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ISSUEBRIEF

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ENERGY AND ENVIRONMENT PROGRAM

Primary Energy and Transportation Fuels and the Energy and Water Nexus: Ten Challenges

Introduction

A substantive dialogue has emerged in the United States under the rubric of "the energy and water nexus," representing the deepening understanding of the circular relationship between water and energy. Both are essential building blocks of US economic and physical security, and interface with efforts to improve health and prosperity. On a national level, the criticality of this relationship to economic and public prosperity is often ignored, as energy and water impacts are largely specific to a watershed or a local surface water source. The United States today needs new policies and significant infrastructure investment in order to meet the increasing demand for water and energy, while dealing with the constraints of growing water scarcity and potential threats to water quality.

To address these growing national concerns, the Atlantic Council initiated a series of workshops centered on the various facets of the energy and water nexus and what solutions are at hand. In May 2011, the Council's workshop focused on the nexus from the perspective of thermoelectric power production. A second workshop was convened in November 2011 to discuss the nexus from the vantage point of the extraction and processing of primary energy and transportation fuels. Plans are underway to hold a third workshop that will focus on how water and energy are consumed in municipal, commercial and industrial water treatment and delivery systems.

This issue brief highlights ten challenges that were brought to light in the November 2011 workshop. Next, the Council will prepare a comprehensive report on the complex interdependent relationships between water and energy, concentrating on primary and transportation fuel production.

The Energy and Environment Program at the Atlantic Council explores the economic and political aspects of energy security and supply, as well as international environmental issues. Major shifts in policies, behavior, and expectations are increasingly required throughout the world to meet the challenges of maintaining secure and sustainable energy supplies and protecting the environment while maintaining economic competitiveness. The Energy and Environment Program facilitates international cooperation on developing strategies, policies, and regulations to address the energy security, environmental and economic challenges posed by increasing energy demands and climate change.

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The Energy and Water Nexus Issue

It is often noted that energy-related water consumption is relatively small on a national level. The Council's report, **Energy for Water and Water for Energy**,[1] showed that of the 100 billion gallons of water the US population consumes per day, only a small fraction—less than 5 percent—is consumed in the production of electricity and primary fuels. However, this report also showed that the 41 percent of water withdrawal for thermoelectric power production tops

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all other withdrawal categories, and can lead to competition for water availability, as well as have an impact on water quality, mainly by changing water temperatures.

In the overall national water picture, over 80 percent of the water consumed is for irrigation purposes; 4 percent is consumed for thermoelectric power production; and only 1 percent is used for fuel production/mining. Water consumed for thermoelectric power production and primary fuel production is forecast to grow from 4.6 billion gallons per day (BGD) in 1995 to over 6.5 BGD by 2035.[2] This low level of consumption seems minor at first glance; however, it is a significant issue, even though largely unnoticed by the US population, because both water resources and demands are not evenly distributed, and demand and availability are not well correlated. Although water may be abundant in some areas, it is still expensive to transport to areas where it is needed, and it is problematic to store due to evaporation and environmental issues with dams. Added to this fundamental mismatch is the concern that even in areas where scarcity is not the overriding issue, there may still be negative impacts on the water quality. Locally, fuel extraction and processing can have a significant impact on water resources.

The environmental and availability impacts associated with the extraction of energy fuels are becoming increasingly important as the competition for water between traditional users and the energy industry intensifies. In just one scenario, likely to be replayed in many other regions of the country, the severe drought in Texas is exacerbating tensions as oil and gas drilling companies are outbidding farmers and cities in the ongoing rush to purchase water rights. In select areas, oil- and gas-drilling water needs are concentrated and have a magnified local impact on already-stressed water supplies. Hurting for jobs, communities may trade off the loss of river and aquifer water supplies for the employment and income gains to be had in drilling for unconventional oil and gas. This could potentially lead to a negative impact on the US food supply if cattle farmers decide that the returns on oil and gas production far outstrip the profits to be earned from raising cattle.

Layered on top of these realities is the growing chorus of public concern about water quality issues. Even in areas of the country not suffering from drought conditions, some stakeholders argue that the economic and energy security benefits of increasing primary energy fuels or growing non-greenhouse-gas-producing biofuels are not worth the perceived environmental costs. In short, different stakeholders' philosophies are at odds, and US prosperity could suffer if the competing interests are not balanced.

The confluence of political, economic, technical, and resource constraints in the United States has reached an inflection point. The public's attention has been galvanized by a range of policies and events, including biofuels mandates for gasoline; the potential emergence of wide-scale hydraulic fracking for unconventional gas and oil; severe droughts in fossil fuel–rich areas; arctic ice disappearance; the potential impacts of climate change; and the push for renewables, some of which are water-intensive.

The Ten Challenges for Primary and Transportation Fuels

This issue brief outlines the ten major challenges and the key data brought out at the November 2011 meeting[3]:

- Congressional action is unlikely in the near term;
- A complex federal bureaucracy hinders progress;
- Adequate data is lacking;
- Fuel-related water consumption is increasing in water-constrained areas;
- Hydro, geothermal, and biopower renewable fuels face water issues;
- The shale gas revolution presents an intertwined array of environmental, regulatory, and water policy issues;
- Coal mining requires continued efforts to protect local water quality;
- Shale oil production presents similar issues to shale gas production;
- There is an uncertain regulatory outlook for unconventional oil and natural gas; and
- It is important to explore how new technologies and innovation may resolve energy and water issues.

The Council recommends that these challenges be addressed so that the United States may come to terms with the water issues related to providing primary energy and transportation fuels.

One: Congressional Action is Needed More than Ever, but is Unlikely in the Current Climate

Just when national leadership is most needed, the 112th Congress faces seemingly intractable roadblocks. Even without the political obstacles posed by the upcoming 2012 presidential election, congressional action is hampered by fractured committee jurisdiction over the myriad federal agencies that both write the rules and control sizable tracts of land that contain primary energy and transportation fuel production areas. Committees are scaling back funding in an effort to reduce the federal deficit, even though there is a significant need to fund public water infrastructure improvements and to collect comprehensive data to support a reassessment of policies and regulations. There is a lack of political will to pass comprehensive energy and water legislation, partly because stakeholder/public interest is not being adequately expressed to representatives and senators, and also because little pressure is being exerted on them to make a change.

Fortunately, the energy and water nexus issues remain on several committees' agendas as they are holding hearings and writing legislation. Bipartisan bills on hydropower, nuclear energy, and oil and gas reserve inventories have cleared a key Senate committee. However, no comprehensive energy and water legislation is expected to pass by the end of the 112th Congress.

Two: Federal Bureaucracy Hinders Progress

There are over twenty federal government agencies that have jurisdiction over the extraction and production of primary energy and transportation fuels. Although agencies are cognizant of the problem and are making improvements in coordinating programs, federal government interagency coordination is still inadequate when it comes to actually addressing system complexities.[4]

While some argue that the federal government has not set a national energy and water policy, it has woven a set of laws and supporting regulations that de facto serve as US national policy. The two major pieces of legislation that underpin US policy are the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA). Government agency priorities are not always consistent and complementary, however. As seen in the following case, the federal government's commitment, initially made in the 1960s, is bumping up against greenhouse gas policy priorities of the twenty-first century.

In the 1960s, the US government made commitments to provide power from the Navajo coal plant in Arizona to transport water supplies from the Colorado River to urban areas such as Phoenix. Population increases now require additional water supplies and more power for their transport. The Colorado River water is oversubscribed, and the problem is exacerbated by the current severe drought in the West. To live up to its commitments, the Department of the Interior (DOI), the majority owner of the Navajo plant, must increase the coal plant's capacity, but Environmental Protection Agency (EPA) regulations discourage coal-fired plant expansion. This is a classic energy and water nexus conundrum that is difficult to resolve due to multiple agency jurisdictions, priorities, and regulations.

The federal government is taking steps to increase water supplies by reducing the amount of power needed to transport water, and by substituting renewable technologies for retiring coal-powered plants at federally owned hydropower production facilities.[5] The Department of Interior controls the Bureau of Reclamation (BR), which is the country's second-largest hydropower producer after the Corps of Engineers. The BR is increasing efficiency and capacity at existing hydropower facilities. It is also providing grants to state agencies for innovative hydropower technologies that save energy and reduce greenhouse gas emissions. Its Title XVI Water Reuse Program encourages saving water through more energy-efficient power and an increased use of recycled water. The United States Geological Survey (USGS) is integrating water and energy policies through better collection of baseline data on the water needs of oil and gas operations and hydroelectric facilities. Together with the Bureau of Land Management (BLM), the USGS is evaluating criteria for siting solar facilities on federal lands in order to bring more renewable power options to produce and transport water supplies.

Three: Comprehensive, Reliable Energy and Water Nexus Data is Lacking

Today, there is no nationwide data collection by an appropriate government authority. The SECURE Water Act in 2009 called for a systematic groundwater-monitoring program and a water-use and -availability assessment program. While the BR issued an assessment of the problems faced by the Colorado River Basin, neither the BR nor any other agency is currently working on a complete national assessment of the country's water uses, needs, and constraints. With the proper funding, the USGS water census program could provide a vehicle for obtaining the needed comprehensive withdrawal and consumption data. Without sufficient information, Congress may not be in a position to develop appropriate policies.

Specifically with regard to the data on water intensity of energy extraction, much of the reported data is five decades out of date and is conveyed with errors of up to four orders of magnitude. Correct data must be reported based on local conditions, taking into account evaporation rates. Reported average water intensities are inaccurate and should not be extrapolated into the future under the assumption that they will remain constant. The good news is that there is probably sufficient data available now to make reasonable models for a variety of scenarios to estimate the future water demands for energy extraction. However, this will require adequate funding for gathering and publishing the data.

Four: Increasing Demand for Energy = Increasing Extraction and Processing of Primary and Transportation Fuels = Increasing Water Consumption in Increasingly Water-constrained Areas

Even with a modest forecast of 2.7 percent GDP annual growth through 2035, primary energy consumption is forecast to increase by 20 percent.[6] The United States is expected to add a net 223 gigawatts (GW) of new power capacity from 2009 to 2035 in order to meet increasing demand.[7] The primary driver behind this expansion is an expected population increase of 70 million people from the early 2000s to 2030.[8] Under a current policy scenario (often referred to as "business as usual"), the growth in electricity-generation capacity correlates to a 36 percent increase in water consumption by 2035.[9]

The vast majority of the increased power capacity will come from natural gas, wind, and other renewables. The extraction/processing of gas, hydro, and bio fuels all lead to greater water consumption. The reality is that even with the rapid growth in renewable power production, under current US policies, fossil fuels will still provide 78 percent of US energy use. In 2035, the Energy Information Administration (EIA) estimates that total US energy use will be provided as follows: 10 percent by (non-liquid biofuel) renewables, 21 percent by coal, 24 percent by natural gas, 3 percent by liquid biofuels, 33 percent by oil and other liquid fuels, and 8 percent by nuclear power.[10]

Layered on top of increased water consumption for power production is a further increase in water consumption and withdrawal for the extraction and processing of primary and transportation fuels. Nationwide, water withdrawals in 2005, and consumption in 1995, were 2.3 billion gallons per day (BGD) and 1.2 BGD, respectively. For 2035, it is forecast that water withdrawals and consumption will both increase slightly, to 2.6 BGD and 1.3 BGD, respectively.[11] These forecasts could change based on different fuel mix, renewable portfolio standards and carbon capture and storage policies to name just a few.

At the November 2011 workshop, up-to-date US data was presented for freshwater consumption for: oil recovery; oil exploration, production, and transportation; oil refining; natural gas; and coal mining. The new data takes into account the crucial regional differences in water intensities.

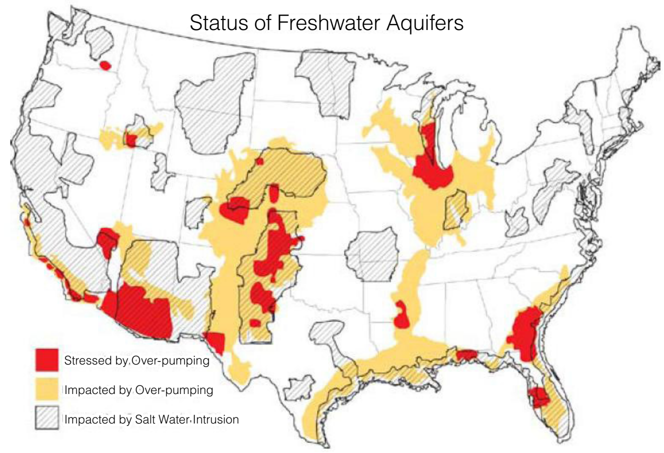
Figure 1: Freshwater Consumption for Primary Energy and Transportation Fuel Extraction[12]

Extraction Process	Freshwater Consumption m3/TJ (cubic meters per terajoule)
Oil exploration, production and transportation	
Drilling mud	0.9 to 1.3
Hydrostatic pipeline testing	less than 0.001
Other plan operations	0
Conventional natural gas exploration, production, and transportation	
Drilling mud	0.9 to 1.3
Hydrostatic testing	less than 0.001
Gas processing	0.05
Other plant operations	0
Coal production and transportation	
Coal mining	0 to 40
Coal washing	0 to 32
Other plant operations	0
Slurry transport	0

This newly published information is shown in figure 1. While data for oil refinery withdrawals, consumption, and discharge are not given in the figure, the workshop learned that over the past sixty years, the trends in petroleum refining show dramatic reductions in all three areas due to more-effective recycling, dry-cooling, and desalination of the wastewater. For North America, the trend is expected to continue, with the refinery water intensity in 2010 of 1.0 cubic meters (m3) per tonne, dropping to 0.2 m3/tonne by 2035. (Estimates for shale gas and oil production were not made available at this workshop.)

Workshop presentations showed a variety of maps indicating potential water-crisis areas and stressed aquifers in the United States. The water stresses to date are due mainly to population increases and severe drought, not mining or electricity production. Areas in the United States that are witnessing an explosion of irrigated biofuels and potential oil- and gas-producing activities are clearly found in water-stressed environments. Map 1 shows that the stressed aquifers are located near the major corn-based ethanol-producing states of Nebraska, Minnesota, Iowa, and Illinois. Some of the major North American shale plays that might be developed—such as Eagle Ford, Fayetteville, Haynesville, and Barnett—are also located in water-stressed areas.

Map 1: Stressed US Aquifers[13]



Five: Water Quality and Quantity Issues are Related to Renewable Hydro, Geothermal, and Biofuel Production

Only wind and solar technologies do not require water for their fuel production. For hydropower, geothermal, and biopower facilities, water is either the fuel or an integral part of the fuel-production process. There can be significant impacts on local water resources from these renewable technologies' fuels.

For geothermal electricity production, geothermal fluids are the primary fuel. For all types of production (dry steam, hydrothermal flash, hydrothermal binary, and enhanced geothermal systems), water is used in well-drilling operations to obtain geothermal resources. Water usage depends on the quality of the geothermal resource, which is defined by its temperature, depth, and how many wells are needed. Usage is location-specific. For enhanced geothermal systems, water is used for "well stimulation." In these wells, hydraulic-stimulation water use per well can be greater than in unconventional gas well fracking. As with all fossil fuel extraction, the quality of local water supplies may be impacted due to well-drilling and well-stimulation accidents. As the temperature of the geothermal fluids rises, the increased presence of contaminants and other solids may pose issues for local water resources.

For both reservoir-based and run-of-the-river hydropower facilities, water is the primary fuel, and is "consumed" through evaporation. Hydropower reservoir evaporation rates are highly variable and site-specific, depending on reservoir depth, temperature, shape, surface area, size of the river, and local climate conditions. Consumption can exceed 50,000 gallons per megawatt hour (MWh).[14] Overall, the temperature and sediment levels, along with the aquatic habitat of local water resources, can be impacted as the water travels to or is stored for the hydropower facility.

For biopower technologies, water is consumed through evapotranspiration during crop production and in the production of the biogas itself. Actual water usage for biofuel crop production is highly variable, and is based on the crop chosen and the local climate conditions. For example, among biofuel crops, sugar beets require 50 cubic meters of water per gigajoule (GJ) of electricity produced, whereas common rapeseed and jatropha biocrops require almost 400 cubic meters of water. When comparing the consumption of water to produce corn-grain based ethanol to petroleum based fuels, expressed as gallons of water per gallon of gasoline equivalent, the former requires in the range of 62-2400, and the latter requires only 1.4-2.9.[15]

There are water-wise biofuel practices that can reduce but not totally resolve water-consumption issues. No matter how or where it is done, there will be a significant water penalty for biofuels as compared to petroleum-based fuels. The major water quality impact is due to agricultural runoff. For example, 52 percent of the nitrogen pollution and 25 percent of the phosphorous pollution entering the Gulf of Mexico comes from the fertilization of corn and soybean crops in the Upper Mississippi River Basin.[16] This has led to a significant dead zone in the Gulf. It is possible that genetically modified crops may reduce water and fertilizer needs, but it is unclear as to whether the US public will accept such crops. There is also an unresolved issue as to whether climate-change temperature increases will decrease productivity. In any case, production of corn ethanol does pose a threat to US freshwater supplies.

There will be many challenges to sustainably scale up biofuels production and reduce its water footprint. Efforts to move to advanced biofuels are behind schedule. The outlook for water needs for emerging cellulosic conversion technologies and other advanced algae biofuels is uncertain, and depends on many variables, such as production location, whether the bioenergy feedstock is irrigated, and where—and whether—biochemical or thermochemical conversion is used to produce the biofuel. Electrification of the transportation sector may not eliminate the need for biofuels because most heavy-duty vehicles are still expected to require diesel fuel, the aviation sector will require liquid transportation fuels, and the cost-effectiveness of vehicle battery storage is uncertain at this point.

Six: The Shale Gas Revolution Presents an Intertwined Array of Environmental, Regulatory, and Water Policy Issues

The EIA estimates that the US natural gas resource base has risen 55 percent since 2008 because drilling techniques are now able to unleash vast quantities of unconventional gas supplies.[17] At this resource level, the United States may have over a hundred years of natural gas supply at current consumption levels. These new supplies will significantly increase the security of the US domestic supply, as well as reduce the carbon footprint of the domestic electricity supply, since natural gas will partially replace the burning of coal for electricity.[18]

As opposed to conventional natural gas—for which relatively little water is used for production (mainly for drilling fluid)—water issues are center stage in the production of unconventional gas. The question is, what will the impact be on the quantity and quality of local water supplies as the United States takes advantage of this exploding domestic energy supply?

Water is used in hydraulic fracking operations for drilling mud, fracturing the shale with proppants, pipeline testing, and gas processing. While the fluid that is injected into the hydraulically fractured well is mostly composed of water, chemical additives have given rise to some concerns related to the disposal of recycled and non-recycled well water.

There are significant variations in the amount of water used for both drilling and hydraulic fracking, depending on the location of the shale play. In general, however, the absolute consumption of water is relatively low. In Barnett Shale wells, the average freshwater volume for drilling and for fracturing is 250,000 and 4,600,000 gallons per well, respectively. In Marcellus Shale plays, the average freshwater volume for drilling and fracturing are 85,000 and 5,600,000 gallons per well, respectively.[19] Again, depending on the location of the shale play, water availability to initiate and keep fracking operations going may or may not be a significant issue; it depends on the availability of the local water resource. In the four major US shale gas plays—Barnett, Fayetteville, Haynesville, and Marcellus—shale gas represents 0.40 percent, 0.10 percent, 0.80 percent, and 0.06 percent of each region's total water use.[20] Industry has taken steps to reduce its consumption through recycling, reuse, and other methods.

Protection of local water quality is a key issue with regard to unconventional gas production. Proper well design and monitoring is critical in protecting groundwater supplies. There are public and regulatory agency concerns about the environmental impacts of fracking on local drinking-water supplies. While the public has been most concerned over the possible migration of methane into local well waters, the real problems are mostly associated with the handling of water and chemicals on the surface. The water that flows back from the fracking operations is not permitted to be disposed of in surface waters without significant treatment. In some areas, discharged waters are injected into underground saline aquifers, or in Class II underground injection control wells (governed under provision of the SDWA). For shale plays in areas like the Pennsylvania Marcellus Shale area, where there are relatively few Class II wells that can accept discharged waters, the public has expressed concern over the treatment of waters that have been transported to industrial or municipal sewage treatment facilities.

While best management practices can lead to relatively small withdrawal rates from local watersheds, disposal of the discharged waters must be safely managed in order to protect the public water supply. Mitigation efforts must be locally designed and implemented, and on-site treatment and reuse of flow-back and treated water is essential to ensure sound practices, both ecologically and economically. Recycling water practices will benefit from new technology and innovation. While some stakeholder complaints may be unfounded, scrutiny of industry practices is justifiable. Industry must seize the moment to demonstrate to the public's satisfaction that, as it claims, hydraulic fracking is safe and time-tested, and that it is working in an environmentally acceptable manner.

Seven: Coal Mining Requires Continued Efforts to Protect Local Water Quality

For coal-to-liquids transportation fuels, all technologies consume water for process water, boiler-feed water, and for cooling water (which is the largest water consumer). For coal mined for electricity production, water use varies by region but is mainly used for coal cutting and washing. On average, between 50 to 59 gallons of water are used per ton of coal. Water use can range between a low of 10 to a high of 150 gallons per ton of coal—again, depending on the production region.[21] In the Central Appalachian and eastern coal fields, where coal comes primarily from underground mines, washing is required, and so water use is high. In the Powder River and other western regions, water use is comparatively much lower. In the United States, water usage for slurry pipeline transportation is very limited.

While overall there is little water consumed in coal mining operations, water issues can be significant from an environmental point of view in certain localities. In the Central Appalachian mining areas, many of the concerns relate to mountaintop coal removal and the impacts on headwater streams, loss of streams, stream-direction changes, and the negative impacts on the ecological and biological character of local streams. Treatment of legacy acid mine drainage remains a problem, and there are concerns related to selenium and water temperatures as well. While it appears that the regulatory agencies and the industry have made progress in managing issues such as those related to selenium,[22] there are questions as to whether the mine operators in the Central Appalachian region can achieve the allowable "total dissolved solids" (TDS) levels set forth by the EPA. Industry has identified mining practices that can decrease the TDS with innovative over-burden material mining methods. The DOI's Office of Surface Mining is preparing a proposed rule on the placement of mining waste near streams that is expected to affect both surface and underground coal mining operations throughout the United States.

Eight: Water Issues are Not Seen as Critical in Conventional Oil Production, but Water for Unconventional Oil has Surfaced as an Issue

The water used for oil production depends upon the type of production. It is primarily employed for drilling fluids, with very little used for producing conventional reserves. For enhanced oil recovery (EOR) operations, water is pumped into an oil well in liquid or steam form to release additional production. This process can be very water-intensive, but high-quality surface waters are rarely used. Increasingly, CO_2 is being utilized for tertiary production (Carbon Capture, Use and Storage—CCUS), and is becoming important in complementing CO_2 capture and storage (Carbon Capture and Storage—CCS).

Producing oil from shale involves identical issues to those raised by shale gas production, discussed above. The production of oil from the mining or in situ recovery of oil from shale remains under study. The majority of the water used in this process is for the production of electricity, and therefore depends on the type of electricity used at the site. To produce oil from oil sands, as in Canada, the oil (bitumen) is extracted by mining or in situ steam injection. Both processes require extra energy and water inputs as compared to conventional oil production.

In areas of Texas, increased oil production from hydraulic fracturing of shale wells is stressing already-drought-stricken aquifers. Many more water wells are expected to be drilled to support unconventional shale oil, and the amount of water per oil well is climbing as well. A number of companies are continually improving processes to recycle and treat flow-back water. Other companies are following the American Petroleum Institute's best practices advice to use nonpotable water for fracking wells to the greatest extent possible. The tension between agriculture, cities, and the oil and natural gas industry over aquifers and access to surface waters (rivers) will only continue to grow in the years to come.

Nine: There is an Uncertain Regulatory Outlook for Unconventional Oil and Natural Gas

The November 2011 workshop addressed the evolving federal regulatory approach to the practice of hydraulic fracturing of shale plays.[23] The CWA gives the EPA the authority to establish water-quality standards and criteria, effluent limitation guidelines, and other discharge permits. The SDWA gives the EPA direct authority to establish the rules for underground injection sites for discharges from produced waters/flow-back waters, enhanced oil recovery operations, natural gas storage, hydraulic fracturing using diesel fuels, mine backfill injection wells, and uranium-related injection wells. Often the state and local agencies implement and enforce federal laws as well as their own requirements. In some instances, the EPA is designated as the state implementing authority for SDWA-related regulations, as in the case of Pennsylvania and New York. There is a complex web of federal, state, and local laws, regulations, and practices.

In March 2010, the EPA announced its intention to conduct a study at the request of the US Congress of the water-cycle profile of hydraulic fracturing operations, from the origin of the water to its disposal. A draft findings report is expected in 2012, with a final report to Congress in 2014. In addition, on October 20, 2011, the EPA announced that the agency would propose national standards for discharge wastewater associated with natural gas production from underground coal bed and shale formations prior to its transportation to a treatment facility. Referred to as "effluent guidelines," they are expected to be proposed by 2014. The BLM is also developing disclosure regulations for fracking fluids and methane leakage from well casings, although to date, relatively minor volumes of unconventional oil and gas are being produced on federal lands.

Successful regulatory actions regarding unconventional gas frackig will depend on the extent to which the federal regulatory agencies are able to balance competing interests. The American public wants protections to human health using the best available technologies that are economically achievable, while allowing for the continued development of shale gas resources. New regulations can be expected that will reduce the risk of contaminating water resources and capture fugitive emissions on natural gas. However, it is not likely that production will be halted. Rather, it is expected that the industry will have to implement new procedures and invest in prevention and treatment assets that will raise the cost of production somewhat.

Ten: To What Extent Will Innovation and New Technologies Address Energy and Water Nexus Issues?

All industry sectors—especially those involved in energy—are evaluating their "water risks," and realize that financial gains are possible by saving both water and energy in their operations. Companies such as Areva, with significant uranium mining operations, are setting internal policies with specific water-conservation targets, and are incentivizing employees to generate innovative energy- and water-saving concepts.

Changes in the energy industry's water- and energy-related goals are in turn driving service companies and industry equipment suppliers to develop innovative technologies and practices. General Electric alone is investing $10 billion over the next five years into new technologies that will reduce the impacts of primary energy and transportation fuels extraction and production on water supplies and quality, based on its expectation that US shale gas and oil production has the potential to "change the global order." In fact, the industry is moving swiftly, often faster than regulators, developing technology to improve well integrity; designing mobile filtration units to clean water on-site; developing next-generation gas-fired and electric generators to replace diesel units; and designing tracking and planning systems to move trucks around more intelligently. For example, to improve oil-recovery capabilities, next-generation pumps are being designed that can lift oil from 13,000 or more feet.

National labs are also proposing innovative wastewater treatment options. For example, improvements are coming that will involve advanced membrane technology. In the workshop it was proposed that discharged water from fracking operations could be moved to nearby coal-fired plants for treatment. Coal plant waste heat could be used to treat the brackish water (by powering membrane distillation operations that only need a 20 degree centigrade differential), which could then be recycled as makeup water in fracking wells, further reducing water consumption and withdrawal. Increasingly, solutions to decreasing the consumption of both water and energy will be found by integrating processes across industries.

Concluding Observations

The complex interrelationship between energy and water is leading to a growing dialogue among US government, industry, and nongovernmental organization leaders. However, much greater public and governmental focus on addressing the energy and water nexus is needed if major crises are to be avoided, or at least diminished. The United States is fortunate in that the potential for crises tend to be regional rather than national. But this is also a curse, as it diminishes the national political will to address topics that can undermine national prosperity. The challenge is to channel the public's demand for clean, sustainable, and affordable energy and water supplies into appropriate government policy and regulatory action that will drive industry innovation.

National requirements for energy are anticipated to increase even with major improvements in energy efficiencies. Renewable energy usage will grow, but the need for base-load power and fossil transportation fuels will remain for many decades. Ensuring that a sustainable supply of usable water meets the growing needs for energy and agriculture will become increasingly difficult due to greater water stress and changing environmental regulations.

US energy security has significantly improved due to dramatic increases in domestic production of oil, gas, wind, and solar. The energy industry has been growing, adding jobs and wealth in the traditional and renewable fuel sectors while also reducing energy imports. Net US crude oil imports reached their peak, at over 60 percent of domestic petroleum consumption in 2005. Today, because of increased domestic production, decreased consumption from stricter fuel economy standards, and substitution with alternative fuels (such as ethanol), oil imports have dropped to less than half of our consumption.[24] At the same time, refinery capacity is expanding for the first time in decades, and the United States is poised to become a net exporter of refined fuels. While the United States is importing a greater percentage of its oil today than in 1973—when the country first began to talk seriously about energy independence—a significant proportion of our imports now come from friendly neighbors, with Canada and Mexico providing 25 percent and 11 percent, respectively.

The United States is at a crossroad. Can the favorable trends toward increasing domestic production of energy and transportation fuels be accomplished while still maintaining sustainable water supplies?

Efforts to deal with the energy and water nexus must be ever mindful of the context in which solutions may be found, and the impacts they may have on these other equally important challenges. There is a danger that in the desire to solve one set of environmental problems, actions may be taken to diminish the country's responsible utilization of its existing substantial resources of conventional fuels that will continue to be required for many decades.

Outside the United States, the energy and water nexus is, or will be, exponentially more difficult to deal with for many countries. The United States has the opportunity to provide leadership on solving this issue, developing integrated solutions and designing new technologies to reduce the consumption of water for energy production and to use less energy to provide clean water. The Council's continuing dialogues are intended to tackle this complex subject, and to bring forth information and policy recommendations on how the United States can develop solutions to reduce the growing tension between energy and water usage. The Council will subsequently take the insights gained from this discussion of domestic issues to engage in international dialogues with countries facing even more difficult challenges than are arising in the United States.

JANUARY 2012

Endnotes

1. Energy for Water and Water for Energy, Atlantic Council, October 2011, www.acus.org/files/publication_pdfs/403/111011_ACUS_EnergyWater.PDF.
2. Vincent Tidwell, Sandia National Laboratories, "Primary Fuels for Power and Transportation in the US," presentation delivered at Workshop on Primary Fuels for Power and Transportation in the US, the Atlantic Council, November 10, 2011, slides 9 and 12.
3. Uranium mining issues were not discussed at the November workshop but will be addressed in the upcoming comprehensive report being prepared by the Council.
4. The Council's forthcoming report will also address federal and state conflicts. State laws and regulations, which primarily define the rules governing the use of water regarding fuel extraction and processing, impact federal government efforts. Ownership of surface and underground water rights differs from state to state. Environmental regulations on mining and water disposal also differ between states. Conflicts may also arise because the federal government both owns fuel mining land with watersheds spanning many states and hydroelectric facilities that use water from rivers that provide water for several states downstream.
5. The private sector is looking at replacing retired coal plants with gas-powered facilities.
6. Energy-efficiency measures are projected to reduce energy consumption by 13 percent between 2011 and 2035, from where they would otherwise be. See www.eia.gov/neic/speeches/newell_12162010.pdf.
7. John Conti, Assistant Administrator, Office of Energy Analysis, U.S. Energy Information Administration, "Annual Energy Outlook 2011 (AEO 2011)," presentation delivered at Workshop on Primary Fuels for Power and Transportation in the US, the Atlantic Council, November 10, 2011, slide 12.
8. Tidwell, slide 7.
9. Ibid, slide 14.
10. Conti, slide 4.
11. Tidwell, slides 9 and 2.
12. Ian Duncan, Research Scientist, Bureau of Economic Geology, University of Texas at Austin, "Water For Primary Fuels Forecasts," presentation delivered at Workshop on Primary Fuels for Power and Transportation in the US, the Atlantic Council, November 10, 2011, slides 29, 30, 48 and 51.
13. Tidwell, slide 6.
14. Jordan Macknick, National Renewable Energy Laboratory, "Water intensity in the extraction and processing of primary fuels: The case of renewables," presentation delivered at Workshop on Primary Fuels for Power and Transportation in the US, the Atlantic Council, November 10, 2011, slide 8.
15. Ron Pate, Earth Systems Analysis, Sandia National Laboratories, "Primary Fuels for Power and Transportation in the US, " presentation delivered at Workshop on Primary Fuels for Power and Transportation in the US, the Atlantic Council, November 10, 2011, slide 13.
16. Jeremy Martin, Ph.D., Senior Scientist, Clean Vehicles Program, Union of Concerned Scientists, "Energy Water Nexus: Biofuels," presentation delivered at Workshop on Primary Fuels for Power and Transportation in the US, the Atlantic Council, November 10, 2011, slide 31.
17. Dave Hager, Executive Vice President, Devon Energy Corporation, "Water Stewardship and the Shale Gas Revolution," presentation delivered at Workshop on Primary Fuels for Power and Transportation in the US, the Atlantic Council, November 10, 2011, slide 3.
18. It should be noted that the carbon footprint of gas is lower than coal, but not insignificant.
19. Ian Duncan, Research Scientist, Bureau of Economic Geology, University of Texas at Austin, "Water Usage in Hydraulic Fracturing of Shale Gas," presentation delivered at Workshop on Primary Fuels for Power and Transportation in the US, the Atlantic Council, November 10, 2011, slide 8.
20. Ibid, slide 22.
21. Jerald J. Fletcher, Director and Professor, West Virginia University, "Coal Mining: Water Resource Implications," presentation delivered at Workshop on Primary Fuels for Power and Transportation in the US, the Atlantic Council, November 10, 2011, slide 3.

22. For a discussion of the selenium issue and promising technologies to address the issues, see Treatment of Selenium-Containing Coal Mining Wastewater with Fluidized Bed Reactor Technology, Envirogen Technologies, August 2011, www.envirogen.com/files/files/ETI_Selenium_GrayPaper_V_FINAL.pdf.
23. Several federal agencies are considering new regulations concerning the use of water for energy and transportation fuels. The Council will include a discussion about the various initiatives in its upcoming report.
24. For information concerning US oil imports, see Annual Energy Outlook 2011, US Energy Information Administration, www.eia.gov/forecasts/aeo/chapter_executive_summary.cfm.

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