An Overview of the Water Management Cross-Cut Plan for Commercialization of America's Unconventional Fuels

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ABSTRACT

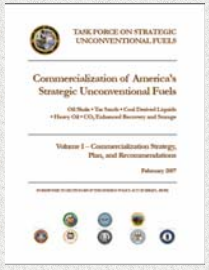
The increasing dependence of the United States on foreign energy resources, and the associated economic and security vulnerabilities, dictate that the nation must produce more petroleum at home. To facilitate development, the Congress in the Energy Policy Act of 2005, directed the Secretary of Energy to establish a Task Force to "...develop a program to coordinate and accelerate the commercial development of strategic unconventional fuels." The Task Force identified water resource stewardship as a key challenge for bringing unconventional fossil resources on-line to help secure the energy future for the United States. A Water Resources Cross-Cut Plan prepared for an Office of Petroleum Reserves Report seeks to assure adequate water supplies to support industry development, community needs, and future water demand, to protect surface and groundwater quality and to protect existing water rights. To harvest these new resources, industry must shift to new processes and to new locations, both of which affect the nature and magnitude of impacts to water resources. Within the U.S., shale-oil constitutes a substantial portion of this unconventional resource. However, development of these energy resources, which promises to increase the nation's energy security, could also impact water resources. If these impacts are not adequately understood and managed, commercial-scale development of the energy resources may be constrained. Careful and thoughtful management of water issues, which occurs in parallel with the scale-up of industry operations, will ensure protection and conservation of water and full development of unconventional energy resources.

The Water Resources Cross-Cut Plan evaluates potential practices that will help decision makers address: surface and groundwater quality, rights and flows; water disposal, recycling and treatment; climate induced variations in water supply and demand; process water handling and reuse, impacts to water from new infrastructure; energy generation; and long-term impacts after site abandonment. This paper describes the goals, objectives, strategies and proposed activities required to protect water resources while accelerating the commercial development of strategic unconventional fuels.

BACKGROUND

Congress through the Energy Policy Act of 2005 (EPACT) directed the Task Force on Strategic Unconventional Fuels (SUFs) to make recommendations and develop an integrated program to coordinate and accelerate the development of fuels from domestic unconventional fuels resources. The Task Force evaluated the global and domestic oil supply outlook, assessed domestic unconventional fuels resources that could augment supply, analyzed constraints to their development, and crafted an integrated commercialization strategy and program plan to expedite development of an unconventional fuels industry.

The Task Force found that America's increasing demand for oil imports in a world of more limited supply from increasingly unstable sources poses strategic risks that the nation can ill afford to ignore. These risks include the reliability of fuels to supply our economy, the availability of assured supplies to fuel our military, and the enormous costs of oil imports to consumers and the economy as a whole. The higher cost and volume of oil and refined product imports combine to exacerbate the nation's trade deficit and weaken the value of the dollar against other currencies. To address this situation, aggressive action must be taken by government and industry to abate growth in U.S. oil demand and to increase production of fuels from domestic sources.



The Task Force on Strategic Unconventional Fuels is an eleven member team, including the Secretaries of the Departments of Energy, Defense, and the Interior; Governors of the States of Colorado, Kentucky, Mississippi, Utah, and Wyoming; and representatives of localities in those states that would be impacted by the development of unconventional fuels. The Task Force has prepared an integrated strategy and program plan for Commercialization of America's Strategic Unconventional Fuels, as directed by Section 369(h)(5)(A) of the Energy Policy Act of 2005. The report reflects the consensus views of the Task Force members.

The Task Force Report finds that responsible development of America's oil shale, tar sands, heavy oil, coal, and CO_2 enhanced oil recovery could reduce the nation's dependence on imports and provide reliable and secure sources of strategically important liquid fuels. The Task Force evaluated both the extent and the potential contributions of each of these resources, individually and in aggregate, identified and addressed constraints to their development, and developed a detailed plan for an integrated program to promote and accelerate their commercial development. In developing its recommendation and plan, the Task Force has carefully considered and addressed the crosscutting issues, including environmental protection, water resources, socioeconomic impacts, markets, infrastructure, and carbon management, associated with concurrent development of these strategic unconventional fuels.

INTRODUCTION

Development of unconventional fuels will occur over a period of decades and the potential for impacts to water resources will also occur over this long schedule. Careful and thoughtful management of water issues, which occurs in a stepwise manner as industries scale up operations, will ensure protection and conservation of water. The Water Management Cross-cut Plan, if funded, will evaluate potential practices that will help decision makers address:

- **Surface water quality, rights and flows,**
- **Ground water quality, rights and flows,**
- **Water disposal, recycling and treatment,**
- **Variations in water demand versus seasonal and climatic variations in supply,**
- **Process water availability, handling and reuse,**
- **Water consumption, or other impacts to water, resulting from new infrastructure,**
- **Water used for energy generation and population growth, and**
- **Long-term impacts to water after site closure.**

The Water Management Cross-Cut Plan addresses five Strategic Unconventional Fuels (SUFs):

Shale Oil
Tar Sands
***Coal to Liquids* (CTL)**
Heavy Oil
CO_2 Enhanced Oil Recovery

Cross-Cutting Program Goal

The goal of the Water Management Cross-Cut Plan (Plan) is to help industry and local communities ensure that development of unconventional fuels does not adversely affect surface or ground water quality and supply or the water rights of local water users, local governments and the affected states.

OBJECTIVES AND STRATIGIES

A major thrust of the Plan will be the development of Regional Water Management Plans region that will include all relevant SUFs within that region. Best management practices on natural water systems will be identified and options identified for their adoption via voluntary and/or regulatory means. Current and proposed uses of water will be integrated into local/regional watershed databases and models to enable prediction of interactions of natural systems and expected water uses.

Development of resources will require a set of site-specific and resource-specific activities to ensure protection of water in the area influenced by the extraction and processing operations. It is anticipated that most site-specific details will necessarily be addressed by the resource developers. However, many water management activities must be addressed at the watershed and larger scales to expedite resource development, while protecting water resources and minimizing cost. Site- and resource-specific activities will be tailored to meet the unique characteristics of each site within the framework of the regional hydrogeologic and regulatory/legal settings of the affected states. Resource Development Plans will be designed to be as water self-sufficient as possible and to limit negative impacts on water resources regionally, especially in areas where water resources are over-allocated.

Objective 1 Manage water resources to satisfy water demand and quality requirements

Strategy 1.1 Understand water requirements of unconventional fuels resource development

The Plan will identify hydrologic, geologic, land use, water quality, resource characterization, and other data and reports relevant for the simultaneous planning and management of unconventional fuels development, and the protection and conservation of water resources. Knowledge gaps and needs for additional data will be identified and prioritized. These data will be used to characterize and rank water resource issues of concern by region and by resource type. To facilitate data analysis, communicate complex water use relationships and improve the quality of information used to make decisions, relational, geo-referenced databases will be developed for regions and SUF resources.

Communication to a wide array of stakeholders with varying backgrounds and interests is an important aspect of the strategy to understand impacts to water resources from SUF development. Computer models are well suited for integrating and simplifying complicated sets of water data. Computer models for groundwater and surface water quantity and quality will be implemented to assess spatial and temporal water supply distribution issues and serve as tools to maximize efficient utilization of water resources for multiple purposes. The models will help decision-makers identify obstacles to making more use of produced water for greater beneficial use.

Strategy 1.2 Employ conservation, recycling, and treatment processes and technologies to put water to greater beneficial use

Water is not generally destroyed in the extraction of unconventional hydrocarbon resources and, with careful management; utilized water can be made available for other uses. The Plan will strive to ensure that developments are "closed" hydraulic systems and only supplemented minimally by waters from outside the process. The Plan will identify and promote:

- Methods to maximize water re-use,
- Technologies to clean contaminated water and responsibly dispose of contaminants,
- Regulation changes to facilitate re-introduction of treated water to natural systems,
- Incentives to manage water rights negotiations,
- Enhanced use of lower quality water for industrial processes,
- Beneficial re-use of water for other purposes,
- Process changes to reduce evaporative losses to the atmosphere.
- Cross-industry cooperative use of water (*e.g.* reject water from one industry used in another).

Another major thrust of the Plan will be identification (and communication) of technologies needed to enhance resource development while simultaneously protecting and preserving water resources. The data management tools developed under this plan will be used to identify gaps in knowledge and identify water-related constraints to resources development. Uncertainties in water management will be estimated and methods identified to reduce decision sensitive uncertainty. Robust, high-confidence approaches to mitigate constraints and reduce costs will be identified, evaluated, and recommended.

The Plan will solicit input from industry, government agencies, and other stakeholders to identify RD&D needs to protect and preserve water. Some of these needs include, but are not limited to, 1) technologies to control contaminant leakage or leaching from the energy resource to surface or ground water during or after processing, 2) improved definition of the geochemistry of potential contaminants generated by unconventional fuel production, 3) changes in the permeability and porosity of the subsurface that may occur due to hydrocarbon extraction, and 4) the impacts to water quality and quantity. Water needs for associated infrastructure (e.g., communities and roads) will be incorporated into the analyses.

Objective.2. Protect rights of existing and prospective water users and meet all relevant laws and regulations

Strategy 2.1 Baseline and monitor water to ensure protection of quality and quantity.

State and federal agencies have collected important data on water resources for decades. The first step in this strategy is to gather this information and take advantage of existing monitoring programs that can be used to more efficiently manage water resources during development of unconventional fuels. A monitoring plan will be developed and implemented to fill data gaps and to meet regulatory needs, particularly at large scales and over long periods. This sort of monitoring might generally be considered outside the scope of resource developers. Short- and long-term monitoring strategies will be developed, modeled, tested, and evaluated to ensure that potential water impacts can be monitored. Existing instruments, sensors, and other systems to monitor water quality will be evaluated, additional needs identified and relevant research, development and demonstration needs will be recommended.

Strategy 2.2 Improve efficiency of regulatory process

Permitting and approval of many new resource development projects has become expensive and time consuming, adding years to when an industrial resource development can expect to receive a return on investment. Water quality and quantity are protected by a wide array of federal, state and local statues. Careful planning of the permitting process, including consolidated or parallel reviews by regulating agencies and other approaches may compress the schedule of the regulatory process while preserving the oversight needed to ensure protection of water resources. Federal and state controls and permitting of water resources will be evaluated and changes recommended to streamline the permitting process for new developments. This strategy will help reduce regulatory uncertainty and improve the efficiency of the permitting processes. Options will be identified to mitigate long-term liabilities due to unanticipated events and suggest incentives to minimize water losses and maximize water re-use.

Strategy 2.3 In collaboration with existing programs, enable public/private outreach for water related issues of concern

Several state and federal programs have viable programs specifically aimed at enhancing communication with all stakeholders in the development of unconventional fuels. These programs will benefit from the updated and state-of-the-art assessments and models of water-related impacts from unconventional fuels developed under this plan. An advantage of the cross-cut approach is that experiences gained in outreach and communication in one industry can be transferred to other SUF industries with minimal expense and effort. Output from ground water and surface water models developed under the plan can be used to communicate at the regional level an understanding of water impacts by individual developments. The Plan will enable integration of ongoing and proposed activities within industry, federal and state agencies and departments, R&D providers (universities, national labs, consultants, non-governmental organizations, etc.) and other stakeholders. In particular, it will interface with the Department of Energy's Energy-Water Nexus Program, the Department of Interior's Water for the 21st Century Program, the Bureau of Land Management's Environmental Impact Statement process, the U.S. Geological Survey's water monitoring and resource assessment programs, and other relevant activities specified in the Energy Policy Act of 2005.(primarily pertinent sections under Title III, Subtitle F, Sections 365 and 369, Subtitle G, Section 384, and Title IX, Subtitle G, Sections 977 and 979).

Objective 3. Ensure adequacy of water infrastructure

Strategy 3.1 Assess current and required infrastructure to support people, industry development and operations

An often overlooked consequence of new developments is the need for more water to support more people, build new roads, new houses, new schools and so forth. These impacts are generally more extreme in rural, arid western sites and less extreme in populated, moist eastern sites. Unconventional fuels development will increase water demand due to power generation and for potable water to support population growth. Increased water demand could strain existing supply, particularly in the west. Disposal of waste water may also present challenges. The Plan will consider issues of supply and demand, needs of other water users, water rights, infrastructure for water storage and delivery/reuse, preservation of water quality, impacts to replenishment due to roads and other community growth, and impacts of waste water disposal. These issues will vary in applicability and magnitude, depending on the resource, technologies applied, and region. Where unconventional fuel development overlaps with other resource development, water resource and quality issues could be more complex and may present opportunities to put water to greater beneficial use.

Power generation for both resource development and infrastructure requires significant quantities of water. In fact, 52 percent (USGS Circular 1268, September 29, 2006) of all surface water withdrawals in the U.S. are made for power generation purposes. As such, changes in power consumption and/or power generation may lead to greater efficiencies in water use for the development of unconventional fuels. For instance, new power generation technologies that use less water are available, but often with cost and efficiency penalties. Power conservation both in processes and infrastructure may also lead to reduced water use. The Plan will assess power requirements by region and resource and identify where improvements can be made to better manage water resources. Recommendations will be made for advancements in technology necessary to properly support the infrastructure power needs of a new unconventional fuels industry.

This strategy will integrate the results from Objectives 1 and 2 and project water need and its availability in the future for various planning scenarios. The results will be used to create an assessment of existing water infrastructure and to evaluate infrastructure needed to support resource developments.

Major Activities

The Plan will focus primarily on regional and national level activities to benefit a wide range of stakeholders, including but not limited to local communities and governments, Indian tribes, state and federal environmental agencies, state and federal land management agencies, energy producers and energy consumers.

1.1.1 Identify and rank water resources issues of concern by resource and by region

Collect and review hydrologic, geologic, land use, water quality, resource characterization, test results of water consumption by process, industry documents and other data and reports to create a summary by region and by resource for water issues of concerns. The data and information collected in this activity will be used to develop a comprehensive relational, geo-referenced database. The results of this activity will be summarized in a report that summarizes by region of the United States the general occurrence of water resources, the potential adverse impacts from resource development and the possibility for mitigating adverse impacts.

1.1.2 Predict potential impacts and provide recommendations to manage water resources

Computer models of groundwater and surface water will be developed to 1) assess spatial and temporal water supply and quality issues 2) maximize water resource utilization, 3) ensure water protection, and communicate water related issues to a wide range of audiences. Laboratory and field tests in conjunction with modeling efforts will identify and characterize potential contaminants and fluxes during and after hydrocarbon extraction operations.

1.2.1 Identify and recommend water conservation, recycling and treatment processes

Processes and technologies that conserve, recycle or treat water to prevent or mitigate unwanted impacts on water resources will be identified and assessed for potential application to unconventional fuels development. This activity will aid industry in implementing existing technologies and develop RD&D plans to identify, promote and expedite development of emerging technologies and promote new technology development.

2.1.1 Baseline and perform water quality and quantity monitoring

Collect water data at regional or other appropriate scales integrating with the activities of private entities or other stakeholders. Monitor surface and groundwater conditions in regional watersheds and hydrogeologic basins to provide input to predictive models and decision-making tools and to enable prompt pre-emptive corrective actions when necessary.

2.2.1 Evaluate regulatory processes and find areas to make more efficient.

Solicit input from industry partners and non-governmental organizations to obtain an inventory of all currently required permitting procedures and other legal processes. Provide an opportunity for these and other stakeholders to identify not only duplicative processes, but also those processes most critical in protecting the environment and serving local needs. Determine the legislative and regulatory foundation for each procedure. Identify technical solutions that are precluded by current regulations or practices.

2.3.1 Implement public/private outreach programs and initiate collaboration with existing programs.

Collaborate with local, state and federal agencies as they engage stakeholders to define water issues, regulations, jurisdiction, and policies. Use stakeholder input to produce a framework for developing appropriate water-management processes, data gathering activities, decision tools and water quality protection technology. Integrate and establish consistency with private and other stakeholder efforts.

3.1.1 Assess current and required infrastructure to support industry development and operations.

Perform an infrastructure analysis to determine opportunities to optimize water and power inputs to the resource development process, as well as minimize impacts to water and wetland resources resulting from societal and industrial changes triggered by the fuels resource development.

Water Resources for Oil Shale

A large Oil shale industry will result in significant new demands on freshwater resources in the Green River Basin. Regional stakeholders want to know the answers to the key questions: "How much water will an oil shale industry use?" "Is there enough water in the Colorado River Basin to support new demands?" "Can we manage our freshwater resources to meet multiple goals, such as protecting endangered species, recreation, ranching/farming while meeting the needs of a new industry?" To fully answer these questions will require a basin-wide water resource analysis, similar to the one developed in the 1980 OTA report[1], but with updated information on water use, river flows, projected population growth and revised stakeholder goals. However, we can start to explore the answers to these questions using current water resource data and updated projections of water use for emerging retorting methods. Here we consider an example of an oil shale industry producing 2.5 million barrels/day (MMbd) in the Green River Formation in the Upper Colorado River Basin.

"How much water will the oil shale industry need?"

An oil-shale industry will need water for mining and handling, refining, retorting, cooling, dust control and reclamation. Water requirements for such activities vary widely according to the resource location and the technology utilized. Past estimates for these resource requirements range from 2.1 to 5 barrels of water per barrel of oil[2,3,4]. Current estimates based on updated oil shale industry water budgets suggest that water requirements for new retorting methods will be between 1 and 3 barrels of water per barrel of oil[4,7,8]. For an oil shale industry producing 2.5 MMbd, this equates to between 105 and 315 million gallons of water per day (MGD). These numbers include water requirements associated with power generation for in-situ heating processes, retorting, refining, reclamation, dust control and on-site worker demands. It does not include municipal and other water requirements related to population growth associated with industry development. The Office of Petroleum Reserve's National Unconventional Resources Model (NSURM) predicts that a new oil shale industry will create 21,000, 60,000 and 100,000 direct and indirect jobs for 0.5, 1.5 and 2.5 Mbbl/d industry, respectively. New residents to the area can be estimated using the 2006 national average household size of 2.57[1]. An additional local freshwater demand of about 135* gallons per person per day (gpd) will be associated with these new residents. This value includes water for households, new commercial development and additional power generation. New water demand for both the oil shale industry and the new residents and commerce associated with the industry is likely to be between 82 and 208 MGD or 92,000 to 233,000 acre-ft/yr.

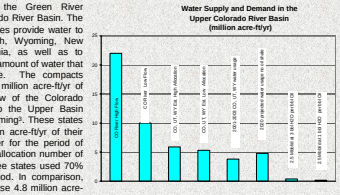
Table 1. Water demand for oil shale production and new residents.

Water requirements bbl of water per bbl of oil	Production rate (Bbl/d)	Water demand for oil shale industry (MGD)	New direct and indirect jobs	Projected population growth (people)	Additional water to support population growth (MGD)	Total new water demand (withdrawals) (MGD)	Total new water demand (million acre-ft/yr)
1	500,000	21	21,000	53,970	7	28	0.031
3	500,000	63	21,000	53,970	7	70	0.078
1	1,500,000	63	60,000	154,200	19	82	0.092
3	1,500,000	189	60,000	154,200	19	208	0.233
1	2,500,000	105	100,000	257,000	32	137	0.154
3	2,500,000	315	100,000	257,000	32	347	0.389

* Per capita freshwater withdrawals are about 1350 gpd[5], as calculated by dividing total water withdrawals by the US population. This includes water for food, industry, commercial uses, thermoelectric power generation, etc. Only about 10% of these withdrawals, or 135 gpd per person are likely to those with new residents into the region. This includes new commercial, municipal and power demands associated with the new residents. Of the 135 gpd, only about 44 gpd are consumed.

"Is there enough water in the Colorado River Basin to support new demands?"

The oil shale deposits of the Green River Formation lie within the Colorado River Basin. The Colorado River and its tributaries provide water to the states of Colorado, Utah, Wyoming, New Mexico, Arizona and California, as well as to Mexico. Compacts control the amount of water that each state is entitled to use. The compacts allocate between 5.3 and 5.9 million acre-ft/yr of the average annual virgin flow of the Colorado River (15 million acre-ft/yr) to the Upper Basin States of Colorado, Utah, Wyoming[3]. These states used an average of 3.8 million acre-ft/yr of their allocated Colorado River water for the period of 2001-2003[3]. Using the lower allocation number of 5.3 million acre-ft/yr, these three states used 70% of their allocation for this period. In comparison, these states are projected to use 4.8 million acre-ft/yr or up to 90% of their allocated flow in the year 2020[2]. A 2.5 Mbbl/d oil shale industry will increase these projections by between 0.183 to 0.418 million acre-ft/yr (from Table 1).



"Can we manage our freshwater resources to meet multiple goals, such as protecting endangered species, recreation, ranching/farming while meeting the needs of a new industry?"

These estimates clearly demonstrate that water use by the unconventional fuels industry could be significant relative to available resources in the Upper Colorado River Basin in the future. Although projected water use falls within the average annual allocation for the Colorado, Utah and Wyoming, it is important to note that flows in the Colorado River have high variability and conflict between water users may arise in drought years. Careful planning will be required to ensure that the new oil shale industry operates within the existing limitations on water supply and in accordance with laws protecting all water users. An oil shale water management plan with an aggressive timetable will be needed to meet oil shale production goals without adverse environmental and social consequences. The plan should include identification of stakeholder goals for the Colorado River and region, as well as processes, projects and technology that are needed to meet those goals. These may include incentives to minimize water consumption and maximize reuse across all water use sectors, development of additional reservoir storage, climate variability/change assessments for water resource projections, and changes to water law and regulations. A supporting research, development, and demonstration program could be undertaken to help bring to practical application more efficient technologies and strategies to conserve, recycle and manage water associated with energy resource development.

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