A R T I C L E S

In Search of Sustainability: Unraveling the Water Quality and Quantity Impacts of Energy Production

By Megan Galey* & Scott Stewart**

Developing a sustainable energy policy that balances the challenges of feeding a burgeoning population, achieving energy independence, and enhancing economic growth against water scarcity, water quality degradation, and increasing climactic variability is one of the most profound policy challenges of the 21st century. To address this challenge, policymakers must decide on a suitable mix of energy sources as well as the pace and scale of domestic energy production. Despite the urgency of establishing sustainable, economically efficient, and secure sources of energy, the fragmentation of environmental and natural resource issues during discussions of energy policy continues to hamper reform. Incomplete information about how different energy sources impact the environment and natural resources at different scales means that policies designed to improve one can create additional challenges for the other. Biofuels, for example, provide a low carbon and secure source of energy, but increasing production of biofuel feedstocks creates additional environmental and natural resource challenges.[1]

To truly assess sustainability, it is imperative to look at the entire available energy portfolio and optimize choice while accounting for economic feasibility. Meeting the United States' ever-growing energy demands in a sustainable manner requires utilizing conventional fossil fuels, including now-abundant natural gas resources, alongside low-carbon energy sources, such as biofuels and nuclear energy, while rationally addressing environmental and natural resource concerns associated with each source.[2]

One of the central policy concerns for current and future energy production revolves around the issue of water use and management.[3] Developing a sound and sustainable energy policy requires addressing the challenges associated with increased competition for water, regional water scarcity,[4] the lack of a robust water market,[5] fragmented and divergent law governing water rights,[6] the impacts of water withdrawals, wastewater management and disposal on groundwater and surface water quality,[7] the reuse of wastewater,[8] permanent sequestration of wastewater,[9] and other water quantity and quality issues. This Article examines how three energy production approaches affect water resources, the current legal framework governing water use and disposal and its limitations, and suggests potential policy changes to address these pressure points.

Part I explains the relationship between energy and water resources. Part II provides an overview of the impact that hydraulic fracturing, biofuels, and thermoelectric power generation have on water quality. It also introduces the basic provisions of the federal Clean Water Act ("CWA")[10] that are intended to protect water quality. Part III examines the water use requirements of hydraulic fracturing, biofuels, and thermoelectric power generation and conservation methods that can reduce the water intensity of these industries. Part IV describes the water conflicts that might arise among water users resulting from water scarcity and illustrates the inadequacies of current water law to deal with these issues. Part V identifies the policy initiatives and potential policy improvements that will facilitate the development of sustainable energy production from a water resources perspective.

* *Attorney at Husch Blackwell LLP in St. Louis, Missouri.*
** *Of Counsel at Husch Blackwell LLP in Washington, D.C.*

1. *See, e.g., RFA on State of the Union: Biofuels Can Eco-Boost the Economy*, Renewable Fuels Ass'n (Feb. 12, 2013), http://www.ethanolrfa.org/news/entry/rfa-on-state-of-the-union-biofuels-can-eco-boost-the-economy/.
2. *See AEO2013 Early Release Overview*, U.S. Energy Info. Admin. (Dec. 5, 2012), http://www.eia.gov/forecasts/aeo/er/early_fuel.cfm (showing the distribution of energy production between different sources in the United States).
3. U.S. Dep't of Energy, Energy Demands on Water Resources—Report to Congress on the Interdependency of Energy and Water 3 (2006).
4. *See A Three-State Competition for Water and Growth*, Growing Blue (Apr. 4, 2011), http://growingblue.com/case-studies/a-three-state-competition-for-water-and-growth/.
5. *See, e.g.,* Ellen Hanak & Elizabeth Stryjewski, *California's Water Market, By the Numbers: Update 2012*, Pub. Pol'y Inst. of Cal. 23 (Nov. 2012), *available at* http://www.ppic.org/content/pubs/report/R_1112EHR.pdf.
6. *See* U.S. Envtl. Prot. Agency, NPDES Permit Writers' Manual 2-2 (2010) [hereinafter NPDES Permit Writers' Manual].
7. U.S. Gov't Accountability Office, GAO-12-732, Oil and Gas: Information on Shale Resources, Development, and Environmental and Public Health Risks 12 (2012).
8. *See Water Recycling and Reuse: The Environmental Benefits*, U.S. Envtl. Prot. Agency, http://www.epa.gov/region9/water/recycling/ (last visited July 5, 2005).
9. *See, e.g.,* Brian O'Neill, *Water Conservation vs. Water Sequestration*, WaterWise Consulting (June 18, 2010), http://waterwiseconsulting.wordpress.com/2010/06/18/water-conservation-vs-water-sequestration/.
10. Federal Water Pollution Control Act Amendments of 1972, 33 U.S.C. §§1251 et seq. (2012).

I. The Water-Energy Nexus

Energy and water are innately intertwined. Just as water is an integral component of producing and utilizing energy, energy is an integral component of utilizing water and protecting water quality.[11] Vast amounts of water are used in energy-resource extraction, refining, and generating and distributing electricity.[12] Likewise, withdrawing, treating, and distributing water from groundwater and surface water sources requires energy.[13] Reductions in the volume of water available or withdrawals of large volumes of water can adversely impact water quality by mobilizing naturally occurring substances, promoting bacterial growth, and reducing the ability to dilute contaminants.[14]

The abnormal weather conditions across the Midwest during 2012 illustrate how water scarcity and water quality issues impact energy production. During the winter of 2011–2012, the Midwest had below average precipitation levels and above average temperatures.[15] This trend continued until the following winter.[16] The drought conditions created low water levels in the Des Plaines, Kankakee, Illinois, and Mississippi river basins.[17] As a result of shallow water levels and high day- and nighttime temperatures, ambient water temperatures were much higher than normal, and in many areas, exceeded water quality standards for temperature and dissolved oxygen.[18]

The combination of increased demand for electricity during hot weather and reduced stream flows with water temperatures at or above the state's thermal limit strained the power plants.[19] Limitations on water withdrawals during low flow conditions and the amount of heat discharged left thermoelectric facilities with few options: either derate or seek a provisional variance from the temperature limits in the facility's discharge permits.[20] Typically, the Illinois Environmental Protection Agency ("IEPA") issues two or three provisional temperature variances per year; IEPA issued 19 in 2012.[21] When surface water temperatures exceed limits for power plant compliance with thermal effluent limitations, energy security is jeopardized.

II. How Energy Production Affects Water Quality

A. *Protecting Water Quality Through the Regulation of Energy Producers as Point Sources Under the Clean Water Act.*

Discharges of heat, chemical additives, and other pollutants in wastewater streams from thermoelectric facilities are regulated under the CWA and its state equivalents.[22] The CWA was drafted to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters."[23] The CWA prohibits the discharge of pollutants into waters of the United States from a point source[24] without a permit issued by the Environmental Protection Agency ("EPA") or states with EPA-approved programs under the National Pollutant Discharge Elimination System ("NPDES").[25] Discharges by point sources must comply with the numeric and narrative effluent limitations for various pollutants at each individual outfall.[26] These limits are derived from state water quality standards or effluent limitation guidelines applicable to facilities by industrial category.[27] Some states

11. A 2006 U.S. Department of Energy report estimated that four percent of the U.S. power generation was used for water supply and treatment. U.S. Dep't of Energy, Energy Demands on Water Resources—Report to Congress on the Interdependency of Energy and Water 25 (2006) [hereinafter Energy Demands on Water Resources]. The amount of energy consumed varies across the U.S. and depends on the depth from which groundwater must be pumped or the distance surface water must be pumped, the amount of treatment required (surface water requires more energy for treatment than non-brackish groundwater), and age and size of the collection and distribution system (older systems with less efficient equipment are more costly than newer systems). *Id.* at 25–26.
12. *Id.* at 9.
13. *Id.* at 27.
14. N.H. Dep't of Envtl. Servs., WD-DWGB-4-2, Causes of Positive Bacteria Results in Water Samples (2010), *available at* http://des.nh.gov/organization/commissioner/pip/factsheets/dwgb/documents/dwgb-4-2.pdf.
15. Nat'l Climatic Data Ctr., Nat'l Oceanic & Atmospheric Admin., State of the Climate: National Snow & Ice for December 2011 (Jan. 2012), *available at* http://www.ncdc.noaa.gov/sotc/snow/2011/12.
16. *See id.*; Nat'l Climatic Data Ctr,, Nat'l Oceanic & Atmospheric Admin., State of the Climate: National Overview for Annual 2012 (Jan. 2013), *available at* http://www.ncdc.noaa.gov/sotc/national/2012/13; Ill. Dep't of Nat. Res. & Ill. Envtl. Prot. agency, The Drought of 2012: A Report of the Governor's Drought Response Task Force 5 (2013), *available at* http://www2.illinois.gov/gov/drought/Documents/The%20Drought%20of%202012.pdf [hereinafter Governor's Drought Response Task Force].
17. By the end of July 2012, many streamflows in Illinois were in the lowest tenth percentile for the time of year. Ill. State Water Survey Prairie Res. Inst., Drought Update, June 19, 2012 (Updated June 21, 2012), *available at* http://www.isws.illinois.edu/hilites/drought/archive/2012/docs/DroughtUpdate20120621.pdf; *see also* Governor's Drought Response Task Force, *supra* note 16, at 12 (noting that low flow conditions caused nuclear power plant on the Kankakee River to temporarily suspended water withdrawals when that river reached the low flow threshold in its public water withdrawal permit and caused three fossil fuel-fired plants on Chicago Sanitary and Ship Canal, Lower Des Plaines River, and one on Mississippi River to reduce power production).
18. *See* Governor's Drought Response Task Force, *supra* note 16, at 13.
19. *See* Ill. Energy Ass'n, Presentation to Illinois Drought Responses Task Force Meeting—Drought Impacts to the Electric Power Industry and Associated Water Use Issues 4 (Oct. 17, 2012), *available at* http://www2.illinois.gov/gov/drought/Documents/DRTF-PowerIndustry-101712.pdf [hereinafter Ill. Energy Ass'n Presentation]; *see also* Exelon Generation, Report to the Illinois Drought Responses Task Force Meeting 1–2 (Aug. 24, 2012), *available at* http://www2.illinois.gov/gov/drought/Documents/DRTF-Exelon-082412.pdf [hereinafter Exelon Generation Report].
20. *See* Governor's Drought Response Task Force, *supra* note 16; Ill. Energy Ass'n Presentation, *supra* note 19, at 6; *see also* Exelon Generation Report, *supra* note 19.
21. Query of Illinois Pollution Control Board's Clerk's Office On-Line database, http://www.ipcb.state.il.us/cool/external/cases.aspx (last visited May 30, 2013) (search for cases beginning with the case number IEPA with media type "water" to see all provisional variances, including those issued for temperature).
22. *See generally* 33 U.S.C. §§1251 et seq.
23. §1251(a).
24. A point source is "any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft from which pollutants are or may be discharged." 33 U.S.C. §1362(14). EPA regulations further specify that the definition of point source includes surface runoff collected and channeled by human effort, as well as discharges through pipes, sewers, or other conveyances leading to privately owned treatment works. 40 C.F.R. §122.44 (1983).
25. *National Pollutant Discharge Elimination System (NPDES): State Program Status*, U.S. Envtl. Prot. Agency (Apr. 14, 2003 1:58 PM), http://cfpub.epa.gov/npdes/statestats.cfm.
26. *See* 33 U.S.C. §1341 (2011).
27. *See* NPDES Permit Writers' Manual, *supra* note 6, at 2–10.

also regulate discharges to groundwater through water quality standards and state permitting programs similar to the NPDES program.[28]

In addition to effluent limitations in NPDES permits, energy producers may also be subject to limits and other conditions included in a CWA-required certification, well before the NPDES permits are issued.[29] Section 401 of the CWA requires permit applicants to submit a certification to federal permitting agencies from the state in which a discharge originated stating that the discharge will comply with certain enumerated CWA provisions.[30] States may use these certification requirements to impose water quality and flow restrictions to protect existing and designated beneficial uses of the affected water bodies.[31]

Rather than describing the technical differences in the classes of pollutants associated with various wastewater streams from unconventional natural gas, biofuel, and nuclear power production, this Article focuses on the most significant water quality impacts associated with these energy production facilities.

1. The Impact of Hydraulic Fracturing on Water Quality

When conducted properly, hydraulic fracturing operations have a limited effect on water quality. Hydraulic fracturing refers to the process of injecting a hydraulic fracturing fluid consisting of water, a propping agent like sand, and chemical additives under high pressure into deep rock formations to create fissures in the rock.[32] A portion of the hydraulic fracturing fluid returns to the surface along with naturally occurring water in the rock formation.[33] The proppant[34] remains in the rock formation to keep the fractures open, which facilitates extraction of natural gas and oil at commercially viable rates.[35] Hydraulic fracturing in vertical wells, a practice referred to as conventional hydraulic fracturing, has been used in the oil and gas industry since the 1950s.[36] In more recent years, the industry's ability to extract natural gas was revolutionized by advances in horizontal drilling in combination with hydraulic fracturing.[37]

One of the primary concerns related to oil and gas development is the management and disposal of wastewater streams.[38] After completion of the fracturing process, the pressure in an oil and gas well is released.[39] The fracturing fluid, along with its chemical additives,[40] that returns to the surface through the wellbore a few hours or even weeks after the fracturing process is completed is known as flowback.[41] The amount of the fracturing fluid recovered varies based on local geologic formation characteristics.[42] Most of the fracturing fluid is recovered, although a small volume of the fracturing fluid remains underground.[43] With the growth of unconventional oil and gas plays,[44] the tension between protecting intellectual property and providing government regulators and the public with enough information to evaluate potential impacts on water quality continues to be a source of controversy.[45]

---

28. For example, Florida uses both federal and state programs to regulate groundwater discharge. Michael T. Olexa et al., Univ. of Fla., Handbook of Florida Water Regulation: Groundwater Discharge Regulations at the Federal Level, FE602 (June 2011), *available at* http://edis.ifas.ufl.edu/pdffiles/FE/FE60200.pdf.
29. *See infra* note 30–31 and accompanying text.
30. This certification requirement applies to parties seeking Nuclear Regulatory Commission permits for nuclear power plants or Federal Energy Regulatory Commission licenses for hydroelectric facilities. *See* 33 U.S.C. §1341.
31. *See* PUD No. 1 of Jefferson Cnty. v. Wash. Dep't of Ecology, 511 U.S. 700, 713 (1994).
32. *See* Am. Petrol. Inst., Freeing Up Energy, Hydraulic Fracturing: Unlocking Am.'s Natural Gas Res. 5 (2010), *available at* http://www.api.org/policy/exploration/hydraulicfracturing/upload/HYDRAULIC_FRACTURING_PRIMER.pdf. Industry and environmental non-governmental organizations have adopted differing definitions of hydraulic fracturing. Industry defines hydraulic fracturing as "the process of pumping into a closed wellbore with powerful hydraulic pumps to create enough downhole pressure to crack or fracture the formation." *North American Resource Development Study*, *Hydraulic Fracturing: Technology and Practices Addressing Hydraulic Fracturing and Completions* 8, (Nat'l Petroleum Council, Working Document Paper #2-29, 2011) (citations omitted). NGOs, however, have adopted a broader definition of hydraulic fracturing. This broad view treats fracing as synonymous with unconventional natural gas production, and includes water quality impacts associated with well construction, the hydraulic fracturing process, and well production and closure. *See generally* Ann Davis Vaughan & David Pursell, Frac Attack: Risks, Hype, and Financial Reality of Hydraulic Fracturing in the Shale Plays, (2010), *available at* http://www.reservoirresearch.com/pdf/TPH_Research_Report_FracturingReport7810_Updated.pdf.
33. Fracturing fluid that returns to the surface is called flowback. Produced water, however, refers to flowback and naturally occurring water collectively. U.S. Gov't Accountability Office, GAO-12732, Shale Oil and Gas Development 12 (2012) [hereinafter GAO-12732, Shale Oil and Gas Development].
34. A proppant is a granular substance held in suspension by the fracturing fluid that aids in keeping the fractures open once the hydraulic pumps are topped. *Schlumberger Online Oilfield Glossary: Proppant*, Schlumberger, http://www.glossary.oilfield.slb.com/Display.cfm?Term=proppant (last visited Aug. 17, 2013).
35. GAO-12732, Shale Oil and Gas Development, *supra* note 33 at 12.
36. *See* U.S. Dep't of Energy, Modern Shale Gas Development in the U.S.: A Primer 46 (2009) [hereinafter Modern Shale Gas Development Primer].
37. *See id.*
38. Modern Shale Gas Development Primer, *supra* note 36, at ES-2-3.
39. *Id.* at ES-4.
40. Hydraulic fracturing fluid is primarily water and sand. *Hydraulic Fracturing: The Process*, FracFocus, http://fracfocus.org/hydraulic-fracturing-how-it-works/hydraulic-fracturing-process, (last visited June, 23, 2013). Less than two percent of the fluid is composed of chemicals and other additives that, among other things, enhance the performance of the fluid and protect against corrosion of the well casing. *Id.* The precise quantity and composition of these materials varies depending on the conditions in the specific well being fractured. *Id.*
41. *See id.* at 66.
42. *Id.* at ES-4.
43. *See* U.S. Envtl. Prot. Agency, Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources 32 (2011) [hereinafter Plan to Study the Potential Impacts of Hydraulic Fracturing], *available at* http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/upload/hf_study_plan_110211_final_508.pdf; *see also Shale Gas Production and Water Resources in the Eastern United States: Hearing Before the Subcomm. of Water & Power of the S. Comm. on Energy & Natural Res.*, 112th Cong. 8–9 (2011), *available at* http://energy.senate.gov/public/index.cfm/files/serve?File_id=0da002e7-87d9-41a1-8e4f-5ab8dd42d7cf (report of Thomas W. Beauduy, Deputy Exec. Dir. & Counsel, Susquehanna River Basin Comm'n).
44. The term "play" refers to areas where oil and gas companies are targeting exploration activity.
45. *See Fracking: The Process,* Clean Water Action, http://cleanwater.org/page/fracking-process (last visited Aug. 17, 2013).

In addition to flowback, naturally occurring water that was released by the hydraulic fracturing process from geologic formations flows through the well to the surface.[46] This produced water continues to flow to the surface over a longer period of time than flowback and is common to all oil and gas development.[47] Flowback and produced water[48] can have varying levels of salinity and may contain dissolved constituents or minerals native to the reservoir rock.[49] The salinity, Total Dissolved Solids ("TDS"), and overall quality of formation water varies by geologic basin and specific rock strata. After initial production, produced water varies from brackish (5,000 parts per million ("ppm") to 35,000 ppm TDS), to saline (35,000 ppm to 50,000 ppm TDS), to supersaturated brine (50,000 ppm to over 200,000 ppm TDS).[50] A few operations have even reported TDS values greater than 400,000 ppm.[51]

Depending on the location of oil and gas operations, produced water that is not transported off-site for reuse at another site may be injected into underground wells or transported to a wastewater treatment plant.[52] Disposal of produced water in underground injection wells is regulated under the Safe Drinking Water Act ("SDWA"),[53] while discharges to surface waters and wastewater treatment plants are regulated under the NPDES permit program.[54]

EPA regulates underground injection of wastewater through the Underground Injection Control program under the SDWA.[55] As part of the Energy Policy Act of 2005, the SDWA was controversially revised to exclude "underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities" from regulation as an underground injection subject to SDWA permitting.[56] The controversy stems from a failure to distinguish between the use of hydraulic fracturing fluid and the disposal of wastewater byproduct.[57] The reasoning behind this distinction is fluid used in hydraulic fracturing is not injected for long-term storage or disposal; rather it is used to open up fissures to release tight gas and then pulled back to the surface as flowback and either disposed of or recycled.[58]

EPA is in the process of enhancing requirements for the control of wastewater discharges associated with oil and gas development. In October 2011, EPA announced its schedule for developing revised standards for wastewater discharges produced during natural gas extraction from underground coalbed and shale formations.[59] EPA is gathering data and consulting stakeholders in support of its efforts and anticipates issuing proposed rules addressing coalbed methane and shale gas in 2014.[60]

Further, at the request of Congress, EPA is in the midst of a far-ranging, multi-year study aimed at better understanding the potential impacts of hydraulic fracturing on drinking water and groundwater. EPA issued its study plan in 2011.[61] In late March 2013, EPA's Science Advisor Board ("SAB"), a chartered Federal Advisory Committee charged with providing independent scientific and technical peer review, advice, consultation, and recommendations to EPA, announced the formation of EPA's Hydraulic Fracturing Research Advisory panel.[62] In light of the breadth of the study, it is critical that the advisory panel be composed of a broad cross-section of experts, including industry experts. Rather than being truly representative, however, there are concerns that the panel only includes five industry representatives and is overwhelmingly comprised of academics.[63] In order for sound science to drive this ambitious study, the SAB should follow the Federal Advisory Committee Act, 5 U.S.C. App. 2, and EPA must be responsive to the input it receives from the advisory panel. Since this process has already been heavily politicized, it is important that interested stakeholders continue to engage and monitor EPA's efforts by closely following EPA updates.[64]

2. The Water Quality Effects of Biofuel Refining

Like hydraulic fracturing operations, biofuel refinery facilities produce wastewater that can negatively impact water

46. *Produced Water Management Information System: Introduction to Produced Water*, U.S. Dep't of Energy, http://www.netl.doe.gov/technologies/pwmis/intropw/ (last visited Aug. 17, 2013).
47. *High Volume Hydraulic Fracturing*, Tip of the Mitt Watershed Council, http://www.watershedcouncil.org/learn/hydraulic-fracturing/ (last visited Aug. 17, 2013).
48. In practice, it is not possible to distinguish flowback from produced water since they return to the surface as a single flow. *See* Modern Shale Gas Development Primer, *supra* note 36, at 67.
49. *Produced Water Management Information System: Introduction to Produced Water*, *supra* note 46.
50. *See* Modern Shale Gas Development Primer, *supra* note 36, at 67.
51. *Id.* at 67–68.
52. *See* Modern Shale Gas Development Primer, *supra* note 36, at 68.
53. *See* Safe Drinking Water Act, 42 U.S.C. §§300f et seq. (1996).
54. Discharges of untreated produced water to surface waters typically violate the CWA and state water quality standards, because produced waters are highly saline and may on occasion contain naturally occurring radioactive materials. Discharging to public water treatment plants, however, is not always a technologically feasible option. Municipal wastewater treatment plants often are not equipped to remove the constituents in produced water. *See* Modern Shale Gas Development Primer, *supra* note 36, at 24.
55. *Id.* at 68.
56. Energy Policy Act of 2004, Pub. L. No. 109-58, §322, 199 Stat. 694 (2005).
57. *See* Modern Shale Gas Development Primer, *supra* note 36, at 32–33.
58. *See id.* at 32.
59. Press Release, U.S. Envt'l Prot. Agency, EPA Announces Schedule to Develop Natural Gas Wastewater Standards (Oct. 20, 2011), *available at* http://yosemite.epa.gov/opa/admpress.nsf/0/91E7FADB4B114C4A8525792F00542001.
60. *Id.*
61. *See generally* Plan to Study the Potential Impacts of Hydraulic Fracturing, *supra* note 43.
62. Press Release, U.S. Envt'l Prot. Agency, EPA's Science Advisory Board Announces Independent Panel to Peer Review Agency's Hydraulic Fracturing Research (Mar. 25, 2013), *available at* http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/bc39e20974be4ed485257b3900707c0d!OpenDocument.
63. More precisely, the panel of thirty-one experts consists of twenty-one academics/university professors, five current employees of companies and consulting firms, and two government employees. *See id.*; *see also Members of the Hydraulic Fracturing Research Advisory Panel*, U.S. Envtl. Prot. Agency, http://yosemite.epa.gov/sab/sabpeople.nsf/WebExternalSubCommitteeRosters?OpenView&committee=BOARD&subcommittee=Hydraulic Fracturing Research Advisory Panel (last visited Aug. 17, 2013).
64. *See EPA's Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources*, U.S. Envtl. Prot. Agency, http://www.epa.gov/hfstudy/ (last updated July 24, 2013); *see also Hydraulic Fracturing Potential Impacts on Drinking Water Resources—2012 Progress Report*, U.S. Envtl. Prot. Agency, http://yosemite.epa.gov/sab/SABPRODUCT.NSF/81e39f4c09954fcb85256ead006be86e/b436304ba804e3f885257a5b00521b3b!OpenDocument (last visited Aug. 17, 2013).

quality. The potential impact of a waste stream, however, is dependent upon the production process for a particular type of biofuel. With the exception of emerging cellulosic biofuel production, biofuel technologies principally rely on converting crops traditionally grown for human consumption into ethanol or biodiesel for use as a transportation fuel.[65] Ethanol is produced from crops with high sugar content, such as corn and sugarcane, by biologically or chemically fermenting sugars into ethanol.[66] Similarly, biodiesel is derived from oil crops such as soybeans and palm oil.[67] Cellulosic biofuels, on the other hand, are derived from cellulose, hemicellulose, or lignin in wood, native grasses, or non-edible parts of plants, such as corn stover.[68]

The impact of wastewater discharges from biofuel refineries on water quality are minimal as these discharges have long been regulated under the CWA.[69] Ethanol facilities discharge waste streams from cooling towers and boilers and effluent from water purification systems.[70] Similar to ethanol plants, biodiesel plants have waste streams and water treatment reject streams,[71] but biodiesel facilities also have the potential to produce wastewater discharges of high biochemical oxygen demand ("BOD") and oil and grease.[72] NPDES permits for these facilities limit the concentration of these constituents in the waste streams due to their potential to cause or contribute to violations of water quality standards.[73] Pursuant to the CWA, ethanol and biodiesel refineries can either transport wastewater to publicly owned treatment works, wherein the refinery is subject to pretreatment standards regulations as an indirect discharger[74] or the refinery can treat wastewater prior to discharge, in which case the refinery must obtain an NPDES permit.[75]

3. The Effect of Thermoelectric Facilities on Water Quality

As thermoelectric power plants rely on surface water for cooling, thermoelectric facilities can have a significant impact on water quality in receiving streams, primarily by discharging heat and thereby increasing stream temperatures. Thermoelectric facilities generate electricity by transferring heat from combustion or fission to a working medium (usually steam).[76] The working medium is then cooled using a condenser or heat exchanger after it passes through the turbine.[77] Non-contact cooling systems as described above discharge both heat and small amounts of treatment chemicals, which can adversely affect water quality in receiving streams.[78] Poor water quality then in turn affects the operational efficiency of these cooling systems. As ambient air temperature and surface water temperatures increase, the efficiency of non-contact cooling systems decreases, with concomitant drops in power generation efficiency.[79] Non-contact cooling systems are also affected by water quality impairments that require more frequent blowdown[80] and additional treatment chemicals, which interfere with the operation of intake structures.[81]

B. *Impact of Energy Production on Water Quality by Nonpoint Sources*

A primary challenge for developing a sustainable energy policy is how to protect water quality as American agriculture expands production of biofuel feedstocks, despite the inability to effectively regulate discharges from nonpoint sources of pollution under the CWA. Nonpoint sources are not defined in the CWA.[82] The absence of definition means a nonpoint source is simply any source that does not fit within the definition of a point source, including agricultural stormwater discharges and return flows from irrigated agriculture, which are expressly excluded from the definition of a point source.[83] Overlooking a few inconsistencies in the case law, diffuse agricultural runoff containing fertilizers, pesticides, and sediments is a significant source of nonpoint source pollution.[84]

Controlling agricultural runoff has proven to be challenging, in part, because it requires regulating land use activities.[85] Consistent with the long-standing legal principle that

65. *See* Comm. on Water Implications of Biofuels Prod. in the U.S., Nat'l Research Council, Water Implications of Biofuels Production in the United States 1 (2008) [hereinafter Water Implications of Biofuels Production].
66. *Id*. at 13.
67. *Id*. at 49.
68. *Id*. at 10, 47.
69. *Id*. at 51.
70. *Id*. at 49–53.
71. As part of the treatment process, water treatment systems create two streams of water—the filtered water and the rejected water. *See, e.g.,* Y. Yang et al., *Two Strategies for Phosphorus Removal From Reject Water of Municipal Wastewater Treatment Plant Using Alum Sludge*, 60 Water Sci. Tech. 3181 (2009); *see also* Nat'l Envtl. Servs. Ctr., W.Va. Univ., *Tech Brief: Water Treatment Plant Residuals Management, A National Drinking Water Clearinghouse Fact Sheet* 1 (Mar. 1998), *available at* http://www.nesc.wvu.edu/pdf/dw/publications/ontap/2009_tb/water_treatment_DWFSOM49.pdf.
72. *See* Water Implications of Biofuels Production, *supra* note 65, at 51.
73. *Id*. at 51–53.
74. *See* 33 U.S.C. §1317(b) (2006).
75. *Id.*
76. *See, e.g.*, *Protecting the Environment: Water Use and Nuclear Power Plant,* Nuclear Energy Inst. (Nov. 2012), http://www.nei.org/CorporateSite/media/filefolder/COMM/Water-Use-and-Nuclear-Power-Plants-Nov-2012.pdf?ext=.pdf.
77. *Id.*
78. *See id*.
79. *See* Energy Demands on Water Resources, *supra* note 11, at 37; *Protecting the Environment: Water Use and Nuclear Power Plants*, *supra* note 76.
80. Blowdown refers to the quantity of water discharged from a cooling water system to avoid scale formation and corrosion.
81. For example, surface waters impaired for nutrients may require more treatment chemicals to prevent biological fouling of the cooling systems and mechanical removal or chemical treatment of aquatic plants, which may restrict flow at intake structures. *See, e.g.* John R. Kruse & Abner Womack, Food & Agric. Policy Research Inst., Implications of Alternative Missouri River Flows for Power Plants 5–7 (2004), *available at* http://www.fapri.missouri.edu/outreach/publications/2004/FAPRI_UMC_Report_04_04.pdf.
82. *What Is Nonpoint Source Pollution?*, U.S. Envtl. Prot. Agency, http://water.epa.gov/polwaste/nps/whatis.cfm (last visited July 4, 2013).
83. *See* 33 U.S.C. §1362(14) (2011).
84. *National Water Quality Inventory: Report to Congress, 2004 Reporting Cycle*, U.S. Envtl. Prot. Agency, http://water.epa.gov/lawsregs/guidance/cwa/305b/2004report_index.cfm (last visited Jan. 2009).
85. *See, e.g.*, James C. Buresh, *State and Federal Land Use Regulation: An Application to Groundwater and Nonpoint Source Pollution Control*, 95 Yale L.J. 1433, 1433 (1986); Miss. River Gulf of Mex. Watershed Nutrient Task Force, Gulf Hypoxia Action Plan 2008 for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico and Improving Water Quality in the Mississippi River Basin 33 (2008) [hereinafter Gulf Hypoxia Action Plan 2008], *available at* http://water.epa.gov/type/

states have the exclusive power to regulate land uses,[86] the CWA's nonpoint source pollution control program encourages states to implement programs that reduce discharges from nonpoint sources.[87] A variety of conservation strategies, such as the adoption of nutrient management plans, may be employed to protect water quality, but regulators have been reticent to control agricultural production by mandate, preferring to incentivize best management practices through voluntary programs.[88] As members of the Hypoxia Task Force, twelve states bordering the Mississippi and Ohio rivers agreed to implement nutrient reduction strategies and other best management practices by the end of 2013 to reduce nutrient runoff into the Mississippi/Atchafalaya River Basin and ultimately the Gulf of Mexico.[89] Only one of the twelve states has introduced a statewide plan to reduce nutrients in state waters.[90] By mandating implementation of nutrient reduction practices in point and nonpoint sources, Iowa's Nutrient Reduction Strategy aims to reduce the state's discharge of total nitrogen and total phosphorus by 45% each.[91] Given that the majority of biofuel feedstock producers are located in the Mississippi/Atchafalaya River Basin, the continued development and implementation of these state nutrient reduction strategies will impact the biofuels market.[92]

Although land use controls are the primary method used to manage agricultural producers, Total Maximum Daily Loads ("TMDLs")[93] and water quality trading programs are additional regulatory tools. EPA interprets the TMDL requirement in section 303(d) of the CWA as applying to all impaired waters,[94] regardless of whether the impairment is caused by point sources or nonpoint sources.[95] Lacking the authority to regulate nonpoint sources, however, EPA cannot implement load allocations.[96] EPA can merely encourage the states to do so.[97] Although TMDLs can be used to regulate nonpoint sources, most TMDLs place the primary burden on point sources because of the difficulty in regulating nonpoint sources like agricultural runoff.[98] Determining how to address run-off from agricultural sources is an ongoing challenge in TMDL development.[99]

1. The Reemergence of Water Quality Trading Programs

Watershed-based pollutant trading provides a market-based method of incentivizing the reduction of agricultural runoff. Pollutant trading among point sources or between point and nonpoint sources in a particular watershed, however, is not feasible until TMDLs have been developed for the watershed. Water quality trading may begin after a limit is set on the amount of effluents each point source is allowed to discharge.[100] The point source is then given an equivalent number of "credits" to match its effluent limit. Sources that can most cost-effectively achieve effluent reductions are able to sell their excess credits as "offsets" to other sources in the same watershed.[101] Trading programs allow point sources to purchase these offsets from nonpoint sources or other point sources instead of reducing their own discharges of effluents.[102] As a result, water quality improvement can be achieved at a lower overall cost.[103]

The EPA began tracking pilot water quality trading projects several years ago[104] and working with the United States Department of Agriculture ("USDA") Natural Resources Conservation Service ("NRCS") to encourage agricultural

---

watersheds/named/msbasin/upload/2008_8_28_msbasin_ghap2008_update 082608.pdf.

86. *See, e.g.*, Michael Allen Wolf, *Fruits of the "Impenetrable Jungle": Navigating the Boundary Between Land-Use Planning and Environmental Law*, 50 Wash. U. Urb. & Contemp. L. 5, 8 (1996); Buresh, *supra* note 85, at 1433.
87. The NRCS under the DOA uses the term conservation practices in its technical guidance documents, but this term is often used interchangeably with "best management practices," which are "effective, practical, structural or nonstructural methods which prevent or reduce the movement of sediment, nutrients, pesticides and other pollutants from the land to surface or ground water, or which otherwise protect water quality from potential adverse effects of agriculture activities." *Research-Nitrogen-BMPs*, Nat'l Water Program, http://www.usawaterquality.org/themes/npm/research/N_BMP.html (last visited July 5, 2013).
88. *See, e.g.*, Iowa Dep't of Agric. & Land Stewardship et al., Iowa Nutrient Reduction Strategy (2012) [hereinafter Iowa Nutrient Reduction Strategy], *available at* http://www.nutrientstrategy.iastate.edu/sites/default/files/documents/NRSfull.pdf; Gulf Hypoxia Action Plan 2008, *supra* note 85, at 32.
89. The twelve states that are represented on the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force are: Arkansas, Illinois, Indiana, Iowa, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Ohio, Tennessee, and Wisconsin. *See* Gulf Hypoxia Action Plan 2008, *supra* note 85, at 32; *see also* Miss. River Gulf of Mex. Watershed Nutrient Task Force, Reassessment 2013: Assessing Progress Made Since 2008.
90. *See generally* Iowa Nutrient Reduction Strategy, *supra* note 88.
91. *Id.*
92. *See id.*
93. Under §303(d) of the CWA, each state must calculate and document TMDLs for waters that have failed to meet water quality standards. 33 U.S.C. §1313(d). A TMDL is the amount of a specific pollutant that may be discharged into impaired waters from all sources, including nonpoint sources, to achieve water quality standards[in specific waters]. *Id.* States must then consider and incorporate TMDLs into their water quality management plans and permit programs to achieve established water quality standards. *Id.*
94. EPA interprets §303(d) as stating that TMDLs apply to nonpoint sources. 33 U.S.C. §1313(d)(1)(A), (C) (requiring TMDLs for all waters for which "effluent limitations . . . are not stringent enough to implement any water quality standard applicable to such waters"); *see also* Thomas v. Jackson, 581 F.3d 658 (8th Cir. 2009); Pronsolino v. Nastri, 291 F.3d 1123, 1140 (9th Cir. 2002).
95. 40 C.F.R. §§130.2(g)–(i); 130.7(b)(1), (5); *see also* Envtl. Prot. Agency, National Clarifying Guidance for 1998 State and Territory Clean Water Act Section 303(d) Listing Decisions (Aug. 17, 1997) *available at* http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/lisgid.cfm.
96. *Pronsolino*, 291 F.3d at 1140 (noting that states must implement TMDLs only to the extent that they seek to avoid losing federal funding).
97. *See id.*
98. *See* U.S. Envtl. Prot. Agency, National Clarifying Guidance for 1998 State and Territory Clean Water Act Section 303(d) Listing Decisions (Aug. 17, 1997) *available at* http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/lisgid.cfm.
99. *See id.*
100. *See generally*, U.S. Envtl. Prot. Agency, Water Quality Trading Evaluation: Final Report 1–2 (2008), *available at* http://www.epa.gov/evaluate/pdf/water/epa-water-quality-trading-evaluation.pdf.
101. *See* U.S. Envtl. Prot. Agency, Partnership Agreement Between the United States Department of Agriculture Natural Resources Conservation Service and the United States Environmental Protection Agency Office of Water (Oct. 13, 2006) [hereinafter Partnership Agreement Between USDA and EPA Office of Water], *available at* http://www.epa.gov/owow/watershed/trading/mou061013.pdf (memorandum of understanding to collaboratively encourage agricultural producer participation in water trading programs).
102. *See id.*
103. *See id.*
104. *State and Individual Trading Programs*, U.S. Envtl. Prot. Agency, http://water.epa.gov/type/watersheds/trading/tradingmap.cfm (last visited Mar. 14, 2013).

producers to participate in water quality trading.[105] Despite the agency's efforts to promote the potential benefits of trading programs, however, only a few such programs exist.[106] Fortunately, the 2008 Gulf Hypoxia Action Plan appears to be bringing renewed interest in trading programs.[107] If, like Iowa, other states in the Mississippi River watershed include the establishment and implementation of voluntary water quality trading programs as a component of their nutrient reduction strategies, more agricultural producers might choose to participate in water quality trading programs.[108]

Despite the prior failures of water quality trading programs, water quality trading programs can be highly successful as illustrated by a trading program in Minnesota among sugar beet producers. The water-quality trading program emerged in response to the Minnesota Pollution Control Agency imposing stricter limits for nitrogen and phosphorous in NPDES permits. To meet the discharge limits in its permit, the Southern Minnesota Beet Sugar Cooperative ("SMBSC") worked with the Minnesota Pollution Control Agency to incorporate water quality trading provisions into SMBSC's permit.[109] To offset its wastewater discharge, SMBSC created a pollutant trading system that paid sugar beet growers to plant cover crops and implement other nitrogen and phosphorous reduction strategies.[110] The trading program allowed SMBSC to construct a new facility and increase its production output by 40% even though the Minnesota Pollution Control Agency would not allow a new discharge into the Minnesota River. The success of this water-quality trading program has proven that trading programs can protect water quality while mutually benefiting nonpoint sources, point sources, and regulators.

2. The Impact of Biofuel Feedstock Production on Water Quality

From a water-quality perspective, one central question for the development of a sustainable energy policy is how water quality will change as American agriculture expands production of biofuel feedstocks. As with any type of crop production, the effects of feedstock production on water quality heavily depend upon the plant selected and regional variables like soil conditions, fertilizer and pesticide applications, and precipitation patterns.[111] Surface runoff can result in excess nutrients from fertilizers—principally nitrogen and phosphorous—polluting waterways.[112] High fertilizer- and pesticide-application rates commonly impact groundwater and surface water in regions with permeable soils and drainage practices that do not divert recharge[113] to surface waters.[114]

The type of feedstock produced also impacts water quality. Perennial crops have less effect on water quality than annual crops, because they require less fertilization and tillage.[115] Although cellulosic biofuel production is highly efficient from a water-use perspective, using corn stover and other crop residues as feedstock has the potential to negatively impact water quality by exacerbating soil erosion, depending on the amount of residue removed.[116] Soil erosion is by no means unique to biofuel production; rather, it is a substantial challenge for all forms of crop production.[117] Nevertheless, an increase in overall crop production through increased biofuel production might intensify erosion, especially on marginal lands.

The impact of biofuel feedstock production on water quality can be reduced by the implementation of conservation practices under the guidance of NRCS.[118] Using special procedures to identify agricultural sources of nonpoint pollution, NRCS is able to incorporate management practices into new or existing conservation plans contained in the National Water Quality Handbook.[119] In cooperation with state and local conservation authorities, NRCS works directly with individual feedstock producers to design and implement conservation plans and practices.[120] NRCS has identified specific

105. *See* Partnership Agreement Between USDA and EPA Office of Water, *supra n*ote 101.
106. In 2008, EPA reported that only a hundred facilities have participated in a water quality trading program, and approximately 80% of trades were in the Long Island Sound Trading Program. U.S. Envtl. Prot. Agency, Water Quality Trading Evaluation: Final Report 1–2 (2008), *available at* http://www.epa.gov/evaluate/pdf/water/epa-water-quality-trading-evaluation.pdf.
107. *See* Gulf Hypoxia Action Plan 2008, *supra* note 85, at 32.
108. *See* Iowa Nutrient Reduction Strategy, *supra* note 88, at 3, 15.
109. *See* U.S. Envtl. Prot. Agency, Water Quality Trading Evaluation: Final Report 2–8 (2008), *available at* http://www.epa.gov/evaluate/pdf/water/epa-water-quality-trading-evaluation.pdf.
110. *Id.*
111. Comm. on Econ. and Envtl. Impacts of Increasing Biofuels Prod., Nat'l Research Council, Renewable Fuel Standard: Potential Economic & Environmental Effects of U.S. Biofuel Policy, 206–07 (2011) [hereinafter Potential Economic & Environmental Effects of U.S. Biofuel Policy].
112. *See* Water Implications of Biofuels Production, *supra* note 65, at 27.
113. Recharge refers to the hydrologic process whereby water percholates into the ground and recharges an aquifer. *See, e.g.,* U.S. Geological Survey, Evolving Issues and Practices in Managing Ground-Water Resources: Case Studies on the Role of Science, Circular 1247, at 25 (2003).
114. *See* Water Implications of Biofuels Production, *supra* note 65, at 32–33.
115. Potential Economic & Environmental Effects of U.S. Biofuel Policy, *supra* note 112, at 206–07 (stating the reduced need for tillage reduces soil erosion and microbial oxidation). Compared to other annual crops, corn requires a large quantity of nitrogen fertilizers. *Id.*
116. *Id.* at 212–13.
117. Charles R. Terrell & Patricia Bytnar Perfetti, Soil Conservation Service, U.S. Dep't of Agric., Water Quality Indicators Guide: Surface Waters 19 (1993) (estimating that erosion from cropland accounts for 40–50% of the sediment that reaches the nation's waterways).
118. Maintaining surface cover is important for minimizing sediment runoff and soil erosion, and utilizing no-till or conservation tillage techniques that leave a portion of crop residues on the soil surface is also helpful. Using cover crops of legumes, cereals, or grasses in fields during non-crop periods to reduce leaching during vulnerable fall and spring periods may be the most effective practice to decrease nitrogen loadings. Planting perennial crops on lands with high erosion, or using perennials as buffer strips between annuals and riparian zones, could improve water quality as deep-rooted perennials absorb excess nutrients from annuals, reduce erosion and runoff, and lower the need for pesticides. Potential Economic & Environmental Effects of U.S. Biofuel Policy, *supra* note 112, at 207–14.
119. Nat. Res. Conservation Serv., U.S. Dep't of Agric., National Water Quality Handbook §§614.0100–.0101 (2003) (defining water quality as "the physical, chemical, and biological composition of water as related to its intended use of such purposes as drinking, recreation, irrigation, and fisheries") [hereinafter National Water Quality Handbook].
120. *See generally* Nat. Res. Conservation Serv., U.S. Dep't of Agric., National Agronomy Manual §500.00 (4th ed. 2011). NRCS defines a conservation practice as a "specific treatment, such as a structural or vegetative measure, or management technique, commonly used to meet specific needs in planning and implementing conservation, for which [quality] standards and specifications have been developed. National Water Quality Handbook, *supra* note 120, at §619.

water resource issues and the corresponding conservation practices to mitigate these issues.[121] The agency provides detailed guidance on a variety of topics, including water erosion and control measures, cropping practices (e.g., crop rotation, tillage, and residues), and water management.[122]

An examination of the sustainability of different energy sources must account for water use and consumption, in addition to the impact that energy development has on water quality. As will be explained in Section V.A., the need for better data is one significant challenge to analyzing the amount of water used and consumed by different energy sectors.

III. Water Quantity: Understanding the Use and Consumption of Water by Different Energy Sources

The production of energy requires a substantial amount of water. Nationally, thermoelectric power accounts for 41% of the water withdrawn from surface water and groundwater, while irrigation accounts for 37%.[123] Water withdrawals are only part of the hydrological picture. The consumptive use of water, meaning water that is evaporated, transpired, or incorporated into crops, is an important measure of water use; but is difficult to measure or estimate.[124]

A. Feedstock Water Availability and Use

The availability of water is a constant challenge for agricultural producers. For biofuel feedstock production, precipitation provides most of the water needed, but irrigation can be necessary during droughts.[125] Irrigation might become more common, particularly on semi-arid lands, as biofuel feedstock production grows to meet the benchmarks established in the revised Renewable Fuel Standard ("RFS2").[126] Water from rainfall and irrigation returns to local water sources through evaporation from soil, runoff, and seepage into underground aquifers. Crops use large amounts of water for growth and transpiration, which is the release of water into the atmosphere.[127] One acre of corn emits between 3,000–4,000 gallons of water per day.[128] For a biofuel feedstock crop to use water in a sustainable manner, the crop should require minimal or no irrigation water or should be produced in accordance with NRCS practice standards to optimize irrigation practices.[129]

The amount of water used to produce feedstock crops depends on the type of crop and the region where it is grown. The amount of water a crop requires is affected by precipitation, soil quality, evapotranspiration, and other hydroclimate conditions, which vary from region to region.[130] For example, in the Pacific and Mountain regions, corn uses less water than soybeans and cotton, but in the Northern and Southern Plains, corn uses more water.[131] Cellulosic production of the non-edible portions of food crops has the potential to generate more fuel without increasing water usage.[132] Corn stover production is estimated to increase yields of ethanol by four to five times per acre.[133] Research in central Illinois indicates that miscanthus and switchgrass consume more water than corn per unit of biomass.[134] Conversely, other research indicates that switchgrass biomass yields per unit of water are greater than corn in Iowa, Missouri, and Nebraska, but not Texas.[135] More research is needed to understand the water requirements of native grasses and other cellulosic crops.

Given this regional variation in rainfall, irrigation use, and groundwater storage, the feasibility and sustainability of biofuel feedstock production varies significantly by region.[136] Increased production is unlikely to alter water use at a national scale, but it will likely impact regional and local areas where water resources are already stressed.[137] The primary challenge is finding reliable sources of water in regions

121. The conservation practices are categorized as National Conservation Practice Standard Codes. *See National Handbook of Conservation Practices*, Nat. Resource Conserv. Service, http://directives.sc.egov.usda.gov/31694.wba (last visited Mar. 13, 2013); *see also Conservation Practices*, Nat. Resource Conserv. Service, http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/cp/ncps/?cid=nrcs143_026849 (last visited Mar. 13, 2013).

122. The National Agronomy Manual provides a general reference of conservation practices. *See* Natural Res. Conservation Serv., *supra* note 121, at §§500–509. The conservation practice standards contain background information on each practice and explain the minimum criteria that must be met in order for each practice to be effective. *Id.* The national standards, however, are merely intended as references. Producers should follow state conservation practice standards, which are available through the Field Office Technical Guides. *See Field Office Technical Guide*, Nat. Resource Conserv. Service, http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/fotg/ (last visited Mar. 13, 2013).

123. U.S. Geological Survey, Estimated Use of Water in the United States in 2005, at 1 (2009) [hereinafter Estimated Use of Water in the United States], *available at* http://pubs.usgs.gov/circ/1344/pdf/c1344.pdf.

124. *See, e.g.,* U.S. Geological Survey, Consumptive Water Use in the Great Lakes Basin 1–2 (Apr. 2008), *available at* http://pubs.usgs.gov/fs/2008/3032/pdf/fs2008-3032.pdf.

125. Water Implications of Biofuels Production, *supra* note 65, at 12.

126. The Energy Independence and Security Act of 2007 increased the minimum quantity of biofuels to 15 billion gallons in 2015 and an additional 21 billion gallons of advanced biofuels by 2022. Energy Independence and Security Act §202(a)(2), 121 Stat. at 1522 (codified at 42 U.S.C. §7545(o)(2)(B) (Supp. II 2009)). The Act divided the required renewable fuel volume into four nested categories: total renewable fuels, advanced renewable fuels, biodiesel, and cellulosic biofuels. Under each category, biofuels must meet minimum lifecycle greenhouse gas thresholds and use renewable biomass that complies with certain land use restrictions. §202(a)(2), 121 Stat. at 1522–24.

127. Water Implications of Biofuels Production, *supra* note 65, at 11–12.

128. *Id.* at 12.

129. *See id.* at 22–23, 56.

130. *Id.* at 19–21.

131. *Id.* at 20.

132. *See id.* at 42.

133. *See* Stanley R. Johnson et al., Nat'l Ctr. for Food & Agric. Policy, Quantification of the Impacts on U.S. Agriculture of Biotechnology-Derived Crops Planted in 2006, at 13 (2008), *available at* http://www.ncfap.org/documents/2007biotech_report/Quantification_of_the_Impacts_on_US_Agriculture_of_Biotechnology_Executive_Summary.pdf.

134. George C. Hickman et al*., A Comparison of Canopy Evapotranspiration for Maize and Two Perennial Grass Species Identified as Potential Bioenergy Crops*, 2 Global Change Biology & Bioenergy 157 (2010). Comparing the water requirements of corn, miscanthus, and switchgrass in Central Illinois, the researchers attributed the increased water consumption of miscanthus and switchgrass to the extended growing season for perennial grasses as well as a higher rate of water use during peak season for miscanthus. *Id.*

135. J.R. Kinry et al., *Biofuels and Water Use: Comparison of Maize and Switchgrass and General Perspectives*, *in* New Research on Biofuels 15 (J.H. Wright & D.A. Evans eds., 2008), *available at* http://afrsweb.usda.gov/SP2UserFiles/Place/62060000/almanac/Ex8B99.pdf.

136. *See* Water Implications of Biofuels Production, *supra* note 65, at 2–3.

137. *See id.*

with an abundance of available land, such as the southwest.[138] One solution is using treated wastewater to irrigate biofuel crops that are resistant to elevated salinity,[139] assuming the effects on soil and shallow groundwater can be minimized by appropriate management.[140]

In comparison to the water used in growing feedstock crops and the variation in water use among feedstock producers, the water used in the biorefining process is modest with little variance in consumption among refineries.[141] The amount of water used, however, depends upon the type of biofuel. By using approximately 1 gallon of fresh water per gallon of fuel produced, biodiesel refining requires less water per unit of energy produced than ethanol, which uses 4 gallons of water per gallon of fuel produced.[142] Consumptive use of water in biorefineries is largely due to evaporation from cooling towers and distillation of ethanol after fermentation. The consumptive use of water, however, is declining as refineries increasingly are able to recycle wastewater and use less water-intensive methods of converting feedstocks to fuels.[143] Although cellulosic feedstock production may require less water, the amount of water used in refining corn ethanol and soybean-based biodiesel is lower than the amount of water used to refine cellulosic fuels.[144] Once the commercial production of cellulosic ethanol has been around longer, it will likely undergo the efficiency improvements that the refining processes of corn-grain ethanol and biodiesel have undergone.[145] Just as water use in biofuel production must be viewed holistically, it is important to assess alternate forms of energy in terms of their entire water use footprint.[146]

B. *Water Requirements of Hydraulic Fracturing Operations*

As is the case with biofuel production, water is crucial for the extraction of natural gas. Conventional hydraulic fracturing requires up to 80,000 gallons of water per well.[147] Unconventional oil and gas production is more water intensive, requiring between 2–4 million gallons of water per well.[148] The quantity of water needed depends upon the depth of the well as well as the number of hydraulic fracturing events.[149] In addition to the water used in the initial hydraulic fracturing, enhanced recovery techniques for extracting natural gas from an aging field also require a substantial amount of water.[150]

The water intensity of hydraulic fracturing operations can be reduced by recycling wastewater from hydraulic fracturing operations.[151] In certain locations, primarily in the Marcellus Shale, wastewater is treated and reused in subsequent hydraulic fracturing operations.[152] Depending on the quality, produced water is also used in western states for agricultural irrigation, power plant cooling, and other productive industrial uses.[153] Deciding whether to reuse wastewater or dispose of it in underground injection wells is primarily an economic decision.[154] The cost of disposal in certain areas such as the Marcellus Shale has driven reuse of wastewater, but in other areas, like Texas, the high cost of treating wastewater and the relatively low cost of transporting wastewater to a disposal site favors the use of disposal wells. Recycling wastewater is not a widespread practice, but recent regulatory changes in Colorado and Texas are expected to encourage recycling of wastewater.[155] In 2010, Colorado, a state which actively regulates the impact of water withdrawals on vested water rights, created an exception to the state's permitting requirements

---

138. *See id.* at 19–20.
139. The FDA recently proposed new regulations for the use of wastewater for irrigation of plants, but the regulations do not apply to plants not intended for human consumption. *See* Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption, 78 Fed. Reg. 3504, 3563 (Jan. 16, 2013) (stating section 112.14 establishes the requirement that all agricultural water that contacts the harvestable portion of certain types of produce for human consumption be safe and of adequate sanitary quality for its intended use).
140. Biofuel crops may be irrigated with wastewater that is biologically and chemically unsuitable for use with food crops. *See* U.S. Envtl. Prot. Agency, Guidelines for Water Reuse, Report No. EPA/600/R-12/618 5–26 (2012). Certain crops, such as switchgrass, can tolerate irrigation water of moderate salinity. G.K. Gangegunte et al., Irrigation With Treated Urban Wastewater for Bioenergy Crop Production in the Far West Texas, American Geophysical Union (2011).
141. M. Wu et al., Argonne Nat'l Lab., Consumptive Water Use in the Production of Ethanol and Petroleum Gasoline, Report No. ANL/ESD/09-1 3(2009).
142. Water Implications of Biofuels Production, *supra* note 65, at 46, 49 (stating gallon of fresh water used for biodiesel but overall water use may be up to three gallons per gallon of biodiesel produced. This figure is still significantly lower than what is required for ethanol production).
143. Older ethanol plants consume up to eleven gallons of water per gallon of ethanol produced. Hosien Shapouri & Paul Gallagher, USDA's 2002 Ethanol Cost-of-Production Survey 14 (2005), *available at* http://www.usda.gov/oce/reports/energy/USDA_2002_ETHANOL.pdf. On average, newer ethanol refineries consume only three gallons of water per gallon of ethanol. Wu et al., *supra* note 141, at 27 (2009). A study of the total consumptive use rates of water of various transportation fuels concluded the fuel with the lowest consumptive use was biodiesel produced from non-irrigated soybeans, which consumed fewer than 0.05 gallons of water per mile. Carey W. King & Michael E. Webber, *Water Intensity of Transportation*, 42 Envtl. Science 7866, 7869 (2008).
144. *See* Wu et al., *supra* note 141, at 30.
145. Water Implications of Biofuels Production, *supra* note 65, at 48.
146. Using fewer than 0.15 gallons of water per mile, conventional petroleum based gasoline and diesel have relatively low consumptive use rates. King & Webber, *supra* note 143, at 7866. Plug-in hybrid vehicles, on the other hand, consumed two to five times more water per mile than vehicles using conventional petroleum fuels. *Id.*
147. *Hydraulic Fracturing,* Getches-Wilkinson Ctr. for Nat. Resources, Energy, and the Env't, http://www.oilandgasbmps.org/resources/fracing.php (last visited July 7, 2013),
148. *See* U.S. Envtl. Prot. Agency, Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources 22 (2011), *available at* http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/upload/hf_study_plan_110211_final_508.pdf; Modern Shale Gas Development Primer, *supra* note 36, at 64 (2009).
149. *See id.*
150. *See* Peter H. Gleick, *Water and Energy*, 19 Ann. Rev. Energy & Env't 267, 286–87 (1994).
151. Modern Shale Gas Development Primer, *supra* note 36, at 48.
152. *Id.* at 70.
153. U.S. Dept. of the Interior, Reclamation Managing Water in the West Oil and Gas Produced Water Management and Beneficial Use in the Western United States, Science and Technology Program Report No. 157, 26-37 (Sept. 2011).
154. *See* Stephen Rossenfoss, From Flowback to Fracturing: Water Recycling Grows in the Marcellus Shale 45 (2011).
155. Treatment of produced water for reuse may be feasible through self-contained systems at well sites or commercial treatment facilities. The type treatment methods employed will be dictated by flow rate and total water volumes to be treated, the constituents to be removed, treatment objectives, and water reuse or discharge requirements. *See id.*

when nontributary water is put to beneficial use within the basin of origin for ordinary oil field purposes like drilling, well stimulation, and well maintenance.[156] More recently, the Texas Railroad Commission adopted new recycling rules that simplify state permitting requirements for recycling activities and broadened the acceptable uses of recycled fluids.[157]

In certain states, such as Pennsylvania, the water intensity of hydraulic fracturing operations could be further reduced by the large quantities of coal mine water[158] and coal mine drainage[159] that are available as potential sources of water.[160] The economic viability of using coal mine drainage varies depending on several factors, including: (1) transportation distance and method; (2) the extent of pretreatment required; (3) the cost of required treatment; and (4) volume and regulatory containment specifications for storage.[161] Although using coal mine drainage may be less expensive than using fresh water in some cases, legal and regulatory hurdles continue to prevent the use of coal mine drainage by hydraulic fracturing operations.

In Pennsylvania, under section 610 of the Solid Waste Management Act ("SWMA"), the discharge of residual waste to the surface or underground is prohibited without a permit. If mine drainage is considered a waste, a natural gas well operator must comply with waste transport requirements to transport mine drainage to the well site and obtain a permit to discharge mine drainage into the ground. Moreover, the party who originally collected the mine drainage would be liable for any spills at the well site. Generators of waste have been held liable for waste improperly disposed of without a permit even when the disposal occurred by a third-party who violated the terms of their contract with the generator.

In addition to the SWMA, liability may also be imposed on operators under the Clean Streams Law ("CSL") for treating mine drainage. Section 315 of the CSL prohibits discharges from a mine into waters of the Commonwealth without a permit. If operators fail to obtain a permit or to otherwise comply with the CSL, they are exposed to liability. Additionally, liability has been imposed without fault under the CSL on persons who own land where historic discharges of mine drainage occur. Section 316 of the CSL allows the state to require landowners to treat existing discharges and secure permits for discharges from mines into waters of the Commonwealth.

Several different potential methods for addressing the potential liability of users of coal mine drainage have been suggested. The Pennsylvania Environmental Good Samaritan Act can help provide some operator immunity if the use of CMD is interpreted as a reclamation or water pollution abatement project addressing the negative effects of past coal mining operations. Secondly, a consent order and agreement with the Department of Environmental Protection could lessen liability for the long-term treatment of CMD. However, the specific requirements placed on each operator would vary, depending on the nature of each project.

C. *The Use and Consumption of Water by Thermoelectric Power Plants*

While most thermal electric facilities require a significant amount of water for their cooling systems, nuclear facilities have a slightly higher water demand than other types of facilities because, in contrast to fossil-fuel-fired facilities that can dissipate some heat with flue gasses, a nuclear facility's turbine efficiencies are lower, and heat can only be dissipated through their cooling systems.[162] The amount of water required for cooling depends upon the type of cooling system used.[163] Of the one hundred and four nuclear plants in the United States, sixty use open-loop wet cooling, thirty-five use closed-loop wet cooling, and nine use hybrid systems.[164]

If a thermoelectric facility is adjacent to a large body of water, the facility may simply run a large amount of water through the condensers in a single pass and then discharge wastewater, at a higher temperature, back into the body of water.[165] Open-loop cooled nuclear plants require between 25,000–60,000 gallons per MWh, but do not consume a great deal of water.[166] Closed-loop cooling systems use cooling towers to cool water through evaporation by utilizing simple heat transfer to the air.[167] These systems require 700–1,100 gallons of water per MWh, which is less than 5% of the water withdrawn by open-loop systems, but much of the water withdrawn is lost to evaporation.[168] However, the more modest water requirements of closed-loop systems do not necessarily ensure the continued production of energy during drought conditions, as seen in Illinois in 2012.[169] Although wastewater may serve as a supplemental source of water for some industries, reusing wastewater in thermoelectric facilities is limited because reclaimed wastewater commonly contains high concentrations of nutrients that promote bacterial growth within the cooling system.[170]

Dry cooling systems use air instead of evaporation.[171] The process can involve cooling towers with a closed circuit

156. *See* Colo. Rev. Stat. §§37-90-137–138, 37-92-308 (2012).
157. *See* 16 Tex. Admin. Code §§4.201 et seq. (2006).
158. Coal mine water refers to water that was previously in coal mining activities.
159. Water that is drained from a coal mine pool is referred to as coal mine drainage.
160. *See* Aimee E. Curtright & Kate Giglio, RAND Corporation, Conference Proceedings: Coal Mine Drainage for Marcellus Shale Natural Gas Extraction (Dec. 14, 2011).
161. *Id.*; *see also* Penn, Dep't of Envtl. Prot., Establishment of an Evaluation and Approval Process for the Use of Abandoned Mine Drainage (AMD) for Industrial Uses Including Natural Gas Extraction (Nov. 2011).
162. *See* Energy Demands on Water Resources, *supra* note 11, at 18, fig. II-1.
163. *Id.*
164. *Id.* Dual systems use cooling towers when ambient air temperatures are relatively high and dry cooling is used when temperatures are relatively low. *See id.*
165. *See id.* at 17; *Protecting the Environment: Water Use and Nuclear Power Plants*, *supra* note 76.
166. The U.S. Geological Survey indicated that 98% of the water withdrawn is returned to the source. *See* Energy Demands on Water Resources, *supra* note 11, at 65.
167. *Id.* at 19.
168. The cooling tower evaporates up to 5% of the flow. *Id.*
169. *See generally* Governor's Drought Response Task Force, *supra* note 16.
170. Reclaimed water is used in thermoelectric applications in only a handful of states (e.g., Arizona, California, Florida and Texas). Estimated Use of Water in the United States, *supra* note 123, at 38.
171. *Cooling Power Plants*, World Nuclear Ass'n, http://www.world-nuclear.org/info/Current-and-Future-Generation/Cooling-Power-Plants/ (see section discussing dry cooling systems) (last visited Mar. 2, 2014).

or high forced draft air flow through a radiator.[172] There is minimal water loss in a dry cooling system, and the whole nuclear plant uses less than ten percent of the water required for a wet-cooled facility.[173] The downside to dry cooling, however, is that facilities use a substantial amount of electricity to run the condensers—estimated to be two to sixteen percent "for the cost of energy compared to evaporative closed-loop cooling."[174] The relative lack of dry cooling facilities in the United States can be attributed to the unreliability of dry cooling in hot weather, the lost electrical generating efficiency, and the increased cost.[175]

IV. Constraints and Complexity Surrounding the Regulation of Water Rights

The United States has substantial freshwater resources.[176] Yet, freshwater is not always available in the desired location at the precise time it is needed. States regulate the quantity of water extracted from a water source through permitting programs, but few watersheds are located within the jurisdictional boundaries of a single state.[177] The allocation of water from interstate bodies of water can quickly become a source of controversy.[178] States have attempted to resolve tensions surrounding the allocation of water resources by entering into interstate compacts or by relying on federally chartered interstate commissions.[179] When all else fails, states engage in protracted litigation to resolve water rights disputes.[180]

Although interstate compacts are useful tools, they do not necessarily prevent tensions over the allocation of water during a water shortage. When the volume of water available cannot meet the demands of all users, an upstream state must limit its withdrawals of water to ensure a downstream state receives the quantity of water it was allotted under the terms of the compact.[181]

The management of interstate water resources is complicated by the complexity and incompatibility of state water laws and withdrawal permitting programs. Using water surpluses in one watershed to mitigate short-term water shortages or water scarcity from depletion of groundwater aquifers in another watershed requires the development of a centralized water market.[182] In the absence of a centralized water market, management of interstate water resources is disjointed, inefficient, and can raise potentially far-reaching electric grid stability and safety issues during persistent severe regional droughts.[183]

Surface water scarcity is already impacting energy production in various regions and causing disputes over the allocations of water.[184] Recent droughts and emerging limitations on water resources have left many states, including two of the biggest natural gas producers, Texas and South Dakota, scrambling to develop water use priorities amid increased water use disputes.[185] The primary challenge with water shortages causing water use conflicts is that state water laws do not provide sufficient tools for resolving these conflicts.[186]

Water rights traditionally are regulated by states, rather than the federal government.[187] Each state follows the riparian or prior appropriation water rights doctrine.[188] Although a full discussion of these doctrines is beyond the scope of this article, being mindful of the basic distinctions between them is important when considering the apportionment of interstate bodies of water.

Generally, the water-rich states east of the Mississippi River follow the riparian doctrine, and the more arid states west of the Mississippi River follow the prior appropriation doctrine.[189] In a riparian system, a person who owns land adjacent to a watercourse has the right to beneficial uses of the water on that land.[190] At common law, a riparian or littoral landowner's use had to be reasonable and was limited only in that the landowner's use could not interfere with the reasonable uses of other riparian or littoral owners.[191] Under the prior appropriation doctrine, however, a person acquires a right to use water by diverting water from a watercourse and making beneficial use of the water.[192] Thus, in a prior appropriation system, first in time, not proximity, controls.[193] Users in a prior appropriation system typically must obtain a permit from a state agency to secure their right to use the amount of water specified in their permit.[194]

To economically and efficiently use water resources in a riparian or prior appropriation system, users must be able to trade water rights within a market system.[195] Prior appropriation systems were designed to provide users with clearly

172. *Id*. (see section discussing 'cooling to condense the steam and discharge surplus heat').
173. *See* Energy Demands on Water Resources, *supra* note 11, at 38.
174. Energy Demands on Water Resources, *supra* note 11, at 40
175. In 2009, the Department of Energy reported that constructing a dry cooling system costs three to four times more than recirculating wet cooling system. *See Cooling Power Plants*, *supra* note 171 (section titled 'Dry cooling').
176. *See* Estimated Use of Water in the United States, *supra* note 123, at 6.
177. *Id.* at 26.
178. *See, e.g.*, Tarrant Reg'l Water Dist. v. Herrmann, 133 S.Ct. 2120 (U.S. 2013).
179. *See id.*
180. *See id.*
181. *See* Josh Clemons, *Interstate Water Disputes*, Mississippi-Alabama sea grant Legal Program (2004), http://masglp.olemiss.edu/acf.htm.
182. *See* Richard A. Wildman, Jr. & Noelani A. Forde, *Management of Water Shortage in the Colorado River Basin: Evaluating Current Policy and the Viability of Interstate Water Trading*, 48 J. Am.Water Resources Assoc. 411, 412 (June 2012) [hereinafter Wildman, *Management of Water Shortage in the Colorado River Basin*].
183. *See id.* at 421.
184. *See* Sara Reardon, *Water Shortages Hit US Power Supply*, NewScientist.com (Aug. 20, 2012), http://www.newscientist.com/article/dn22178-water-shortages-hit-us-power-supply.html.
185. *See, e.g., id.*; Charles B. Stockdale et al., *The Ten Biggest American Cities That Are Running Out of Water*, 24/7 Wall St. (Nov. 1, 2010), http://finance.yahoo.com/news/pf_article_111186.html; Mitch Weiss, *Drought Could Force Nuke-Plant Shutdowns*, USA Today (Jan. 25, 2008), http://usatoday30.usatoday.com/weather/drought/2008-01-24-drought-power_N.htm.
186. *See* Richard R. Powell, Powell on Real Property §65.04[2] (James A. Davenport, ed. 1995).
187. *See id.* at §65.02.
188. *See id.* at §65.04.
189. *Id.* at §65.04[1].
190. *See* Energy & Envtl. Research Ctr., Water Appropriation Systems 1 (2012) [hereinafter Energy & Envtl. Research Ctr.], *available at* http://www.radford.edu/~gsantopi/nrem/WaterApprSystems.pdf.
191. Powell, *supra* note 186, at §65.06[4].
192. *See id.* at §65.05 n.1.
193. Energy & Envtl. Research Ctr., *supra* note 190, at 2.
194. *See id.* at 2.
195. *See* Wildman, *Management of Water Shortage in the Colorado River Basin, supra* note 182, at 412.

defined water rights in part to manage water scarcity, but clearly defined rights do not encourage efficient use of water resources in the absence of a water market.[196] Efficient development and utilization of water resources requires permitting systems to provide credits for water conservation efforts and to allow users to bank and trade credits.[197] Under both types of water rights system, procedures for transferring water rights need to be simplified and the legal constraints on transfers of water rights should be removed.

States that share compatible water rights doctrines ought to have an easier time resolving interstate water disputes, but that typically is not the case. Without a functioning water market efficiently apportioning water rights in those streams not governed by the Great Lakes-St. Lawrence River Basin Compact, power plants in Illinois may not receive enough water to continue operating during a severe drought.[198] This concern became a reality in 2012 when reduced snowpack and rainfall led to significant reductions in streamflows across Illinois.[199] This problem is not unique to the midwest.[200] As water shortages continue to intensify disagreements between competing water users, if states are unable to negotiate an allocation among themselves with the assistance of the Army Corps of Engineers, an equitable apportionment by Congress or the Supreme Court may be needed to resolve interstate disagreements.

Several states that use water from interstate bodies of water have entered into interstate compacts to clarify how water should be allocated among the different states. Although interstate compacts protect the interests of downstream users, the process of transferring water between different states remains contentious.[201] The number of conflicts arising from water compacts, however, can be further reduced by creating watershed-based commissions, like the Susquehanna and Delaware River Basin Commissions, to regulate the interstate transfer of water, as well as the withdrawal and use of water throughout an entire watershed.[202]

Until recently, the U.S. Army Corps of Engineers was minimally involved in the allocation of water among states.[203] The Corps has, however, become increasingly involved in water resource management decisions beyond merely flood control, hydropower generation, and navigation.[204] Protracted litigation among the states of Florida, Georgia, and Alabama surrounding the allocation of water in the Lake Lanier dam culminated in a decision by Eleventh Circuit that required the Corps to examine its authority to allocate storage for water supply uses under the Rivers and Harbors Act of 1946[205] and the Water Supply Act of 1958.[206] The Corps subsequently concluded it had authority under both statutes to make the water supply allocations that were the subject of the litigation.[207] In the future, allocation decisions made by the Corps and unauthorized water withdrawals from impoundments managed by the Corps will be the basis of enforcement actions and civil litigation during times of water scarcity.

All of these state, federal, and interstate programs work to a certain degree, but the utility of many of these programs is limited because they were developed in response to existing water rights laws put in place due to early, localized concerns about water.[208] The solution to making water use sustainable in the 21st century is to create a functioning water market that incentivizes movement of water from water-rich watersheds to other areas if there is a higher and better use for the water.

V. Toward Sustainable Energy and Water Resource Policies

Sustainability is an increasingly important concept in energy, agricultural, and environmental policy development.[209] Yet, the process of determining what constitutes a sustainable system remains elusive.[210] Despite the number of differing answers policymakers and researchers have provided, it is clear that the water and energy sectors are tightly linked.[211] Not only does the production of energy require water, but the water sector continues to become even more energy-intensive as demand increases for advanced water

196. *See id.* at 412.
197. *See id.*
198. *See* Great Lakes Water Inst.*, Our Waters The Great Lakes Compact,* Univ. Of Wisc. Madison, http://www.glwi.freshwater.uwm.edu/ourwaters/documents/GreatLakesCompact.pdf. (last visited July 7, 2013).
199. *See* Governor's Drought Response Task Force, *supra* note 16, at 1-8, K-4.
200. *See* Kate Galbraith, *Drought Could Pose Problems for Texas Power Plants*, Texas Tribune (Sept. 16, 2011), http://www.texastribune.org/texas-environmental-news/water-supply/drought-could-post-problems-texas-power-plants/.
201. *See* Thomas Merrill, *Opinion Analysis: Oklahoma Skunks Texas in Cross-Border Water Rivalry*, SCOTUSblog (June 13, 2013, 8:13 PM), http://www.scotusblog.com/2013/06/opinion-analysis-oklahoma-skunks-texas-in-cross-border-water-rivalry/.
202. *See* Pa. State Univ., River Basin Approaches to Water Management in the Mid-Atlantic States (2010), *available at* http://pubs.cas.psu.edu/freepubs/pdfs/ua466.pdf.
203. *See The U.S. Army Corps of Engineers: A Brief History*, U.S. Army Corps of Eng'rs, http://www.usace.army.mil/About/History/BriefHistoryoftheCorps/WaterResourcesDevelopment.aspx.
204. *See id.*
205. Rivers and Harbors Act of 1946, Pub.L. No. 79–525, 60 Stat. 634 (1946).
206. Pub.L. 85-500, Title III, July 3, 1958, 72 Stat. 319; *see generally* In re Tri-State Water Rights Litigation, 644 F.3d 1160 (11th Cir. 2011).
207. Office of Chief Counsel, U.S. Army Corps of Eng'rs, Authority to Provide for Municipal and Industrial Water Supply From the Buford Dam/Lake Lanier Project, Georgia (June 25, 2012), *available at* http://www.sam.usace.army.mil/Portals/46/docs/planning_environmental/acf/docs/2012ACF_legalopinion.pdf.
208. *See, e.g.*, Steven Clyde, Dallin Jensen & Warren Peterson, Utah Div. of Water Rights, Review of Agreement for Management of the Snake Valley Ground Water System and Snake Valley Environmental Monitoring and Management Agreement*, available at* http://www.waterrights.utah.gov/snakeValleyAgreement/Review_Clyde_Jensen_Peterson.pdf.
209. *See What Is Sustainable Agriculture,* Agric. Sustainability Inst, U.C. Davis, http://asi.ucdavis.edu/sarep/about/def (last visited July 7, 2013); *see also* Eric Herzog, Timothy Lipman & Daniel Kammen, Univ. of Cal., Berkeley, Renewable Energy Sources, *available at* http://rael.berkeley.edu/sites/default/files/old-site-files/ 2001/Herzog-Lipman-Kammen-RenewableEnergy-2001.pdf.
210. *See* Roddy Scheer & Doug Moss, *What Makes a Community "Sustainable"?,* Sci. Am. (Aug. 8, 2012), http://www.scientificamerican.com/article.cfm?id=defining-sustainable-communities.
211. *See generally* Ron Pate et al., Sandia Nat'l Lab., Overview of Energy-Water Interdependencies and the Emerging Energy Demands on Water Resources (Mar. 2007), *available at* http://www.circleofblue.org/waternews/wp-content/uploads/2010/09/SANDIA-research-needs2007-1349C_revised.pdf.

treatment technologies, such as desalination.[212] Consequently, an energy source cannot be truly sustainable unless its impact on water is also sustainable.

Although biofuel feedstock production is water intensive, biofuel production continues to grow as a result of federal policies, including the RFS2 mandates and farm bill initiatives aimed at promoting biomass production, because it is currently the most viable renewable transportation fuel option.[213] The RFS2 has contributed to bringing significant volumes of ethanol into the vehicle-fuel market.[214] To date, most of this ethanol has been corn-based, but the statute calls for further growth in second-generation biofuels.[215] Cellulosic and "drop-in" fuels, such as biobutanol, are advantageous because they generally use nonedible biomass or can be used with existing infrastructure (i.e., "dropped-in") without costly modifications.[216] As construction of the first commercial-scale cellulosic biofuel refineries continues, cellulosic biofuel production was expected to increase almost twenty-fold in 2013.[217]

The impact of biofuel feedstock production on water resources depends on the management practices used to grow the feedstocks. During the last few years, interest has grown among producers and consumers to implement sustainable standards and business practices.[218] Several organizations have been formulating third-party certification standards for sustainably produced biofuels, including the International Sustainability and Carbon Certification's ("ISCC") Sustainability Requirements for the Production of Biomass.[219] Most standards are performance-based and rely on conservation practices like growing crops in the appropriate climatic regions, minimizing soil erosion and irrigation to protect water resources, and achieve other environmental goals.[220] Standards typically address similar issues as components of sustainability, despite substantial variability among the elements of different standards.[221] The challenge with all voluntary sustainability standards, however, is the effectiveness of conservation practices at the watershed scale depends on coordinating the actions of all agricultural producers in a watershed.

In addition to utilizing conservation practices, genetically engineered crop varieties provide another strategy for using existing water supplies as efficiently as possible. Advances in biotechnology already have improved yields through increased productivity, improved resistance to pests and weeds, and improved drought tolerance.[222] Moreover, there is growing evidence that the use of genetically engineered seeds helps improve water quality by encouraging changes in farm practices.[223] The changes in agronomic practices most widely noted are: improving use of conservation tillage practices and reducing the amount of pesticides and fertilizers applied by growers.[224] By continuing to make such advances, biotechnology may enable biofuel feedstock production on arid and semi-arid lands and significantly reduce the impact of biofuels on water resources.[225] Continued investment in biofuels and progress toward reducing the cost of large-scale cellulosic biofuel production should remain a priority so that second generation biofuels can be competitive with conventional fuels on a basis that values their inherent environmental benefit.[226]

---

212. *Id.* at 16.
213. The 2008 Farm Bill established the Biomass Crop Assistance Program (BCAP) to subsidize energy biomass produced pursuant to a conservation plan. Food, Conservation, and Energy Act of 2008, Pub. L. No. 110-246, §§9001, 9011, 122 Stat. 1651, 2089–93 (codified as amended at 7 U.S.C. §8111 (2008)). To prevent using food crops for energy production, the program does not apply to Title I crops. Biomass Crop Assistance Program, 75 Fed. Reg. 66202, 66236 (Oct. 27, 2010). To qualify, producers must comply with land use restrictions, including a prohibition against cropping on lands with native vegetation not previously tilled for an annual crop as of the enactment date of the 2008 Farm Bill or on land that receives conservation, wetland, or grassland reserve payments. Biomass Crop Assistance Program, 75 Fed. Reg. 66202, 66241 (Oct. 27, 2010). In addition to BCAP, energy biomass producers may receive additional federal assistance by participating in "working lands" environmental enhancement programs, such as the Conservation Stewardship Program, *See* Farm Security and Rural Investment Act of 2002, Pub. L. No. 107-171, §2001(a), §1238A, 116 Stat. 134, 225-30 (codified as amended at 16 U.S.C. §3838a (2006 & Supp. III 2010)), *amended by* Food Conservation, and Energy Act of 2008, Pub. L. No. 110-246, §2301(b)-(c), 122 Stat. 1651, 1775-76 (codified at 16 U.S.C. §3838a(b)(3)(C), (g)), and the Environmental Quality Incentives Program (EQIP). EQIP is based on national resource priorities, which include reductions in nonpoint source water pollution and soil erosion. Federal Agriculture Improvement and Reform Act of 1996, Pub. L. No. 104-127, §334, §1240, 99 Stat. 888, 997 (codified at 16 U.S.C. §3839aa (2006)), *amended by* Food, Conservation, and Energy Act of 2008, Pub. L. No. 110-246, §2501(a), 122 Stat. 1651, 1785–86 (codified at 16 U.S.C. §3839aa (Supp. III 2010)); *see also* Commodity Credit Corporation, 74 Fed. Reg. 2293 (Jan. 15, 2009) (codified at 7 C.F.R. pt. 1466 (2010)).
214. *See* Randy Schnepf & Brent D. Yacobucci, Cong. Research Serv., R40155, Renewable Fuel Standard (RFS): Overview and Issue (2013).
215. *Id.* at 1.
216. The National Research Council defines a drop-in fuel as a non-petroleum fuel that is compatible with existing infrastructure, such as pipelines and delivery mechanisms, for petroleum-based fuels. *See* Potential Economic & Environmental Effects of U.S. Biofuel Policy, *supra* note 111, at 302.
217. Andrew Herndon, *Cellulosic Biofuel to Surge in 2013 as First Plants Open,* Bloomberg (Dec. 11, 2012, 2:22 PM), http://www.bloomberg.com/news/2012-12-11/cellulosic-biofuel-to-surge-in-2013-as-first-plants-open.html.
218. *See* Stephen Kaffka, *Can Feedstock Production for Biofuels Be Sustainable in California?,* Cal. Agric. (Oct.-Dec. 2009), http://californiaagriculture.ucanr.org/landingpage.cfm?article=ca.v063n04p202&fulltext=yes; *see also* Erin Voegele, *MASBI Makes Recommendations to Expedite Biojet Development,* Biomass Mag. (July 3, 2013), http://www.biomassmagazine.com/articles/9166/masbi-makes-recommendations-to-expedite-biojet-development.
219. The ISCC's Sustainability Requirements for the Production of Biomass Standard is an international biomass and bioenergy certification initiative. *See Sustainability Requirements for the Production of Biomass*, Int'l Sustainability & Carbon Certification Ass'n (Apr. 19, 2010), http://www.iscc-system.org/en/certification-process/certification/. Principle 2 addresses the impact of biomass production on water resources by evaluating several criterion, including ground water and irrigation, soil erosion, fertilizer applications, and integrated pest management. *See id.*
220. International Sustainability & Carbon Certification, Sustainability Requirements for the Production of Biomass, 14–21 (2011).
221. As the National Research Council stated, "there is no consensus on the appropriateness of the current sets of indicators or the scientific basis for choosing among them." Nat'l Research Council, Our Common Journey: A Transition Toward Sustainability 243 (2000).
222. *See* J. Fernandez-Cornejo & M. Caswell, Econ. Research Serv., The First Decade of Genetically Engineered Crops in the United States 1 (2006).
223. *Id.* at 13.
224. *See, e.g.,* Nat'l research Council, The Impact of Genetically Engineered Crops on Farm Sustainability in the United States 59–60 (2010).
225. *See* Fernadez-Cornejo & Caswell, *supra* note 222, at 13 (finding adoption of genetically engineered crops was frequently associated with increased yield and decreased pesticide use); *see also* Johnson et al., *supra* note 133, at 12–15 (summarizing the impacts of genetically engineered crops).
226. *See id.* at 12.

Although biofuels and other emerging renewable energy sources such as wind and solar are important parts of a sustainable energy policy, a reliable and technologically feasible sustainable framework must include natural gas as a lower-carbon bridge fuel.[227] The growth in domestic natural gas production spurred by the boom in unconventional gas development during the last decade dwarfed the expected growth of biofuels and other renewable energy sources,[228] despite federal incentives for the development of renewable energy sources.[229] Reliance solely on renewable energy sources might be the most sustainable solution in the future, but renewable energy sources are not currently capable of meeting even a fraction of our national energy demands.[230] Furthermore, many renewable energy sources are still far from cost competitive and intermittent output and insufficient storage capabilities continue to be significant barriers to wider adoption of renewable energy sources like wind and solar.[231] In 2012, electricity from natural gas increased by 217 TWh, while wind electricity increased by 20.5 TWh and solar increased by 2.5 TWh.[232]

The importance of natural gas as a bridge fuel is also in part due to the financial robustness of the industry. Unlike the renewable energy sector, the natural gas industry no longer requires governmental programs to increase production or to develop new water management technologies.[233] This was not always the case. The recent boom in hydraulic fracturing in shale gas reserves was the result of over thirty years of federal programs driving technological development in collaboration with private companies.[234] Even though the government subsidized unconventional gas exploration, natural gas has been increasing its share of the energy market without any governmental subsidies since 2002.[235]

Creating an integrated policy for energy and water resources requires governmental agencies to work together at federal, state, and local levels, but the unexpected drop in carbon dioxide emissions in the United States in the absence of mandated regulatory programs illustrates that market forces, such as those driving the development of sustainability standards, can efficiently facilitate the attainment of a sustainable energy policy. At this point, however, little discussion has occurred surrounding sustainability certification standards for producers outside of the agricultural, forestry, and fishery industries, despite the numerous competing sustainability standards in the agricultural industry.[236]

One exception is the Center for Sustainable Shale Development's ("CSSD") consensus-based performance standards and regional certification process for "unconventional exploration, development, and gathering activities including site construction, drilling, hydraulic fracturing and production in the Appalachian Basin."[237] The water performance standards focus on wastewater disposal,[238] plans and requirements for recycling flowback and produced water,[239] closed loop drilling,[240] impoundment integrity,[241] adequate confining layers to prevent adverse migration of hydraulic fracturing fluids,[242] plans for monitoring groundwater and surface water sources,[243] adequate casing and cement, and public disclosure of chemical constituents.[244] CSSD's performance standards help focus the industry on the primary water management issues associated with hydraulic fracturing—effective disposal of wastewater and recycling flowback and produced water. The impact of hydraulic fracturing on water resources, however, could be further reduced if the industry continues to improve methods for recycling flowback and produced water, thereby reducing the amount of freshwater used in the hydraulic fracturing process.[245]

---

227. *See, e.g.,* Mass. Inst. of Tech. Energy Initiative, The Future of Natural Gas 16 (2011), *available at* http://mitei.mit.edu/publications/reports-studies/future-natural-gas.
228. *See AEO2013 Early Release Overview*, U.S. Energy Info. Admin. (Dec. 5, 2012), http://www.eia.gov/forecasts/aeo/er/early_production.cfm.
229. *See Renewable Energy Production Incentives*, U.S. Envtl. Prot. Agency, http://www.epa.gov/osw/hazard/wastemin/minimize/energyrec/rpsinc.htm (last visited July 5, 2013).
230. *See id.* at 4.
231. *Id.* at 2.
232. U.S. Energy Info. Admin., Electric Power Monthly With Data for January 2013 Table ES1.B. (2013), *available at* http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_es1b.
233. Although not the focus of this Article, there are several governmental programs facilitating the development of wind energy. *See, e.g.,* Dep't of Energy, Federal Incentives for Wind Power Deployment 1 (2011), *available at* http://www1.eere.energy.gov/wind/pdfs/51452.pdf. Moreover, the importance of governmental programs is illustrated by the fact that uncertainty over whether Congress would renew the primary wind subsidy is expected to result in less than half as much investment in wind farms in 2013 as in 2012. *See* Iain Wilson & Christopher Martin, *U.S. Credit Extension May Revive Stalled Wind Industry*, Bloomberg (Jan. 2, 2013), http://www.bloomberg.com/news/2013-01-02/wind-tax-credit-extension-seen-driving-growth-trade-group-says.html.
234. *See* Alex Trembath et al, *Where the Shale Gas Revolution Came From: Government's Role in the Development of Hydraulic Fracturing in Shale*, Breakthrough Inst. (May 2012), http://thebreakthrough.org/blog/Where_the_Shale_Gas_Revolution_Came_From.pdf (discussing the Windfall Profits Tax Act provision for unconventional natural gas production and coordinated research efforts between natural gas companies and federal researchers and engineers).
235. *See id.*
236. *See* Sustainable Agric. Network, Sustainable Agriculture Standard 17–44 (2d ed. 2010) (describing sustainability standards for agriculture related topics including ecosystem conservation, wildlife protection, and soil and waste management); Food Alliance, Food Alliance Sustainability Standard for Crop Operations 6–7 (2013) (describing sustainability standards for agriculture related topics including soil and water conservation, pesticide risk reduction, and safe and fair working conditions).
237. Ctr. for Sustainable Shale Dev., Performance Standards: Geographic Scope and Applicability of CSSD Performance Standards 1 (2013) [hereinafter CSSD Performance Standards], *available at* http://037186e.netsolhost.com/site/wp-content/uploads/2013/03/CSSD-Performance-Standards-3-13R.pdf.
238. *Id.* Performance standard number 1 requires operators to not discharge wastewater, which includes drilling, flowback, and produced waters, into fresh groundwater or surface waters. *Id.* The standard neither applies to nor prohibits disposal of wastewater by deep well injection. *Id.*
239. *Id.* at 1–2. Performance standard number 2 requires operators to develop and implement a plan to recycle flowback and produced water. *Id.* In areas where an operator is a net water user, the operator has two years from the date of implementing the standards to begin recycling at least ninety percent of flowback and produced water. *Id.*
240. *Id.* at 2. Performance standard number 3 requires the use of closed loop drilling when using oil-containing drilling fluids and subsequently requires containing drilling fluid and flowback water in a closed loop system. *Id.*
241. *Id.* at 2. Performance standard number 4 requires the removal of free hydrocarbons prior to storage and the double-lining with an impermeable material. *Id.*
242. *Id.* at 2–3. Performance standard number 5 requires establish an Area of Review and conduct a comprehensive characterization of subsurface geology. *Id.*
243. *Id.* at 3. Performance standard number 6 requires monitoring plans for water sources within a 2,500 foot radius of the wellhead in order to demonstrate that water quality and chemistry are not impacted by operations. *Id.*
244. *See id.* at 3–4 (listing the required chemical constituent disclosures under performance standard number 7).
245. *See* Rossenfoss, *supra* note 154, at 48–49.

A. *Increasing Energy Production and Sustainable Decision-Making*

The United States needs a national objective and overarching principles to guide the management of water resources. In the absence of a consistent and concise objective, water policy has evolved during the last few decades through piecemeal legislation and disjointed executive and judicial actions.[246] Moreover, the lack of a national objective has exacerbated tensions over the resolution and coordination of difficult water resource issues.[247] Federal and state laws and regulations, local ordinances, tribal treaties, contractual obligations, economies dependent on existing water use patterns, and infrastructure all affect water management decision-making.[248] Attempting to untangle the complexities of water management involves the participation of stakeholders with a wide range of interests. The challenges caused by the presence of stakeholders pursuing different goals, and the political and legal hurdles that must be overcome, necessitate federal guidance on water resource policies.

Yet, as important as the federal government may be, its role remains limited. Water resources must be addressed, at least in part, at the watershed level, where unique geographic characteristics and the concerns of different users can be evaluated and resolved in a comprehensive manner. The federal government, therefore, should serve as a facilitator, rather than a leader. The role of the Delaware River Basin Commission in facilitating the management of water resources among constituent states with divergent needs provides a useful example of how the federal government can encourage cooperative watershed planning.[249] An even better solution is the movement toward functioning regional and super-regional water markets, where market forces provide some of the drive toward rational water use decisionmaking. Safeguards would be needed to ensure fairness to all water consumers, but the biggest obstacle to the exploration of a functioning water marketplace is the lack of focus on the collection of useful water data.[250]

Good water resource management requires robust data upon which to base decisionmaking. Water quality, availability, and use are a function of the total flow of water through a basin, its quality, and the structure, laws, regulations, and economic factors that control its use. Developing sound energy and water resource policies requires an in-depth understanding of all of these factors across the United States. As part of that process, a federal assessment of the quality, availability, and use of water in the United States is needed.[251]

Although some state and local governments conduct extensive planning to quantify current and future water use and availability, the quantity and type of data collected varies substantially.[252] Nationally, the United States Geological Survey ("USGS") collects basic water flow data.[253] The agency monitors water flows in streams and rivers by a network of stream gauges as part of the National Streamflow Information Program.[254] USGS also works with states to estimate water withdrawals and assess water quality in different water bodies.[255] Data on trends in freshwater fisheries is available, but the majority of the information available is on a species-specific basis rather than by watershed or ecosystem.[256] Further, USGS's programs are not comprehensive and are frequently subject to budget cuts.[257] For that reason, a comprehensive assessment of the quality, availability, and use of water in the United States is needed.[258] A broad range of data on the condition of water should be collected, including data on water quality factors, geological attributes, soil properties, storage volumes, flow rates, and uses of water nationwide.[259]

---

246. *See* Energy Policy Act of 2005 §322, 42 U.S.C. §300h(d) (exempting hydraulic fracturing from regulation under the Safe Water Drinking Act); Rossenfoss, *supra* note 154, at 48 (describing actions taken by the Pennsylvania Department of Environmental Protection and the Environmental Protection Agency to ensure that water treatment facilities were not processing flowback water and disposing of it in state waterways).
247. *See generally* Tarrant Reg'l Water Dist. v. Herrmann, 656 F.3d 1222 (10th Cir. 2011) (involving a dispute over the enforcement of state laws regulating surface water use and transfer); Thomas v. Jackson, 581 F.3d 658 (8th Cir. 2009) (involving a dispute over the Environmental Protection Agency's ability to approve Iowa's list of state waters that did not meet quality standards under the Clean Water Act).
248. *See generally* Energy Policy Act of 2005 §322; San Diego, Cal. Muni. Code ch. 6 art. 7, div. 2 (2013) (discussing city regulation of the water system); Judith V. Royster, *Winters in the East: Tribal Reserved Rights to Water in Riparian States*, 25 Wm. & Mary Envtl. L. & Pol'y Rev. 169 (2000) (discussing tribal reserved rights to water in riparian jurisdictions).
249. *See supra* note 204 and accompanying text.
250. *See* U.S. Geological Survey, Report to Congress: Concepts for National Assessment of Water Availability and Use 2 (2002) [hereinafter USGS, Concepts for National Assessment of Water Availability and Use], *available at* http://pubs.usgs.gov/circ/circ1223/pdf/C1223.pdf.
251. The last time a federal entity comprehensively assessed the availability and use of water in the United States was in 1978. U.S. General Accounting Office, Freshwater Supply: States' Views of How Federal Agencies Could Help Them Meet the Challenges of Expected Shortages 7 (July 2003) [hereinafter GAO, Freshwater Supply]; U.S. Geological Survey, Concepts for National Assessment of Water Availability and Use, *supra* note 250, at 2.
252. *Compare* Governor's Drought Response Task Force, *supra* note 16 (collecting data from wide variety of sources including the state departments, Federal studies and universities), *with* Texas Surface Water Quality Monitoring Program, 2012 Guidance for Assessing and Reporting Surface Water Quality in Texas 1–2 *available at* http://www.tceq.texas.gov/assets/public/waterquality/swqm/assess/12twqi/2012_guidance.pdf (using data provided by public after using "public outreach mechanisms" such as public meetings and publications and other "readily available data and information" among other sources).
253. *See, e.g.*, U.S. Geological Survey Streamflow of 2012—Water year Summary (2013).
254. *See* U.S. Geological Survey, Streamflow Information for the Next Century: A Plan for the National Streamflow Information Program of the U.S. Geological Survey, Report 99-456; USGS, Concepts for National Assessment of Water Availability and Use, *supra* note 250, at 7.
255. *See* U.S. Geological Survey, National Streamflow Information Program Implementation Status Report, Fact Sheet 2009–2020, 5 (Mar. 2011).
256. *See Ecological National Synthesis (ENS) Project*, U.S. Geological Survey (July 7, 2013), http://water.usgs.gov/nawqa/ecology/.
257. *See* Michael Lewis, U.S. Geological Survey, USGS Streamgage Network: Implications of Budget Cuts, 3 (2013); USGS, Concepts for National Assessment of Water Availability and Use, *supra* note 251, at 2; *see also* Doyle Rice, *Up to 375 Flood Gauges to Turn Off Because of Fund Cuts*, USA Today (Apr. 26, 2013), http://www.usatoday.com/story/news/nation/2013/04/25/flood-gauges-sequester/2113141/.
258. The last time a federal entity comprehensively assessed the availability and use of water in the United States was in 1978. GAO, Freshwater Supply, *supra* note 251, at 7; USGS, Concepts for National Assessment of Water Availability and Use, *supra* note 250, at 2.
259. *See* Subcomm. on Water Availability and Quality, Nat'l Sci. & Tech. Council, A Strategy for Federal Science and Technology to Support

VI. Conclusion

The interdependence of water and energy is clear. Large and reliable quantities of water are required to produce energy.[260] The treatment and distribution of water requires reliable sources of energy.[261] Nevertheless, data on water resources are collected by states at the watershed or drainage basin level, while energy supply and demand are commonly studied at the power grid or census division level.[262] Attempts to develop a sustainable energy policy that adequately accounts for water resources continue to be hampered by ad hoc policy decisions by various governmental bodies and insufficient data upon which to base good decision-making.[263] Collaboration is critical. Governmental bodies have an important role to play in the transition to a functioning water marketplace, as well as the collection and analysis of the robust data needed to inform policymakers of this secure and economically rationalized water use solution.

Water Availability and Quality in the United States 15 (Sept. 2007), *available at* http://www.epa.gov/etop/pubs/reportwateravailqual092007.pdf.

260. *See* Energy Demands on Water Resources, *supra* note 11, at 25.
261. *See supra* note 213 and accompanying text.
262. *See* Governor's Drought Response Task Force, *supra* note 16.
263. *See supra* notes 203–09 and accompanying text.