steam to drive turbine-generators, require large quantities of water to cool their exhaust streams. The same is true of geothermal power plants. Water also plays an important role in fossil fuel production via injection into conventional oil wells to increase production, and its use in production of oil from unconventional oil resources such as oil shale and tar sands. In the future, if we move aggressively towards a hydrogen economy, large quantities of water will be required to provide the needed hydrogen via electrolysis.

While water and energy have, each in its own right, become well-established as top development priorities, this inter-relation between the two fields is very rarely mentioned. It is, therefore essential to realize the truth that the world energy system depends largely on finite fossil and nuclear energy sources, which require long and complex resource chains - from mining and extraction over transportation and processing to conversion in the power plant and disposal of waste. Along these chains water is the single most vital link reinforcing the fact that use of one resource is inextricably linked to use of the other. Any energy security measure, therefore, should necessarily consider water use and vice versa.

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